TRANSISTOR
DATABOOK

FIELD-EFFECT/POWER/SMALL SIGNAL

NATIONAL
SEMICONDUCTOR
CORPORATION

TRANSISTOR
DATABOOK

National Semiconductor Corporation 2900 Semiconductor Drive Santa Clara, California 95051 Tel: (408) 737-5000* TWX: (910) 339-9240

*after June 6, 1982, call (408) 721-5000

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1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

2900 Semiconductor Drive, Santa Clara, California 95051, (408) 737-5000/TWX: (910) 339-9240

Introduction

National Semiconductor has added many new transistors and product families since publication of the last databook. Many have already been widely acclaimed by users.

In addition to small signal and power bipolar and field effect transistors that have been the mainstay of our catalog, there is a section for multiple field effect transistors. More part numbers will be added as market needs expand.

To keep current on all new National transistors, please contact your National sales representative or franchised distributor and ask to be placed on the customer mailing list.

HOW TO USE THIS CATALOG

If you know the part/type number

Turn to the standard parts listing which begins on page 8 and find the desired part number. The electrical specifications page number will be shown. The list also identifies the process number from which that product is selected and the particular package code in which it is assembled. Package codes are cross-referenced to JEDEC code on page 12-14.

If performance data is required

Turn to the process data sheet indicated in the standard parts listing. Process data sheets are indexed in their appropriate sections by numerical order and begin on page 8-1, 9-1 or 10-1.

If you know the application

Turn to the selector guide section that begins on page 4-1 and select a potential process type. Selector guides as follows:

Then refer to the applicable process sheet, which will give the process/chip performance data and a common reference part type.

Or one can also refer to the Table of Contents, which is organized by general applications.

To convert a metal can transistor to a molded epoxy type, see page 18.

To convert a TO-105/TO-106 product type to a TO-92, see page 19. To convert a TO-18/TO-5 metal can product type to a TO-92/TO-237 molded epoxy type, see page 19.

Refer to the Package Outlines section beginning on page 12-14 for complete physical dimensions.

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2N699	1-27	12	10	2N2857	1-6	42	25	2N3370	3-7	52	02
2N706	1-2	21	18	2N2890	1-31	34	10	2N3390	1-14	04	94
2N708	1-3	22	18	2N2891	1-32	34	10	2N3391	1-14	04	94
2N718	1-18	19	02	2N2894	2-2	64	18	2N3391A	1-14	04	94
2N718A	1-18	19	02	2N2894A	2-2	64	18	2N3392	1-14	04	94
2N722	2-8	63	02	2N2897	1-19	19	02	2N3393	1-14	04	94
2N743	1-2	21	18	2N2904	2-8	63	10	2N3394	1-25	27	94
2N744	1-2	21	18	2N2904A	2-8	63	10	2N3395	1-14	04	94
2N753	1-2	21	18	2N2905	2-8	63	10	2N3396	1-14	04	94
2N760	1-10	07	02	2N2905A	2-8	63	10	2N3397	1-14	04	94
2N760A	1-10	07	02	2N2906	2-8	63	02	2N3398	1-15	04	94
2N834	1-2	21	18	2N2906A	2-8	63	02	2N3414	1-20	19	94
2N869	2-2	64	18	2N2907	2-8	63	02	2N3415	1-15	04	94
2N869A	2-2	64	18	2N2907A	2-9	63	02	2N3416	1-15	04	94
2N915	1-23	23	02	2N2923	1-14	04	94	2N3417	1-15	04	94
2N916	1-23	23	02	2N2924	1-14	04	94	2N3440	1-32	36	10
2N917	1-7	43	25	2N2925	1-14	04	94	2N3444	1-4	25	17
2N918	1-7	43	25	2N2926	1-14	04	94	2N3451	2-3	65	18
2N929	1-10	07	02	2N3009	1-4	22	18	2N3458	3-7	52	02
2N929A	1-10	07	02	2N3011	1-2	21	18	2N3459	3-7	52	02
2N930	1-10	07	02	2N3012	2-2	64	18	2N3460	3-7	52	02
2N956	1-18	19	02	2N3013	1-4	22	18	2N3467	2-4	70	17
2N995	2-2	64	18	2N3015	1-4	25	17	2N3468	2-5	70	17
2N995A	2-2	64	18	2N3019	1-28	12	10	2N3478	1-6	42	25
2N1132	2-8	63	10	2N3020	1-28	12	10	2N3502	2-9	63	10
2N1420	1-18	19	10	2N3053	1-28	12	10	2N3503	2-10	63	10
2N1566	1-18	19	10	2N3070	3-7	52	02	2N3504	2-10	63	02
2N1613	1-27	12	10	2N3071	3-7	52	02	2N3505	2-10	63	02
2N1711	1-27	12	10	2N3072	2-9	63	10	2N3545	2-2	64	18
2N2017	1-27	12	10	2N3073	2-9	63	10	2N3546	2-3	64	18
2N2102	1-27	12	10	2N3107	1-28	12	10	2N3547	2-6	62	02
2N2192	1-27	12	10	2N3108	1-28	12	10	2N3548	2-6	62	02
2N2192A	1-27	12	10	2N3109	1-29	12	10	2N3549	2-6	62	02
2N2193	1-27	12	10	2N3110	1-29	14	10	2N3550	2-6	62	02
2N2193A	1-28	12	10	2N3115	1-20	19	02	2N3563	1-7	43	92
2N2195	1-28	12	10	2N3116	1-20	19	02	2N3564	1-7	43	92
2N2195A	1-28	12	10	2N3117	1-10	07	02	2N3565	1-11	07	92
2N2218	1-18	19	10	2N3120	2-9	63	02	2N3566	1-30	13	92
2N2218A	1-18	19	10	2N3121	2-9	63	02	2N3567	1-30	13	92
2N2219	1-19	19	10	2N3133	2-9	63	02	2N3568	1-29	12	92
2N2219A	1-19	19	10	2N3134	2-9	63	02	2N3569	1-30	13	92
2N2221	1-19	19	02	2N3135	2-9	63	02	2N3576	2-3	64	18
2N2221A	1-19	19	02	2N3136	2-9	63	02	2N3600	1-6	42	25
2N2222	1-19	19	02	2N3209	2-2	64	18	2N3605	1-2	21	94
2N2222A	1-19	19	02	2N3244	2-4	70	17	2N3606	1-2	21	94
2N2243	1-28	12	10	2N3245	2-4	70	17	2N3607	1-2	21	94
2N2243A	1-28	12	10	2N3246	1-10	07	02	2N3638	2-10	63	92
2N2270	1-28	12	10	2N3248	2-2	64	18	2N3638A	2-10	63	92
2N2369	1-2	21	18	2N3249	2-2	64	18	2N3639	2-3	65	92
2N2369A	1-2	21	18	2N3250	2-14	66	02	2N3640	2-3	65	92
2N2484	1-10	07	02	2N3251	2-14	66	02	2N3641	1-20	19	92
2N2509	1-10	07	02	2N3252	1-4	25	17	2N3642	1-20	19	92
2N2510	1-10	07	02	2N3253	1-4	25	17	2N3643	1-20	19	92
2N2511	1-10	07	02	2N3299	1-20	19	10	2N3644	2-10	63	92
2N2586	1-10	07	02	2N3300	1-20	19	10	2N3645	2-10	63	92
2N2604	2-6	62	06	2N3301	1-20	19	02	2N3646	1-4	22	92
2N2605	2-6	62	06	2N3302	1-20	19	02	2N3662	1-7	43	94
2N2608	3-15	89	11	2N3304	2-3	65	18	2N3663	1-7	43	94
2N2609	3-15	88	11	2N3329	3-15	89	23	2N3665	1-29	12	10
2N2657	1-31	34	10	2N3330	3-15	89	23	2N3666	1-29	12	10
2N2658	1-31	34	10	2N3331	3-15	89	23	2N3678	1-20	19	10
2N2696	2-8	63	02	2N3332	3-15	89	23	2N3684	3-7	52	25

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2N3686	3-7	52	25
2N3687	3-7	52	25
2N3691	1-23	23	92
2N3692	1-23	23	92
2N3693	1-25	27	92
2N3694	1-25	27	92
2N3700	1-29	12	02
2N3702	2-10	63	94
2N3703	2-10	63	94
2N3704	1-16	13	94
2N3705	1-16	13	94
2N3706	1-16	13	94
2N3707	1-11	07	94
2N3708	1-11	07	94
2N3709	1-11	07	94
2N3710	1-11	07	94
2N3711	1-11	07	94
2N3721	1-25	27	94
2N3724	1-4	25	17
2N3724A	1-4	25	17
2N3725	1-4	25	17
2N3725A	1-5	25	17
2N3742	1-38	48	10
2N3794	1-16	13	94
2N3799	2-6	62	02
2N3819	3-4	50	94
2N3820	3-15	89	94
2N3821	3-7	55	25
2N3822	3-7	55	25
2N3823	3-4	50	29
2N3824	3-2	55	25
2N3825	1-7	43	94
2N3827	1-25	27	94
2N3858	1-25	27	94
2N3858A	1-11	07	94
2N3859	1-26	27	94
2N3859A	1-11	07	94
2N3860	1-26	27	94
2N3877	1-11	07	94
2N3877A	1-11	07	94
2N3900	1-15	04	94
2N3900A	1-11	07	94
2N3901	1-11	07	94
2N3903	1-23	23	92
2N3904	1-23	23	92
2N3905	2-14	66	92
2N3906	2-15	66	92
2N3921	3-10	83	12
2N3922	3-10	83	12
2N3932	1-6	42	25
2N3933	1-6	42	25
2N3934	3-10	83	12
2N3935	3-10	83	12
2N3945	1-29	12	10
2N3946	1-23	23	02
2N3947	1-24	23	02
2N3954	3-10	83	12
2N3954A	3-10	83	12
2N3955	3-10	83	12
2N3955A	3-10	83	12
2N3956	3-10	83	12
2N3957	3-10	83	12
2N3958	3-10	83	12
2N3966	3-2	50	29
2N3967	3-7	55	25
2N3967A	3-7	55	25
2N3968	3-7	55	25
2N3968A	3-7	55	25
2N3969	3-7	55	25
2N3969A	3-7	55	25
2N3970	3-2	51	02
2N3971	3-2	51	02
2N3972	3-2	51	02
2N4013	1-5	25	02
2N4014	1-5	25	02
2N4030	2-19	67	10
2N4031	2-19	67	10
2N4032	2-19	67	10
2N4033	2-19	67	10
2N4036	2-19	67	10
2N4037	2-19	67	10
2N4047	1-5	25	17
2N4058	2-6	62	94
2N4059	2-6	62	94
2N4061	2-6	62	94
2N4062	2-6	62	94
2N4082	3-10	83	12
2N4083	3-10	83	12
2N4084	3-10	83	12
2N4085	3-10	83	12
2N4091	3-2	51	02
2N4092	3-2	51	02
2N4093	3-2	51	02
2N4117	3-6	53	25
2N4117A	3-6	53	25
2N4118	3-6	53	25
2N4118A	3-6	53	25
2N4119	3-6	53	25
2N4119A	3-6	53	25
2N4121	2-15	66	92
2N4122	2-15	66	92
2N4123	1-24	23	92
2N4124	1-24	23	92
2N4125	2-15	66	92
2N4126	2-15	66	92
2N4134	1-8	44	25
2N4135	1-8	44	25
2N4140	1-20	19	92
2N4141	1-21	19	92
2N4142	2-10	63	92
2N4143	2-10	63	92
2N4208	2-3	65	18
2N4209	2-3	65	18
2N4220	3-7	55	25
2N4220A	3-7	55	25
2N4221	3-7	55	25
2N4221A	3-7	55	25
2N4222	3-7	55	25
2N4222A	3-7	55	25
2N4223	3-4	50	29
2N4224	3-4	50	29
2N4237	1-30	14	10
2N4248	2-6	62	92
2N4249	2-6	62	92
2N4250	2-6	62	92
2N4250A	2-7	62	92
2N4258	2-3	65	92
2N4258A	2-3	65	92
2N4259	1-6	42	25
2N4274	1-2	21	92
2N4275	1-2	21	92
2N4286	1-11	07	94
2N4287	1-11	07	94
2N4288	2-7	62	94
2N4289	2-7	62	94
2N4290	2-10	63	94
2N4291	2-11	63	94
2N4292	1-7	43	94
2N4293	1-7	43	94
2N4294	1-2	21	94
2N4295	1-2	21	94
2N4314	2-19	67	10
2N4338	3-7	52	02
2N4339	3-7	52	02
2N4340	3-7	52	02
2N4341	3-7	52	02
2N4354	2-17	67	92
2N4355	2-17	67	92
2N4356	2-17	67	92
2N4381	3-15	89	11
2N4384	1-11	07	02
2N4386	1-11	07	02
2N4391	3-2	51	02
2N4392	3-2	51	02
2N4393	3-2, 3-5, 3-6	51	02
2N4400	1-16	13	92
2N4401	1-16	13	92
2N4402	2-11	63	92
2N4403	2-11	63	92
2N4409	1-11	07	92
2N4410	1-12	07	92
2N4416	3-4	50	29
2N4416A	3-4	50	29
2N4424	1-15	04	94
2N4856	3-2	51	02
2N4856A	3-2	51	02
2N4857	3-2	51	02
2N4857A	3-2	51	02
2N4858	3-2	51	02
2N4858A	3-2	51	02
2N4859	3-2	51	02
2N4859A	3-2	51	02
2N4860	3-2	51	02
2N4860A	3-2	51	02
2N4861	3-2	51	02
2N4861A	3-2	51	02
2N4916	2-15	66	92
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2N4919	2-26	5F	58
2N4920	2-26	5F	58
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2N4927	1-38	48	10
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2N4954	1-16	13	94
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2N4965	2-7	62	92
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2N4967	1-12	07	92
2N4968	1-12	07	92
2N4969	1-21	19	92
2N4970	1-21	19	92
2N4971	2-11	63	92
2N4972	2-11	63	92
2N5018	3-14	88	11
2N5019	3-14	88	11
2N5020	3-15	89	11
2N5021	3-15	89	11
2N5022	2-5	70	17
2N5023	2-5	70	17
2N5030	1-2	21	94
2N5045	3-10	83	12
2N5046	3-10	83	12
2N5047	3-10	83	12
2N5056	2-3	64	18
2N5057	2-3	64	18
2N5078	3-4	50	29
2N5086	2-7	62	92
2N5087	2-7	62	92
2N5088	1-12	07	92
2N5089	1-12	07	92
2N5103	3-7	50	29
2N5104	3-7	50	29
2N5105	3-8	50	29
2N5114	3-14	88	11
2N5115	3-14	88	11
2N5116	3-14	88	11
2N5127	1-26	27	92
2N5128	1-21	19	92
2N5129	1-21	19	92
2N5130	1-7	43	92
2N5131	1-26	27	92
2N5132	1-26	27	92
2N5133	1-12	07	92
2N5134	1-2	21	92
2N5135	1-21	19	92
2N5136	1-21	19	92
2N5137	1-21	19	92
2N5138	2-15	66	92
2N5139	2-15	66	92
2N5140	2-3	65	92
2N5142	2-11	63	92
2N5143	2-11	63	92
2N5148	1-32	34	10
2N5150	1-32	34	10
2N5172	1-15	04	94
2N5179	1-6	42	25
2N5180	1-6	42	25
2N5189	1-6	25	17
2N5190	1-43	4E	58
2N5191	1-43	4E	58
2N5192	1-43	4E	58
2N5193	2-26	5E	58
2N5194	2-26	5E	58
2N5195	2-26	5E	58
2N5196	3-10	83	12
2N5197	3-10	83	12
2N5198	3-10	83	12
2N5199	3-10	83	12
2N5209	1-12	07	92
2N5210	1-12	07	92
2N5219	1-26	27	92
2N5220	1-16	13	92
2N5221	2-11	63	92
2N5223	1-26	27	92
2N5224	1-2	21	92
2N5225	1-16	13	92
2N5226	2-11	63	92
2N5227	2-7	62	92
2N5232	1-12	07	94
2N5232A	1-12	07	94
2N5245	3-4	90	97
2N5246	3-4	90	97
2N5247	3-4	90	97
2N5248	3-4	50	94
2N5294	1-43	4E	57
2N5296	1-43	4E	57
2N5298	1-43	4E	57
2N5305	1-47	05	94
2N5306	1-47	05	94
2N5307	1-47	05	94
2N5308	1-47	05	94
2N5336	1-32	34	10
2N5338	1-32	34	10
2N5354	2-11	63	94
2N5355	2-11	63	94
2N5358	3-8	55	25
2N5359	3-8	55	25
2N5360	3-8	55	25
2N5361	3-8	55	25
2N5362	3-8	55	25
2N5363	3-8	55	25
2N5364	3-8	55	25
2N5365	2-11	63	94
2N5366	2-11	63	94
2N5397	3-4	90	29
2N5398	3-4	90	29
2N5400	2-18	74	92
2N5401	2-18	74	92
2N5432	3-2	58	07
2N5433	3-2	58	07
2N5434	3-2	58	07
2N5447	2-12	63	97
2N5448	2-17	67	97
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2N5452	3-10	83	12
2N5453	3-10	83	12
2N5454	3-10	83	12
2N5457	3-8	55	92
2N5458	3-8	55	92
2N5459	3-8	55	92
2N5460	3-15	89	91
2N5461	3-15	89	91
2N5462	3-15	89	91
2N5484	3-4	50	92
2N5485	3-4	50	92
2N5486	3-4	50	92
2N5490	1-43	4E	57
2N5492	1-43	4E	57
2N5494	1-43	4E	57
2N5496	1-43	4E	57
2N5515	3-11	95	12
2N5516	3-11	95	12
2N5517	3-11	95	12
2N5518	3-11	95	12
2N5519	3-11	95	12
2N5520	3-11	95	12
2N5521	3-11	95	12
2N5522	3-11	95	12
2N5523	3-11	95	12
2N5524	3-11	95	12
2N5545	3-10	83	12
2N5546	3-10	83	12
2N5547	3-10	83	12
2N5550	1-17	16	92
2N5551	1-17	16	92
2N5555	3-2	50	92
2N5556	3-8	50	29
2N5557	3-8	50	29
2N5558	3-8	50	29
2N5561	3-10	98	12
2N5562	3-10	98	12
2N5563	3-10	98	12
2N5564	3-12	96	12
2N5565	3-12	96	12
2N5566	3-12	96	92
2N5638	3-2	51	92
2N5639	3-2	51	92
2N5640	3-2	51	92
2N5653	3-3	51	92
2N5654	3-3	51	92
2N5655	1-41	36	58
2N5656	1-41	36	58
2N5657	1-41	36	58
2N5668	3-4	50	92
2N5669	3-4	50	92
2N5670	3-4	50	92
2N5769	1-3	21	92
2N5770	1-7	43	92
2N5771	2-4	65	92
2N5772	1-3	22	92
2N5817	2-12	63	97
2N5830	1-17	16	92
2N5902	3-13	84	24
2N5903	3-13	84	24
2N5904	3-13	84	24
2N5905	3-13	84	24
2N5906	3-13	84	24
2N5907	3-13	84	24
2N5908	3-13	84	24
2N5909	3-13	84	24
2N5910	2-4	65	92
2N5911	3-12	93	24
2N5912	3-12	93	24
2N5949	3-4	50	97
2N5950	3-4	50	97
2N5951	3-4	50	97
2N5952	3-4	50	97
2N5953	3-4	50	97
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2N6042	2-31	5K	57	2N6712	1-38	48	90	92PU391	1-39	48	91
2N6043	1-49	4K	57	2N6713	1-38	48	90	92PU392	1-39	48	91
2N6044	1-49	4K	57	2N6714	1-34	37	91	92PU393	1-39	48	91
2N6045	1-49	4K	57	2N6715	1-35	38	91	AM1000H	10-21	87	25
2N6076	2-18	71	94	2N6716	1-35	38	91	AM1001H	10-21	87	25
2N6099	1-42	4A	57	2N6717	1-37	39	91	AM1002H	10-21	87	25
2N6101	1-42	4A	57	2N6718	1-37	39	91	BC107*	5-2	04	02
2N6103	1-42	4A	57	2N6719	1-38	48	91	BC108*	5-2	04	02
2N6107	2-26	5E	57	2N6720	1-32	36	91	BC109*	5-2	04	02
2N6109	2-26	5E	57	2N6721	1-32	36	91	BC140*	5-2	14	10
2N6110	2-26	5E	57	2N6722	1-32	36	91	BC141*	5-2	14	10
2N6111	2-26	5E	57	2N6723	1-32	36	91	BC143	5-3	61	10
2N6121	1-43	4E	57	2N6724	1-47	05	91	BC146*	5-3	61	10
2N6122	1-43	4E	57	2N6725	1-47	05	91	BC160*	5-3	67	10
2N6123	1-43	4E	57	2N6726	2-20	77	91	BC161*	5-3	67	10
2N6124	2-26	5E	57	2N6727	2-20	77	91	BC167*	5-3	04	94
2N6125	2-26	5E	57	2N6728	2-23	79	91	BC168*	5-3	04	94
2N6126	2-26	5E	57	2N6729	2-23	79	91	BC169*	5-4	04	94
2N6129	1-43	4E	57	2N6730	2-23	79	91	BC177*	5-4	71	02
2N6130	1-43	4E	57	2N6731	1-37	39	91	BC178*	5-4	71	02
2N6131	1-43	4E	57	2N6732	2-23	79	91	BC179*	5-4	71	02
2N6132	2-26	5E	57	2N6733	1-38	48	91	BC182*	5-5	04	97
2N6133	2-26	5E	57	2N6734	1-39	48	91	BC183*	5-5	04	97
2N6134	2-26	5E	57	2N6735	1-39	48	91	BC184*	5-6	04	97
2N6288	1-43	4E	57	2N6737	1-6	25	91	BC204	5-6	71	92
2N6290	1-43	4E	57	40235	1-6	42	25	BC207	5-6	04	92
2N6292	1-43	4E	57	40236	1-6	42	25	BC212*	5-6	63	97
2N6386	1-49	4J	57	40237	1-6	42	25	BC213*	5-7	63	97
2N6387	1-49	4K	57	40238	1-6	42	25	BC214*	5-8	63	97
2N6388	1-49	4K	57	40239	1-6	42	25	BC237*	5-8	04	97
2N6426	1-47	05	92	40240	1-7	42	25	BC238*	5-9	04	97
2N6427	1-47	05	92	40242	1-7	42	25	BC239*	5-9	04	97
2N6473	1-44	4F	57	40314	1-29	12	10	BC261*	5-9	71	02
2N6474	1-44	4F	57	40319	2-19	67	10	BC262*	5-10	71	02
2N6475	2-27	5F	57	40321	1-39	48	10	BC263*	5-10	71	02
2N6476	2-27	5F	57	92PE37A	1-35	38	90	BC264*	5-37	50	97
2N6483	3-11	95	12	92PE37B	1-35	38	90	BC307*	5-10	71	97
2N6484	3-11	95	12	92PE37C	1-35	38	90	BC308*	5-10	71	97
2N6485	3-11	95	12	92PE77A	2-21	78	90	BC309*	5-11	71	97
2N6486	1-42	4A	57	92PE77B	2-21	78	90	BC317*	5-11	04	92
2N6487	1-42	4A	57	92PE77C	2-21	78	90	BC318*	5-11	04	92
2N6488	1-42	4A	57	92PE487	1-39	48	90	BC319*	5-12	04	92
2N6489	2-25	5A	57	92PE488	1-39	48	90	BC327*	5-12	67	97
2N6490	2-25	5A	57	92PE489	1-39	48	90	BC328*	5-12	67	97
2N6491	2-25	5A	57	92PU01	1-34	37	90	BC337*	5-12	38	97
2N6548	1-47	05	55	92PU01A	1-34	37	90	BC338*	5-13	38	97
2N6549	1-47	05	55	92PU05	1-37	39	90	BC415*	5-13	71	97
2N6551	1-35	38	55	92PU06	1-37	39	90	BC485*	5-13	38	97
2N6552	1-35	38	55	92PU07	1-37	39	91	BC547*	5-13	04	97
2N6553	1-37	39	55	92PU10	1-39	48	91	BC548*	5-14	04	97
2N6554	2-21	78	55	92PU36	1-33	36	91	BC549*	5-14	04	97
2N6555	2-21	78	55	92PU36A	1-33	36	91	BC550*	5-14	04	97
2N6556	2-21	78	55	92PU36B	1-33	36	91	BC557*	5-14	71	97
2N6591	1-32	36	55	92PU36C	1-33	36	91	BC558*	5-15	71	97
2N6592	1-32	36	55	92PU45	1-47	05	91	BC559*	5-15	71	97
2N6593	1-32	36	55	92PU45A	1-47	05	91	BC560*	5-15	71	97
2N6705	1-35	38	90	92PU51	2-20	77	91	BCX58*	5-16	04	97
2N6706	1-35	38	90	92PU51A	2-20	77	91	BCX59*	5-16	04	97
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BCY59*	5-18	04	02	BD438	5-28	5F	58	BF241	5-32	47	98
BCY70	5-19	71	02	BD439	5-28	4E	58	BF244*	5-37	50	94
BCY71	5-19	71	02	BD440	5-29	5E	58	BF245*	5-37	50	97
BCY71A	5-19	71	02	BD441	5-29	4E	58	BF246*	5-37	51	94
BCY72	5-19	71	02	BD442	5-29	5E	58	BF247*	5-37	51	97
BD135*	5-19	37	58	BD533	5-29	4E	57	BF254	5-33	46	98
BD136*	5-19	77	58	BD534	5-29	5E	57	BF255	5-33	46	98
BD137*	5-19	38	58	BD535	5-29	4E	57	BF256*	5-37	50	97
BD138*	5-20	78	58	BD536	5-29	5E	57	BF257	5-33	48	10
BD139*	5-20	39	58	BD537	5-29	4E	57	BF258	5-33	48	10
BD140*	5-20	79	58	BD538	5-29	5E	57	BF259	5-33	48	10
BD157	5-20	36	58	BD633	5-29	4F	57	BF457	5-33	48	58
BD158	5-20	36	58	BD634	5-29	5F	57	BF458	5-33	48	58
BD159	5-20	36	58	BD635	5-29	4F	57	BF459	5-33	48	58
BD185	5-20	4F	58	BD636	5-30	5F	57	BFX13	5-33	66	02
BD186	5-20	5F	58	BD637	5-30	4F	57	BFX29	5-33	63	10
BD187	5-20	4F	58	BD638	5-30	5F	57	BFX30	5-33	63	10
BD188	5-20	5F	58	BD675*	5-30	4J	58	BFX37	5-33	62	02
BD189	5-20	4F	58	BD676*	5-30	5J	58	BFX65	5-33	62	02
BD190	5-20	5F	58	BD677*	5-30	4J	58	BFX84	5-34	12	10
BD201	5-20	4A	57	BD678*	5-30	5J	58	BFX85	5-34	12	10
BD202	5-20	5A	57	BD679*	5-30	4J	58	BFX86	5-34	14	10
BD203	5-21	4A	57	BD680*	5-30	5J	58	BFX87	5-34	63	10
BD204	5-21	5A	57	BD681	5-30	4J	58	BFX88	5-34	63	10
BD220	5-21	4F	57	BD682	5-30	5J	58	BFY39*	5-34	23	02
BD221	5-21	4F	57	BD733	5-30	4F	57	BFY50	5-34	14	10
BD222	5-21	4F	57	BD734	5-30	5E	57	BFY51	5-34	14	10
BD223	5-21	5F	57	BD735	5-30	4F	57	BFY52	5-34	14	10
BD224	5-21	5F	57	BD736	5-30	5E	57	BFY56	5-34	14	10
BD225	5-21	5F	57	BD737	5-30	4F	57	BFY72	5-35	19	04
BD233	5-21	4F	58	BD738	5-30	5E	57	BFY76	5-35	07	02
BD234	5-21	5F	58	BD795	5-30	4E	57	BSX21	5-35	07	02
BD235	5-21	4F	58	BD796	5-30	5E	57	BSX45*	5-35	14	10
BD236	5-21	5F	58	BD797	5-30	4E	57	BSX46*	5-35	12	10
BD237	5-21	4F	58	BD798	5-31	5E	57	BSX48	5-35	19	02
BD238	5-21	5F	58	BD799	5-31	4E	57	BSX88	5-35	21	18
BD239*	5-21	4F	57	BD800	5-31	5E	57	BSY38	5-35	21	18
BD240*	5-21	5F	57	BD801	5-31	4E	57	BSY39	5-35	21	18
BD241*	5-22	4F	57	BD802	5-31	5E	57	BSY51	5-35	19	10
BD242*	5-22	5E	57	BD895*	5-31	4K	57	BSY52	5-35	19	10
BD243*	5-22	4A	57	BD896*	5-31	5K	57	BSY53	5-35	19	10
BD244*	5-22	5A	57	BD897*	5-31	4K	57	BSY54	5-36	19	10
BD344	5-22	78	58	BD898*	5-31	5K	57	BSY95A	5-36	21	92
BD345	5-23	38	58	BD899*	5-31	4K	57	CS9011*	6-2	27	92
BD346	5-23	5A	57	BD900*	5-31	5K	57	CS9012*	6-2	68	92
BD347	5-23	4A	57	BD901	5-31	4K	57	CS9013*	6-2	09	92
BD348	5-23	79	58	BD902	5-31	5K	57	CS9014*	6-2	04	92
BD349	5-23	39	58	BDX33*	5-31	4K	57	CS9015*	6-2	71	92
BD370*	5-23	78/79	91	BDX34*	5-31	5K	57	CS9016*	6-2	46	92
BD371*	5-24	38/39	91	BF167	5-32	45	28	CS9018*	6-2	43	92
BD372*	5-24	78/79	90	BF180	5-32	41	25	D40C*	1-47	05	55
BD373*	5-25	38/39	90	BF181	5-32	41	25	D40D*	1-36	38	55
BD375*	5-26	38	58	BF194	5-32	46	98	D40E*	1-36	38	55
BD376*	5-26	78	58	BF195	5-32	46	98	D40K*	1-48	05	55
BD377*	5-27	38	58	BF196	5-32	46	98	D40N*	1-39	48	55
BD378*	5-27	78	58	BF197	5-32	47	98	D40P*	1-33	36	55
BD379*	5-27	39	58	BF198	5-32	45	98	D41D*	2-22	78	55
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DH3724CN	1-5	25	39
DH3725CD	1-5	25	40
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ED1602*	6-2	62	92
ED1702*	6-2	37	92
ED1802*	6-2	77	92
J108	3-3	58	92
J109	3-3	58	92
J110	3-3	58	92
J111	3-3	51	92
J112	3-3	51	92
J113	3-3	51	92
J114	3-3	90	92
J174	3-14	88	94
J175	3-14	88	94
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J201	3-8	52	92
J202	3-8	52	92
J203	3-8	52	92
J210	3-8	90	92
J211	3-8	90	92
J212	3-8	90	92
J270	3-15	88	94
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J401	3-10	92	92
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J410	3-10	83	60
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MJE5191J	1-44	4E	58
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MPF103	3-8	55	92
MPF104	3-8	55	92
MPF105	3-8	55	92
MPF106	3-5	50	92
MPF107	3-5	50	92
MPF108	3-5	55	92
MPF109*	3-8	55	92
MPF110	3-8	50	92
MPF111	3-8	50	92
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MPS2926	1-24	23	92
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MPS3393	1-15	04	92
MPS3394	1-15	27	92
MPS3395	1-15	04	92
MPS3396	1-15	04	92
MPS3397	1-15	04	92
MPS3398	1-15	04	92
MPS3563	1-7	43	92
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MPS3638A	2-12	63	92
MPS3639	2-4	65	92
MPS3640	2-4	65	92
MPS3642	1-24	19	92
MPS3644	2-12	63	92
MPS3645	2-12	63	92
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MPS6512	1-24	23	92
MPS6513	1-24	23	92
MPS6514	1-24	23	92
MPS6515	1-24	27	92
MPS6516	2-15	66	92
MPS6517	2-15	66	92
MPS6518	2-16	66	92
MPS6520	1-15	04	92
MPS6521	1-15	04	92
MPS6522	1-17	66	92

*All suffixes

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Device	Page	Process	Pkg
MPS6523	2-7	66	92
MPS6530	1-17	13	92
MPS6531	1-17	13	92
MPS6532	1-17	13	92
MPS6533	2-12	63	92
MPS6534	2-12	63	92
MPS6535	2-12	63	92
MPS6539	1-7	42	96
MPS6540	1-9	49	96
MPS6541	1-8	43	92
MPS6542	1-9	47	96
MPS6543	1-9	47	96
MPS6544	1-9	49	96
MPS6546	1-9	47	96
MPS6547	1-9	47	96
MPS6548	1-7	42	96
MPS6560	1-31	14	92
MPS6561	1-31	14	92
MPS6562	2-17	67	92
MPS6563	2-18	60	92
MPS6564	1-26	27	92
MPS6565	1-26	27	92
MPS6566	1-26	27	92
MPS6567	1-9	49	96
MPS6568A	1-8	44	96
MPS6569	1-8	44	96
MPS6570	1-8	44	96
MPS6571	1-12	07	92
MPS6573	1-14	02	92
MPS6574	1-14	02	92
MPS6575	1-14	02	92
MPS6576	1-14	02	92
MPS8098	1-18	18	92
MPS8099	1-18	18	92
MPSA05	1-29	12	92
MPSA06	1-29	12	92
MPSA09	1-12	07	92
MPSA10	1-26	27	92
MPSA12	1-48	05	92
MPSA13	1-48	05	92
MPSA14	1-48	05	92
MPSA20	1-14	02	92
MPSA42	1-39	48	92
MPSA43	1-40	48	92
MPSA55	2-17	67	92
MPSA56	2-17	67	92
MPSA62	2-30	61	92
MPSA63	2-30	61	92
MPSA64	2-30	61	92
MPSA65	2-30	61	92
MPSA66	2-30	61	92
MPSA70	2-7	62	92
MPSH10	1-7	42	96
MPSH11	1-9	47	96
MPSH19	1-9	47	96
MPSH20	1-9	49	96
MPSH24	1-9	47	96
MPSH30	1-8	44	96
MPSH31	1-8	44	96
MPSH32	1-8	45	96
MPSH34	1-9	47	96
MPSH37	1-9	49	96
MPSL01	1-18	16	92
MPSL51	2-18	74	92
MRF501	1-7	42	25
MRF502	1-7	42	25
NA0IE*	7-4	09	92
NA0IF*	7-4	09	94
NA02E*	7-4	68	92
NA02F*	7-4	68	94
NA11E*	7-8	09	92
NA11F*	7-8	09	94
NA12E*	7-8	68	92
NA12F*	7-8	68	94
NA21E*	7-12	37	92
NA21F*	7-12	37	94
NA21X*	7-12	37	91
NA21Y*	7-12	37	90
NA22E*	7-12	77	92
NA22F*	7-12	77	94
NA22X*	7-12	77	91
NA22Y*	7-12	77	90
NA31K*	7-16	37	55
NA31M*	7-16	37	56
NA31X*	7-16	37	91
NA31Y*	7-16	37	90
NA32K*	7-16	77	55
NA32M*	7-16	77	56
NA32X*	7-16	77	91
NA32Y*	7-16	77	90
NA41U*	7-20	4F	58
NA42U*	7-20	5F	58
NA51U	7-24	4F	58
NA51W	7-24	4F	57
NA52U	7-24	5F	58
NA52W	7-24	5F	57
NA61U	7-28	4E	58
NA61W	7-28	4E	57
NA62U	7-28	5E	58
NA62W	7-28	5E	57
NA71U	7-32	4E	58
NA71W	7-32	4E	57
NA72U	7-32	5E	58
NA72W	7-32	5E	57
NB011E*	7-36	04	92
NB011F*	7-36	04	94
NB012E*	7-36	04	92
NB012F*	7-36	04	94
NB013E*	7-40	04	92
NB013F*	7-40	04	94
NB014E*	7-40	04	92
NB014F*	7-40	04	94
NB021E*	7-36	62	92
NB021F*	7-36	62	94
NB022E*	7-36	62	92
NB022F*	7-36	62	94
NB023E*	7-40	62	92
NB023F*	7-40	62	94
NB024E*	7-40	62	92
NB111E*	7-44	04	92
NB111F*	7-44	04	94
NB112E*	7-44	04	92
NB112F*	7-44	04	94
NB113E*	7-44	07	92
NB113F*	7-44	07	94
NB121E*	7-44	71	92
NB121F*	7-44	71	94
NB122E*	7-44	71	92
NB122F*	7-44	71	94
NB123E*	7-44	71	92
NB123F*	7-44	71	94
NB211E*	7-48	19	92
NB211F*	7-48	19	94
NB211X*	7-48	19	91
NB211Y*	7-48	19	90
NB212E*	7-48	19	92
NB212F*	7-48	19	94
NB212X*	7-48	19	91
NB212Y*	7-48	19	90
NB213E*	7-48	19	92
NB213F*	7-48	19	94
NB213X*	7-48	19	91
NB213Y*	7-48	19	90
NB221E*	7-48	63	92
NB221F*	7-48	63	94
NB221X*	7-48	63	91
NB221Y*	7-48	63	90
NB222E*	7-48	63	92
NB222F*	7-48	63	94
NB222X*	7-48	63	91
NB222Y*	7-48	63	90
NB223E*	7-48	63	92
NB223F*	7-48	63	94
NB223X*	7-48	63	91
NB223Y*	7-48	63	90
NB311E	7-52	38	92
NB311F	7-52	38	94
NB311K	7-52	38	55
NB311M	7-52	38	56
NB311X	7-52	38	91
NB311Y	7-52	38	90
NB312E	7-52	38	92
NB312F	7-52	38	94
NB312K	7-52	38	55
NB312M	7-52	38	56
NB312X	7-53	38	91
NB312Y	7-53	38	90
NB313E	7-53	38	92
NB313F	7-53	38	94
NB313K	7-53	38	55
NB313M	7-53	38	56
NB313X	7-53	38	91
NB313Y	7-53	38	90
NB321E	7-53	78	92
NB321F	7-53	78	94
NB321K	7-53	78	55
NB321M	7-53	78	56
NB321X	7-53	78	91
NB321Y	7-52	78	90
NB322E	7-52	78	92
NB322F	7-52	78	94
NB322K	7-52	78	55
NB322M	7-52	78	56
NB322X	7-52	78	91
NB322Y	7-52	78	90
NB323E	7-52	78	92
NB323F	7-52	78	94
NB323K	7-52	78	55
NB323M	7-52	78	56

*All suffixes

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Device	Page	Process	Pkg
NB323X	7-52	78	91
NB323Y	7-52	78	90
NCBT13	1-17	13	92
NCBV14	1-31	14	55
NDF9406	3-12	94	12
NDF9407	3-12	94	12
NDF9408	3-12	94	12
NDF9409	3-12	94	12
NDF9410	3-12	94	12
NF5101	3-5	51	29
NF5102	3-5	51	29
NF5103	3-5	51	29
NF5301*	3-6	53	25
NPD5564	3-12	96	67
NPD5565	3-12	96	67
NPD5566	3-12	96	67
NPD8301	3-11	83	67
NPD8302	3-11	83	67
NPD8303	3-11	83	67
NR041E	7-56	04	92
NR421D*	7-60	42	96
NR421F*	7-60	42	94
NR431E*	7-64	43	92
NR431F*	7-64	43	94
NR461E*	7-68	46	92
NR461F*	7-68	46	94
NS3762	2-5	70	17
NS3763	2-5	70	17
NS3903	1-25	23	02
NS3904	1-25	23	02
NS3905	2-16	66	02
NS3906	2-16	66	02
NS4234	2-17	67	10
NSD36*	1-33	36	55
NSD102	1-34	38	55
NSD103	1-34	38	55
NSD104	1-38	39	55
NSD105	1-38	39	55
NSD106	1-38	39	55
NSD131	1-40	48	55
NSD132	1-40	48	55
NSD133	1-40	48	55
NSD134	1-40	48	55
NSD135	1-40	48	55
NSD151	1-48	05	55
NSD152	1-48	05	55
NSD153	1-48	05	55
NSD154	1-48	05	55
NSD202	2-20	77	55
NSD203	2-20	77	55
NSD204	2-24	79	55
NSD205	2-24	79	55
NSD206	2-24	79	55
NSD457	1-40	48	55
NSD458	1-40	48	55
NSD459	1-40	48	55
NSD3439	1-33	36	55
NSD3440	1-34	36	55
NSD6178	1-37	38	55
NSD6179	1-37	38	55
NSD6180	2-23	78	55
NSD6181	2-23	78	55
NSDU01	1-34	37	55
NSDU01A	1-34	38	55
NSDU02	1-35	38	55
NSDU05	1-37	38	55
NSDU06	1-38	39	55
NSDU07	1-38	39	55
NSDU10	1-40	48	55
NSDU45	1-48	05	55
NSDU45A	1-48	05	55
NSDU51	2-20	77	55
NSDU51A	2-20	77	55
NSDU52	2-21	77	55
NSDU55	2-23	78	55
NSDU56	2-24	79	55
NSDU57	2-24	79	55
NSDU95	2-30	61	55
NSDU95A	2-30	61	55
NSE170	2-21	77	56
NSE171	2-23	78	56
NSE180	1-35	38	56
NSE181	1-37	38	56
NSE457	1-40	48	56
NSE458	1-40	48	56
NSE459	1-40	48	56
NSE871	1-31	17	51
NSE872	2-20	76	51
P1086	3-14	88	91
P1087	3-14	88	91
PE3100	1-9	47	96
PE4010	1-13	07	92
PE5025	1-8	46	92
PE5029	1-9	47	96
PE5030B	1-9	47	96
PE5031	1-9	47	96
PF5101	3-6	51	92
PF5102	3-6	51	92
PF5103	3-6	51	92
PF5301*	3-6	53	92
PN918	1-8	43	92
PN930	1-13	07	92
PN2221	1-21	19	92
PN2221A	1-21	19	92
PN2222	1-21	19	92
PN2222A	1-22	19	92
PN2369	1-3	21	92
PN2369A	1-3	21	92
PN2484	1-13	07	92
PN2906	2-12	63	92
PN2906A	2-12	63	92
PN2907	2-12	63	92
PN2907A	2-13	63	92
PN3563	1-8	43	92
PN3564	1-8	43	92
PN3565	1-13	07	92
PN3566	1-17, 1-30	13	92
PN3567	1-17, 1-30	13	92
PN3568	1-29	12	92
PN3569	1-17, 1-30	13	92
PN3638	2-13	63	92
PN3638A	2-13	63	92
PN3639	2-4	65	92
PN3640	2-4	65	92
PN3641	1-22	19	92
PN3642	1-22	19	92
PN3643	1-22	19	92
PN3644	2-13	63	92
PN3645	2-13	63	92
PN3646	1-4	22	92
PN3684	3-8	52	92
PN3685	3-8	52	92
PN3686	3-8	52	92
PN3687	3-8	52	92
PN3691	1-25	23	92
PN3692	1-25	23	92
PN3694	1-26	27	92
PN4091	3-3	51	92
PN4092	3-3	51	92
PN4093	3-3	51	92
PN4117*	3-6	53	92
PN4118*	3-6	53	92
PN4119*	3-6	53	92
PN4121	2-16	66	92
PN4122	2-16	66	92
PN4140	1-22	19	92
PN4141	1-22	19	92
PN4142	2-13	63	92
PN4143	2-13	63	92
PN4220	3-9	55	92
PN4221	3-9	55	92
PN4222	3-9	55	92
PN4223	3-5	50	92
PN4224	3-5	50	92
PN4248	2-7	62	92
PN4249	2-7	62	92
PN4250	2-7	62	92
PN4250A	2-7	62	92
PN4258	2-4	65	92
PN4258A	2-4	65	92
PN4274	1-3	21	92
PN4275	1-3	21	92
PN4302	3-9	52	92
PN4303	3-9	52	92
PN4304	3-9	52	92
PN4342	3-15	89	92
PN4354	2-17	67	92
PN4355	2-17	67	92
PN4356	2-18	67	92
PN4360	3-15	89	92
PN4391	3-3	51	92
PN4392	3-3	51	92
PN4393	3-3, 3-6	51	92
PN4416	3-5	50	92
PN4856	3-3	51	92
PN4857	3-3	51	92
PN4858	3-3	51	92
PN4859	3-3	51	92
PN4860	3-3	51	92
PN4861	3-3	51	92
PN4916	2-16	66	92
PN4917	2-16	66	92
PN5019	3-14	88	94
PN5033	3-15	89	92
PN5127	1-26	27	92
PN5128	1-22	19	92
PN5129	1-22	19	92
PN5130	1-8	43	92
PN5131	1-26	27	92

*All suffixes

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Device	Page	Process	Pkg
PN5132	1-26	27	92
PN5133	1-13	07	92
PN5134	1-3	21	92
PN5135	1-22	19	92
PN5136	1-22	19	92
PN5137	1-22	19	92
PN5138	2-16	66	92
PN5139	2-16	66	92
PN5140	2-4	65	92
PN5142	2-14	63	92
PN5143	2-14	63	92
PN5163	3-9	50	92
PN5179	1-7	42	96
PN5432	3-3	58	92
PN5433	3-3	58	92
PN5434	3-3	58	92
PN5447	2-18	67	92
PN5449	1-17	13	92
PN5816	1-17	13	92
PN5910	2-4	65	92
PN7055	1-40	48	92
SE5020	1-8	44	25
SE5021	1-8	44	25
SE5022	1-8	44	25
SE5023	1-8	44	25
SE5024	1-8	44	25
SE5050	1-8	44	25
SE5051	1-8	44	25
SE5052	1-8	44	25
SE5055	1-8	45	28
SE7055	1-40	48	10
SE7056	1-41	48	10
SE9300	1-49	4K	57
SE9301	1-50	4K	57
SE9302	1-50	4K	57
SE9400	2-31	5K	57
SE9401	2-31	5K	57
SE9402	2-31	5K	57
ST3904	1-25	23	92
ST3906	2-16	66	92
ST5771	2-4	65	92
SV7056	1-41	48	55
TIP29*	1-44	4F	57
TIP30*	2-27	5F	57
TIP31*	1-44	4F	57
TIP32*	2-27	5F	57
TIP41*	1-42	4A	57
TIP42*	2-25	5A	57
TIP61*	1-44	4F	57
TIP62*	2-27	5F	57
TIP100	1-50	4K	57
TIP101	1-50	4K	57
TIP102	1-50	4K	57
TIP105	2-31	5K	57
TIP106	2-31	5K	57
TIP107	2-31	5K	57
TIP110	1-49	4J	57
TIP111	1-49	4J	57
TIP112	1-49	4J	57
TIP115	2-31	5J	57
TIP116	2-31	5J	57
TIP117	2-31	5J	57
TIP120	1-49	4J	57
TIP121	1-49	4J	57
TIP122	1-49	4J	57
TIP125	2-31	5J	57
TIP126	2-31	5J	57
TIP127	2-31	5J	57
TIP130	1-50	4K	57
TIP131	1-50	4K	57
TIP132	1-50	4K	57
TIP135	2-31	5K	57
TIP136	2-31	5K	57
TIP137	2-31	5K	57
TIS58*	3-9	50	94
TIS59	3-9	50	94
TIS73	3-3	51	97
TIS74	3-3	51	97
TIS75	3-3	51	97
TIS86	1-9	47	98
TIS87	1-9	47	98
TIS90	1-23	19	94
TIS91	2-14	63	94
TIS92	1-23	19	97
TIS93	2-14	63	97
TIS97	1-15	04	97
TIS98	1-18	18	97
TIS99	1-18	18	97
TN1711	1-29	12	91
TN2017	1-30	12	91
TN2102	1-30	12	91
TN2218A	1-22	19	91
TN2219	1-23	19	91
TN2219A	1-23	19	91
TN2270	1-30	12	91
TN2904A	2-14	63	91
TN2905	2-14	63	91
TN2905A	2-14	63	91
TN3019	1-30	12	91
TN3020	1-30	12	91
TN3053	1-30	12	91
TN3244	2-19	70	91
TN3245	2-20	70	91
TN3252	1-31	25	91
TN3253	1-31	25	91
TN3440	1-34	36	91
TN3444	1-31	25	91
TN3467	2-20	70	91
TN3724	1-31	25	91
TN3725	1-31	25	91
TN3742	1-41	48	91
TN4030	2-19	67	91
TN4033	2-19	67	91
TN4036	2-18	67	91
TN4037	2-18	67	91
TN4234	2-23	78	91
TN4235	2-23	78	91
TN4236	2-23	78	91
TN4314	2-19	67	91
TN5022	2-20	70	91
TN5023	2-20	70	91
U231	3-11	83	12
U232	3-11	83	12
U233	3-11	83	12
U234	3-11	83	12
U235	3-11	83	12
U257	3-12	93	24
U308	3-5	92	07
U309	3-5	92	07
U310	3-5	92	07
U312	3-5	90	07
U401	3-11	98	12
U402	3-11	98	12
U403	3-11	98	12
U404	3-11	98	12
U405	3-11	98	12
U406	3-11	98	12
U421	3-13	86	24
U422	3-13	86	24
U423	3-13	86	24
U424	3-13	86	24
U425	3-13	86	24
U426	3-13	86	24
U1897	3-3	51	92
U1898	3-3	51	92
U1899	3-3	51	92

*All suffixes

Bipolar Transistor and FET Dice

Dice

Standard types from National's transistor families are available in unencapsulated die form for use in hybrid circuits. Contact factory for conditions of sale.

Conversion of Bipolar Metal Can to Plastic

Metal P/N	Plastic Equivalent	Electrical Equivalency*	Process	Metal P/N	Plastic Equivalent	Electrical Equivalency*	Process
2N697	2N4400	A	13	2N2905	TN2905	E	63
2N706	MPS706	E	21	2N2905A	TN2905A	E	63
2N708	PN3646	N	22	2N2906	PN2906	E	63
2N718	2N4400	A	13	2N2906A	PN2906A	E	63
2N722	PN2906	N	63	2N2907	PN2907	E	63
2N744	PN2369	N	21	2N2907A	PN2907A	E	63
2N753	PN2369	N	21	2N3009	PN3646	N	22
2N760A	2N4409	N	07	2N3011	PN2369	N	21
2N834	MPS834	E	21	2N3012	PN3640	A	65
2N869A	PN3640	A	65	2N3013	PN3646	E	22
2N915	MPS6565	A	27	2N3019	TN3019	E	12
2N917	PN3563	E	43	2N3020	TN3020	E	12
2N918	PN918	E	43	2N3053	2N3053	E	12
2N929	2N4409	N	07	2N3117	2N5210	N	07
2N930	PN930	E	07	2N3133	MPS3703	N	63
2N956	PN2222A	N	19	2N3134	PN3645	N	63
2N995A	PN3640	A	65	2N3135	MPS3703	N	63
2N1132	PN2906	N	63	2N3136	PN3645	N	63
2N1613	PN2221A	N	19	2N3250	2N3905	A	66
2N1711	PN2222A	N	19	2N3251	2N3906	A	66
2N2218	TN2218	E	19	2N3300	2N4401	A	13
2N2218A	TN2218A	E	19	2N3301	2N4400	A	13
2N2219	TN2219	E	19	2N3302	2N4401	A	13
2N2219A	TN2219A	E	19	2N3304	PN3639	A	65
2N2221	PN2221	E	19	2N3440	TN3440	E	36
2N2221A	PN2221A	E	19	2N3724	TN3724	E	25
2N2222	PN2222	E	19	2N3725	TN3725	E	25
2N2222A	PN2222A	E	19	2N3944	2N3903	N	23
2N2369	PN2369	E	21	2N3947	2N3904	N	23
2N2369A	PN2369A	E	21	2N3962	2N5086	N	62
2N2483	2N5209	N	07	2N3964	2N5087	N	62
2N2484	2N5210	N	07	2N3965	2N5087	N	62
2N2604	2N5086	N	62	2N4033	TN4033	E	67
2N2605	2N5086	N	62	2N4036	TN4036	E	67
2N2894	PN3640	A	65	2N4037	TN4037	E	67
2N2894A	PN3639	A	65	2N4208	PN3640	N	65
2N2904	TN2904	E	63	2N4209	PN3640	N	65
2N2904A	TN2904A	E	63				

* E = Exact electrical equivalent
N = Near electrical equivalent
A = Approximate electrical equivalent

Note: On "N" and "A" categories please refer to device specification section for deviation from metal can specifications.

This list is for use when an alternative to a metal can transistor is needed.

To facilitate conversions on the most popular types National is offering the "PN" series, TO-92 devices that use the same die type and are screened to same electrical specifications. The TO-92 transistors produced by National Semiconductor are the most advanced Plastic Transistors ever manufactured. They utilize epoxy B encapsulation and a copper lead frame to give a power dissipation of up to 625 mW @ $T_A = 25°C$. These transistors provide electrical performance and reliability equivalent to their metal can versions in most applications where T_J does not exceed 150°C.

The same situation is applicable to the "TN" series, except that the National-originated TO-237 (TO-92+) case outline is used, which permits power dissipation of up to 1.0W @ $T_A = 25°C$.

Conversion of TO-105/TO-106 to TO-92

National has chosen to no longer produce the TO-105/106 plastic transistor line. The decision to drop this line was based on two major factors: cost and performance.

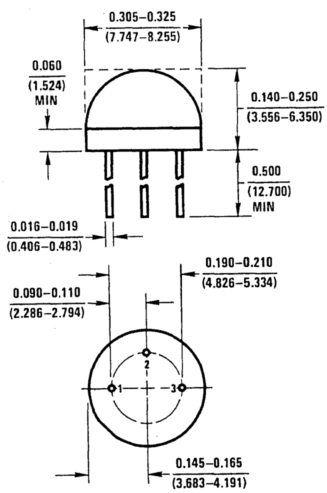
The TO-92 is the most advanced transistor offered today. With its automated assembly, it has the lowest potential cost. By contrast, the TO-105/106 is a hand-assembled product and its cost is tied to ever-increasing labor costs.

Our TO-92 is encapsulated in "Epoxy B" and has a copper lead frame. This is *the* superior TO-92 available today. As compared with TO-105/106, our TO-92 has better than twice the power dissipation of either package.

We have done several things in order to make this conversion as easy as possible. We are offering a series on "PN" ("PN and "J" in FETs) part numbers that have exactly the same number as the original part; i.e., 2N3565 becomes a PN3565. These PN types use the same chip and are screened to the same electrical specification as the original part. The original parts have a pin circle, TO-106 = TO-18 and TO-105 = TO-5, so we will supply TO-92 lead formed to the appropriate configuration at no extra charge. If you enter an order to the old part number, our computer will automatically convert it to the correct PN number *with* the correct lead form; i.e., 2N3565 becomes PN3565-18. In the case of some of the less popular types, we have converted to the nearest part type using the same chip. Please use the conversion chart on the next page as a guide.

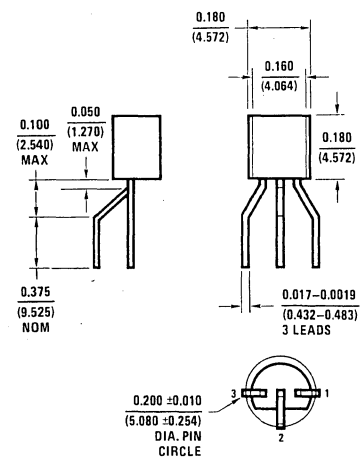
It is our intent to service our customers with the highest quality and most cost-effective product available.

TO-105

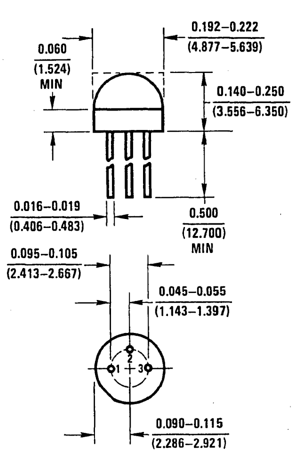


Pin	T
1	E
2	B
3	C

TO-92 Device to TO-5 Pin Circle

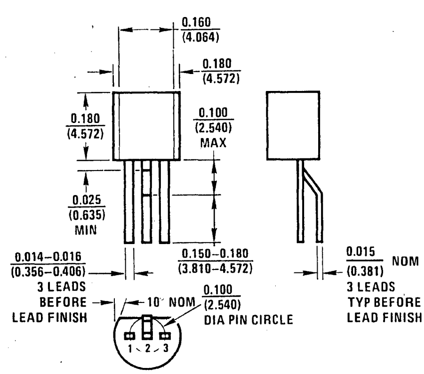


TO-106



Pin	FET	T
1	S	E
2	D	B
3	G	C

TO-92 Device to TO-18 Pin Circle



Conversion of TO-105/TO-106 to TO-92 (Continued)

Bipolar

TO-105/106	TO-92	TO-105/106	TO-92	TO-105/106	TO-92
EN2222	PN2222-18	2N3692	PN3692-18	2N4965	2N5086-18
EN2369A	PN2369A-18	2N3693	MPS3693-18	2N4966	2N5209-18
EN2484	PN2484-18	2N3694	PN3694-18	2N4967	2N5210-18
3N2907	PN2907-18	2N4121	PN4121-18	2N4968	2N5209-18
EN918	PN918-18	2N4122	PN4122-18	2N4969	PN2221-18
EN930	PN930-18	2N4140	PN4140-18	2N4970	PN2222-18
SM3904	2N3904-18	2N4141	PN4141-18	2N4971	PN2906-18
SM3906	2N3906-18	2N4142	PN4142-18	2N4972	PN2907-18
2N3563	PN3563-18	2N4143	PN4143-18	2N5127	PN5127-18
2N3564	PN3564-18	2N4248	PN4248-18	2N5128	PN5128-5
2N3565	PN3565-18	2N4249	PN4249-18	2N5129	PN5129-18
2N3566	PN3566-5	2N4250	PN4250-18	2N5130	PN5130-18
2N3567	PN3567-5	2N4250A	PN4250A-18	2N5131	PN5131-18
2N3568	PN3568-5	2N4258	PN4258-18	2N5132	PN5132-18
2N3569	PN3569-5	2N4258A	PN4258A-18	2N5133	PN5133-18
2N3638	PN3638-5	2N4274	PN4274-18	2N5134	PN5134-18
2N3638A	PN3638A-5	2N4275	PN4275-18	2N5135	PN5135-18
2N3639	PN3639-18	2N4354	PN4354-5	2N5136	PN5136-5
2N3640	PN3640-18	2N4355	PN4355-5	2N5137	PN5137-18
2N3641	PN3641-5	2N4356	PN4356-5	2N5138	PN5138-18
2N3642	PN3642-5	2N4916	PN4916-18	2N5139	PN5139-18
2N3643	PN3643-5	2N4917	PN4917-18	2N5142	PN5142-18
2N3644	PN3644-5	2N4944	PN2222A-18	2N5143	PN5143-18
2N3645	PN3645-5	2N4945	PN2222A-18	2N5910	PN5910-18
2N3646	PN3646-18	2N4946	PN2222A-18		
2N3691	PN3691-18	2N4964	MPSA70-18		

FETs

TO-106	TO-92	TO-106	TO-92	TO-106	TO-92
E100	J203-18	E300	J300-18	KE4393	PN4393-18
E101	J201-18	E304	J304-18	KE4416	PN4416-18
E102	J202-18	E305	J305-18	KE4857	PN4857-18
E103	J203-18	E308	J308-18	KE4858	PN4858-18
E108	J108-18	E309	J309-18	KE4859	PN4859-18
E109	J109-18	E310	J310-18	KE4860	PN4860-18
E110	J110-18	E311	J309-18	KE4861	PN4861-18
E111	J111-18	E312	J310-18	ITE4391	PN4391-18
E112	J112-18	KE3684	PN3684-18	ITE4392	PN4392-18
E113	J113-18	KE3685	PN3685-18	ITE4393	PN4393-18
E114	J114-18	KE3686	PN3686-18	P1086E	P1086-18
E174	J174-18	KE3687	PN3687-18	P1087E	P1087-18
E175	J175-18	KE4091	PN4091-18	U1897E	U1897-18
E176	J176-18	KE4092	KE4092-18	U1898E	U1898-18
E201	J201-18	KE4093	PN4093-18	U1899E	U1899-18
E202	J202-18	KE4220	PN4220-18	2N4302	PN4302-18
E203	J203-18	KE4221	PN4221-18	2N4303	PN4303-18
E210	J210-18	KE4222	PN4222-18	2N4304	PN4304-18
E211	J211-18	KE4223	PN4223-18	2N4342	PN4342-18
E212	J212-18	KE4224	PN4224-18	2N4343	PN4343-18
E270	J270-18	KE4391	PN4391-18	2N4360	PN4360-18
E271	J271-18	KE4392	PN4392-18	2N5033	PN5033-18
				2N5163	PN5163-18

Reliability and Quality

B + PROGRAM

The B + Program is a quality enhancement program intended primarily for users of transistors who either cannot or choose not to perform incoming inspection of transistors, or desire significantly better than usual incoming quality levels for their parts.

Transistor users who specify B + processed parts will find that the program can:

- Eliminate incoming inspection
- Eliminate the need for, and thus the cost of, independent testing laboratories
- Reduce the cost of reworking assembled boards/ assemblies

RELIABILITY VIS-A-VIS QUALITY

The words "reliability" and "quality" are often used interchangeably, as though they connote identical facets of a product's merit. However, reliability and quality are different, and discrete component users must understand the essential difference between the two concepts in order to properly evaluate the various vendors' programs for product improvement that are generally available, and National's B + program in particular.

The concept of quality gives us information about the population of faulty components among good components, and generally relates to the number of faulty components that arrive at a user's plant. Looked at in another way, quality can instead relate to the number of faulty components that escape detection at the component vendor's plant.

It is the function of a vendor's Quality Control arm to monitor the degree of success of that vendor in reducing the number of faulty components that escape detection. QC does this by testing the outgoing parts on a sampled basis. The Acceptable Quality Level (AQL) determines the stringency of the sampling. As the AQL decreases, it becomes more difficult for bad parts to escape detection, thus the quality of the shipped parts increases.

The concept of reliability, on the other hand, refers to how well a part that is initially good will withstand its environment. Reliability is measured by the percentage of parts that fail in a given period of time.

QUALITY IMPROVEMENT

When purchasing a component or a system, it is expected that each item delivered has been thoroughly tested and will perform according to data sheet or detailed specifications. However, some test escapes do occur.

Additional screening programs can be implemented to reduce the number of escapes. To be effective, however, a screening program must not only reduce escapes but must also be tailored specifically to detect and remove the types of residual defects that are predicted by process and line monitor control data. A frequently used screening procedure consists of a short, accelerated burn-in, but this will not usually detect the primary historical failure mechanism, which is thermo-mechanical in origin.

DOUBLE PASS + HOT SCREENING

National's double pass + hot screen flow, B +, provides a cost effective screening technique. By testing each B + transistor at both room temperature and at +125°C, the following benefits are realized:

- Escapes caused by mishandling are reduced significantly.
- Residual thermo-mechanical defects not detected during normal room temperature testing or high temperature lot buy-off are removed.
- Anomalous high temperature parametric effects that may have been created during wafer fabrication are removed.
- An AQL of 0.05% or better is guaranteed.

RELIABILITY THROUGH DESIGN

With increased component density in modern electronic products has come an increased concern with component failures in such products. Virtually all equipment manufacturers thoroughly exercise their products before shipment. This "system burn-in" is designed to simulate, as closely as possible, field operating conditions. A high failure rate of discrete components at the system burn-in level can dramatically increase manufacturing costs.

The most important factor affecting a component's reliability is its construction; i.e., the materials used and the method by which they are fabricated and assembled. Reliability cannot be tested in per se. Yet most transistor reliability enhancement programs utilize standardized procedures (usually MIL-STD) for either screening or lot acceptance. Frequently these standardized screening methods have only a minor influence on transistor field failure rates.

NATIONAL'S ON-GOING RELIABILITY IMPROVEMENT PROGRAM

Transistor reliability improvement at National Semiconductor is a continuous program.

Implementation of a program for field reliability improvement requires knowledge of field environments and their influence on device performance. National's broad experience in commercial reliability programs has led to the development of an extensive in-house reliability monitoring program that permits us to monitor device performance under combinations of the following stresses:

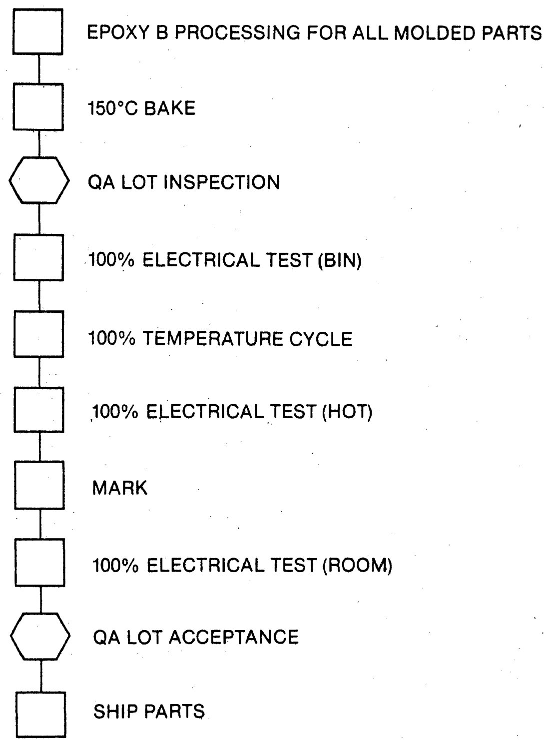
- Thermal
- Thermo-Mechanical
- Mechanical
- Voltage
- Humidity

The data generated by these monitors is continually ranked and analyzed to determine appropriate corrective action necessary for any failure mechanisms noted. This continuous cycle of testing, analysis, and corrective action assures the continued improvement of transistor field reliability.

Reliability and Quality (Continued)

NATIONAL'S B+ PROGRAM—A Logical Choice

A quality improvement program, the B+ program actually combines the benefits of National's on-going reliability improvement program with the quality enhancement benefits of double pass + hot screening. The practical benefit realized from this program is a significant reduction in rework at the device and PC board levels. The following flow chart shows how we do it, step by step:



Section 1

NPN Transistors

1

SATURATED SWITCHES

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA) ($I_B = \frac{I_C}{10}$)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	$t_{(off)}$ (ns) Max	Test Conditions	Process No.
2N706	TO-18	25	15	5	500	15	20		10	1	0.6	0.7	0.9	10	6	200		10	75	2	21
2N743	TO-52		12		1 μA	20	10		100	1		0.65	0.85	10	5	300		10	24	1	21
							20	60	10	0.35											
							10		1	0.25			1.5	100							
2N744	TO-52	20	12	5	1 μA	20	20		100	1		0.65	0.85	10	5	280		10	24	1	21
							40	120	10	0.35											
							20		1	0.25			1.5	100							
2N753	TO-52	25	15	5	500	15	40	120	10	1	0.6	0.7	0.9	10	5	200		10	75	2	21
2N834	TO-52	40		5	500	20	25		10	1	0.25		0.9	10	4	350		10	30	2	21
2N2369	TO-52	40	15	4.5	400	20	20		100	2	0.25	0.7	0.85	10	4	500		10	18	1	21
							40	120	10	1											
2N2369A	TO-18	40	15	4.5	400*	20	20	120	100	1	0.2	0.7	0.85	10	4	500		10	18	1	21
							30	120	30	0.4	0.25		1.5	30							
							40	120	10	1											
							40	120	10	0.35	0.5		1.6	100							
2N3011	TO-52	30	12	5	400*	20	12		100	1	0.2	0.72	0.85	10	4	400		20	20	4	21
							25		30	0.4	0.25		1.5	30							
							30	120	10	0.35	0.5		1.6	100							
2N3605	TO-92 (94)		14		500	18	30		10	1	0.25		0.85	10	6	300		10	45	2	21
2N3606	TO-92 (94)		14		500	18	30		10	1	0.25		0.85	10	6	300		10	60	2	21
2N3607	TO-92 (94)		14		500	18	30		10	1	0.25		0.85	10	6	300		10	70	2	21
2N4274	TO-92 (92)	Same as PN4274, see page 1-3 for explanation																			21
2N4275	TO-92 (92)	Same as PN4275, see page 1-3 for explanation																			21
2N4294	TO-92 (94)	30	12	4.5	400	20	20		100	2	0.25	0.6	0.9	10	5	400		10	20	1	21
							30	120	10	1											
2N4295	TO-92 (94)	40	15	5	100	20	20		100	2	0.25	0.6	0.9	10	4	500		10	15	1	21
							40	120	10	1											
2N5030	TO-92 (94)	30	12	4	250	20	30		10	1	0.25	0.72	0.87	10	4	400		10	30	9	21
2N5134	TO-92 (92)	Same as PN5134, see page 1-3 for explanation																			21
2N5224	TO-92 (92)	25	12	5	500	15	15		100	1	0.35		0.9	10	4	250		10	60	11	21
							40	100	10	1											

SATURATED SWITCHES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA) ($I_B = \frac{I_C}{10}$)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	$t_{(off)}$ (ns) Max	Test Conditions	Process No.
2N5769	TO-92	40	15	4.5	400	20	20		100	1	0.2	0.7	0.85	10	4	500		10	18	1	21
	(92)						30		30	0.4	0.25		1.5	30							
							40	120	10	0.35	0.5		1.6	100							
2N5772	TO-92	40	15	5	500	20	15		300	1	0.2	0.75	0.95	30	5	350		30	28	3	21
	(92)						25		100	0.5	0.28		1.2	100							
							30	120	30	0.4	0.5		1.7	300							
MPS706	TO-92	15	15	3	500	15	20		10	1	0.6		0.9	10	6	200		10	75	11	21
	(92)																				
MPS834	TO-92	40		5	500	20	25		10	1	0.25		0.9	10	4	350		10	30	2	21
	(92)										0.4			50							
MPS2369	TO-92	40*	15	4.5	400	20	20		100	2	0.25	0.7	0.85	10	4	500		10	18	7	21
	(92)						40	120	10	1											
MPS2713	TO-92	18	15	5	500	18	30	90	2	4.5	0.3		1.3	50							21
	(92)																				
MPS2714	TO-92	18	15	5	500	18	75	225	2	4.5	0.3	0.6	1.3	50							21
	(92)																				
MPS3646	TO-92	Same as PN3646, see page 1-4 for explanation																			21
	(92)																				
PN2369	TO-92	40*	15	4.5	400	20	20		100	2	0.25	0.7	0.85	10	4	500		10	18	1	21
	(92)						40	120	10	1											
PN2369A	TO-92	40*	15	4.5	30	20	20		100	1	0.2	0.7	0.85	10	4	500		10	18	1	21
	(92)						30		30	0.4	0.2		1.15	30							
							40	120	10	1											
							40		10	0.35	0.5		1.6	100							
PN4274	TO-92	30*	12	4.5	500	20	18		100	1	0.2	0.7	0.85	10	4	400		10	12	12	21
	(92)						30		30	0.4	0.25		1.15	30							
							35	120	10	1	0.5		1.6	100							
PN4275	TO-92	40*	15	4.5	500	20	18		100	1	0.2	0.72	0.85	10	4	400		10	12	12	21
	(92)						30		30	0.4	0.25		1.15	30							
							35	120	10	1	0.5		1.6	100							
PN5134	TO-92	20*	10	3.5	100	15	15		30	0.4	0.25	0.7	0.9	10	4	250		10	18	12	21
	(92)						20	150	10	1											
2N708	TO-52	40	15	5	25	20	30	120	10	1	0.4	0.72	0.8	10	6	300		10			22
							15		0.5	1											

TEST CONDITIONS:

(1) V_{CC} = 3V, I_C = 10 mA, I_B^1 = 3 mA, I_B^2 = 1.5 mA. **(2)** V_{CC} = 3V, I_C = 10 mA, I_B^1 = 3 mA, I_B^2 = 1 mA. **(3)** V_{CC} = 10V, I_C = 300 mA, $I_B^1 = I_B^2$ = 30 mA. **(4)** V_{CC} = 2V, I_C = 30 mA, $I_B^1 = I_B^2$ = 3 mA. **(5)** V_{CC} = 25V, I_C = 300 mA, $I_B^1 = I_B^2$ = 30 mA. **(6)** V_{CC} = 25V, I_C = 500 mA, $I_B^1 = I_B^2$ = 50 mA. **(7)** V_{CC} = 30V, I_C = 500 mA, $I_B^1 = I_B^2$ = 50 mA. **(8)** V_{CC} = 30V, I_C = 1A, $I_B^1 = I_B^2$ = 100 mA. **(9)** V_{CC} = 3V, I_C = 10 mA, $I_B^1 = I_B^2$ = 1 mA. **(10)** V_{CC} = 10.7V, I_C = 1A, $I_B^1 = I_B^2$ = 100 mA. **(11)** V_{CC} = 3V, I_C = 10 mA, $I_B^1 = I_B^2$ = 3 mA. **(12)** V_{CC} = 3V, I_C = 10 mA, $I_B^1 = I_B^2$ = 3.3 mA.

SATURATED SWITCHES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA) ($I_B = \frac{I_C}{10}$)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	$t_{(off)}$ (ns) Max	Test Conditions	Process No.
2N3009	TO-52	40	15	4	500*	20	15		300	1	0.18	0.75	0.95	30	5	350		30	25	3	22
							25		100	0.5	0.28		1.2	100							
							30	120	30	0.4	0.5		1.7	300							
2N3013	TO-52	40	15	5	300*	20	15		300	1	0.18	0.75	0.95	30	5	350		30	25	3	22
							25		100	0.5	0.28		1.2	100							
							30	120	30	0.4	0.5		1.7	300							
2N3646	Same as PN3646, see below for explanation																				22
PN3646	TO-92 (92)	40*	15	5	500*	20	15		300	1	0.2	0.75	0.95	30	5	350		30	28	3	22
							20		100	0.5	0.28		1.2	100							
							30	120	30	0.4	0.5		1.7	300							
2N3015	TO-39	60	30	5	200	30	10		300	0.7	0.4		1.2	150	8	250		50	60	5 & 6	25
							30	120	150	10	1.0		1.6	500							
2N3252	TO-39	60	30	5	500	40	25		1A	5	0.3		1.0	150	12	200		50	70	7	25
							30	90	500	1	0.5	0.7	1.3	500							
							30		150	1	1.0		1.8	1A							
2N3253	TO-39	75	40	5	500	60	20		750	5	0.35		1.0	150	12	175		50	70	7	25
							25	75	375	1	0.6	0.7	1.3	500							
							25		150	1	1.2		1.8	1A							
2N3444	TO-39	80	50	5	500	60	15		1A	5	0.35		1.0	150	12	150		50	70	7	25
							20	60	500	1	0.6		1.3	500							
							20		150	1	1.2		1.8	1A							
2N3724	TO-39	50	30	6	1.7 μA	40	30		1A	5	0.32		1.1	300		300		50	60	7	25
							25		800	2				500	12						
							35		500	1	0.42	0.9	1.2								
							40		300	1	0.65		1.5	800							
							60	150	100	1											
							30		10	1	0.75		1.7	1A							
2N3724A	TO-39	50	30	6	500	40	25		1.5A	5	0.32		1.1	300	12	300		50	50	8	25
							30		1A	5				500							
							30		800	2	0.42		1.2								
							35		500	1											
							40		300	1	0.65		1.3	800					60	7	
							60	150	100	1											
							30		10	1	0.75		1.4	1A							
2N3725	TO-39	80	50	6	1.7 μA	60	25		1A	5	0.4		1.1	300	10	300		50	60	7	25
							20		800	2	0.52	0.9	1.2	500							
							35		500	1											
							40		300	1	0.8		1.5	800							
							60	150	100	1				1A							
							30		10	1	0.95		1.7								

SATURATED SWITCHES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA) ($I_B = \frac{I_C}{10}$)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	$t_{(off)}$ (ns) Max	Test Conditions	Process No.
2N3725A	TO-39	80	50	6	500	60	20		1.5A	5	0.4		1.1	300	10			50	50	8	25
							25		1A	5	0.52		1.2	500							
							25		800	2											
							35		500	1	0.8		1.3	800							
							40		300	1											
							60	150	100	1	0.9		1.4	1A					60	7	
							30		10	1											
DH3724CD	Ceramic DIP (40)	50*	36	60	1.7 μA	40	30		1A	5	0.75		1.7	500	12	300		50	60	7	25
							35		500	1											
							60	150	100	1	0.45		1.2	1A							
DH3724CN	Molded DIP (39)	Electrical same as DH3724CD																			25
DH3725CD	Ceramic DIP (40)	80*	50	6	1.7 μA	60	25		1A	5	0.95		1.7	500	10	250		50	60	7	25
							35		500	1											
							60	150	100	1	0.52		1.2	1A							
DH3725CN	Molded DIP (39)	Electrical same as DH3725CD																			25
2N4013	TO-18	50	30	6	1.7 μA	40	30		1A	5	0.25		0.76	10	12	300		50	60	7	25
							25		800	2	0.2		0.86	100							
							35		500	1	0.32		1.1	300							
							40		300	1	0.42	0.9	1.2	500							
							60	150	100	1	0.65		1.5	800							
							30		10	1	0.75		1.7	1A							
2N4014	TO-18	80	50	6	1.7 μA	60	25		1A	5	0.25		0.76	10	10	300		50	60	7	25
							20		800	2	0.26		0.86	100							
							35		500	1	0.4		1.1	300							
							40		300	1	0.25	0.9	1.2	500							
							60	150	100	1	0.8		1.5	800							
							30		10	1	0.9		1.7	1A							
2N4047	TO-39	80	50	6	1.7 μA	60	15		1A	5	0.4		1.1	300	10	250		50	60	7	25
							15		800	2											
							20		500	1	0.52	0.9	1.2	500							
							30		300	1	0.8		1.5	800							
							40	150	100	1											
							20		10	1	0.95		1.7	1A							

TEST CONDITIONS:

(1) V_{CC} = 3V, I_C = 10 mA, I_B^1 = 3 mA, I_B^2 = 1.5 mA. **(2)** V_{CC} = 3V, I_C = 10 mA, I_B^1 = 3 mA, I_B^2 = 1 mA. **(3)** V_{CC} = 10V, I_C = 300 mA, $I_B^1 = I_B^2$ = 30 mA. **(4)** V_{CC} = 2V, I_C = 30 mA, $I_B^1 = I_B^2$ = 3 mA. **(5)** V_{CC} = 25V, I_C = 300 mA, $I_B^1 = I_B^2$ = 30 mA. **(6)** V_{CC} = 25V, I_C = 500 mA, $I_B^1 = I_B^2$ = 50 mA. **(7)** V_{CC} = 30V, I_C = 500 mA, $I_B^1 = I_B^2$ = 50 mA. **(8)** V_{CC} = 30V, I_C = 1A, $I_B^1 = I_B^2$ = 100 mA. **(9)** V_{CC} = 3V, I_C = 10 mA, $I_B^1 = I_B^2$ = 1 mA. **(10)** V_{CC} = 10.7V, I_C = 1A, $I_B^1 = I_B^2$ = 100 mA. **(11)** V_{CC} = 3V, I_C = 10 mA, $I_B^1 = I_B^2$ = 3 mA. **(12)** V_{CC} = 3V, I_C = 10 mA, $I_B^1 = I_B^2$ = 3.3 mA.

SATURATED SWITCHES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA) ($I_B = \frac{I_C}{10}$)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	$t_{(off)}$ (ns) Max	Test Conditions	Process No.
2N5189	TO-39	60	35	5	500	30	15 35 30		1A 500 100	1 1 1	1.0		1.5	1A	12	250		50	70	10	25
2N6737	TO-237 (EBC)	80	45	6	1.7 μA	60	35		500	1	0.52	0.8	1.1	500	10	300		50	60	7	25

TEST CONDITIONS:
(1) V_{CC} = 3V, I_C = 10 mA, I_B^1 = 3 mA, I_B^2 = 1.5 mA. **(2)** V_{CC} = 3V, I_C = 10 mA, I_B^1 = 3 mA, I_B^2 = 1 mA. **(3)** V_{CC} = 10V, I_C = 300 mA, I_B^1 = I_B^2 = 30 mA. **(4)** V_{CC} = 2V, I_C = 30 mA, I_B^1 = I_B^2 = 3 mA. **(5)** V_{CC} = 25V, I_C = 300 mA, I_B^1 = I_B^2 = 30 mA. **(6)** V_{CC} = 25V, I_C = 500 mA, I_B^1 = I_B^2 = 50 mA. **(7)** V_{CC} = 30V, I_C = 500 mA, I_B^1 = I_B^2 = 50 mA. **(8)** V_{CC} = 30V, I_C = 1A, I_B^1 = I_B^2 = 100 mA. **(9)** V_{CC} = 3V, I_C = 10 mA, I_B^1 = I_B^2 = 1 mA. **(10)** V_{CC} = 10.7V, I_C = 1A, I_B^1 = I_B^2 = 100 mA. **(11)** V_{CC} = 3V, I_C = 10 mA, I_B^1 = I_B^2 = 3 mA. **(12)** V_{CC} = 3V, I_C = 10 mA, I_B^1 = I_B^2 = 3.3 mA.

RF AMPS AND OSCILLATORS

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob}/C_{re} (pF) Min	C_{ob}/C_{re} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	NF (dB) Max	@ Freq (MHz)	Process No.
2N2857	TO-72	30	15	2.5	10	15	30	150	3	1						1	1000	1900	5	4.5	450	42
2N3478	TO-72	30	15	2	20	1	25	150	2	8						1	750	1600	5	4.5	200	42
2N3600	TO-72	30	15	3	10	15	20	150	3	1						1	850	1500	5	4.5	200	42
2N3932	TO-72	30	20	2.5	10	15	40	150	2	8						0.55	750	1600	2	4.5	200	42
2N3933	TO-72	40	30	2.5	10	15	60	200	2	8						0.55	750	1600	2	4	200	42
2N4259	TO-72	40	30	2.5	10	15	60	250	2	8						0.55	750	1600	2	5	450	42
2N5179	TO-72	20	12	2.5	20	15	25	250	3	1	0.4		1.0	10		1	900	2000	5	4.5	200	42
2N5180	TO-72	30	15	2	500	8	20	200	2	8						1	650	1700	2			42
40235	TO-72	35		3	1 μA 20	35 1	40	170	1	6						0.65						42
40236	TO-72	35		3	1 μA 20	35 1	40	275	1	6						0.65						42
40237	TO-72	35		3	1 μA 20	35 1	27	275	1	6						0.8						42
40238	TO-72	35		3	1 μA 20	35 1	40	170	1	6						0.65						42
40239	TO-72	35		3	1 μA 20	35 1	27	100	1	6						0.65						42

RF AMPS AND OSCILLATORS (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob}/C_{re} (pF) Min	C_{ob}/C_{re} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	NF (dB) Max	@ Freq (MHz)	Process No.
40240	TO-72	35		3	1 μA 20	35 1	27	275	1	6						0.65						42
40242	TO-72	35		3	20	1	40	170	1	6						0.65						42
MPS6539	TO-92 (91)	20	20		50	15	20		4	10						0.7	500		4	4.5	100	42
MPS6548	TO-92 (91)	30	25	3	100	25	25		4	10	0.5		0.95	4		0.7	650		4			42
MPSH10	TO-92 (91)	30	25	3	100	25	60		4	10	0.5			4	0.35	0.65	650		4			42
MRF501	TO-72	25	15	3.5	50	1	30	250	1	6							600		5			42
MRF502	TO-72	35	15	3.5	20	1	40	170	1	6							800		5			42
PN5179	TO-92 (91)	20	15	2.5	2	15	25	250	3	1	0.4		1.0	10		1.0	900	2000	5	4.5	200	42
2N917	TO-72	30	15	3	1	15	20		3	1	0.5		0.87	3		3	500		4	6	60	43
2N918	TO-72	30	15	3	10	15	20		3	1	0.4		1.0	10		3	600		4	6	60	43
2N3563	TO-92 (92)	Same as PN3563, see page 1-8 for explanation																				43
2N3564	TO-92 (92)	Same as PN3564, see page 1-8 for explanation																				43
2N3662	TO-92 (94)	18	12	3	500	15	20		8	10					0.8	1.7	700	2100	5	6.5	60	43
2N3663	TO-92 (94)	30	12	3	500	15	20		8	10					0.8	1.7	700	2100	5	6.5	60	43
2N3825	TO-92 (94)	30	15	4	100	15	20		2	10	0.25			2		3.5	200	800	2	5.5	1	43
2N4292	TO-92 (94)	30	15	3	500	15	20		3	1	0.6			10		3.5	600		4	6	60	43
2N4293	TO-92 (94)	30	15	3	500	15	20		3	1	0.6			10		3.5	600		4	6	60	43
2N5130	TO-92 (92)	Same as PN5130, see page 1-8 for explanation																				43
2N5770	TO-92 (92)	30	15	4.5	10	15	50 20	200	8 3	10 1	0.4		1.0	10	0.7	1.1	900	1800	8	6	60	43
MPS3563	TO-92 (92)	Same as PN3563, see page 1-8 for explanation																				43
MPS6507	TO-92 (92)	30*	20		5	15	25		2	10						2.5	700		10			43

RF AMPS AND OSCILLATORS (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob}/C_{re} (pF) Min	C_{ob}/C_{re} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	NF (dB) Max	@ Freq (MHz)	Process No.
MPS6511	TO-92 (92)	30*	20		50	15	25		10	10						2.5						43
MPS6541	TO-92 (92)	30*	20	4	50	15	25		4	10						1.7	600	1500	4			43
PN918	TO-92 (92)	30	15	3	10	15	20		3	1	0.4		1.0	10		1.7	600		4	6	60	43
PN3563	TO-92 (92)	30	15	2	50	15	20	200	8	10						1.7	600	1500	8			43
PN3564	TO-92 (92)	30	15	4	50	15	20	500	15	10	0.3		0.97	20		3.5	400	1200	15			43
PN5130	TO-92 (92)	30	12	1	50	10	15	250	8	10	0.6		1.0	10		1.7	450		8			43
2N4134	TO-72	30	30	3	50	10	25	200	4	5						0.5	350	800	4	2.5	60	44
2N4135	TO-72	30	30	3	50	10	25	200	4	5						0.5	425	800	4	5	450	44
MPS6568A	TO-92 (91)	20	20	3	50	10	20	200	4	5	0.3		0.96	10		0.65	375	800	4	3.3	200	44
MPS6569	TO-92 (91)	20	20	3	50	10	20	200	4	5	3		0.96	10	0.25	0.5	300	800	4	6	45	44
MPS6570	TO-92 (91)	20	20	3	50	10	20	200	4	5	3		0.96	10	0.25	0.5	300	800	4	6	45	44
MPSH30	TO-92 (91)	20	20	3	50	10	20	200	4	5	0.3		0.96	10		0.65	300	800	4	6	45	44
MPSH31	TO-92 (91)	20	20	3	50	10	20	200	4	5	0.3		0.96	10		0.65	300	800	4	6	45	44
SE5020	TO-72	20	20	3	50	10	20	200	4	5	3.0		0.96	10	0.25	0.5	375	800	4	3.3	200	44
SE5021	TO-72	20	20	3	50	10	20	200	4	5	3.0		0.96	10	0.25	0.5	375	800	4	4	200	44
SE5022	TO-72	20	20	3	50	10	20	200	4	5	3.0		0.96	10	0.25	0.5	300	800	4			44
SE5023	TO-72	20	20	3	50	10	20	200	4	5	3.0		0.96	10	0.25	0.5	300	800	4	6	45	44
SE5024	TO-72	20	20	3	50	10	20	200	4	5	3.0		0.96	10	0.25	0.5	300	800	4	6	45	44
SE5050	TO-72	20	20	3	50	10	20	200	4	5	3.0		0.96	10	0.25	0.5	300		4	4	100	44
SE5051	TO-72	20	20	3	50	10	20	200	4	5	3.0		0.96	10	0.25	0.5	300		4			44
SE5052	TO-72	20	20	3	50	10					3.0			10			375		4	4	200	44
MPSH32	TO-92 (96)	30	30	4	50	10	27	200	4	5	0.3		1.2	10		0.22	300		4			45
SE5055	TO-72	20	20	3	50	20	20	220	2	10	2.75			10	0.22		300		2	5	45	45
PE5025	TO-92 (92)	30	30	3	50	30	20	100	10	10	0.6			20	0.6	1	300	700	10			46

RF AMPS AND OSCILLATORS (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob}/C_{re} (pF) Min	C_{ob}/C_{re} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	NF (dB) Max	@ Freq (MHz)	Process No.
MPS6542	TO-92 (96)	30*	20		50	15	25		2	10						1.5	700		10			47
MPS6543	TO-92 (96)	35	20	3	100	25	25		4	10	0.35		0.95	10		1	750		4			47
MPS6546	TO-92 (96)	35	25	3	100	25	20		2	10	0.35			10		0.45	600		2			47
MPS6547	TO-92 (96)	35	25	3	100	25	20		2	5	0.35			10		0.35	600		2			47
MPSH11	TO-92 (96)	30	25	3	100	25	60		4	10	0.5			4	0.6	0.9	650	4				47
MPSH19	TO-92 (96)	30	25	3	100	15	45		4	10						0.65	300		4			47
MPSH24	TO-92 (96)	40	30	4	50	15	30		8	10						0.36	400		8			47
MPSH34	TO-92 (96)	45	45	4	50	30	15 40		20 7	2 15	0.5			20		0.32	500		15			47
PE3100	TO-92 (96)	30*	30	3	200	30	30	225	5	10						0.8	500		5			47
PE5029	TO-92 (96)	30	30	3	200	30	30	225	5	10						0.4	500		5	6	45	47
PE5030B	TO-92 (96)	45	40	4.5	100	30	45	150	7	15	3		 0.92	20 10	0.25	0.4	600		7			47
PE5031	TO-92 (96)	40	30	4	100	30	30	180	5	10	1			10		0.4	500		5	4.5	200	47
TIS86	TO-92 (98)	30	30		100	15	40	200	4	10	0.5			15		0.45	500		4	5	200	47
TIS87	TO-92 (98)	45	45		100	15	30	150	12	12	0.5			15		0.45	500		12			47
MPS6540	TO-92 (91)	30	30	4	100	25	25		2	10	0.5			10		0.65	350		2			49
MPS6544	TO-92 (91)	60	45	4	500	35	20		30	10	0.5			30		0.65						49
MPS6567	TO-92 (91)		40	5	500	35	25		10	5	0.5			10		0.7						49
MPSH20	TO-92 (91)	40	30	4	50	15	25		4	10			0.95	10		0.65	400		4			49
MPSH37	TO-92 (91)		40	5	500	35	25		5	10	0.5			10		0.7	300		5			49

LOW LEVEL AMPS

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	NF (dB) Max	Test Conditions	Process No.
2N760	TO-18	45	45	8	200	30	76	300 (1 kHz)	1	5	1.0	0.6	1.1	10	8	50		1.0			07
2N760A	TO-18	60	60	8	100	30	76	333	1	5	1.0		1.1	10	8	50		1.0			07
							40	(1 kHz)	10 µA	5											
2N929	TO-18	45	45	5	10	45		350	10	5	1.0	0.6	1.0	10	8	30		0.5	4	1	07
							60		500 µA	5											
							40	120	10 µA	5											
2N929A	TO-18	60	45	6	2	45		350	10	5	0.5	0.7	0.9	10	6	45		0.5	4		07
							60		500 µA	5											
							40	120	10 µA	5											
							25		1 µA	5											
2N930	TO-18	45	45	5	10	45		600	10	5	1.0	0.6	1.0	10	8	30		0.5	3	1	07
							150		500 µA	5											
							100	300	10 µA	5											
2N2484	TO-18	60	60	6	10	45	250		1	5	0.35			1	10	15		0.05	3	1	07
							200		500 µA	5											
							175		100 µA	5											
							100	500	10 µA	5											
							30		1 µA	5											
2N2509	TO-18	125	80	7	5	100	40		10	5	1.0		0.9	5	6	45		5	7	1	07
							25		10 µA	5											
2N2510	TO-18	100	65	7	5	80	150	500	10	5	1.0		0.9	5	6	45		5	4	2	07
							75		10 µA	5											
2N2511	TO-18	80	50	7	5	60	240	750	10	5	1.0		0.9	5	6	45		5	4	2	07
							120		10 µA	5											
							80		1 µA	5											
2N2586	TO-18	60	45	6	2	45		600	10	5	0.5	0.7	0.9	10	7	45		0.5	3.5	2	07
							150		500 µA	5											
							120	360	10 µA	5											
							80		1	5											
2N3117	TO-18	60	60	6	10	45	400		1	5	0.35			1	4.5	60		0.5	1	2	07
							300		100 µA	5											
							250	500	10 µA	5											
							100		1 µA	5											
2N3246	TO-18	60	40	10	1	40		800	10	5	0.5	0.7	0.9	5	5	60	180	1	2	1	07
							400		1	5											
							350		500 µA	5											
							300		100 µA	5											
							200	600	10 µA	5											
							150		1 µA	5											

LOW LEVEL AMPS (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	NF (dB) Max	Test Conditions	Process No.
2N3565	TO-92 (92)	Same as PN3565, see page 1-13 for explanation																			07
2N3707	TO-92 (94)	30	30	6	100	20	100	400	100 μA	5	1.0			10					5	1	07
2N3708	TO-92 (94)	30	30	6	100	20	45	660	1	5	1.0			10							07
2N3709	TO-92 (94)		30		100	20	45	165	1	5	1.0			10							07
2N3710	TO-92 (94)	30	30	6	100	20	90	330	1	5	1.0			10							07
2N3711	TO-92 (94)	30	30	6	100	20	180	660	1	5	1.0			10							07
2N3858A	TO-92 (94)	60	60	6	500	18	60 45	120	10 1	1 1					4	90	250	2			07
2N3859A	TO-92 (94)	60	60	6	500	18	100 75	200	10 1	1 1					4	90	250	2			07
2N3877	TO-92 (94)	70	70	4	500	70	20	250	2	4.5		0.5	0.9	10							07
2N3877A	TO-92 (94)	85	85	4	500	70	20	250	2	4.5		0.5	0.9	10							07
2N3900A	TO-92 (94)	18	18	5	100	18	250	500	2	4.5					12				5	4	07
2N3901	TO-92 (94)	18	18	5	100	15	350	700	2	4.5									5	4	07
2N4286	TO-92 (94)	30	25	6	50	25	150 100	600	1 100 μA	5 5	0.35		0.8	1	6	40		1			07
2N4287	TO-92 (94)	45	45	7	10	30	150 100	600	1 100 μA	5 5	0.35		0.8	1	6	40		1	5	1	07
2N4384	TO-18	40	30	5	10	30	150 120 100 60	 500 	10 1 10 μA 1 μA	5 5 5 5	0.2	0.65	0.8	10	8	30	120	0.5	2	1	07
2N4386	TO-18	40	30	5	10	30	120 100 40	 500	10 1 10 μA	5 5 5	0.2	0.65	0.8	10	8	30	120	0.5	3	1	07
2N4409	TO-92 (92)	80	50	5	10	60	60 60	400	10 1	1 1	0.2		0.8	1	12	60	300	10			07

TEST CONDITIONS:
(1) I_C = 10 μA, V_{CE} = 5V, f = 10 Hz–15.7 kHz. **(2)** I_C = 10 μA, V_{CE} = 5V, f = 1 kHz. **(3)** I_C = 5 μA, V_{CE} = 5V, f = 1 kHz. **(4)** I_C = 100 μA, V_{CE} = 5V, f = 10 Hz–15.7 kHz. **(5)** I_C = 10 μA, V_{CE} = 5V, f = 10 kHz. **(6)** I_C = 100 μA, V_{CE} = 5V, f = 5 kHz.

LOW LEVEL AMPS (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	NF (dB) Max	Test Conditions	Process No.
2N4410	TO-92 (92)	120	80	5	10	100	60	400	10	1	0.2		0.8	1	12	60	300	10			07
							60		1	1											
2N4966	TO-92 (92)	50	40	6	25	25	40	200	0.01	5	0.4			10	6	40		1			07
							50		10	5											
2N4967	TO-92 (92)	50	40	6	25	25	100	600	0.01	5	0.4			10	6	40		1			07
							120		10	5											
2N4968	TO-92 (92)	30	25	6	50	25	40	200	0.01	5	0.4			10	6						07
							50		10	5											
2N5088	TO-92 (92)	35	30		50	20	300		10	5	0.5			10	4				3	3	07
							350		1	5											
							300	900	100 µA	5											
2N5089	TO-92 (92)	30	25		50	15	400		10	5	0.5			10	4				2	3	07
							450		1	5											
							400	1200	100 µA	5											
2N5133	TO-92 (92)	20	18	3	50	15	60	1000	1 mA	5	0.4			1	5						07
2N5209	TO-92 (92)	50	50		50	35	150		10	5	0.7			10	4	30		0.5	4	5	07
							150		1	5											
							100	300	100 µA	5											
2N5210	TO-92 (92)	50	50		50	35	250		10	5	0.7			10	4	30		0.5	3	4	07
							250		1	5											
							200	600	100 µA	5											
2N5232	TO-92 (94)		50		30	50	250	500	2	5	0.125			10	4						07
2N5232A	TO-92 (94)		50		30	50	250	500	2	5	0.125			10	4				5	2	07
MPS3707	TO-92 (92)		30		100	20	100	400	100 µA	5	1.0			10					5	4	07
MPS3708	TO-92 (92)		30		100	20	45	660	1	5	1.0			10							07
MPS3709	TO-92 (92)		30		100	20	45	165	1	5	1.0			10							07
MPS3710	TO-92 (92)		30		100	20	90	330	1	5	1.0			10							07
MPS3711	TO-92 (92)		30		100	20	180	660	1	5	1.0			10							07
MPS6571	TO-92 (92)	25	20	3	50	20	250	1000	100 µA	5	0.5			10	4.5	50		0.5			07
MPSA09	TO-92 (92)	50	50		100	25	100	600	100 µA	5	0.9			10	5	600		0.5			07

LOW LEVEL AMPS (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	NF (dB) Max	Test Conditions	Process No.
PE4010	TO-92 (92)	30	25	6	200	5	200	1000	1	10	0.35			1	4	20		0.05			07
																60		1			
PN930	TO-92 (92)	45	45	5	10	45		600	10	5	1.0	0.6	1.0	10	8	30		0.5	3	1	07
							150		500 µA	5											
							100	300	10 µA	5											
PN2484	TO-92 (92)	60	60	6	10	45		800	10	5	0.35			10	6						07
							250		1	5											
							200		500 µA	5											
							175		100 µA	5											
							100	500	10 µA	5											
							30		1 µA	5											
PN3565	TO-92 (92)	30	25	6	50	25	150	600	1	10	0.35			1	4	40	240	1			07
PN5133	TO-92 (92)	20	18	3	50	15	60	1000	1	5	0.4			1	5	40	240	1			07

TEST CONDITIONS:
(1) I_C = 10 µA, V_{CE} = 5V, f = 10 Hz–15.7 kHz. **(2)** I_C = 10 µA, V_{CE} = 5V, f = 1 kHz. **(3)** I_C = 5 µA, V_{CE} = 5V, f = 1 kHz. **(4)** I_C = 100 µA, V_{CE} = 5V, f = 10 Hz–15.7 kHz. **(5)** I_C = 10 µA, V_{CE} = 5V, f = 10 kHz. **(6)** I_C = 100 µA, V_{CE} = 5V, f = 5 kHz.

GENERAL PURPOSE AMPS AND SWITCHES

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
MPS3903	TO-92 (92)	60	40	6			20		0.1	1	0.2	0.65	0.85	10	4	200		10		5	8	02
							35		1	1												
							50	150	10	1												
							30		50	1												
							15		100	1	0.3		1.0	50								

TEST CONDITIONS:
(1) I_C = 300 µA, V_{CE} = 10V, f = 1 kHz. **(2)** I_C = 150 mA, V_{CC} = 30V, $I_{B1} = I_{B2}$ = 15 mA. **(3)** I_C = 100 µA, V_{CE} = 10V, f = 1 kHz. **(4)** I_C = 300 mA, V_{CC} = 25V, $I_{B1} = I_{B2}$ = 30 mA. **(5)** I_C = 100 µA, V_{CE} = 4.5V, f = 15.7 kHz. **(6)** I_C = 10 mA, V_{CC} = 3V, $I_{B1} = I_{B2}$ = 1 mA. **(7)** I_C = 100 µA, V_{CE} = 5V, f = 15.7 kHz. **(8)** I_C = 250 µA, V_{CE} = 5V, f = 10 Hz–15.7 kHz. **(9)** I_C = 3 mA, V_{CE} = 10V, f = 1 MHz. **(10)** I_C = 10 µA, V_{CE} = 5V, f = 15.7 kHz.

GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
MPS3904	TO-92	60	40	6			40		0.1	1	0.2	0.65	0.85	10	4	200		10		5	8	02
	(92)						70		1	1												
							100	300	10	1												
							60		50	1												
							30		100	1	0.3		1.0	50								
MPS6573	TO-92		35		100	35	100		100 μA	5	0.5			10	12	100	300	10				02
	(92)						200	500	10	5												
MPS6574	TO-92 (92)		35		100	35	100 (4 Groups)	300	1	5	0.5			10	12	100	300	10				02
MPS6575	TO-92		45		100	45	100		100 μA	5	0.5			10	12	100	300	10				02
	(92)						200	500	10	5												
MPS6576	TO-92 (92)		45		100	45	100 (4 Groups)	300	1	5	0.5			10	12	100	300	10				02
MPSA20	TO-92 (92)		40	4	100	30	40	400	5	10					4	125		5				02
2N2923	TO-92 (94)	25	25	5	100	25	90	180 (1 kHz)	2	10					10							04
2N2924	TO-92 (94)	25	25	5	100	25	150	300 (1 kHz)	2	10					10							04
2N2925	TO-92 (94)	25	25	5	100	25	235	470 (1 kHz)	2	10					10							04
2N2926	TO-92 (94)	18	18	5	500	18	35	470 (1 kHz)	2	10					10							04
2N3390	TO-92 (94)	25	25	5	100	18	400	800	2	4.5					10							04
2N3391	TO-92 (94)	25	25	5	100	18	250	500	2	4.5					10					5	5	04
2N3391A	TO-92 (94)	25	25	5	100	18	250	500	2	4.5					10					5	5	04
2N3392	TO-92 (94)	25	25	5	100	18	150	300	2	4.5					10							04
2N3393	TO-92 (94)	25	25	5	100	18	90	180	2	4.5					10							04
2N3395	TO-92 (94)	25	25	5	100	18	150	500	2	4.5					10							04
2N3396	TO-92 (94)	25	25	5	100	18	90	500	2	4.5					10							04
2N3397	TO-92 (94)	25	25	5	100	18	55	500	2	4.5					10							04

GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N3398	TO-92 (94)	25	25	5	100	18	55	800	2	4.5					10							04
2N3415	TO-92 (94)	25	25	5	100	25	180	540	2	4.5	0.3	0.6	1.3	50								04
2N3416	TO-92 (94)	50	50	5	100	25	75	225	2	4.5	0.3	0.6	1.3	50								04
2N3417	TO-92 (94)	50	50	5	100	25	180	540	2	4.5	0.3	0.6	1.3	50								04
2N3900	TO-92 (94)	18	18	5	100	18	250	500	2	4.5						12						04
2N4424	TO-92 (94)	40	40	5	100	25	180	540	2	4.5	0.3	0.6	1.3	50								04
2N5172	TO-92 (94)	25	25	5	100	25	100	500	10	10	0.25			10	10							04
MPS3392	TO-92 (92)	25	25	5	100	18	150	300	2	4.5					10							04
MPS3393	TO-92 (92)		25		100	18	90	180	2	4.5					3.5							04
MPS3394	TO-92 (92)		25		100	18	55	110	2	4.5					3.5							04
MPS3395	TO-92 (92)		25		100	18	150	500	2	4.5					3.5							04
MPS3396	TO-92 (92)		25		100	18	90	500	2	4.5					3.5							04
MPS3397	TO-92 (92)		25		100	18	55	500	2	4.5					3.5							04
MPS3398	TO-92 (92)		25		100	18	55	800	2	4.5					3.5							04
MPS5172	TO-92 (92)	25	25	5	100	25	100	500	10	10	0.25			10	10							04
MPS6520	TO-92 (92)		25	4	50	30	200 100	400	2 100 μA	10 10	0.5			50	3.5					3	10	04
MPS6521	TO-92 (92)		25	4	50	30	200 150	600	2 100 μA	10 10	0.5			50	3.5					3	10	04
TIS97	TO-92 (97)		40		10	40	250	700	0.1	5										3	7	04

TEST CONDITIONS:

(1) I_C = 300 μA, V_{CE} = 10V, f = 1 kHz. **(2)** I_C = 150 mA, V_{CC} = 30V, $I_{B1} = I_{B2}$ = 15 mA. **(3)** I_C = 100 μA, V_{CE} = 10V, f = 1 kHz. **(4)** I_C = 300 mA, V_{CC} = 25V, $I_{B1} = I_{B2}$ = 30 mA. **(5)** I_C = 100 μA, V_{CE} = 4.5V, f = 15.7 kHz. **(6)** I_C = 10 mA, V_{CC} = 3V, $I_{B1} = I_{B2}$ = 1 mA. **(7)** I_C = 100 μA, V_{CE} = 5V, f = 15.7 kHz. **(8)** I_C = 250 μA, V_{CE} = 5V, f = 10 Hz–15.7 kHz. **(9)** I_C = 3 mA, V_{CE} = 10V, f = 1 MHz. **(10)** I_C = 10 μA, V_{CE} = 5V, f = 15.7 kHz.

GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N3704	TO-92 (94)	50	30	5	100	20	100	300	50	2	0.6			100	12	100		50				13
2N3705	TO-92 (94)	50	30	5	100	20	50	150	50	2	0.8			100	12	100		50				13
2N3706	TO-92 (94)	40	20	5	100	20	30	600	50	2	1.0			100	12	100		50				13
2N3794	TO-92 (94)	40	20	5	500	15	100		100	10	0.4			10	10	100	600	10				13
							100	600	10	10												
							35		1	10												
2N4400	TO-92 (92)	60	40	6			20		500	2	0.4	0.75	0.95	150	6.5	200		20	255		2	13
							50	150	150	1												
							40		10	1	0.75		1.2	500								
							20		1	1												
2N4401	TO-92 (92)	60	40	6			40		500	2	0.4	0.75	0.95	150	6.5	250		20	255		2	13
							100	300	150	1												
							80		10	1	0.75		1.2	500								
							40		1	1												
							20		100 µA	1												
2N4944	TO-92 (92)	80	40	5	50	40	40	120	150	1	0.25			150		60	900	50				13
							40		30													
2N4946	TO-92 (92)	80	40	5	50	40	100	300	150	1	0.25			150		60	900	50				13
							100		30													
2N4951	TO-92 (94)	60	30	5	50	40	60	200	150	10	0.3		1.3	150	8	250		20	400		2	13
							40		10	10												
							20		1	10												
2N4952	TO-92 (94)	60	30	5	50	40	100	300	150	10	0.3		1.3	150	8	250		20	400		2	13
							75		10	10												
							50		1	10												
2N4953	TO-92 (94)	60	30	5	50	40	200	600	150	10	0.3		1.3	150	8	250		20	400		2	13
							150		10	10												
							75		1	10												
2N4954	TO-92 (94)	40	30	5	50	30	60	600	150	10	0.3		1.3	150	8	250		20	400		2	13
							40		10	10												
							20		1	10												
2N5220	TO-92 (92)	15	15	3	100	10	30	600	50	10	0.5		1.1	150	10	100		20				13
							25		10	10												
2N5225	TO-92 (92)	25	25	4	300	15	30	600	50	10	0.8		1.0	100	20	50		20				13
							25		50	10												
MPS3704	TO-92 (92)	50	30	5	100	20	100	300	50	2	0.6			100	12	100		50				13

GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
MPS3705	TO-92 (92)	50	30	5	100	20	50	150	50	2	0.8			100	12	100		50				13
MPS3706	TO-92 (92)	40	20	5	100	20	30	600	50	2	1.0			100	12	100		50				13
MPS6522	TO-92 (92)		25	4	50	20	100		0.1	10	0.5			50	4							13
							200	400	2	10												
MPS6530	TO-92 (92)	60	40	5	50	40	25		500	10	0.5		1.0	100	5							13
							40	120	100	1												
							30		10	1												
MPS6531	TO-92 (92)	60	40	5	50	40	50		500	10	0.3		1.0	100	5							13
							90	270	100	1												
							60		10	1												
MPS6532	TO-92 (92)	50	30	5	100	30	30		100	1	0.5		1.2	100	5							13
NCBT13	TO-92 (92)	80	40	4	100	30	40		20	1	0.15			100	6	150		20				13
PN3566	TO-92 (92)	40	30	5	50	20	80		2	10	1			100	25	40	700	30				13
							150	600	10	10												
PN3567	TO-92 (92)	80	40	5	50	40	40	120	30	1	0.25			150	20	60	900	50				13
							40		150	1	1											
PN3569	TO-92 (92)	80	40	5	50	40	100	300	150	1	0.25			150		60	900	50				13
							100		30	1												
PN5449	TO-92 (92)	50	30	5	100	20	100	300	50	2	0.6			100		100		50				13
PN5816	TO-92 (92)	50	40	5	100	25	100	200	2	2	0.75		1.2	500		100		50				13
2N5550	TO-92 (92)	160	140	6	100	100	20		50	5	0.15		1.0	10	6	100	300	10		10	8	16
							60	250	10	5												
							60		1	5	0.25		1.2	50								
2N5551	TO-92 (92)	180	160	6	50	120	30		50	5	0.15		1.0	10	6	100	300	10		8	8	16
							80	250	10	5												
							80		1	5	0.2		1.0	50								
2N5830	TO-92 (92)	120	100	5	50	100	60		1	5	0.15		0.8	1		100	500	10				16
							80	500	10	5	0.2		1	10								
							80		50	5	0.25		1	50								

TEST CONDITIONS:
(1) I_C = 300 μA, V_{CE} = 10V, f = 1 kHz. **(2)** I_C = 150 mA, V_{CC} = 30V, $I_{B1} = I_{B2}$ = 15 mA. **(3)** I_C = 100 μA, V_{CE} = 10V, f = 1 kHz. **(4)** I_C = 300 mA, V_{CC} = 25V, $I_{B1} = I_{B2}$ = 30 mA. **(5)** I_C = 100 μA, V_{CE} = 4.5V, f = 15.7 kHz. **(6)** I_C = 10 mA, V_{CC} = 3V, $I_{B1} = I_{B2}$ = 1 mA. **(7)** I_C = 100 μA, V_{CE} = 5V, f = 15.7 kHz. **(8)** I_C = 250 μA, V_{CE} = 5V, f = 10 Hz–15.7 kHz. **(9)** I_C = 3 mA, V_{CE} = 10V, f = 1 MHz. **(10)** I_C = 10 μA, V_{CE} = 5V, f = 15.7 kHz.

GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
MPSL01	TO-92 (92)	140	120	6	1 μA	40	50	300	10	5	0.2		1.2	10	8	60		10				16
											0.2		1.4	50								
MPS8098	TO-92 (92)	60	0	6	100	60	100	300	1	5	0.3			100	6	150		10				18
							100		10	5												
							75		100	5												
MPS8099	TO-92 (92)	80	80	6	100	60	100	300	1	5	0.3			100	6	150		10				18
							100		10	5												
							75		100	5												
TIS98	TO-92 (97)		60		10	40	100	300	1	5	0.5			100		2		10				18
TIS99	TO-92 (97)		65		10	40	55	300	100	5	0.5			100		2		10				18
2N696	TO-5	60		5	1 μA	30	20	60	150	10	1.5		1.3	150	20	40		50				19
2N697	TO-5	60	45	5	1 μA	30	40	120	150	10	1.5		1.3	150	35	50		50				19
2N718	TO-18	60	30	5	1 μA	30	40	120	150	10	1.5		1.3	150	35	50		15				19
2N718A	TO-18	75		7	10	60	20		500	10	1.5		1.3	150	25	60		50		12	1	19
							40	120	150	10												
							35		10	10												
							20		100 μA	10												
2N956	TO-18	75	35	7	10	60	40		500	10	1.5		1.3	150	25	70		50		8	1	19
							100	300	150	10												
							75		10	10												
							35		100 μA	10												
							20		10 μA	10												
2N1420	TO-5	60	30	5	1 μA	30	100	300	150	10	1.5		1.3	150	35	50		50				19
2N1566	TO-5	80	60	5	1 μA	40	80	200	5	5	1.0			10	10	60		5				19
							(1 kHz)															
2N2218	TO-5	60	30	5	10	50	20		500	10	0.4		1.3	150	8	250		20				19
							20		150	1												
							40	120	150	10	1.6		2.6	500								
							35		10	10												
							25		1	10												
							20		100 μA	10												
2N2218A	TO-5	75	40	6	10	60	25		500	10	0.3	0.6	1.2	150	8	250		20	285		2	19
							20		150	1												
							40	120	150	10												
							35		10	10												
							25		1	10												
							20		100 μA	10												

GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N2219	TO-5	60	30	5	10	50	30		500	10	0.4		1.3	150	8	250		20				19
							50		150	1												
							100	300	150	10	1.6		2.6	500								
							75		10	10												
							50		1	10												
							35		100 μA	10												
2N2219A	TO-5	75	40	6	10	60	40		500	10		0.6	1.2	150	8	300		20	285		2	19
							50		150	1			2	500								
							100	300	150	10												
							75		10	10												
							50		1	10												
							35		100 μA	10												
2N2221	TO-18	60	30	5	10	50	20		500	10	0.4		1.3	150	8	250		20				19
							20		150	1												
							40	120	150	10	1.6		2.6	500								
							35		10	10												
							25		1	10												
							20		100 μA	10												
2N2221A	TO-18	75	40	6	10	60	25		500	10	0.3	0.6	1.2	150	8	250		20	285		2	19
							40	120	150	10												
							35		10	10	1.0		2.0	500								
							25		1	10												
							20		100 μA	10												
2N2222	TO-18	60	30	5	10	50	30		500	10	0.4		1.3	150	8	250		20				19
							50		150	1												
							100	300	150	10	1.6		2.6	500								
							75		10	10												
							50		1	10												
							35		100 μA	10												
2N2222A	TO-18	75	40	6	10	60	40		500	10	0.3	0.6	1.2	150	8	250		20	285	4	2/3	19
							50		150	1												
							100	300	150	10	1		2	500								
							75		10	10												
							50		1	10												
							35		100 μA	10												
2N2897	TO-18	60		7	50	60	35		1	10	1		1.3	150	15							19
							50	200	150	10												

TEST CONDITIONS:
(1) I_C = 300 μA, V_{CE} = 10V, f = 1 kHz. **(2)** I_C = 150 mA, V_{CC} = 30V, $I_B^1 = I_B^2$ = 15 mA. **(3)** I_C = 100 μA, V_{CE} = 10V, f = 1 kHz. **(4)** I_C = 300 mA, V_{CC} = 25V, $I_B^1 = I_B^2$ = 30 mA. **(5)** I_C = 100 μA, V_{CE} = 4.5V, f = 15.7 kHz. **(6)** I_C = 10 mA, V_{CC} = 3V, $I_B^1 = I_B^2$ = 1 mA. **(7)** I_C = 100 μA, V_{CE} = 5V, f = 15.7 kHz. **(8)** I_C = 250 μA, V_{CE} = 5V, f = 10 Hz–15.7 kHz. **(9)** I_C = 3 mA, V_{CE} = 10V, f = 1 MHz. **(10)** I_C = 10 μA, V_{CE} = 5V, f = 15.7 kHz.

GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max @	V_{CB} (V)	h_{FE} Min	h_{FE} Max @	I_C (mA) &	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max &	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max @	I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max @	I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N3115	TO-18	60	20	5	25	50	40	120	150	10	0.5		1.3	150	8	250		20	500		2	19
2N3116	TO-18	60	20	5	25	50	100	300	150	10	0.5		1.3	150	8	250		20	500		2	19
2N3299	TO-5	60	30	5	10*	50	20		500	10	0.22		1.1	150	8	250		50	150		4	19
							20		150	1												
							40	120	150	10												
							35		10	10	0.6		1.5	500								
							25		1	10												
							20		100 μA	10												
2N3300	TO-5	60	30	5	10*	50	50		500	10	0.22		1.1	150	8	250		50	150		4	19
							50		150	1												
							100	300	150	10												
							75		10	10	0.6		1.5	500								
							50		1	10												
							35		100 μA	10												
2N3301	TO-18	60	30	5	10*	50	20		500	10	0.22		1.1	150	8	250		50	150		4	19
							20		150	1												
							40	120	150	10	0.6		1.5	500								
							35		10	10												
							25		1	10												
							20		100 μA	10												
2N3302	TO-18	60	30	5	10*	50	50		500	10	0.22		1.1	150	8	250		50	150		4	19
							50		150	1												
							100	300	150	10	0.6		1.5	500								
							75		10	10												
							50		1	10												
							35		100 μA	10												
2N3414	TO-92 (94)	25	25	5	100	25	75	225	2	4.5	0.3	0.6	1.3	50								19
2N3641	TO-92 (92)	Same as PN3641, see page 1-22 for explanation																				19
2N3642	TO-92 (92)	Same as PN3642, see page 1-22 for explanation																				19
2N3643	TO-92 (92)	Same as PN3643, see page 1-22 for explanation																				19
2N3678	TO-5	75	55	6	10	60	25		500	10	0.4	0.6	1.2	150					250		2	19
							20		150	1												
							40	120	150	10	1.0		2.0	500								
							35		10	10												
							25		1	10												
							20		100 μA	10												
2N4140	TO-92 (92)	Same as PN4140, see page 1-22 for explanation																				19

GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N4141	TO-92 (92)	Same as PN4141, see page 1-22 for explanation																				19
2N4969	TO-92 (92)	Same as PN2221, see below for explanation																				19
2N4970	TO-92	50	30	5			100	350	150	10	0.4	0.6	1.2	150	8	200		20				19
	(92)						70		10	10												
							50		150	1												
2N5128	TO-92 (92)	Same as PN5128, see page 1-22 for explanation																				19
2N5129	TO-92 (92)	Same as PN5129, see page 1-22 for explanation																				19
2N5135	TO-92 (92)	Same as PN5135, see page 1-22 for explanation																				19
2N5136	TO-92 (92)	Same as PN5136, see page 1-22 for explanation																				19
2N5137	TO-92 (92)	Same as PN5137, see page 1-22 for explanation																				19
PN2221	TO-92	60	30	5	10	50	20		500	10	0.4		1.3	150	8	250		20				19
	(92)						20		150	1												
							40	120	150	10	1.6		2.6	500								
							35		10	10												
							25		1	10												
							20		100 µA	10												
PN2221A	TO-92	75	40	6	10	60	25		500	10	0.3	0.6	1.2	150	8	250		20	285		2	19
	(92)						20		150	1												
							40	120	150	10	1.0		2.0	500								
							35		10	10												
							25		1	10												
							20		100 µA	10												
PN2222	TO-92	60	30	5	10	50	30		500	10	0.4		1.3	150	8	250		20				19
	(92)						50		150	1												
							100	300	150	10	1.6		2.6	500								
							75		10	1												
							50		1	1												
							35		100 µA	1												

TEST CONDITIONS:

(1) I_C = 300 µA, V_{CE} = 10V, f = 1 kHz. **(2)** I_C = 150 mA, V_{CC} = 30V, $I_{B1} = I_{B2}$ = 15 mA. **(3)** I_C = 100 µA, V_{CE} = 10V, f = 1 kHz. **(4)** I_C = 300 mA, V_{CC} = 25V, $I_{B1} = I_{B2}$ = 30 mA. **(5)** I_C = 100 µA, V_{CE} = 4.5V, f = 15.7 kHz. **(6)** I_C = 10 mA, V_{CC} = 3V, $I_{B1} = I_{B2}$ = 1 mA. **(7)** I_C = 100 µA, V_{CE} = 5V, f = 15.7 kHz. **(8)** I_C = 250 µA, V_{CE} = 5V, f = 10 Hz–15.7 kHz. **(9)** I_C = 3 mA, V_{CE} = 10V, f = 1 MHz. **(10)** I_C = 10 µA, V_{CE} = 5V, f = 15.7 kHz.

GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
PN2222A	TO-92	75	40	6	10	60	40		500	10	0.3	0.6	1.2	150	8	300		20	285		2	19
	(92)						50		150	1												
							100	300	150	10	1.0		2.0	500								
							75		10	1												
							50		1	1												
							35		100 μA	1												
PN3641	TO-92	60*	30	5	50*	50	15		500	10	0.22			150	8	250		50				19
	(92)						40	120	150	10												
PN3642	TO-92	60	45	5	50*	50	15		500	10	0.22			150	8	250		50				19
	(92)						40	120	150	10												
PN3643	TO-92	60	30	5	50*	50	20		500	10	0.22			150	8	250		50				19
	(92)						100	300	150	10												
PN4140	TO-92	60	30	5			20		500	10	0.4		1.3	150	8	250		20	310		2	19
	(92)						20		150	1												
							40	120	150	10	1.6		2.6	500								
							35		10	10												
							25		1	10												
							20		100 μA	10												
PN4141	TO-92	60	30	5			30		500	10	0.4		1.3	150	8	250		20	310		2	19
	(92)						50		150	1												
							100	300	150	10	1.6		2.6	500								
							75		10	10												
							50		1	10												
							35		100 μA	10												
PN5128	TO-92	15	12	3	50	10	35	350	50	10	0.25		1.1	150	10	200	800	50				19
	(92)						20		10	10												
PN5129	TO-92	15	12	3	50	10	35	350	50	10	0.25		1.1	150	10	200	800	50				19
	(92)						20		10	10												
PN5135	TO-92	30	25	4	300	15	50	60*	10	10	1.0		1.0	100	25	40	500	30				19
	(92)						15		2	10												
PN5136	TO-92	30	20	3	100	20	20	400	150	1	0.25		1.1	150	35	40	400	50				19
	(92)						20		30	1												
PN5137	TO-92	30	20	3	100	20	20	400	150	1	0.25		1.1	150	35	40	400	50				19
	(92)						20		30	1												
TN2218A	TO-237	75	40	6	10	60	25		500	10	0.3	0.6	1.2	150	8	250		20	285		2	19
	(91)						20		150	1												
							40	120	150	10												
							35		10	10												
							25		1	10												
							20		100 μA	10												

GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
TN2219	TO-237 (91)	60	30	5	10	50	30		500	10	0.4		1.3	150	8	50		20				19
							50		150	1												
							100	300	150	10	1.6		2.6	500								
							75		10	10												
							50		1	10												
							35		0.1	10												
TN2219A	TO-237 (91)	75	40	6	10	60	40		500	10	0.3	0.6	1.2	150	8	60		20		4	3	19
							50		150	1												
							100	300	150	10	1.0		2.0	500								
							75		10	10												
							50		1	10												
							35		0.1	10												
TIS90	TO-92 (94)	40	40	5	100	20	100	300	50	2	0.25	0.6	1	50								19
TIS92	TO-92 (97)	40	40	5	100	20	100	300	50	2	0.25	0.6	1	50								19
2N915	TO-18	70	50	5	10	60	50	200	10	5	1.0		0.9	10	3.5	250		10				23
2N916	TO-18	45	25	5	10	30	50	200	10	1	0.5		0.9	10	6	300		10				23
2N3691	TO-92 (92)	Same as PN3691, see page 1-25 for explanation																				23
2N3692	TO-92 (92)	Same as PN3692, see page 1-25 for explanation																				23
2N3903	TO-92 (92)	60	40	6			15		100	1	0.2	0.6	0.85	10	4	250		10	225	6	6/7	23
							30		50	1												
							50	150	10	1	0.3		0.95	50								
							35		1	1												
							20		100 μA	1												
2N3904	TO-92 (92)	60	40	6		30	30		100	1	0.2	0.65	0.85	10	4	300		10	250	5	6/7	23
							60		50	1												
							100	300	10	1	0.3		0.95	50								
							70		1	1												
							40		100 μA	1												
2N3946	TO-18	60	40	6			20		50	1	0.2	0.6	0.9	10	4	250		10	375	5	6/7	23
							50	150	10	1												
							45		1	1	0.3		1.0	50								
							30		100 μA	1												

TEST CONDITIONS:
(1) I_C = 300 μA, V_{CE} = 10V, f = 1 kHz. **(2)** I_C = 150 mA, V_{CC} = 30V, $I_B{}^1 = I_B{}^2$ = 15 mA. **(3)** I_C = 100 μA, V_{CE} = 10V, f = 1 kHz. **(4)** I_C = 300 mA, V_{CC} = 25V, $I_B{}^1 = I_B{}^2$ = 30 mA. **(5)** I_C = 100 μA, V_{CE} = 4.5V, f = 15.7 kHz. **(6)** I_C = 10 mA, V_{CC} = 3V, $I_B{}^1 = I_B{}^2$ = 1 mA. **(7)** I_C = 100 μA, V_{CE} = 5V, f = 15.7 kHz. **(8)** I_C = 250 μA, V_{CE} = 5V, f = 10 Hz–15.7 kHz. **(9)** I_C = 3 mA, V_{CE} = 10V, f = 1 MHz. **(10)** I_C = 10 μA, V_{CE} = 5V, f = 15.7 kHz.

GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max @	V_{CB} (V)	h_{FE} Min	h_{FE} Max @	I_C (mA) &	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max &	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max @	I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max @	I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N3947	TO-18	60	40	6			40		50	1	0.2	0.6	0.9	10	4	300		10	450	5	6/7	23
							100	300	10	1												
							90		1	1	0.3		1.0	50								
							60		100 μA	1												
2N4123	TO-92 (92)	40	30	5	50	20	25		50	1	0.3		0.95	50	4	250		10		6	7	23
							50	150	2	1												
2N4124	TO-92 (92)	30	25	5	50	20	60		50	1	0.3		0.95	50	4	300		10		5	7	23
							120	360	2	1												
MPS2711	TO-92 (92)	18	18	5	500	18	30	90	2	4.5					4							23
MPS2712	TO-92 (92)	18	18	5	500	18	75	225	2	4.5					4							23
MPS2716	TO-92 (92)	18	18	5	500	18	75	225	2	4.5					3.5							23
MPS2923	TO-92 (92)	25	25	5	500	25	90	180 (1 kHz)	2	10					12							23
MPS2924	TO-92 (92)	25	25	5	500	25	150	300 (1 kHz)	2	10					12							23
MPS2925	TO-92 (92)	25	25	5	500	25	235	470 (1 kHz)	2	10					12							23
MPS2926	TO-92 (92)	25	25	5	500	18	35 (1 kHz)	470 (5 Groups)	2	10					3.5							23
MPS3642	TO-92 (92)	Same as PN3642, see page 1-22 for explanation																				23
MPS3721	TO-92 (92)				500	18	60	660 (1 kHz)	2	10					3.5							23
MPS3826	TO-92 (92)	60	45	4	100	30	40	160	10	10					3.5	200	800	10				23
MPS3827	TO-92 (92)	60	45	4	100	30	100	400	10	10					3.5	200	800	10				23
MPS6512	TO-92 (92)	40	30	4	50	30	30		100	10	0.5			50	3.5							23
							50	100	2	10												
MPS6513	TO-92 (92)	40	30	4	50	30	60		100	10	0.5			50	3.5							23
							90	180	2	10												
MPS6514	TO-92 (92)	40	25	4	50	30	90		100	10	0.5			50	3.5							23
							150	300	2	10												
MPS6515	TO-92 (92)	40	25	4	50	30	150		100	10	0.5			50	3.5							23
							250	500	2	10												

GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
NS3903	TO-18	60	40	6			15		100	1	0.2	0.65	0.85	10	4	250		10	225		6	23
							30		50	1												
							50	150	10	1	0.3		0.95	50								
							35		1	1												
							20		100 μA	1												
NS3904	TO-18	60	40	6			30		100	1	0.2	0.65	0.85	10	4	300		10	250		6	23
							60		50	1												
							100	300	10	1	0.3		0.95	50								
							70		1	1												
							40		100 μA	1												
PN3691	TO-92 (92)	35	20	4	50	15	40	160	10	1	0.7		0.9	10	3.5	200	500	10				23
PN3692	TO-92 (92)	35	20	4	50	15	100	400	10	1	0.7		0.9	10	3.5	200	500	10				23
ST3904	TO-92 (92)	60	40	6			40		0.1	1	0.2	0.65	0.85	10	4	300		10		8	7	23
							70		1	1												
							100	300	10	1												
							60		50	1												
							30		100	1	0.3		0.95	50								
2N2712	TO-92 (94)	18	18	5	500	18	75	225	2	4.5					12	80	300	2				27
2N2714	TO-92 (94)	18	18	5	500	18	75	225	2	4.5	0.3	0.6	1.2	50								27
2N3394	TO-92 (94)	25	25	5	100	18	55	110	2	4.5					10							27
2N3693	TO-92 (92)	Same as MPS3693, see page 1-26 for explanation																				27
2N3694	TO-92 (92)	Same as PN3694, see page 1-26 for explanation																				27
2N3721	TO-92 (94)	18	18	5	500	18	60	660 (1 kHz)	2	10					12							27
2N3827	TO-92 (94)	60	45	4	100	30	100	400	10	10					3.5	200	800	10				27
2N3858	TO-92 (94)	30	30	4	500	18	60	120	2	4.5					4	90	250	2				27

TEST CONDITIONS:

(1) I_C = 300 μA, V_{CE} = 10V, f = 1 kHz. **(2)** I_C = 150 mA, V_{CC} = 30V, $I_{B1} = I_{B2}$ = 15 mA. **(3)** I_C = 100 μA, V_{CE} = 10V, f = 1 kHz. **(4)** I_C = 300 mA, V_{CC} = 25V, $I_{B1} = I_{B2}$ = 30 mA. **(5)** I_C = 100 μA, V_{CE} = 4.5V, f = 15.7 kHz. **(6)** I_C = 10 mA, V_{CC} = 3V, $I_{B1} = I_{B2}$ = 1 mA. **(7)** I_C = 100 μA, V_{CE} = 5V, f = 15.7 kHz. **(8)** I_C = 250 μA, V_{CE} = 5V, f = 10 Hz–15.7 kHz. **(9)** I_C = 3 mA, V_{CE} = 10V, f = 1 MHz. **(10)** I_C = 10 μA, V_{CE} = 5V, f = 15.7 kHz.

GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max @	V_{CB} (V)	h_{FE} Min	h_{FE} Max @	I_C (mA) &	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max &	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max @	I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max @	I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N3859	TO-92 (94)	30	30	4	500	18	100	200	2	4.5					4	90	250	2				27
2N3860	TO-92 (94)	30	30	4	500	18	150	300	2	4.5					4	90	250	2				27
2N5127	TO-92 (92)	Same as PN5127, see below for explanation																				27
2N5131	TO-92 (92)	Same as PN5131, see below for explanation																				27
2N5132	TO-92 (92)	Same as PN5132, see below for explanation																				27
2N5219	TO-92 (92)	20	15	3	100	10	35	500	2	10	0.4		1.0	10	4	150		10				27
2N5223	TO-92 (92)	25	20	3	100	10	50	800	2	10	0.7		1.2	10	4	150		10				27
MPS3693	TO-92 (92)	45	45	4	50	35	40	160	10	10					3.5	200		10		4	9	27
MPS3694	TO-92 (92)	45	45	4	50	35	100	400	10	10					3.5	200		10		4	9	27
MPS6564	TO-92 (92)		45	5	500	40	25		10	5	0.5			10	4							27
MPS6565	TO-92 (92)	60	45	4	100	30	40	160	10	10	0.4			10	3.5							27
MPS6566	TO-92 (92)	60	45	4	100	30	100	400	10	10	0.4			10	3.5	200		10				27
MPSA10	TO-92 (92)		40	4	100	30	40	400	5	10					4	50		5				27
PN3694	TO-92 (92)	45	45	4	50	30	100	400	10	1					6	200		10				27
PN5127	TO-92 (92)	20	12	3	50	10	15	300	2	10	0.3		1.0	10	3.5	150		2				27
PN5131	TO-92 (92)	20	15	3	50	10	35	500	10	1	1.0			10	6	100		10				27
PN5132	TO-92 (92)	20	20	3	50	10	30	400	10	10	2.0		0.9	10	3.5	200		10				27

TEST CONDITIONS:

(1) I_C = 300 μA, V_{CE} = 10V, f = 1 kHz. **(2)** I_C = 150 mA, V_{CC} = 30V, $I_B{}^1 = I_B{}^2$ = 15 mA. **(3)** I_C = 100 μA, V_{CE} = 10V, f = 1 kHz. **(4)** I_C = 300 mA, V_{CC} = 25V, $I_B{}^1 = I_B{}^2$ = 30 mA. **(5)** I_C = 100 μA, V_{CE} = 4.5V, f = 15.7 kHz. **(6)** I_C = 10 mA, V_{CC} = 3V, $I_B{}^1 = I_B{}^2$ = 1 mA. **(7)** I_C = 100 μA, V_{CE} = 5V, f = 15.7 kHz. **(8)** I_C = 250 μA, V_{CE} = 5V, f = 10 Hz–15.7 kHz. **(9)** I_C = 3 mA, V_{CE} = 10V, f = 1 MHz. **(10)** I_C = 10 μA, V_{CE} = 5V, f = 15.7 kHz.

MEDIUM POWER

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N699	TO-39	120	60	5	2	60	40	120	150	10	5.0		1.3	150	20	50		50				12
2N1613	TO-5	75	35	7	10	60	20		500	10	1.5		1.3	150	25	60		50		12	1	12
							40	120	150	10												
							35		10	10												
							20		100 μA	10												
2N1711	TO-5	75	35	7	10	60	40		500	10	1.5		1.3	150	25	70		50		8	1	12
							100	300	150	10												
							75		10	10												
							35		100 μA	10												
							20		10 μA	10												
2N2017	TO-39	60	60	8	10 μA	30	20		10	10	2.0			200								12
							50	200	200	10												
							20		1A	15												
2N2102	TO-39	120	65	7	2	60	10		0.01	10	0.5		1.1	150	15	60		50				12
							20		0.1	10												
							35		10	10												
							40	120	150	10												
							25		500	10												
							10		1A	10												
2N2192	TO-39	60	40	5	10	30	15		0.01	10	0.35		1.3	150	10	50		50				12
							75		0.1	10												
							100	300	10	10												
							70		150	10												
							35		500	10												
							15		1A	10												
2N2192A	TO-39	60	40	5	10	30	15		0.01	10	0.25		1.3	150	20	50		50				12
							75		0.1	10												
							100	300	10	10												
							70		150	10												
							35		500	10												
							15		1A	10												
2N2193	TO-39	80	50	8	10	80	15		0.01	10	0.35		1.3	150	20	50		50				12
							30		0.1	10												
							40	120	10	10												
							30		150	10												
							20		500	10												
							15		1A	10												

TEST CONDITIONS:
(1) I_C = 50 mA, V_{CC} = 100V, $I_B^1 = I_B^2$ = 5 mA. **(2)** I_C = 500 μA, V_{CE} = 10V, f = 1 kHz. **(3)** I_C = 500 mA, V_{CC} = 30V, $I_B^1 = I_B^2$ = 50 mA. **(4)** I_C = 150 mA, V_{CC} = 30V, $I_B^1 = I_B^2$ = 15 mA. **(5)** I_C = 100 μA, V_{CC} = 10V, f = 1 kHz. **(6)** I_C = 500 mA, V_{CC} = 30V, $I_B^1 = I_B^2$ = 50 mA. **(7)** I_C = 2A, V_{CC} = 40V, $I_B^1 = I_B^2$ = 200 mA.

MEDIUM POWER (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N2193A	TO-39	80	50	8	10	60	15		0.1	10	0.25		1.3	150	20	50		50				12
							30		10	10												
							40	120	150	10												
							30		150	1												
							20		500	10												
							15		1A	10												
2N2195	TO-39	45	25	5	100	30	10		150	1	0.35		1.3	150	20	50		50				12
							20		150	10												
2N2195A	TO-39	45	25	5	100	30	10		150	1	0.25		1.3	150	20	50		50				12
							20		150	10												
2N2243	TO-39	120	80	7	10	60	15		0.1	10	0.35		1.3	150	15	50		50				12
							30		10	10												
							40	120	150	10												
							30		150	1												
							15		500	10												
2N2243A	TO-39	120	80	7	10	60	15		0.1	10	0.25		1.3	150	15	50		50				12
							30		10	10												
							40	120	150	10												
							30		150	1												
							15		500	10												
2N2270	TO-39	60	45	7	50	60	30		1	10	0.9		1.2	150	15	100		50				12
							50	200	150	10												
2N3019	TO-39	140	80	7	10	90	50		0.1	10	0.2		1.1	150	12	100		50				12
							90		10	10												
							100	300	150	10												
							50		500	10												
							15		1A	10												
2N3020	TO-39	140	80	7	10	90	30	100	0.1	10	0.2		1.1	150	12	80		50				12
							40	120	10	10												
							40	120	150	10	0.5			500								
							30	100	500	10												
							15		1A	10												
2N3053	TO-39	60	40	5	250	30	25		150	2.5	1.4		1.7	150	15	100		50				12
							50	250	150	10												
2N3107	TO-39	100	60	7	10	60	35		0.1	10	0.25		1.1	150	20	70		50	1000	7	5/6 (See page 1-27)	12
							100	300	150	10												
							40		500	10	1.0		2.0	1A								
2N3108	TO-39	100	60	7	10	60	20		0.1	10	0.25		1.1	150	20	60		50	600	7	5/6 (See page 1-27)	12
							40	120	150	10												
							25		500	10	1.0		2.0	1A								

MEDIUM POWER (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N3109	TO-39	80	40	7	10*	60	35		0.1	10	0.25		1.1	150	25	70		50	1000	7	5/6	12
							100	300	150	10											(See page	
							40		500	10	1.0		2.0	1A							1-27)	
2N3110	TO-39	80	40	7	10*	60	20		0.1	10	0.25		1.1	150	25	60		50	600	7	5/6	12
							40	120	150	10											(See page	
							25		500	10	1.0		2.0	1A							1-27)	
2N3568	TO-92 (92)	Same as PN3568, see below for explanation																				12
2N3665	TO-39	120	80	10	50	60	30		10	10	0.5		1.2	150	12	60		50				12
							40	120	150	10												
							25		500	10	1.2		1.8	500								
2N3666	TO-39	120	80	10	50	60	70		10	10	0.5		1.2	150	12	60		50				12
							100	300	150	10												
							50		500	10	1.2		1.8	500								
2N3700	TO-18	140	80	7	10	90	50		1	10	0.2		1.1	150	12	100	200	5				12
							90		10	10												
							100	300	150	10	0.5			500								
							50		500	10												
							15		1A	10												
2N3945	TO-39	70	50	8	40	60	25		10	10	0.5		1.2	150	12	60		50				12
							40	250	150	10												
							20		500	10	1.8		1.8	500								
2N4924	TO-39	100	100	5	100	50	25		1	10	0.25			10	10	10	500	20				12
							35		10	10												
							40	120	150	10	0.4			50								
2N4945	TO-92 (92)	80	60	5	50	40	40	120	150	1	0.25			150		60	900	50				12
							40		30													
40314	TO-39		40		250	15	70	350	50	4	1.4			150								12
MPSA05	TO-92 (92)		60	4	100	60	50		10	1	0.25			100		100		100				12
							50		100	1												
MPSA06	TO-92 (92)		80	4	100	80	50		10	1	0.25			100		100		100				12
							50		100	1												
PN3568	TO-92 (92)	80	60	5	50	40	40		30	1	0.25			150	20	60	600	50				12
							40	120	150	1												
TN1711	TO-237 (91)	75		7	10	60	20		0.01	10	1.5			150	25							12
							35		0.1	10				150								
							75		10	10	1.3											
							100		150	10												
							40	300	500	10												

MEDIUM POWER (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
TN2017	TO-237 (91)	60	60	8	10 μA	30	35		10	10												12
							50	200	200	10												
							20		1A	10												
TN2102	TO-237 (91)	120	65	7	10	60	10		0.01	10	0.5		1.1	150	15	60		50				12
							20		0.1	10												
							35		10	10												
							40	120	150	10												
							25		500	10												
							10		1A	10												
TN2270	TO-237 (91)	60	45	7	50	60	30		1	10	0.9		1.2	150	15	100		50				12
							50	200	150	10												
TN3019	TO-237 (91)	140	80	7	10	90	50		1	10	0.2		1.1	150	12	100		50				12
							90		10	10												
							100	300	150	10	0.5			500								
							50		500	10												
							15		1A	10												
TN3020	TO-237 (91)	140	80	7	10	90	30	100	1	10	0.2		1.1	150	12	80		50				12
							40	120	10	10												
							40	120	150	10	0.5			500								
							30	100	500	10												
							15		1A	10												
TN3053	TO-237 (91)	60	40	5	250	30	25		150	2.5	1.4		1.7	150	15	100		50				12
							50	250	150	10												
2N3566	TO-92 (92)	40	30	5	50	20	150	600	10	10	1.0			100	25	4	100	30				13
							80		2	10												
2N3567	TO-92 (92)	80	40	5	50	40	40	120	150	1	0.25			150	20	60	600	50				13
							40		30	1												
2N3569	TO-92 (92)	80	40	5	50	40	100	300	150	1	0.25			150	20	60	600	50				13
							100		30	1												
PN3566	TO-92 (92)	Same as 2N3566, see above for explanation																				13
PN3567	TO-92 (92)	Same as 2N3567, see above for explanation																				13
PN3569	TO-92 (92)	Same as 2N3569, see above for explanation																				13
2N4237	TO-39		40		100 μA	50	15		1A	1	0.6		1.5	1A	100	1		100				14
							30		500	4												
							30	150	250	1	0.3			500								

MEDIUM POWER (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
MPS6560	TO-92	25	25	5	100	20	35		10	1	0.5		1.2*	500	30	60		10				14
	(92)						50		100	1												
							50	200	500	1												
MPS6561	TO-92	20	20	5	100	20	35		10	1	0.5		1.2*	350	30	60		10				14
	(92)						50		100	1												
							50	200	500	1												
NCBV14	TO-202 (55)	60	40	4	100	30	75		50	1	0.4			500	10	125		50				14
NSE871	TO-202 (51)	300			100	200	50		25	20						60		10				17
MPQ3725	TO-39		40	6	500	40	35	200	100	1	0.45	0.8	1.0	500	10	250		50				25
							25		500	2												
TN3252	TO-237	60	30		500	40	30		150	1	0.3		1.0	150	12	200		50				25
	(91)						30	90	500	1	0.5	0.7	1.3	500								
							25		1A	5												
TN3253	TO-237	75	40	5	500	60	25		150	1	0.35		1.0	150	12							25
	(91)						25	75	375	1												
							20		750	5												
TN3444	TO-237	80	50	5	500	60	20		150	1	0.35		1.0	150	12	150		50				25
	(91)						20	60	500	1												
							15		1A	5	0.6		1.3	500								
TN3724	TO-237	50	30	6	1.7 µA	40	30		10	1	0.25		0.76	10	12				60		6	25
	(91)						60	150	150	1											(See page	
							40		300	1											1-27)	
							35		500	1												
							25		800	2												
							30		1A	5												
TN3725	TO-237	80	50	6	1.7 µA	60	30		10	1	0.25		0.76	10	10				60		6	25
	(91)						60	150	150	1											(See page	
							40		300	1											1-27)	
							35		500	1												
							20		800	2												
							25		1A	5												
2N2657	TO-39	80	50	8	100	60	15		5A	6	0.5		1.5	1A	150	20		200	15		2 (See	34
							40	120	1A	2	3.0		2.5	5A							page 1-27	
2N2658	TO-39	100	80	8	100	60	15		5A	6	0.5		1.5	1A		20		200	15		2 (See	34
							40	120	1A	2	3.0		2.5	5A							page 1-27	
2N2890	TO-39	100	80	5	50 µA	60	25		2A	5	0.5		1.2	1A	70	30		200	15		3	34
							30	90	1A	2											(See page	
							20		100	2											1-27)	

MEDIUM POWER (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N2891	TO-39	100	80	5	50 µA	60	50	300	50	10	0.5		1.2	1A	70	30		200	15		3 (See page 1-27)	34
							36		100													
							50	150	1A	2	0.75		1.3	2A								
							40		2A	5												
2N5148	TO-39		80		1 µA	60	20		50	5	0.46		1.2	100	70	60		200				34
							30	90	1A	5												
							15		2A	5	0.85		1.5	200								
							5		3A	5												
2N5150	TO-39		80		1 µA	60	60		50	5	0.46		1.2	100	70	60		200				34
							70	200	1A	5												
							30		2A	5	5.0			3A								
							15		3A	5												
2N5336	TO-39		80		10 µA	80	30		600	2	0.7		1.2	2A		30		500	2200		7 (See page 1-27)	34
							30	120	2A	2												
							20		5A	2	1.2		1.8	5A								
2N5338	TO-39		100		10 µA	100	30		600	2	0.7		1.2	2A		30		500	2200		7 (See page 1-27)	34
							30	120	2A	2												
							20		5A	2	1.2		1.8	5A								
2N3440	TO-39		250		20 µA*	300	40	160	20	10												36
2N6591	TO-202 (55)	150	150	5	200	100	40	250	10	10	0.8			200								36
							40	200	100	10												
2N6592	TO-202 (55)	200	200	5	200	150	30	250	10	10	0.8			200								36
							40	200	100	10												
2N6593	TO-202 (55)	250	250	5	200	200	30	250	10	10	0.8			200								36
							30	200	100	10												
2N6720	TO-237 (91)	175	150	6	1 µA	150	25		50	10	0.5			100		30	300	50				36
							30		100	10												
							15		250	10												
							10	50	500	10												
2N6721	TO-237 (91)	225	200	6	1 µA	200	25		50	10	0.5			100		30	300	50				36
							30		100	10												
							15		250	10												
							10	50	500	10												
2N6722	TO-237 (91)	275	250	6	1 µA	250	25		50	10	0.5			100		30	300	50				36
							30		100	10												
							15		250	10												
							10	50	500	10												
2N6723	TO-237 (91)	325	300	6	1 µA	300	25		50	10	0.5			100		30	300	50				36
							30		100	10												
							15		250	10												
							10	50	500	10												

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
92PU36	TO-237 (91)	175	150	6	1 μA	150	25		50	10	0.5			100								36
							30	300	100	10												
							15		250	10												
							10		500	10												
92PU36A	TO-237 (91)	225	200	6	1 μA	200	25		50	10	0.5			100								36
							30	300	100	10												
							15		250	10												
							10		500	10												
92PU36B	TO-237 (91)	275	250	6	1 μA	250	25		50	10	0.5			100								36
							30	300	100	10												
							15		250	10												
							10		500	10												
92PU36C	TO-237 (91)	325	300	6	1 μA	300	25		50	10	0.5			100								36
							30	300	100	10												
							15		250	10												
							10		500	10												
D40P1	TO-202 (55)		120		10 μA	200	20	2		10	1.0			100	15	10		80				36
							40	80		10												
D40P3	TO-202 (55)		180		10 μA	250	20	2		10	1.0		1.5	100	15	10		80				36
							40	80		10												
D40P5	TO-202 (55)		225		10 μA	300	20	2		10	1.0		1.5	100	15	10		80				36
							40	80		10												
NSD36	TO-202 (55)	175	150	6	1 μA	150	25		50	10	0.5				15	10		50				36
							30	300	100	10												
							15		250	10												
							10		500	10												
NSD36A	TO-202 (55)	225	200	6	1 μA	200	25		50	10	0.5				15	10		50				36
							30	300	100	10												
							15		250	10												
							10		500	10												
NSD36B	TO-202 (55)	275	250	6	1 μA	250	25		50	10	0.5				15	10		50				36
							30	300	100	10												
							15		250	10												
							10		500	10												
NSD36C	TO-202 (55)	325	300	6	1 μA	300	25		50	10	0.5				15	10		50				36
							30	300	100	10												
							15		250	10												
							10		500	10												
NSD3439	TO-202 (55)		350		20 μA	300	30		2	10	0.5		1.3	50	20	15		10				36
							40	160	20	10												

MEDIUM POWER (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
NSD3440	TO-202		250		500 μA	200	30		2	10	0.5		1.3	50	20	15		10				36
	(55)						40	160	20	10												
TN3440	TO-237		250		20 μA	250	30		2	10	0.5		1.3	50		15		10				36
	(91)						40	160	20	10												
2N6714	TO-237	40	30	5	100	40	55		10	1	0.5			100		50	500	50				37
	(91)						60		100	1												
							50	250	1A	1												
92PU01	TO-237		30	5	100	40	55		10	1	0.5			1A	30	100		50				37
	(90)						60		100	1												
							50		1A	1												
92PU01A	TO-237		40	5	100	50	55		10	1	0.5			1A	30	100		50				37
	(90)						60		100	1												
							50		1A	1												
D42C1	TO-202		30		1 μA	30	25		200	1	0.5		1.3	1A	30							37
	(56)						10		1A	1												
D42C2	TO-202		30		1 μA	30	40	120	200	1	0.5		1.3	1A	30							37
	(56)						20		1A	1												
D42C3	TO-202		30		1 μA	30	40		200	1	0.5		1.3	1A	30							37
	(56)						20		2A	1												
D42C4	TO-202		45		1 μA	45	25		200	1	0.5		1.3	1A	30							37
	(56)						10		1A	1												
D42C5	TO-202		45		1 μA	45	40	120	200	1	0.5		1.3	1A	30							37
	(56)						20		1A	1												
D42C6	TO-202		45		1 μA	45	40		200	1	0.5		1.3	1A	30							37
	(56)						20		2A	1												
NSD102	TO-202	60	45	5	100	60	40		10	5	0.2		0.9	100	30	60		50				37
	(55)						50	150	100	5												
							40		500	5	0.4		1.2	500								
							25		1A	5												
NSD103	TO-202	60	45	5	100	60	50		10	5	0.2		0.9	100	30	60		50				37
	(55)						120	360	100	5												
							50		500	5	0.4		1.2	500								
							30		1A	5												
NSDU01	TO-202	40	30	5	100	30	55		10	1	0.5		1.2	1A	30	50		50				37
	(55)						60		100	1												
							50		1A	1												
NSDU01A	TO-202	50	40	5	100	40	55		10	1	0.5		1.2	1A	30	50		50				37
	(55)						60		100	1												
							50		1A	1												

MEDIUM POWER (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
NSDU02	TO-202 (55)	60	40	5	100	40	60		10	10	0.4		1.3	150	20	50		20				37
							50	300	150	10												
							30		500	10												
NSE180	TO-202 (55)		40		100	60	50	250	100	1	0.3			500		50		100				37
							30		500	1												
							12		1A	1.5	0.9		1.5	1.5A								
2N5449	TO-92 (97)	50	30	5	100	20	100	300	50	2	0.6			100		5		50				38
2N6551	TO-202 (55)	60	60	5	100	40	60		10	1	0.5			500								38
							80	250	50	1												
							60		250	1												
							25		500	1	1.0			1A								
2N6552	TO-202 (55)	80	80	5	100	60	60		10	1	1.0			1A		75	250	100				38
							80	250	50	1												
							60		250	1												
							25		500	1												
2N6705	TO-237 (90)	60	45	5	100	60	40		50	2	0.5			500		50	400	200				38
							40	250	250	2												
							25		500	2	1.0			1A								
2N6706	TO-237 (90)	80	60	5	100	80	40		50	2	0.5			500		50	400	200				38
							40	250	250	2												
							25		500	2	1.0			1A								
2N6707	TO-237 (90)	100	80	5	100	100	40		50	2	0.5			500		50	400	200				38
							40	250	250	2												
							25		500	2	1.0			1A								
2N6715	TO-237 (91)	50	40	5	100	50	55		10	1	0.5			1A		50	400	50				38
							60		100	1												
							50	250	1A	1												
2N6716	TO-237 (91)	60	60	5	100	40	80		50	1	0.35			250		50	500	50				38
							50	250	250	1												
							20		500	1												
92PE37A	TO-237 (90)		45		100	60	25		50	2	0.5			500	30	50		200				38
							40		250	2												
							40		500	2	1.0			1A								
92PE37B	TO-237 (90)		60		100	80	25		50	2	0.5			500	30	50		200				38
							40		250	2												
							40		500	2	1.0			1A								
92PE37C	TO-237 (90)		80		100	100	25		50	2	0.5			500	30	50		200				38
							40		250	2												
							40		500	2	1.0			1A								

MEDIUM POWER (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BD137-6	TO-126	60	60	5	100	30	40 25	100	150 500	2 2	0.5			500		50		50				38
BD137-10	TO-126	60	60	5	100	30	63 25	160	150 500	2 2	0.5			500		50		50				38
BD345	TO-126	60	60	5	500	60	60 40	 250	50 200	1 1	0.4			200	15	50		50				38
D40D1	TO-202 (55)		30		100*	45	50 10	150	100 1A		0.5		1.5	500								38
D40D2	TO-202 (55)		30		100*	45	120 20	360	100 1A		0.5		1.5	500								38
D40D3	TO-202 (55)		30		100*	45	290 10		100 1A				1.5	500								38
D40D4	TO-202 (55)		46		100*	60	50 10	150	100 1A		0.5		1.5	500								38
D40D5	TO-202 (55)		45		100*	60	120 10	360	100 1A		0.5		1.5	500								38
D40D6	TO-202 (55)		45		100*	60	50 10	150	100 1A		1.0		1.5	500								38
D40D7	TO-202 (55)		60		100*	60	50 10	150	100 1A		1.0		1.5	500								38
D40D8	TO-202 (55)		60		100*	75	120 10	360	100 1A	2 2	1.0		1.5	500								38
D40D10	TO-202 (55)		75		100*	90	50 10	150	100 1A	2 2	1.0		1.5	500								38
D40D11	TO-202 (55)		75		100*	90	120 10	360	100 1A	2 2	1.0		1.5	500								38
D40D13	TO-202 (55)		75		100*	90	50	150	100	2	1.0		1.5	500								38
D40D14	TO-202 (55)		75		100*	90	120	360	100	2	1.0		1.5	500								38
D40E1	TO-202 (55)		30		100*	40	50 10		100 1A	2 2	1.0		1.3	1A								38
D40E5	TO-202 (55)		60		100*	70	50 10		100 1A	2 2	1.0		1.3	1A								38
D40E7	TO-202 (55)		80		100*	90	50 10		100 1A	2 2	1.0		1.3	1A								38
MJE721	TO-126 (58)		60				40 20 8		150 500 1A	1 1 1	1.0 0.15 0.4		1.3	1.5A 150 500								38

MEDIUM POWER (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
NSD6178	TO-202		75		500 μA	80	30		50	2	0.5		1.2	500								38
	(55)						40	250	500	2												
							10		1A	2												
NSD6179	TO-202		50		500 μA	60	30		500	2	0.5		1.2	500								38
	(55)						40	250	500	2												
							10		1A	2												
NSDU05	TO-202	60	60	4	100	60	80		50	1	0.35			250	30	50		200				38
	(55)						50		250	1												
							20		500	1												
NSE181	TO-202		60		100	80	50	250	10	1	0.3			500		50		100				38
	(56)						30		500	1												
							12		1A	1.5	0.9		1.5	1.5A								
2N6553	TO-202	100	100	5	100	80	60		10	1	1.0			1A		75	250	100				39
	(55)						80	250	50	1												
							60		250	1												
							25		500	1												
2N6717	TO-237	80	80	5	100	60	80		50	1	0.35			250		50	500	200				39
	(91)						50	250	250	1												
							20		500	1												
2N6718	TO-237	100	100	5	100	80	80		50	1	0.35			350		50	500	200				39
	(91)						50	250	250	1												
							20		500	1												
2N6731	TO-237	100	80	5	100	80	100		10	2	0.35			350		50	500	200				39
	(91)						100	300	350	2												
92PU05	TO-237		100		100	80	80		50	1	0.35			250	30	50		200				39
	(90)						50		250	1												
							20		500	1												
92PU06	TO-237		100		100	80	20	500	500	1	0.35			250	30	50		200				39
	(90)						50	250	250	1												
							80	50	50	1												
92PU07	TO-237		100		100	80	80		50	1	0.35			250	30	50		200				39
	(91)						50		250	1												
							20		500	1												
92PU100	TO-237	100	80		100	80	20		10	5	0.35			350	20	50		100				39
	(91)						50	150	100	5												
							10		1A	5												
MJE722	TO-126		80				40		150	1	1.0		1.3	1.5A								39
	(58)						20		500	1	0.15			150								
							8		1A	1	0.4			500								

MEDIUM POWER (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
NSD104	TO-202 (55)	100	80	7	100	100	20		10	5	0.2		0.9	100	30	60		50				39
							50	150	100	5												
							10		1A	5	0.5		1.2	500								
NSD105	TO-202 (55)	100	80	7	100	100	10		10	5	0.2		0.9	100	30	60		50				39
							120	360	100	5												
							10		1A	5	0.5		1.2	500								
NSD106	TO-202 (55)	140	100	7	100	140	20		10	5	0.2		0.9	100	30	60		50				39
							50	150	100	5												
							25		500	5	0.5		1.2	500	50							
NSDU06	TO-202 (55)	80	80	4	100	80	80		50	1	0.35			250	30	50		200				39
							50		250	1												
							20		500	1												
NSDU07	TO-202 (55)	100	100	4	100	100	80		50	1	0.35			250	30	50		200				39
							50		250	1												
							20		500	1												
2N3742	TO-39	300	300	7	200	200	10		3	10	0.75		1.0	10	6	60		10				48
							15		10	10												
							20	200	30	10	1.0		1.2	30								
							20		50	20												
2N4926	TO-39	200	200	7	100	100	10		3	10					6	30	300	20				48
							15		10	10												
							20	200	30	10												
							20		50	20												
2N4927	TO-39	250	250	7	100	150	10		3	10					6	30	300	20				48
							15		10	10												
							20	200	30	10												
							30		50	20												
2N6711	TO-237 (90)	160	160	7	50	100	15		1	10						40	200	10				48
							15		10	10												
							30	200	30	10												
2N6712	TO-237 (90)	250	250	7	50	200	15		1	10						40	200	10				48
							15		10	10												
							30	200	30	10												
2N6713	TO-237 (90)	300	300	7	50	250	15		1	10						40	200	10				48
							15		10	10												
							30	200	30	10												
2N6719	TO-237 (91)	300	300	7	100	200	25		1	10						30	300	15				48
							40		10	10												
							40	200	30	10												
2N6733	TO-237 (91)	200	200	6	100	160	25		1	10	2.0			20		50	200	10				48
							40	200	10	10												

MEDIUM POWER (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N6734	TO-237	250	250	6	100	200	25		1	10	2.0					50	200	10				48
	(91)						40	200	10	10												
2N6735	TO-237	300	300	6	100	260	25		1	10						50	200	10				48
	(91)						40	200	10	10												
40321	TO-39		300		100	150	25	200	20	10					6	30	300	20				48
92PE487	TO-237	160	160	7	50	100	15		1	10	1.0			30	3							48
	(90)						15		10	10												
							30		30	10												
92PE488	TO-237	250	250	7	50	100	15		10	10	1.0			30	3							48
	(90)						15		10	10												
							30		30	10												
92PE489	TO-237	300	300	7	50	200	15		1	10	1.0			30	3							48
	(90)						15		10	10												
							30		30	10												
92PU10	TO-237		300		100	200	25		1	10	0.75			30	3.5							48
	(91)						40		10	10												
							40		30	10												
92PU391	TO-237	200	200	6	100	160	25		1	10	2.0		2.0	20	2.5	50		10				48
	(91)						40		10	10												
92PU392	TO-237	250	250	6	100	200	25		1	10	2.0		2.0	20	2.5	50		10				48
	(91)						40		10	10												
92PU393	TO-237	300	300	6	100	260	25		1	10	2.0		2.0	20	2.5	50		10				48
	(91)						40		10	10												
D40N1	TO-202		250		10 μA	250	20		4	10						50		20				48
	(55)						30	90	20	10												
							20		40	10												
D40N2	TO-202		250		10 μA	250	30		4	10						50		20				48
	(55)						60	180	20	10												
							30		40	10												
D40N3	TO-202		300		10 μA	300	20		4	10						50		20				48
	(55)						30	90	20	10												
							20		40	10												
D40N4	TO-202		300		10 μA	300	30		4	10						50		20				48
	(55)						60	180	20	10												
							30		40	10												
MPSA42	TO-92	300	300	6	100	200	25		1	10	0.5		0.9	20	3	50		10				48
	(92)						40		10	10												
							40		30	10												

MEDIUM POWER (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
MPSA43	TO-92 (92)	200	200	6	100	160	25 40 50	 200	1 10 30	10 10 10	0.4		0.9	20	4	50		10				48
NSD131	TO-202 (55)	250	250	7	100	150	15 15 30	 90	1 10 30	10 10 10	1.0		0.85	20	3							48
NSD132	TO-202 (55)	250	250	7	100	150	15 30 60	 180	1 10 30	10 10 10	1.0		0.85	20	3							48
NSD133	TO-202 (55)	300	300	7	100	150	15 15 30	 90	1 10 30	10 10 10	1.0		0.85	20	3							48
NSD134	TO-202 (55)	300	300	7	100	150	15 30 60	 180	1 10 30	10 10 10	1.0		0.85	20	3							48
NSD135	TO-202 (55)	375	375	7	100	150	15 30 30		1 10 30	10 10 10	1.0		0.85	20	3							48
NSD457	TO-202 (55)	160	160	5	50	100	25		30	10	1.0			30								48
NSD458	TO-202 (55)	250	250	5	50	200	25		30	10	1.0			30								48
NSD459	TO-202 (55)	300	300	5	50	250	25		30	10	1.0			30								48
NSDU10	TO-202 (55)	300	300	8	200	200	25 40 40		1 10 30	15 15 10	1.5		0.8	20	3	60						48
NSE457	TO-202 (56)	160	160	5	50	100	25		30	10	1.0			30								48
NSE458	TO-202 (56)	250	250	5	50	200	25		30	10	1.0			30								48
NSE459	TO-202 (56)	300	300	5	50	250	25		30	10	1.0			30								48
PN7055	TO-92 (92)	220	220	7	100	150	20 40 40		1 10 30	20 20 20	1.0		0.85	20	3.5	50		15				48
SE7055	TO-39	220	220	7	100	150	20 40 40		1 10 30	20 20 20	1.0		0.85	20	3.5	50		15				48

MEDIUM POWER (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
SE7056	TO-39	300	300	7	100	200	20		1	20	1.0		0.85	20	3.5	50		15				48
							40		10	20												
							40		30	20												
SV7056	TO-202 (55)	300	300	7	100	200	20		1	20	1.0		0.85	20		50		15				48
							40		10	20												
							40		30	20												
TN3742	TO-237 (91)	300	300	7	200	200	10		3	10	0.75		1.0	10	6	30		10				48
							15		10	10												
							20	200	30	10	1.0		1.2	30								
							20		50	20												

POWER

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CEX}* I_{CEB}† I_{CBO} (µA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (A)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (A)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (A)	Process No.
2N5655	TO-126		250		10	275	25		0.05	10	1.0			0.1					36
							30	250	0.1	10	2.5			0.25					
							15		0.25	10	10.0			0.5					
							5		0.5	10									
2N5656	TO-126		300		10	350	25		0.05	10	1.0			0.1	25	10		0.05	36
							30	250	0.1	10	2.5			0.25					
							15		0.25	10	10.0			0.5					
							5		0.5	10									
2N5657	TO-126		350		10	375	25		0.05	10	1.0			0.1	25	10		0.05	36
							30	250	0.1	10	2.5			0.25					
							15		0.25	10	10.0			0.5					
							5		0.5	10									
MJE340	TO-126		300		100	300	30	240	0.05	10									36
MJE341	TO-126		150		300	175	20		0.01	10	1.0			0.05	15	15		0.05	36
							25	200	0.05	10									
							20		0.15	10	2.3			0.15					
MJE344	TO-126		200		100	200	30	300	0.05	10	1.0			0.05	15	15		0.05	36

POWER (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CEX}* I_{CEB}† I_{CBO} (μA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (A)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (A)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (A)	Process No.
MJE3439	TO-126		360		20	360	30		0.002	10	0.5		1.3	0.05	10	15		0.01	36
							40	160	0.02	10									
MJE3440	TO-126		250		20	250	30		0.002	10	0.5		1.3	0.05	10	15		0.01	36
							40	160	0.02	10									
MJE180	TO-126		40		0.1	60	50	250	0.1	1	0.3			0.5	30	50		0.05	37
							30		0.5	1	0.9		1.5	1.5					
							12		1.5	1	1.7		2.0	3.0		50		0.1	
MJE720	TO-126		40		100*	40	40		0.15	1	0.15			0.15					37
							20		0.5	1	0.4			0.5					
							8		1	1	1.0		1.3	1.5					
MJE181	TO-126		60		0.1	80	50	250	0.1	1	0.3			0.5	30	50		0.1	38
							30		0.5	1	0.9		1.5	1.5					
							12		1.5	1	1.7		2.0	3.0					
MJE182	TO-126 (58)		80		100	100	50	250	100	1	0.3			500	30	50		0.1	39
							30		500	1	0.9			1.5A					
							12		1.5A	1	1.7		2.0	3A					
2N6099	TO-220		60		2 mA	50	20	80	4	4	2.5			10					4A
							5		10	4									
2N6101	TO-220		70		2 mA	60	20	80	5	4	2.5			10					4A
							5		10	4									
2N6103	TO-220		40		2 mA	40	15	60	8	4	2.5			16					4A
							5		16	4									
2N6486	TO-220		40		100	35	20	150	5	4	1.3			5		5		1	4A
									15	4	3.5			15					
2N6487	TO-220		60		100	55	20	150	5	4	1.3			5		5		1	4A
									15	4	3.5			15					
2N6488	TO-220		80		100	75	20	150	5	4	1.3			5		5		1	4A
									15	4	3.5			15					
MJE2801T	TO-220		60				25	100	3	2									4A
MJE3055T	TO-220		60		1 mA	70	20	70	4	4	1.1			4					4A
							5		10	4	8			10					
TIP41	TO-220		40		400*	40	30		0.3	4	1.5			6					4A
							15	75	3	4									
TIP41A	TO-220		60		400*	60	30		0.3	4	1.5			6					4A
							15	75	3	4									
TIP41B	TO-220		80		400*	80	30		0.3	4	1.5			6					4A
							15	75	3	4									
TIP41C	TO-220		100		400*	100	30		0.3	4	1.5			6					4A
							15	75	3	4									

POWER (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CEX}* I_{CEB}† I_{CBO} (μA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (A)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (A)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (A)	Process No.
2N5190	TO-126		40		100	40	25 10	100	1.5 4	2 2	0.6 1.4			1.5 4		2		1	4E
2N5191	TO-126		60		100	60	25	100	1.5 4	2 2	0.6 1.4			1.5 4		2		1	4E
2N5192	TO-126		80		100	80	20 7	80	1.5 4	2 2	0.6 1.4			1.5 4		2		1	4E
2N5294	TO-220		70		500†	50 (100Ω)	30	120	0.5	4	1			0.5		2		0.2	4E
2N5296	TO-220		40		100	35	30	120	1	4	1.0			1		2		0.2	4E
2N5298	TO-220		60		500†	50 (100Ω)	20	80	1.5	1	1.0			1.5		2		0.2	4E
2N5490	TO-220		40		5 mA*	55	20 5	100	2 6.5	4 4	2.0			0.5					4E
2N5492	TO-220		55		1 mA*	70	20 5	100	2.5 6.5	4 4	2.0			0.2					4E
2N5494	TO-220		40		1 mA*	55	20 5	100	3 6.5	4 4	2.0			0.5					4E
2N5496	TO-220		70		1 mA*	85	20 5	100	3.5 7	4 4	2.0			7					4E
2N6121	TO-220		45		100	45	25 10	100	1.5 4	2 2	0.6 1.4			1.5 4		2.5		1	4E
2N6122	TO-220		60		100	60	25 10	100	1.5 4	2 2	0.6 1.4			1.5 4		2.5		1	4E
2N6123	TO-220		80		100	80	20 7	80	1.5 4	2 2	0.6 1.4			1.5 4		2.5		1	4E
2N6129	TO-220		40		100	40	20 7	100	2.5 7	4 4	1.4			7					4E
2N6130	TO-220		60		100	60	20 7	100	2.5 7	4 4	1.4			7					4E
2N6131	TO-220		80		100	80	20 5	100	2.5 7	4 4	2.0			7					4E
2N6288	TO-220		30		100*	37.5	30 5	150	3 6.5	4 4	1.0 2.0			3 6.5	250	4		0.5	4E
2N6290	TO-220		50		100*	56	30 5	150	3 6.5	4 4	1.0 2.0			2.5 6.5	250	4		0.5	4E
2N6292	TO-220		70		100*	75	30 5	150	2 6.5	4 4	1.0 2.0			2 6.5	250	4		0.5	4E

POWER (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CEX}* I_{CEB}† I_{CBO} (µA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (A)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (A)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (A)	Process No.
MJE5190J	TO-126		40		100	40	25 10	250	1.5 4	2 2	0.6			1.5					4E
MJE5191J	TO-126		60		100	60	25 10	250	1.5 4	2 2	0.6			1.5					4E
MJE5192J	TO-126		80		100	80	50 7	250	1.5 4	2 2	0.6			1.5					4E
2N6473	TO-220		100		100*	100	15	150	1.5	4	1.2			1.5	250				4F
2N6474	TO-220		120		100*	120	15	150	1.5	4	1.2			1.5	250				4F
MJE520	TO-220		30		100	30	25		1	1									4F
MJE521	TO-220		40		100	40	40		1	1									4F
TIP29	TO-220		40		200*	40	40 15	 75	0.2 1	4 4	0.7			1		3		0.2	4F
TIP29A	TO-220		60		200*	60	40 15	 75	0.2 1	4 4	0.7			1		3		0.2	4F
TIP29B	TO-220		80		200*	80	40 15	 75	0.2 1	4 4	0.7			1		3		0.2	4F
TIP29C	TO-220		40		200*	40	25 10	 50	1 3	4 4	0.7			1		3		0.2	4F
TIP31	TO-220		40		200*	40	25 10	 50	1 3	4 4	1.2			3		3		0.5	4F
TIP31A	TO-220		60		200*	60	25 10	 50	1 3	4 4	1.2			3		3		0.5	4F
TIP31B	TO-220		80		200*	80	25 10	 50	1 3	4 4	1.2			3		3		0.5	4F
TIP31C	TO-220		100		200*	100	25 10	 50	1 3	4 4	1.2			3		3		0.5	4F
TIP61	TO-220		40		200*	40	40 15	 100	0.05 0.5	4 4	0.7			0.5		3		0.05	4F
TIP61A	TO-220		60		200*	60	40 15	 100	0.05 0.5	4 4	0.7			0.5		3		0.05	4F
TIP61B	TO-220		80		200*	80	40 15	 100	0.05 0.5	4 4	0.7			0.5		3		0.05	4F
TIP61C	TO-220		100		200*	100	40 15	 100	0.05 0.5	4 4	0.7			0.5		3		0.05	4F
2N4921	TO-220		40		100	40	40 20 10	 100 	0.05 0.5 1	1 1 1	0.6		1.3	1	100	300		0.25	4H

POWER (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CEX}* I_{CEB}† I_{CBO} (µA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (A)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (A)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (A)	Process No.
2N4922	TO-220		60		100	60	40		0.05	1	0.6		1.3	1	100	300		0.25	4H
							20	100	0.5	1									
							10		1	1									
2N4923	TO-220		80		100	80	40		0.05	1	0.6		1.3	1	100	300		0.25	4H
							20	100	0.5	1									
							10		1	1									
D44C1	TO-220		30		10*	40	25		0.2	1	0.5		1.3	1	100	3		0.02	4P
							10		1	1									
D44C2	TO-220		30		10*	40	40	120	0.2	1	0.5		1.3	1	100	3		0.02	4P
							20		1	1									
D44C3	TO-220		30		10*	40	40		0.2	1	0.5		1.3	1	100	3		0.02	4P
							20		2	1									
D44C4	TO-220		45		10*	55	25		0.2	1	0.5		1.3	1	100	3		0.02	4P
							10		1	1									
D44C5	TO-220		45		100	55	40	120	0.2	1	0.5		1.3	1	100	3		0.02	4P
							20		1	1									
D44C6	TO-220		45		10*	55	40		0.2	1	0.5		1.3	1	100	3		0.02	4P
							20		2	1									
D44C7	TO-220		60		100	75	25		0.2	1	0.5		1.3	1	100	3		0.02	4P
							10		1	1									
D44C8	TO-220		60		100	70	40	120	0.2	1	0.5		1.3	1	100	3		0.02	4P
							20		1	1									
D44C9	TO-220		60		10*	70	40		0.2	1	0.5		1.3	1	100	3		0.02	4P
							20		2	1									
D44C10	TO-220		80		100	90	25		0.2	1	0.5		1.3	1	100	3		0.02	4P
							10		1	1									
D44C11	TO-220		80		10*	90	40	120	0.2	1	0.5		1.3	1	100	3		0.02	4P
							20		1	1									
D44C12	TO-220		80		10*	90	40		0.2	1	0.5		1.3	1	100	3		0.02	4P
MJE200	TO-220		25		0.1	40	70		0.5	1	0.3			0.5	80	65		0.1	4P
							45	180	2	1	0.75			2					
							10		5	2	1.8			5					
MJE220	TO-220		100		0.1	60	40	200	0.2	1	0.3			0.5	80	50		0.1	4P
							20		2	1									
MJE221	TO-220		40		0.1	60	40	150	0.2	1	0.3			0.5	50	50		0.1	4P
							20		1	1	0.6			1.0					
MJE222	TO-220		40		0.1	60	25		0.2	1	0.3			0.5	50	50		0.1	4P
							10		1	1			1.8	2					

POWER (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CEX}* I_{CEB}† I_{CBO} (μA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (A)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (A)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (A)	Process No.
MJE223	TO-220		60		0.1	80	40	200	0.2	1	0.3			0.5	50	50		0.1	4P
							20		2	1	0.8		1.8	2					
MJE224	TO-220		60		0.1	80	40	150	0.2	1	0.3			0.5	50	50		0.1	4P
							20		1	1	0.6			1					
MJE225	TO-220		60		0.1	80	25		0.2	1	0.3			0.5	50	50		0.1	4P
							10		1	1									
MJE240	TO-220		80		0.1	80	40	200	0.2	1	0.3			0.5	50	40		0.1	4P
							15		2	1	0.8		1.8	2					
MJE241	TO-126		80		0.1	80	40	120	0.2	1	0.3			0.5	50	40		100	4P
											0.6			1					
													1.8	2					
							20		1	1	2.5			4					
MJE242	TO-126		80		0.1	80	25		0.2	1	0.3			0.5	50	40		100	4P
													1.8	2					
							10		1	1	2.5			4					
MJE243	TO-126		100		0.1	100	40	120	0.2	1	0.3			0.5	50	40		100	4P
											0.8		1.8	2					
											2.5			4					
MJE244	TO-126		100		0.1	100	25		0.2		0.3			0.5	50	40		100	4P
														2					
							10		1		2.5			4					
D44H1	TO-220		30		10	30	35		2	1	1.0		1.5	8					4Q
							20		4	1									
D44H2	TO-220		30		10	30	60		2	1	1.0		1.5	8					4Q
							40		4	1									
D44H4	TO-220		45		10	45	35		2	1	1.0		1.5	8					4Q
							20		4	1									
D44H5	TO-220		45		10	45	60		2	1	1.0		1.5	8					4Q
							40		4	1									
D44H7	TO-220		60		10	60	35		2	1	1.0		1.5	8					4Q
							20		4	1									
D44H8	TO-220		60		10	60	60		2	1	1.0		1.5	8					4Q
							40		4	1									
D44H10	TO-220		80		10	80	35		2	1	1.0		1.5	8					4Q
							20		4	1									
D44H11	TO-220		80		10	80	60		2	1	1.0		1.5	8					4Q
							40		4	1									

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Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (μA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	@ V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	Process No.
2N5305	TO-92 (94)				0.1	25	2000	20,000	2	5	1.4			200	10	60		2	05
2N5306	TO-92 (94)				0.1	25	7000	70,000	2	5	1.4			200	10	60		2	05
2N5307	TO-92 (94)				0.1	40	2000	20,000	2	5	1.4			200	10	60		2	05
2N5308	TO-92 (94)				0.1	40	7000	70,000	2	5	1.4			200	10	60		2	05
2N6426	TO-92 (92)	40	40	12	0.05	30	20,000	200,000	10	5	1.2			50	7	150		10	05
							30,000	300,000	100	5									
							20,000	300,000	500	5	1.5		2	500					
2N6427	TO-92 (92)	40	40	12	0.05	30	10,000	100,000	10	5	1.2			50	7	130		10	05
							20,000	200,000	100	5									
							14,000	140,000	500	5	1.5		2	500					
2N6548	TO-202 (55)	50	40	12	0.1	30	25,000	150,000	200	5					7	1		200	05
							15,000		500	5									
							5000		1A	5									
2N6549	TO-202 (55)	50	40	12	0.1	30	15,000	150,000	200	5					7	1		200	05
							10,000		500	5									
							3000		1A	5									
2N6724	TO-126	50		12			25,000		200	5	1.0			200		1	10	200	05
							15,000		500	5									
							4000	40,000	1A	5									
2N6725	TO-126	60		12	0.1	40	25,000		200	5	1.0			200		1	10	200	05
							15,000		500	5									
							4000	40,000	1A	5									
92PU45	TO-237 (91)	50		12	0.1	30	4000		1A	5	1.5		2.0	1A		100		200	05
							15,000		500	5									
							25,000		200	5	1.0			200					
92PU45A	TO-237 (91)	60		12	0.1	40	4000		1A	5	1.5		2.0	1A		100		200	05
							15,000		500	5									
							25,000		200	5	1.0			200					
D40C1	TO-202 (55)		30		0.5*	30	10,000	60,000	200	5	1.5		2.0	500	10				05
D40C2	TO-202 (55)		30		0.5*	30	40,000		200	5	1.5		2.0	500	10				05
D40C3	TO-202 (55)		30		0.5*	30	90,000		200	5	1.5		2.0	500	10				05
D40C4	TO-202 (55)		40		0.5*	40	10,000	60,000	200	5	1.5		2.0	500	10				05

DARLINGTON (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (μA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	@ V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	Process No.
D40C5	TO-202 (55)		40		0.5*	40	40,000		200	5	1.5		2.0	500	10				05
D40C7	TO-202 (55)		50		0.5*	50	10,000	60,000	200	5	1.5		2.0	500	10				05
D40C8	TO-202 (55)		50		0.5*	5	40,000		200	5	1.5		2.0	500	10				05
D40K1	TO-202 (55)		30				10,000 1000 1000		200 1.5A 1A	5 5 5					10				05
D40K2	TO-202 (55)		50				10,000 1000 1000		200 1.5A 1A	5 5 5									05
D40K3	TO-202 (55)		30				10,000 1000 1000		200 1.5A 1A	5 5 5									05
D40K4	TO-202 (55)		50				10,000 1000 1000		200 1.5A 1A	5 5 5									05
MPSA12	TO-92 (92)	20			0.1	15	20,000		10	5	1.0			10					05
MPSA13	TO-92 (92)	30			0.1	30	10,000 5000		100 10	5 5	1.5			100		125		10	05
MPSA14	TO-92 (92)	30			0.1	30	20,000 10,000		100 10	5 5	1.5			100		125		10	05
NSD151	TO-202 (55)		30	12			5000 10,000	 150,000	10 100	5 5	1.5			100	8	5		10	05
NSD152	TO-202 (55)			12			5000 10,000	 25,000	10 100	5 5	1.5			100	8	5		10	05
NSD153	TO-202 (55)			12			20,000 5000		10 100	5 5	1.5			100	8	5		10	05
NSD154	TO-202 (55)			12			20,000 5000		10 100	5 5	1.5			100	8	5		10	05
NSDU45	TO-202 (55)	50		12			25,000 15,000 4000	150,000	200 500 1A	5 5 5	1.0			200	8	1		200	05
NSDU45A	TO-202 (55)	60		12	0.1	10	25,000 15,000 4000	150,000	200 500 1A	5 5 5	1.0			200	8	1		200	05

DARLINGTON (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (μA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	@ V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	Process No.
2N6037	TO-126		40		500	40	100		4A	3	2.0		4.0	2A	200	25		0.75A	4J
							750	1500	2A	3	3.0			4A					
							500		0.5	3									
2N6038	TO-126		60		500	60	100		4A	3	2.0		4.0	2A	200	25		0.75A	4J
							750	1500	2A	3									
							500		0.5	3	3.0			4A					
2N6039	TO-126		80		500	80	100		4A	3	2.0		4.0	2A	200	25		0.75A	4J
							750	1500	2A	3									
							500		0.5	3	3.0			4A					
2N6386	TO-220		40		300*	40	100		8	3	2.0			3	200	20		1	4J
							1000	20,000	3	3	3.0			8					
MJE800	TO-126		60		200	60	750		1.5	3	2.5			1.5					4J
MJE801	TO-126		60		200	60	750		2	3	2.8			2					4J
MJE802	TO-126		80		200	80	750		1.5	3	2.5			1.5					4J
MJE803	TO-126		80		200	80	750		2	3	2.8			2					4J
TIP110	TO-220		60		1 mA	60	500		2	4	2.5			2					4J
							1000		1	4									
TIP111	TO-220		80		1 mA	80	500		2	4	2.5			2					4J
							1000		1	4									
TIP112	TO-220		100		1 mA	100	500		2	4	2.5			2					4J
							1000		1	4									
TIP120	TO-220		60		200	60	1000		3	3	2.0			3					4J
							1000		0.5	3	4.0			5					
TIP121	TO-220		80		200	80	1000		3	3	2.0			3					4J
							100		0.5	3	4.0			5					
TIP122	TO-220		100		200	100	1000		3	3	2.0			3					4J
2N6387	TO-220	60	60	5			1000	20,000	5	3	3.0			10	200				4K
							100		10	3									
2N6388	TO-220	80	80	5			1000	20,000	5	3	3.0			10	200				4K
							100		10	3									
2N6043	TO-220		60		500	60	10,000	20,000	4	4	2.0			4	200	4		3	4K
							100		8	4	4.0		4.5	8					
2N6044	TO-220		80		500	80	1000	20,000	4	4	2.0			4	200	4		3	4K
							100		8	4	4.0		4.5	8					
2N6045	TO-220		100		500	100	1000	20,000	4	4	2.0		4.5	4	200	4		3	4K
							100		8	4	4.0			8					
SE9300	TO-220		60	4			750		1	3									4K
							1000		4	3									
							100		7.5	3									

DARLINGTON (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (μA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	@ V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	Process No.
SE9301	TO-220		80	4			750		1	3									4K
							1000		4	3									
							100		7.5	3									
SE9302	TO-220		100	4			750		1	3									4K
							1000		4	3									
							100		7.5	3									
TIP100	TO-220	60			50	40	1000	20,000	3	4	2.0			3					4K
							200		8	4	2.5			8					
TIP101	TO-220	80			50	60	1000	20,000	3	4	2.0			3					4K
							200		8	4	2.5			8					
TIP102	TO-220	100			50	80	1000	20,000	3	4	2.0			3					4K
							200		8	4	2.5			8					
TIP130	TO-220		60		200	60	1000	15,000	4	4	2.0			4					4K
							500		1	4	3.0			6					
TIP131	TO-220		80		200	60	1000	15,000	4	4	2.0			4					4K
							500		1	4	3.0			6					
TIP132	TO-220		100		200	100	1000	15,000	4	4	2.0			4					4K
							500		1	4	3.0			6					

Section 2

PNP Transistors

2

SATURATED SWITCHES

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N869	TO-52	25		5	10	15	20	120	10	5	1.0		1.0	10	9	100		10				64
2N869A	TO-52	25	18	5	10	15	25		100	1	0.15	0.78	0.98	10	6	400		10	80		1	64
							40	120	30	0.5												
							30		10	0.3												
							40	120	10	5	0.2	0.85	1.2	30								
2N995	TO-52	20	15	4	5	15	35	140	20	1	0.2		0.95	20	10	100		10				64
2N995A	TO-52	20	15	4	5	15	25		100	1	0.2		0.95	20	6	100		10	90		2	64
							25		50	1												
							25		20	1	0.5		1.7	100								
							35	140	1	1												
2N2894	TO-52	12	12	4	10*	6	25		100	1	0.15	0.78	0.98	10	6	400		30	90		2	64
							40	150	30	0.5	0.2	0.85	1.2	30								
							30		10	0.3	0.5		1.7	100								
2N2894A	TO-52	12	12	4.5	50*	10	30		100	1	0.13	0.78	0.92	10	4.5	800		30	25		3	64
							40	120	30	0.5	0.19	0.85	1.15	30								
							30		10	0.3	0.45	1	1.5	100								
							20		1	0.5												
2N3012	TO-52	12	12	4	80*	6	20		100	1	0.15	0.78	0.98	10	6	400		30	75		2	64
							30	120	30	0.5	0.2	0.85	1.2	30								
							25		10	0.3	0.5		1.7	100								
2N3209	TO-52	20	20	4	80*	10	15		100	1	0.15	0.78	0.98	10	5	400		30	90		2	64
							30	120	30	0.5	0.2	0.85	1.2	30								
							20		10	3	0.6		1.7	100								
2N3248	TO-52	15	12	5			25		100	1	0.125	0.6	0.9	10	8	250		20	100		5	64
							35		50	1												
							50		10	1	0.25	0.7	1.1	50								
							50		1	1												
							50	150	0.1	1	0.4		1.3	100								
2N3249	TO-52	15	12	5			35		100	1	0.125	0.6	0.9	10	8	300		20	100		5	64
							75		50	1												
							100		10	1	0.25	0.7	1.1	50								
							100		1	1												
							100	300	0.1	1	0.45		1.3	100								
2N3545	TO-52	20	20	5	10	10	30		100	1	0.2	0.6	0.85	10	8	250		10	90		8	64
							35		50	1	0.3		1.1	50								
							40	120	10	1	0.5		1.3	100								
							30		1	1												

SATURATED SWITCHES (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N3546	TO-52	15	12	4.5	10	10	15		100	1	0.15	0.7	0.9	10	6	700		10	30		9	64
							25		50	1	0.25	0.8	1.3	50								
							30	120	10	1	0.5		1.6	100								
							20		1	1												
2N3576	TO-52	20	15	5	10	15	10		100	1	0.15	0.75	0.95	10	4.5	400		10	50		5	64
							40	120	10	0.5	0.5		1.1	100								
2N5056	TO-52	15	15	4.5	50*	10	20		100	1	0.13	0.72	0.92	10	4.5	600		30	35		3	64
							30	100	30	0.5	0.19	0.8	1.15	30								
							20		10	0.3												
							12		1	0.5	0.45	0.95	1.5	100								
2N5057	TO-52	15	15	4.5	50*	10	30		100	1	0.13	0.72	0.92	10	4.5	800		30	35		3	64
							40	100	30	0.5	0.19	0.8	1.15	30								
							30		10	0.3	0.45	0.95	1.5	100								
							20		1	0.5												
2N3304	TO-52	6	6	4	10*	3	20		50	1	0.15	0.7	0.8	1	3.5	500		10	60		7	65
							30	120	10	0.3	0.16	0.8	1.0	10								
							15		1	0.5	0.5		1.5	50								
2N3451	TO-52	6	6	4	10*	3	20		50	1	0.16	0.8	1.0	10	5.5	500		10	60		7	65
							30	120	10	0.3	0.5		1.5	50								
2N3639	TO-92 (92)	Same as PN3639, see page 2-4 for explanation																				65
2N3640	TO-92 (92)	Same as PN3640, see page 2-4 for explanation																				65
2N4208	TO-52	12	12	4.5	10*	6	30		50	1	0.13		0.8	1	3	700		10	20		5	65
							30	120	10	0.3	0.15	0.8	0.95	10								
							15		1	0.5	0.5		1.5	50								
2N4209	TO-52	15	15	4.5	10*	8	40		50	1	0.15		0.8	1	3	850		10	20		5	65
							50	120	10	0.3	0.18	0.8	0.95	10								
							35		1	0.5	0.6		1.5	50								
2N4258	TO-92 (92)	Same as PN4258, see page 2-4 for explanation																				65
2N4258A	TO-92 (92)	Same as PN4258A, see page 2-4 for explanation																				65
2N5140	TO-92 (92)	Same as PN5140, see page 2-4 for explanation																				65

TEST CONDITIONS:

(1) I_C = 30 mA, V_{CC} = 3V, I_B^1 = 3 mA, I_B^2 = 1.5 mA. **(2)** I_C = 30 mA, V_{CC} = 3V, $I_B^1 = I_B^2$ = 1.5 mA. **(3)** I_C = 30 mA, V_{CC} = 3V, $I_B^1 = I_B^2$ = 3 mA. **(4)** I_C = 500 mA, V_{CC} = 30V, $I_B^1 = I_B^2$ = 50 mA. **(5)** I_C = 10 mA, V_{CC} = 3V, $I_B^1 = I_B^2$ = 1 mA. **(6)** I_C = 10 mA, V_{CC} = 1.5V, $I_B^1 = I_B^2$ = 1 mA. **(7)** I_C = 10 mA, V_{CC} = 1.5V, $I_B^1 = I_B^2$ = 500 μA. **(8)** I_C = 10 mA, V_{CC} = 2V, $I_B^1 = I_B^2$ = 1 mA. **(9)** I_C = 50 mA, V_{CC} = 3V, $I_B^1 = I_B^2$ = 5 mA. **(10)** I_C = 1A, V_{CC} = 30V, $I_B^1 = I_B^2$ = 100 mA.

SATURATED SWITCHES (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N5771	TO-92 (92)	15	15	4.5	10	8	40 50 35	 120 	50 10 1	1.0 0.3 0.5	0.15 0.18 0.6	 0.8 	0.8 0.95 1.5	1 10 50	3	850		10	20		6	65
2N5910	TO-92 (92)	Same as PN5910, see below for explanation																				65
MPS3639	TO-92 (92)	Same as PN3639, see below for explanation																				65
MPS3640	TO-92 (92)	Same as PN3640, see below for explanation																				65
PN3639	TO-92 (92)	6	6	4	10*	3	20 30	 120	50 10	1.0 0.3	0.16 0.5	0.8	1.0 1.5	10 50	3.5	300		10	60		7	65
PN3640	TO-92 (92)	12	12	4	10*	6	20 30	 120	50 10	1.0 0.3	0.2 0.6	0.8	1.0 1.5	10 50	3.5	300		10	75		7	65
PN4258	TO-92 (92)	12	12	4.5	10*	6	30 30 15	 120 	50 10 1	1 3 0.5	0.15 0.5	0.7	0.95 1.5	10 50	3	700		10	20		6	65
PN4258A	TO-92 (92)	12	12	4.5	10*	6	30 30 15	 120 	50 10 1	1 3 0.5	0.15 0.5	0.7	0.95 1.5	10 50	3	700		10	18		6	65
PN5140	TO-92 (92)	5	5	4	50*	3	20	40	10	1	0.2 0.75		1.2	10 50	5	400		10	20		6	65
PN5910	TO-92 (92)	20	20	4.5	10*	10	30 30 15	 120 	50 10 1	1 0.3 0.5	0.15 0.5	0.75	0.95 1.5	10 50	3	700		10	20		6	65
ST5771-1	TO-92 (92)	15	15	4.5	10	8	30 30 20	150 	10 1 50	0.3 0.5 1	0.15 0.18 0.6	 0.8 	0.8 0.95 1.5	1 10 50		700		10				65
ST5771-2	TO-92 (92)	15	15	4.5	10	8	40 35 30	150 	10 1 50	0.3 0.5 1	0.15 0.18 0.6	 0.8 	0.8 0.95 1.5	1 10 50		700		10				65
2N3244	TO-39	40	40	5	50	30	25 50 60	 150 	750 500 150	5 1 1	0.3 0.5	 0.75	1.1 1.5	150 500	25	175		50	185		4	70
2N3245	TO-39	50	50	5	50	50	20 30 35	 90 	1A 500 150	5 1 1	0.35 0.6 1.2	 0.75 	1.1 1.5 2	150 500 1A	25	150		50	165		4	70
2N3467	TO-39	40	40	5	100	30	40 40 40	 120 	1 500 150	5 1 1	0.3 0.5	 0.8	1.0 1.2	150 500	25	175		50	90		4	70

SATURATED SWITCHES (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max @	V_{CB} (V)	h_{FE} Min	h_{FE} Max @	I_C (mA) &	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max &	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max @	I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max @	I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N3468	TO-39	50	50	5	100	30	20		1	5	0.35		1.0	150	25	150		50	90		4	70
							25	75	500	1												
							25		150	1	0.6	0.8	1.2	500								
NS3762	TO-39	40	40	5			30		1.5A	5	0.9		1.4	1A	18	180		50	115		10	70
							30	120	1A	1.5	0.5		1.2	500								
							35		500	1	0.22		1.0	150								
							40		150	1	0.15		0.8	10								
							35		10	1												
NS3763	TO-39	60	60	5			20		1.5A	5	0.9		1.4	1A	18	180		50	115		10	70
							20	80	1A	1.5	0.5		1.2	500								
							35		500	1	0.22		1.0	150								
							40		150	1	0.15		0.8	10								
							35		10	1												
2N5022	TO-39	50	50	5	100*	30	25		1A	5	0.2		1.0	100	25	170		50	90		4	70
							25	100	500	1	0.4	0.8	1.4	500								
							15		100	1	0.8		1.75	1A								
2N5023	TO-39	30	30	5	100*	20	40		1A	5	0.17		1.0	100	25	200		50	90		4	70
							40	100	500	1	0.35	0.8	1.4	500								
							30		100	1	0.7		1.75	1A								
DH3467CD	Ceramic DIP (40)	40	40	5	100	30	40		1A	5	1.0		1.6	1A	25	175		50	90		4	70
							40	120	500	1	0.5	0.8	1.2	500								
							40		150	1	0.3		1.0	150								
DH3467CN	Molded DIP (39)	40	40	5	100	30	40		1A	5	1.0		1.6	1A	25	175		50	90		4	70
							40	120	500	1	0.5	0.8	1.2	500								
							40		150	1	0.3		1.0	150								
DH3468CD	Ceramic DIP (40)	50	50	5	100	30	20		1A	5	1.2		1.6	1A	25	150		50	90		4	70
							25	75	500	1	0.6	0.8	1.2	500								
							25		150	1	0.35		1.0	150								
DH3468CN	Molded DIP (39)	50	50	5	100	30	20		1A	5	1.2		1.6	1A	25	150		50	90		4	70
							25	75	500	1	0.6	0.8	1.2	500								
							25		150	1	0.36		1.0	150								

TEST CONDITIONS:
(1) I_C = 30 mA, V_{CC} = 3V, $I_B{}^1$ = 3 mA, $I_B{}^2$ = 1.5 mA. **(2)** I_C = 30 mA, V_{CC} = 3V, $I_B{}^1 = I_B{}^2$ = 1.5 mA. **(3)** I_C = 30 mA, V_{CC} = 3V, $I_B{}^1 = I_B{}^2$ = 3 mA. **(4)** I_C = 500 mA, V_{CC} = 30V, $I_B{}^1 = I_B{}^2$ = 50 mA. **(5)** I_C = 10 mA, V_{CC} = 3V, $I_B{}^1 = I_B{}^2$ = 1 mA. **(6)** I_C = 10 mA, V_{CC} = 1.5V, $I_B{}^1 = I_B{}^2$ = 1 mA. **(7)** I_C = 10 mA, V_{CC} = 1.5V, $I_B{}^1 = I_B{}^2$ = 500 μA. **(8)** I_C = 10 mA, V_{CC} = 2V, $I_B{}^1 = I_B{}^2$ = 1 mA. **(9)** I_C = 50 mA, V_{CC} = 3V, $I_B{}^1 = I_B{}^2$ = 5 mA. **(10)** I_C = 1A, V_{CC} = 30V, $I_B{}^1 = I_B{}^2$ = 100 mA.

LOW LEVEL AMPS

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max @	V_{CB} (V)	h_{FE} Min	h_{FE} Max @	I_C (mA) &	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max &	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max @	I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max @	I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N2604	TO-46	60	45	6	10	45		350	10	5	0.5	0.7	0.9		10	6	30		0.5	3	1	62
							60		0.5	5												
							40	120	0.01	5												
2N2605	TO-46	60	45	6	10	45		600	10	5	0.5	0.7	0.9		10	6	30		0.5	3	2	62
							150		0.5	5												
							100	300	0.01	5												
2N3547	TO-18	60	60	6	25	45	75		10	5	1.0		1.0		10	8	45		1	5	1	62
							100	500	1	5												
							60		0.1	5												
2N3548	TO-18	60	45	6	10	45		600	10	5	1.0		1.0		10	8	60	150	1	4	1	62
							150		0.1	5												
							100	300	0.01	5												
2N3549	TO-18	60	60	6	10	45		800	10	5	1.0		1.0		10	8	60	150	1	4	1	62
							200		1	5												
							150		0.1	5												
							100	500	0.01	5												
2N3550	TO-18	60	45	8	1	45		800	10	5	0.5	0.7	0.9		5	8	60	150	1	4	1	62
							300		1	5												
							250		0.1	5												
							200	600	0.01	5												
							125		0.001	5												
2N3799	TO-18	60	60	5	10	50	300		0.1	5	0.25		0.8		1	4	30		0.5	2.5	3	62
							300	900	0.5	5												
							300		0.1	5	0.2		0.7		0.1							
							225		0.01	5												
							75		0.001	5												
2N4058	TO-92 (94)	30	30	6	100	20	100	400	0.1	5	0.7				10					5	3	62
2N4059	TO-92 (94)	30	30	6	100	20	45	660	1	5	0.7				10							62
2N4061	TO-92 (94)	30	30	6	100	20	90	330	1	5	0.7				10							62
2N4062	TO-92 (94)	30	30	6	100	20	180	660	1	5	0.7				10							62
2N4248	TO-92 (92)	Same as PN4248, see page 2-7 for explanation																				62
2N4249	TO-92 (92)	Same as PN4249, see page 2-7 for explanation																				62
2N4250	TO-92 (92)	Same as PN4250, see page 2-7 for explanation																				62

LOW LEVEL AMPS (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N4250A	TO-92 (92)	Same as PN4250A, see below for explanation																				62
2N4288	TO-92 (94)	30	25	6	50	25	75 150 100	 600 	10 1 0.1	5 5 5	0.35		0.8		1	8	40		1			62
2N4289	TO-92 (94)	60	45	7	10	45	75 150 100	 600 	10 1 0.1	5 5 5	0.35		0.8		1	8	40		1	4	1	62
2N4964	TO-92 (92)	Same as MPSA70, see below for explanation																				62
2N4965	TO-92 (92)	Same as 2N5086, see below for explanation																				62
2N5086	TO-92 (92)	50	50		50	35	150 150 150	 500	10 1 0.1	5 5 5	0.3				10	4	40		0.5	3	4	62
2N5087	TO-92 (92)	50	50		50	35			10 1 0.1	5 5 5	0.3				10	4	40		0.5	2	4	62
2N5227	TO-92 (92)	30	30	3	100	10	50 30	700 	2 0.1	10 10	0.4		1.0		10	5	100		10			62
MPSA70	TO-92 (92)		40	4	100	30	40	400	5	10	0.25				10	4	125		5			62
MPS6523	TO-92 (92)		25	4	50	20	300 150	600 	2 0.1	10 10	0.5				50	4						62
PN4248	TO-92 (92)	40	40	5	10	40	50		0.1	5	0.25				10	6						62
PN4249	TO-92 (92)	60	60	5	10	40	100	300	0.1	5	0.25				10	6						62
PN4250	TO-92 (92)	40	40	5	10	40	250	700	0.1	5	0.25				10	6				2	4	62
PN4250A	TO-92 (92)	60	60	5	10	50	250	700	0.1	5	0.25				10	6				2	4	62

TEST CONDITIONS:

(1) I_C = 10 μA, V_{CE} = 5V, f = 10 Hz–15.7 kHz. **(2)** I_C = 10 μA, V_{CE} = 5V, f = 10 kHz. **(3)** I_C = 100 μA, V_{CE} = 5V, f = 10 Hz–15.7 kHz. **(4)** I_C = 20 μA, V_{CE} = 5V, f = 10 Hz–15.7 kHz.

GENERAL PURPOSE AMPS AND SWITCHES

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N722	TO-18	50	35	5	100	30	30	90	150	10	1.5		1.3	150	45	60		50				63
							25		5	10												
2N1132	TO-5	50	35	2	100	30	30	90	150	10	1.5		1.3	150	45	60		50				63
							25		5	10												
2N2696	TO-18	25	25		25	10	20		300	2	0.25		1.1	50	20	100		50	170		1	63
							30	130	50	1	1.0		2.0	300								
2N2904	TO-5	60	40	5	20	50	20		500	10	0.4		1.3	150	8	200		50	100		2	63
							40	120	150	10												
							35		10	10	1.6		2.6	500								
							25		1	10												
							20		0.1	10												
2N2904A	TO-5	60	60	5	10	50	40		500	10	0.4		1.3	150	8	200		50	100		2	63
							40		150	10												
							40		10	10	1.6		2.6	500								
							40	120	1	10												
							40		0.1	10												
2N2905	TO-5	60	40	5	20	50	30		500	10	0.4		1.3	150	8	200		50	100		2	63
							100	300	150	10												
							75		10	10	1.6		2.6	500								
							50		1	10												
							35		0.1	10												
2N2905A	TO-5	60	60	5	10	50	50		500	10	0.4		1.3	150	8	200		50	100		2	63
							100	300	150	10												
							100		10	10	1.6		2.6	500								
							100		1	10												
							75		0.1	10												
2N2906	TO-18	60	40	5	20	50	20		500	10	0.4		1.3	150	8	200		50	100		2	63
							40	120	150	10												
							35		10	10	1.6		2.6	500								
							25		1	10												
							20		0.1	10												
2N2906A	TO-18	60	60	5	10	50	40		500	10	0.4		1.3	150	8	200		50	100		2	63
							40	120	150	10												
							40		10	10	1.6		2.6	500								
							40		1	10												
							40		0.1	10												
2N2907	TO-18	60	40	5	20	50	35		500	10	0.4		1.3	150	8	200		50	100		2	63
							100	300	150	10												
							75		10	10	1.6		2.6	500								
							50		1	10												
							35		0.1	10												

GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N2907A	TO-18	60	60	5	10	50	50		500	10	0.4		1.3	150	8	200		50	100		2	63
							100	300	150	10												
							100		10	10	1.6		2.6	500								
							100		1	10												
							75		0.1	10												
2N3072	TO-5	60	60	4	10*	30	15		300	2	0.25		1.2	50	10	130		50	100		3	63
							30	130	50	1	1.0		2.0	300								
2N3073	TO-18	60	60	4	10*	30	15		300	2	0.25		1.2	50	10	130		50	100		3	63
							30	130	50	1	1.0		2.0	300								
2N3120	TO-5	45	45	4	10*	30	15		300	2	0.25		1.2	50	10	130		50	100		4	63
							30	130	50	1	1.0		2.0	500								
2N3121	TO-18	45	45	4	10*	30	15		300	2	0.25		1.2	50	10	130		50	100		4	63
							30	130	50	1	1.0		2.0	500								
2N3133	TO-5	50	35	4	50	30	10		150	1	0.6		1.5	150	10	200		50	150		2	63
							40	120	150	10												
							25		1	10												
2N3134	TO-5	50	35	4	50	30	50		150	1	0.6		1.5	150	10	200		50	150		2	63
							100	300	150	10												
							50		1	10												
2N3135	TO-18	50	35	4	50	30	25		150	1	0.6		1.5	150	10	200		50	150		2	63
							40	120	150	10												
							10		1	10												
2N3136	TO-18	50	35	4	50	30	25		150	1	0.6		1.5	150	10	200		50	157		2	63
							100	300	150	10												
							50		1	10												
2N3502	TO-5	45	45	5	10	30	50		500	10	0.25		1.0	50	8	200		50	100	4	4/7	63
							100	300	150	10												
							140		10	10	0.4		1.3	150								
							135		1	10	1		2	300								
							120		0.1	10												
							80		0.01	10	1.6		2	500								

TEST CONDITIONS:

(1) I_C = 300 mA, V_{CC} = 10V, $I_B{}^1 = I_B{}^2$ = 30 mA. **(2)** I_C = 150 mA, V_{CC} = 6V, $I_B{}^1 = I_B{}^2$ = 15 mA. **(3)** I_C = 300 mA, V_{CC} = 15V, $I_B{}^1 = I_B{}^2$ = 30 mA. **(4)** I_C = 300 mA, V_{CC} = 30V, $I_B{}^1 = I_B{}^2$ = 30 mA. **(5)** I_C = 10 mA, V_{CC} = 3V, $I_B{}^1 = I_B{}^2$ = 1 mA. **(6)** I_C = 100 μA, V_{CE} = 5V, f = 100 Hz. **(7)** I_C = 30 μA, V_{CE} = 5V, f = 1 kHz. **(8)** I_C = 100 μA, V_{CE} = 5V, f = 1 kHz. **(9)** I_C = 250 μA, V_{CE} = 5V, f = 1 kHz. **(10)** I_C = 10 μA, V_{CE} = 5V, f = 1 kHz. **(11)** I_C = 50 mA, V_{CC} = 30V, $I_B{}^1 = I_B{}^2$ = 5 mA. **(12)** I_C = 150 mA, V_{CC} = 30V, $I_B{}^1 = I_B{}^2$ = 15 mA. **(13)** I_C = 50 mA, V_{CC} = 10V, $I_B{}^1 = I_B{}^2$ = 5 mA.

GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N3503	TO-5	60	60	5	10	50	50		500	10	0.25											
							100	300	150	10			1	50	8	200		50	100	4	4/7	63
							140		10	10	0.4		1.3	150								
							135		1	10	1		2	300								
							120		0.1	10												
							80		0.01	10	1.6		2	500								
2N3504	TO-18	45	45	5	10	30	50		500	10	0.25		1	50	8	200		50	100	4	4/7	63
							100	300	150	10												
							140		10	10	0.4		1.3	150								
							135		1	10												
							120		0.1	10	1.6		2	500								
							80		0.01	10												
2N3505	TO-18	60	60	5	10	50	100	300	150	10	0.25		1	50	8	200		50	100	4	4/7	63
							115	300	50	1												
							140		10	10	0.4		1.3	150								
							135		1	10	2		2	300								
							120		0.1	10	1.6		2	500								
2N3638	TO-92 (92)	Same as PN3638, see page 2-13 for explanation																				63
2N3638A	TO-92 (92)	Same as PN3638A, see page 2-13 for explanation																				63
2N3644	TO-92 (92)	Same as PN3644, see page 2-13 for explanation																				63
2N3645	TO-92 (92)	60	60	5			40		0.1	10					8	200		20				63
							80		1	10	0.4		1.3	150								
							100		10	10	1	0.8	2	300								
							100	300	150	10												
							20		300	2												
							80	240	50	1												
2N3702	TO-92 (94)	40	25	5	100	20	60	300	50	5	0.25			50	12	100		50				63
2N3703	TO-92 (94)	50	30	5	100	20	30	150	50	5	0.25			50	12	100		50				63
2N4142	TO-92 (92)	Same as PN4142, see page 2-13 for explanation																				63
2N4143	TO-92 (92)	Same as PN4143, see page 2-13 for explanation																				63
2N4290	TO-92 (94)	30	20	5	500	20	50	300	100	10	0.4		1.5	100	10	100		10				63
							40		10	10												
							20		0.1	10												

GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N4291	TO-92 (94)	40	30	6	200	30	100	300	100	10	0.4		1.5	100	10	100		10				63
							50		10	10												
							30		0.1	10												
2N4402	TO-92 (94)	40	40	5			20		500	2	0.4	0.7	0.95	150	10	150		20	255		4	63
							50	150	150	2												
							50		10	1	0.75		1.3	500								
							30		1	1												
2N4403	TO-92 (92)	40	40	5			20		500	2					10	200		20	255		4	63
							100	300	150	2	0.4	0.75	0.95	150								
							100		10	1												
							60		1	1	0.75		1.3	500								
							30		0.1	1												
2N4971	TO-92 (92)	Same as PN2906, see page 2-12 for explanation																				63
2N4972	TO-92 (92)	Same as PN2907, see page 2-12 for explanation																				63
2N5142	TO-92 (92)	Same as PN5142, see page 2-14 for explanation																				63
2N5143	TO-92 (92)	Same as PN5143, see page 2-14 for explanation																				63
2N5221	TO-92 (92)	15	15	3	100	10	30	600	50	10	0.5		1.1	150	15	100		20				63
							30		10	10												
2N5226	TO-92 (92)	25	25	4	300	15	30	600	50	10	0.8		1.0	100	20	50		20				63
							25		10	10												
2N5354	TO-92 (94)	25	25	4	100	25	40	120	50	1	0.25			50	8							63
2N5355	TO-92 (94)	25	25	4	100	25	100	300	50	1	0.25			50	8							63
2N5365	TO-92 (94)	40	40	4	100	40	20		300	5	0.25		1.1	50	8							63
							40	120	50	1												
							32		2	1	1.0		2.0	200								
2N5366	TO-92 (94)	40	40	4	100	40	40		300	5	0.25		1.1	50	8							63
							100	300	50	1												
							80		2	1	1.0		2.0	300								

TEST CONDITIONS:

(1) I_C = 300 mA, V_{CC} = 10V, $I_B^1 = I_B^2$ = 30 mA. **(2)** I_C = 150 mA, V_{CC} = 6V, $I_B^1 = I_B^2$ = 15 mA. **(3)** I_C = 300 mA, V_{CC} = 15V, $I_B^1 = I_B^2$ = 30 mA. **(4)** I_C = 300 mA, V_{CC} = 30V, $I_B^1 = I_B^2$ = 30 mA. **(5)** I_C = 10 mA, V_{CC} = 3V, $I_B^1 = I_B^2$ = 1 mA. **(6)** I_C = 100 μA, V_{CE} = 5V, f = 100 Hz. **(7)** I_C = 30 μA, V_{CE} = 5V, f = 1 kHz. **(8)** I_C = 100 μA, V_{CE} = 5V, f = 1 kHz. **(9)** I_C = 250 μA, V_{CE} = 5V, f = 1 kHz. **(10)** I_C = 10 μA, V_{CE} = 5V, f = 1 kHz. **(11)** I_C = 50 mA, V_{CC} = 30V, $I_B^1 = I_B^2$ = 5 mA. **(12)** I_C = 150 mA, V_{CC} = 30V, $I_B^1 = I_B^2$ = 15 mA. **(13)** I_C = 50 mA, V_{CC} = 10V, $I_B^1 = I_B^2$ = 5 mA.

GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N5447	TO-92 (97)	40	25	5			60	300	50	5	0.25			50	12	100		50				63
2N5817	TO-92 (97)	50	40	5	100	25	25 100	 200	500 2	2 2	0.75		1.2	500	15	100		50				63
MPS3638	TO-92 (92)	Same as PN3638, see page 2-13 for explanation																				63
MPS3638A	TO-92 (92)	Same as PN3638A, see page 2-13 for explanation																				63
MPS3644	TO-92 (92)	Same as PN3644, see page 2-13 for explanation																				63
MPS3645	TO-92 (92)	Same as PN3645, see page 2-13 for explanation																				63
MPS3702	TO-92 (92)	40	25	5	100	20	60	300	50	5	0.25			50	12	100		50				63
MPS3703	TO-92 (92)	50	30	5	100	20	30	150	50	5	0.25			50	12	100		50				63
MPS6533	TO-92 (92)	40	40	4	50	30	25 40 30	 120 	500 100 10	10 1 1	0.5		1.0	100	6							63
MPS6534	TO-92 (92)	40	40	4	50	30	50 90 60	 270 	500 100 10	10 1 1	0.3		1.0	100	6							63
MPS6535	TO-92 (92)	30	30	4	100	20	30		100	1	0.5		1.2	100	6							63
PN2906	TO-92 (92)	60	40	5	20	50	20 40 35 25 20	 120 	500 150 10 1 0.1	10 10 10 10 10	0.4 1.6		1.3 2.6	150 500	8	200		50	100		2	63
PN2906A	TO-92 (92)	60	60	5	10	50	40 40 40 40 40	 120 	500 150 10 1 0.1	10 10 10 10 10	0.4 1.6		1.3 2.6	150 500	8	200		50	100		2	63
PN2907	TO-92 (92)	60	40	5	20	50	30 100 75 50 35	 300 	500 150 10 1 0.1	10 10 10 10 10	0.4 1.6		1.3 2.6	150 500	8	200		50	100		2	63

GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
PN2907A	TO-92 (92)	60	60	5	20	50	50		500	10	0.4		1.3	150	8	200		50	100		2	63
							100	300	150	10												
							100		10	10	1.6		2.6	500								
							100		1	10												
							75		0.1	10												
PN3638	TO-92 (92)	25	25	4	35*	15	20		300	2	0.25		1.1	50	20	100		50	170		1	63
							20		50	1												
							30		10	10	1.0	0.8	2.0	300								
PN3638A	TO-92 (92)	25	25	4	25*	15	20		300	2	0.25		1.1	50	10	150		50	170		1	63
							100		50	1												
							100		10	10	1.0	0.8	2.0	300								
							80		1	10												
PN3644	TO-92 (92)	45	45	5	35*	30	20		300	2	0.25		1.0	50	8	200		20	100		4	63
							100	300	150	10												
							80	240	50	1	0.4		1.3	150								
							100		10	10												
							80		1	10	1.0	0.8	2.0	300								
							40		0.1	10												
PN3645	TO-92 (92)	60	60	5	35*	50	20		300	2	0.25		1.0	50	8	200		20	100		4	63
							100	300	150	10												
							80	240	50	1	0.4		1.3	150								
							100		10	10												
							80		1	10	1.0	0.8	2.0	300								
							40		0.1	10												
PN4142	TO-92 (92)	60	40	5			20		500	10	0.4		1.3	150	8	200		50	100		12	63
							20		150	1												
							40	120	150	10	1.6		2.6	500								
							35		10	10												
							25		1	10												
							20		0.1	10												
PN4143	TO-92 (92)	60	40	5			30		500	10	0.4		1.3	150	8	200		50	100		12	63
							50		150	1												
							100	300	150	10	1.6		2.6	500								
							75		10	10												
							50		1	10												
							35		0.1	10												

TEST CONDITIONS:

(1) I_C = 300 mA, V_{CC} = 10V, $I_B^1 = I_B^2$ = 30 mA. **(2)** I_C = 150 mA, V_{CC} = 6V, $I_B^1 = I_B^2$ = 15 mA. **(3)** I_C = 300 mA, V_{CC} = 15V, $I_B^1 = I_B^2$ = 30 mA. **(4)** I_C = 300 mA, V_{CC} = 30V, $I_B^1 = I_B^2$ = 30 mA. **(5)** I_C = 10 mA, V_{CC} = 3V, $I_B^1 = I_B^2$ = 1 mA. **(6)** I_C = 100 μA, V_{CE} = 5V, f = 100 Hz. **(7)** I_C = 30 μA, V_{CE} = 5V, f = 1 kHz. **(8)** I_C = 100 μA, V_{CE} = 5V, f = 1 kHz. **(9)** I_C = 250 μA, V_{CE} = 5V, f = 1 kHz. **(10)** I_C = 10 μA, V_{CE} = 5V, f = 1 kHz. **(11)** I_C = 50 mA, V_{CC} = 30V, $I_B^1 = I_B^2$ = 5 mA. **(12)** I_C = 150 mA, V_{CC} = 30V, $I_B^1 = I_B^2$ = 15 mA. **(13)** I_C = 50 mA, V_{CC} = 10V, $I_B^1 = I_B^2$ = 5 mA.

GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
PN5142	TO-92 (92)	20	20	4	50*	12	15		300	10	0.5		1.5	50	10	100		50	200		1	63
							30		50	1	0.2	0.8	2.5	300								
PN5143	TO-92 (92)	20	20	4	50*	12	15		300	10	0.5		1.5	50	10	100		50	200		1	63
							30		50	1	0.2	0.8	2.5	300								
TIS91	TO-92 (94)	40	40	5	100	20	100	300	50	2	0.25	0.6	1.0	50								63
TIS93	TO-92 (97)	40	40	5	100	20	100	300	50	2	0.25	0.6	1.0	50								63
TIS93	TO-92 (97)	40	40	5	100	20	100	300	50	2	0.25			50								63
TN2904A	TO-237 (91)	60	60	5	10	50	40		0.1	10	0.4		1.3	150	8	200		50	100		2	63
							40		1.0	10	1.6		2.6	500								
							40		10	10												
							40	120	150	10												
							40		500	10												
TN2905	TO-237 (91)	60	40	5	20	50	30		500	10	0.4		1.3	150	8	200		50	100		2	63
							100	300	150	10												
							75		10	10	1.6		2.6	500								
							50		1	10												
							35		0.1	10												
TN2905A	TO-237 (91)	60	60	5	10	50	50		500	10	0.4		1.3	150	8	200		50	100		2	63
							100	300	150	10												
							100		10	10	1.6		2.6	500								
							100		1	10												
							75		0.1	10												
2N3250	TO-18	50	40	5			15		50	1	0.25	0.6	0.9	10	6	250		10	225	6	5/6	66
							50	150	10	1												
							45		1	1												
							40		0.1	1	0.5		1.2	50								
2N3251	TO-18	50	40	5			30		50	1	0.25	0.6	0.9	10	6	300		20	250	6	5/6	66
							100	300	10	1												
							90		1	1												
							80		0.1	1	0.5		1.2	50								
2N3905	TO-92 (92)	40	40	5			15		100	1	0.25	0.65	0.85	10	4.5	200		10	260	5	5/8	66
							30		50	1												
							50	150	10	1	0.4		0.95	50								
							40		1	1												
							30		0.1	1												

GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N3906	TO-92 (92)	40	40	5			30		100	1	0.25	0.65	0.85	10	4.5	250		10	300	4	5/8	66
							60		50	1												
							100	300	10	1	0.4		0.95	50								
							80		1	1												
							60		0.1	1												
2N4121	TO-92 (92)	Same as PN4121, see page 2-16 for explanation																				66
2N4122	TO-92 (92)	Same as PN4122, see page 2-16 for explanation																				66
2N4125	TO-92 (92)	30	30	4	50	20	25		50	1	0.4		0.95	50	4.5	200		10		5	8	66
							50	150	2	1												
2N4126	TO-92 (92)	25	25	4	50	20	60		50	1	0.4		0.95	50	4.5	250		10		4	8	66
							120	360	2	1												
2N4916	TO-92 (92)	Same as PN4916, see page 2-16 for explanation																				66
2N4917	TO-92 (92)	Same as PN4917, see page 2-16 for explanation																				66
2N5138	TO-92 (92)	Same as PN5138, see page 2-16 for explanation																				66
2N5139	TO-92 (92)	Same as PN5139, see page 2-16 for explanation																				66
MPS3905	TO-92 (92)	40	40	5			30		0.1	1	0.25	0.65	0.85	10	4.5	200		10		5	8	66
							40		1	1												
							50	150	10	1												
							30		50	1												
							15		100	1	0.4		0.95	50								
MPS3906	TO-92 (92)	40	40	5			60		0.1	1	0.25	0.65	0.85	10	4.5	250		10		4	8	66
							80		1	1												
							100	300	10	1												
							60		50	1												
							30		100	1	0.4		0.95	50								
MPS6516	TO-92 (92)	40	40	4	50	30	30		100	10	0.5			50	4							66
							50	100	2	10												
MPS6517	TO-92 (92)	40	40	4	50	30	60		100	10	0.5			50	4							66
							90	180	2	10												

TEST CONDITIONS:

(1) I_C = 300 mA, V_{CC} = 10V, I_{B1} = I_{B2} = 30 mA. **(2)** I_C = 150 mA, V_{CC} = 6V, I_{B1} = I_{B2} = 15 mA. **(3)** I_C = 300 mA, V_{CC} = 15V, I_{B1} = I_{B2} = 30 mA. **(4)** I_C = 300 mA, V_{CC} = 30V, I_{B1} = I_{B2} = 30 mA. **(5)** I_C = 10 mA, V_{CC} = 3V, I_{B1} = I_{B2} = 1 mA. **(6)** I_C = 100 μA, V_{CE} = 5V, f = 100 Hz. **(7)** I_C = 30 μA, V_{CE} = 5V, f = 1 kHz. **(8)** I_C = 100 μA, V_{CE} = 5V, f = 1 kHz. **(9)** I_C = 250 μA, V_{CE} = 5V, f = 1 kHz. **(10)** I_C = 10 μA, V_{CE} = 5V, f = 1 kHz. **(11)** I_C = 50 mA, V_{CC} = 30V, I_{B1} = I_{B2} = 5 mA. **(12)** I_C = 150 mA, V_{CC} = 30V, I_{B1} = I_{B2} = 15 mA. **(13)** I_C = 50 mA, V_{CC} = 10V, I_{B1} = I_{B2} = 5 mA.

GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max @	V_{CB} (V)	h_{FE} Min	h_{FE} Max @	I_C (mA) &	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max &	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max @	I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max @	I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
MPS6518	TO-92		40	4	500	30	90		100	10	0.5			50	4							66
	(92)						150	300	2	10												
NS3905	TO-18	40	40	5			15		100	1	0.25	0.65	0.85	10	4.5	200		10	200	5	5/8	66
							30		50	1												
							50	150	10	1	0.4		0.95	50								
							40		1	1												
							30		0.1	1												
NS3906	TO-18	40	40	5			30		100	1	0.25	0.65	0.85	10	4.5	250		10	300	4	5/8	66
							60		50	1												
							100	300	10	1	0.4		0.95	50								
							80		1	1												
							60		0.1	1												
PN4121	TO-92	40	40	5	25*	30	15		50	1	0.13		0.75	1	4.5	400		10	150	4	11/8	66
	(92)						70	200	10	1	0.14	0.7	0.9	10								
							60		1	1	0.3		1.1	50								
							40		0.1	1												
PN4122	TO-92	40	40	5	25*	30	30		50	1	0.13		0.75	1	4.5	450		10	150	4	11/8	66
	(92)						150	300	10	1												
							150		1	1	0.14	0.7	0.9	10								
							100		0.1	1	0.3		1.1	50								
PN4916	TO-92	30	30	5	25*	15	15	200	50	1	0.13		0.75	1	4.5	400		10	150	4	13/8	66
	(92)						70		10	1	0.14	0.7	0.9	10								
							60		1	1	0.3	0.75	1.1	50								
							40		0.1	1												
PN4917	TO-92	30	30	5	25*	15	30		50	1	0.13		0.75	1	4.5	450		10	150	4	13/8	66
	(92)						150	300	10	1	0.14	0.7	0.9	10								
							150		1	1	0.3	0.75	1.1	50								
							100		0,1	1												
PN5138	TO-92	30	30	5	50	20	50		10	10	0.3		1.0	10	7	30		0.5				66
	(92)						50		1	10												
							50	800	0.1	10												
PN5139	TO-92	20	20	5	50*	15	15		50	10	0.2	0.7	1.0	10	5	300		10	200		13	66
	(92)						40		10	1												
							40		1	10												
							30		0.1	10	0.5	0.75	1.25	50								
ST3906	TO-92	40	40	5			60		0.1	1	0.25	0.65	0.85	10	4.5	250		10				66
	(92)						80		1	1	0.4		0.95	50								
							100	300	10	1												
							60		50	1												
							30		100	1												

GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N4354	TO-92 (92)	Same as PN4354, see below for explanation																				67
2N4355	TO-92 (92)	Same as PN4355, see below for explanation																				67
2N4356	TO-92 (92)	Same as PN4356, see page 2-18 for explanation																				67
2N5448	TO-92 (97)	50	30	5	100	20	30	150	50	5	0.25			50	12	100		50				67
MPSA55	TO-92 (92)		60	4	100	60	50 50		100 10	1 1	0.25			100		50		100				67
MPSA56	TO-92 (92)		80	4	100	80	50 50		100 10	1 1	0.25			100		50		100				67
MPS4354	TO-92 (92)	Same as PN4354, see below for explanation																				67
MPS4355	TO-92 (92)	Same as PN4355, see below for explanation																				67
MPS4356	TO-92 (92)	Same as PN4356, see page 2-18 for explanation																				67
MPS6562	TO-92 (92)			5	100	20	50 50 35	200	500 100 10	1 1 1	0.5			500	30	60		10				67
NS4234	TO-39		40		100 μA	40	40 30 20 10	 150	100 250 500 1A	1 1 1 1	0.6		1.5 1.0	1A 250	100	300		100				67
PN4354	TO-92 (92)	60	60	5	50	50	30 40 50 40 25	 500	500 100 10 1 0.1	10 10 10 10 10	0.15 0.5		0.9 1.1	150 500	30	100	500	50	400	3	14/15	67
PN4355	TO-92 (92)	60	60	5	50	50	75 75 100 75 60	 400	500 100 10 1 0.1	10 10 10 10 10	0.15 0.5		0.9 1.1	150 500	30	100	500	50	400	3	14/15	67

TEST CONDITIONS:

(1) I_C = 300 mA, V_{CC} = 10V, $I_B{}^1 = I_B{}^2$ = 30 mA. **(2)** I_C = 150 mA, V_{CC} = 6V, $I_B{}^1 = I_B{}^2$ = 15 mA. **(3)** I_C = 300 mA, V_{CC} = 15V, $I_B{}^1 = I_B{}^2$ = 30 mA. **(4)** I_C = 300 mA, V_{CC} = 30V, $I_B{}^1 = I_B{}^2$ = 30 mA. **(5)** I_C = 10 mA, V_{CC} = 3V, $I_B{}^1 = I_B{}^2$ = 1 mA. **(6)** I_C = 100 μA, V_{CE} = 5V, f = 100 Hz. **(7)** I_C = 30 μA, V_{CE} = 5V, f = 1 kHz. **(8)** I_C = 100 μA, V_{CE} = 5V, f = 1 kHz. **(9)** I_C = 250 μA, V_{CE} = 5V, f = 1 kHz. **(10)** I_C = 10 μA, V_{CE} = 5V, f = 1 kHz. **(11)** I_C = 50 mA, V_{CC} = 30V, $I_B{}^1 = I_B{}^2$ = 5 mA. **(12)** I_C = 150 mA, V_{CC} = 30V, $I_B{}^1 = I_B{}^2$ = 15 mA. **(13)** I_C = 50 mA, V_{CC} = 10V, $I_B{}^1 = I_B{}^2$ = 5 mA. **(14)** I_C = 500 mA, V_{CC} = 30V, $I_B{}^1 = I_B{}^2$ = 50 mA. **(15)** I_C = 100 μA, V_{CC} = 10V, f = 1 kHz.

GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max @	V_{CB} (V)	h_{FE} Min	h_{FE} Max @	I_C (mA) &	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max &	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max @	I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max @	I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
PN4356	TO-92 (92)	80	80	5	50	50	30		500	10	0.15		0.9	150	30	100	500	50	400	3	14/15	67
							40		100	10												
							50	250	10	10	0.5		1.1	500								
							40		1	10												
							25		0.1	10												
PN5447	TO-92 (92)	40	25	5	100	20	60	300	50	5	0.25			50	12	100		50				67
TN4036	TO-237 (91)	90	65	7	20	60	20		0.1	10	0.65		1.4	150	30	60	50					67
							40	140	150	10												
							20		500	10												
TN4037	TO-237 (91)	60	40	7	250	60	15		1	10	1.4			150	30	60	200	50				67
							50	250	150	10												
MPS6563	TO-92 (92)			5	100	20	50	200	350	1	0.5			350	30	60		10				68
							50		100	1												
							35		10	1												
2N6076	TO-92 (94)	25	25	5	100	25	100	500	10	10	0.25		0.8	10								71
2N5400	TO-92 (92)	130	120	5	100	100	40		50	5	0.2		1.0	10	6	100	400	10		8	9	74
							40	180	10	5												
							30		1	5	0.5		1.0	50								
2N5401	TO-92 (92)	160	150	5	50	120	50		50	5	0.2		1.0	10	6	100	300	10		8	9	74
							60	240	10	5												
							50		1	5	0.5		1.0	50								
MPSL51	TO-92 (92)	100	100	4	1 μA	50	40	250	50	5	0.25		1.2	10	8	60		10				74
											0.3		1.2	50								

TEST CONDITIONS:
(1) I_C = 300 mA, V_{CC} = 10V, $I_B{}^1 = I_B{}^2$ = 30 mA. **(2)** I_C = 150 mA, V_{CC} = 6V, $I_B{}^1 = I_B{}^2$ = 15 mA. **(3)** I_C = 300 mA, V_{CC} = 15V, $I_B{}^1 = I_B{}^2$ = 30 mA. **(4)** I_C = 300 mA, V_{CC} = 30V, $I_B{}^1 = I_B{}^2$ = 30 mA. **(5)** I_C = 10 mA, V_{CC} = 3V, $I_B{}^1 = I_B{}^2$ = 1 mA. **(6)** I_C = 100 μA, V_{CE} = 5V, f = 100 Hz. **(7)** I_C = 30 μA, V_{CE} = 5V, f = 1 kHz. **(8)** I_C = 100 μA, V_{CE} = 5V, f = 1 kHz. **(9)** I_C = 250 μA, V_{CE} = 5V, f = 1 kHz. **(10)** I_C = 10 μA, V_{CE} = 5V, f = 1 kHz. **(11)** I_C = 50 mA, V_{CC} = 30V, $I_B{}^1 = I_B{}^2$ = 5 mA. **(12)** I_C = 150 mA, V_{CC} = 30V, $I_B{}^1 = I_B{}^2$ = 15 mA. **(13)** I_C = 50 mA, V_{CC} = 10V, $I_B{}^1 = I_B{}^2$ = 5 mA. **(14)** I_C = 500 mA, V_{CC} = 30V, $I_B{}^1 = I_B{}^2$ = 50 mA. **(15)** I_C = 100 μA, V_{CC} = 10V, f = 1 kHz.

MEDIUM POWER

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N4030	TO-39	60	60	5	50	50	15 25 40 30	 120	1A 500 100 0.1	5 5 5 5	1.0 0.5 0.15		 0.9	1A 500 150	20	100	400	50	400		3	67
2N4031	TO-39	80	80	5	50	60	10 25 40 30	 120 	1A 500 100 0.1	5 5 5 5	0.5 0.15		 0.9	500 150	20	100	400	50	400		3	67
2N4032	TO-39	60	60	5	50	50	40 70 100 75	 300 	1A 500 100 0.1	5 5 5 5	1.0 0.5 0.15		 0.9	1A 500 150	20	150	500	50	400		3	67
2N4033	TO-39	80	80	5	50	60	25 70 100 75	 300 	1A 500 100 0.1	5 5 5 5	0.5 0.15		 0.9	500 150	20	150	500	50	400		3	67
2N4036	TO-39	90	65	7	20	60	20 40 20	 140 	500 150 0.1	10 10 10	0.6		1.4	150	30	60		50	700		4	67
2N4037	TO-39	60	40	7	250	60	50 15	250 	150 1	10 10	1.4			150	30	60		50				67
2N4314	TO-39	90	65		250	60	50 15	250 	150 1	10 10	1.4			150	30	60		50				67
40319	TO-39		40		250	15	35	200	50	4	1.4			150								67
TN4030	TO-237 (91)	60	60	5	50	50	30 40 25 15	 120 	0.1 100 500 1A	5 5 5 5	0.5 0.15 1.0		 0.9 	500 150 1A	20	100	400	50				67
TN4033	TO-237 (91)	80	80	5	50	60	75 100 70 25	 300 	0.1 100 500 1A	5 5 5 5	0.15 0.5		0.9 	150 500	20	150	500	50				67
TN4314	TO-237 (91)	90	65		250	60	15 50	 250	1 150	10 10	1.4			150		60		50				67
TN3244	TO-237 (91)	40	40	5	50	30	60 50 25	 150 	150 500 750	1 1 5	0.3 0.5 1.0	 0.75 	1.1 1.5 2.0	150 500 750	25	175		50				70

TEST CONDITIONS:
(1) I_C = 50 mA, V_{CC} = 100V, $I_{B1} = I_{B2}$ = 5 mA. **(2)** I_C = 500 μA, V_{CE} = 10V, f = 1 kHz. **(3)** I_C = 500 mA, V_{CC} = 30V, $I_{B1} = I_{B2}$ = 50 mA. **(4)** I_C = 150 mA, V_{CC} = 30V, $I_{B1} = I_{B2}$ = 15 mA. **(5)** I_C = 100 μA, V_{CC} = 10V, f = 1 kHz. **(6)** I_C = 500 mA, V_{CC} = 30V, $I_{B1} = I_{B2}$ = 50 mA.

MEDIUM POWER (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
TN3245	TO-237 (91)	50	50	5	50	50	35 30 20	 90 	150 500 1A	1 1 5	0.35 0.6 1.2	 0.75 	1.1 1.5 2.0	150 500 1A	25	150		50				70
TN3467	TO-237 (91)	40	40	5	100	30	40 40 40	 120 	150 500 1A	1 1 5	0.3 0.5 1.0	 0.8 	1.0 1.2 1.6	150 500 1A	25	175		50				70
TN5022	TO-237 (91)	50	50	5			15 25 25	 100 	100 500 1A	1 1 5	0.2 0.4 0.8	 0.8 	1.0 1.4 1.75	100 500 1A	25	170		50	90		6	70
TN5023	TO-237 (91)	30	30	5			30 40 40	 100 	100 500 1A	1 1 5	0.17 0.35 0.7	 0.8 	1.0 1.4 1.75	100 500 1A		200		50	90		6	70
NSE872	TO-202 (51)	300	300		100	200	50		25	20						60		10				76
2N6726	TO-237 (91)	40	30	5	100	40	55 60 50	 200	10 100 1A	1 1 1	0.5			1A		50		50				77
2N6727	TO-237 (91)	50	40	5	100	50	55 60 50	 250	10 100 1A	1 1 1	0.5			1A		50	500	50				77
92PU51	TO-237 (91)		30		100	40	50 60 55		1A 100 10	1 1 1	0.5			1A	30	50		50				77
92PU51A	TO-237 (91)		40		100	50	50 60 55		1A 100 10	1 1 1	0.5			1A	30	50		50				77
NSD202	TO-202 (55)	60	45	5	100	60	25 40 50 40	 150 	1A 500 100 10	5 5 5 5	0.2 0.4		0.9 1.2	100 500	30	60		50				77
NSD203	TO-202 (55)	60	45	5	100	60	30 50 120 50	 360 	1A 500 100 10	5 5 5 5	0.2 0.4		0.9 1.2	100 500	30	60		50				77
NSDU51	TO-202 (55)	40	30	5	100	30	50 60 55		1A 100 10	1 1 1	0.7			1A	30	50		50				77
NSDU51A	TO-202 (55)	50	40	5	100	40	50 60 55		1A 100 10	1 1 1	0.7			1A	30	50		50				77

MEDIUM POWER (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
NSDU52	TO-202 (55)	60	40	5	100	40	30		500	10	0.4		1.3	150	20	150		20				77
							50	300	150	10												
							50		10	10												
NSE170	TO-202 (56)		40		100	60	12		1.5A	1	0.9		1.5	1.5A		50		100				77
							30		500	1												
							50	250	100	1	0.3			500								
2N6554	TO-202 (55)	60	60	5	100	40	25		500	1	1.0			1A	18	75	250	100				78
							60		250	1												
							80	300	50	1												
							60		10	1	0.5			250								
2N6555	TO-202 (55)	60	60	5	100	60	25		500	1	1.0			1A	18	75	250	100				78
							60		250	1												
							80	300	50	1												
							60		10	1	0.5			250								
2N6556	TO-202 (55)	100	100	5	100	80	25		500	1	1.0			1A	18	75	250	100				78
							60		250	1												
							80	300	50	1												
							60		10	1	0.5			250								
2N6708	TO-237 (90)	60	45	5	100	60	40		50	2	1.0			1A		50		50				78
							40	250	250	2												
							25		500	2	0.5			500								
2N6709	TO-237 (90)	80	60	5	100	80	40		50	2	1.0			1A		50		50				78
							40	250	250	2												
							25		500	2	0.5			500								
2N6710	TO-237 (90)	100	80	5	100	100	40		50	2	1.0			1A		50		50				78
							40	250	250	2												
							25		500	2	0.5			500								
92PE77A	TO-237 (90)		45		100	60	25		500	2	0.5			500	30	50		200				78
							40		250	2												
							40		50	2	1.0			1A								
92PE77B	TO-237 (90)		60		100	80	25		500	2	0.5			500	30	50		200				78
							40		250	2												
							40		50	2	1.0			1A								
92PE77C	TO-232 (90)		80		100	100	25		500	2	0.5			500	30	50		200				78
							40		250	2												
							40		50	2	1.0			1A								

TEST CONDITIONS:
(1) I_C = 50 mA, V_{CC} = 100V, $I_{B1} = I_{B2}$ = 5 mA. **(2)** I_C = 500 µA, V_{CE} = 10V, f = 1 kHz. **(3)** I_C = 500 mA, V_{CC} = 30V, $I_{B1} = I_{B2}$ = 50 mA. **(4)** I_C = 150 mA, V_{CC} = 30V, $I_{B1} = I_{B2}$ = 15 mA. **(5)** I_C = 100 µA, V_{CC} = 10V, f = 1 kHz. **(6)** I_C = 500 mA, V_{CC} = 30V, $I_{B1} = I_{B2}$ = 50 mA.

MEDIUM POWER (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
D41D1	TO-202 (55)		30		100*	45	10 50	 150	1A 100	2 2	0.5		1.5	500								78
D41D2	TO-202 (55)		30		100*	45	20 120	 300	1A 100	2 2	0.5		1.5	500								78
D41D4	TO-202 (55)		45		100*	60	10 50	 150	1A 100	2 2	0.5		1.5	500								78
D41D5	TO-202 (55)		45		100*	60	20 120	 360	1A 100	2 2	0.5		1.5	500								78
D41D7	TO-202 (55)		60		100*	75	10 50	 150	1A 100	2 2	1.0		1.5	500								78
D41D8	TO-202 (55)		60		100*	75	20 120	 360	1A 100	2 2	1.0		1.5	500								78
D41D10	TO-202 (55)		75		100*	90	10 50	 150	1A 100	2 2	1.0		1.5	500								78
D41D11	TO-202 (55)		75		100*	90	20 120	 360	1A 100	2 2	1.0		1.5	500								78
D41D13	TO-202 (55)		75		100*	90	50	150	100	2	1.0		1.5	500								78
D41D14	TO-202 (55)		75		100*	90	120	360	100	2	1.0		1.5	500								78
D41E1	TO-202 (55)		30		100*	40	10 50		1A 100	2 2	1.0		1.3	1A								78
D41E5	TO-202 (55)		60		100*	70	10 50		1A 100	2 2	1.0		1.3	1A								78
D41E7	TO-202 (55)		80		100*	90	10 50		1A 100	2 2	1.0		1.3	1A								78
D43C7	TO-202 (55)		60		1 μA*	60	10 25		1A 200	1 1	0.5		1.3	1A	30							78
D43C8	TO-202 (55)		60		1 μA*	60	20 40	 120	1A 200	1 1	0.5		1.3	1A	30							78
D43C9	TO-202 (55)		60		1 μA*	60	20 40		2A 200	1 1	0.5		1.3	1A	30							78
D43C10	TO-202 (55)		80		10 μA*	90	10 25		1A 200	1 1	0.5		1.3	1A	100							78
D43C11	TO-202 (55)		80		10 μA*	90	20 40	 120	1A 200	1 1	0.5		1.3	1A	100							78
D43C12	TO-202 (55)		80		10 μA*	90	20 40	 120	2A 200	1 1	0.5		1.3	1A	100							78

MEDIUM POWER (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max @	V_{CB} (V)	h_{FE} Min	h_{FE} Max @	I_C (mA) &	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max &	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max @	I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max @	I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
NSD6180	TO-202 (55)		75		500	80	10		1A	2	0.5		1.2	500	30	50		50				78
							40	250	500	2												
							30		50	2												
NSD6181	TO-202 (55)		50		500	60	10		1A	2	0.5		1.2	500	30	50		50				78
							40	250	500	2												
							30		50	2												
NSDU55	TO-202 (55)	60	60	4	100	60	20		500	1	0.35			250	30	50		200				78
							50		250	1												
							80		50	1												
NSE171	TO-202 (56)		60		100	80	12		1.5A	1	0.9		1.5	1.5A		50		100				78
							30		500	1												
							50	250	100	1	0.3			500								
TN4234	TO-237 (91)		40		0.1 mA	40	40		100	1			1.5	1A	100							78
							30	150	250	1												
							20		500	1												
							10		1A	1												
TN4235	TO-237 (91)		60		0.1 mA	60	40		100	1			1.5	1A	100							78
							30	150	250	1												
							20		500	1												
							10		1A	1												
TN4236	TO-237 (91)		80		0.1 mA	80	40		100	1			1.5	1A	100							78
							30	150	250	1												
							20		500	1												
							10		1A	1												
2N6728	TO-237 (91)	60	60	5	100	40	80		50	1	0.35			250		50		50				79
							50	250	250	1												
							20		500	1												
2N6729	TO-237 (91)	80	80	5	100	60	80		50	1	0.35			250		50		50				79
							50	250	250	1												
							20		500	1												
2N6730	TO-237 (91)	100	100	5	100	80	80		50	1	0.35			250		50		50				79
							50	250	250	1												
							20		500	1												
2N6732	TO-237 (91)	100	80	5	100	80	100		10	2	0.35			350		50		50				79
							100	300	350	2												

TEST CONDITIONS:
(1) I_C = 50 mA, V_{CC} = 100V, $I_B{}^1 = I_B{}^2$ = 5 mA. **(2)** I_C = 500 μA, V_{CE} = 10V, f = 1 kHz. **(3)** I_C = 500 mA, V_{CC} = 30V, $I_B{}^1 = I_B{}^2$ = 50 mA. **(4)** I_C = 150 mA, V_{CC} = 30V, $I_B{}^1 = I_B{}^2$ = 15 mA. **(5)** I_C = 100 μA, V_{CC} = 10V, f = 1 kHz. **(6)** I_C = 500 mA, V_{CC} = 30V, $I_B{}^1 = I_B{}^2$ = 50 mA.

MEDIUM POWER (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
92PU55	TO-237 (91)		60		100	40	20		500	1	0.35			250	30	50		200				79
							50		250	1												
							80		50	1												
92PU56	TO-237 (91)		80		100	60	20		500	1	0.35			250	30	50		200				79
							50		250	1												
							80		50	1												
92PU57	TO-237 (91)		100		100	80	20		500	1	0.35			250	30	50		200				79
							50		250	1												
							80		50	1												
92PU200	TO-237 (91)	100	80		100	80	100	300	350	2	0.35			350	20	500		100				79
							100		10	2												
NSD204	TO-202 (55)	100	80	7	100	100	10		1A	5	0.2		0.9	100	30	60		50				79
							50	150	100	5												
							20		10	5	0.5		1.2	500								
NSD205	TO-202 (55)	100	80	7	100	100	10		1A	5	0.2		0.9	100	30	60		50				79
							120	360	100	5												
							20		10	5	0.5		1.2	500								
NSD206	TO-202 (55)	140	100	7	100	140	25		500	5	0.2		0.9	100	30	60		50				79
							50	150	100	5												
							20		10	5	0.5		1.2	500								
NSDU56	TO-202 (55)	80	80	4	100	80	20		500	1	0.35			250	30	50		200				79
							50		250	1												
							80		50	1												
NSDU57	TO-202 (55)	100	100	4	100	100	20		500	1	0.35			250	30	50		200				79
							50		250	1												
							80		50	1												

TEST CONDITIONS:

(1) I_C = 50 mA, V_{CC} = 100V, $I_{B1} = I_{B2}$ = 5 mA. **(2)** I_C = 500 μA, V_{CE} = 10V, f = 1 kHz. **(3)** I_C = 500 mA, V_{CC} = 30V, $I_{B1} = I_{B2}$ = 50 mA. **(4)** I_C = 150 mA, V_{CC} = 30V, $I_{B1} = I_{B2}$ = 15 mA. **(5)** I_C = 100 μA, V_{CC} = 10V, f = 1 kHz. **(6)** I_C = 500 mA, V_{CC} = 30V, $I_{B1} = I_{B2}$ = 50 mA.

POWER

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CEX}† (μA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (A)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (A)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (A)	Process No.
MJE170	TO-126		40		0.1	60	12		1.5	1	1.7		2.0	3	50	50		0.1	77
							30		0.5	1	0.9		1.5	1.5					
							50	250	0.1	1	0.3			0.5					
MJE710	TO-126		40		100†	40	8		1	1	1.0		1.3	1.5					77
							20		0.5	1	0.4			0.5					
							40		0.15	1	0.15			0.15					
MJE171	TO-126		60		0.1	80	12		1.5	1	1.7		2.0	3	50	50		0.1	78
							30		0.5	1	0.9		1.5	1.5					
							50	250	0.1	1	0.3			0.5					
MJE711	TO-126		60		100†	80	8		1	1	1.0		1.3	1.5					78
							20		0.5	1	0.4			0.5					
							40		0.15	1	0.15			0.15					
MJE172	TO-126		80		0.1	100	12		1.5	1	1.7		2.0	3	50	50		0.1	79
							30		0.5	1	0.9		1.5	1.5					
							50	250	0.1	1	0.3			0.5					
MJE712	TO-126		80		100†	80	8		1	1	1.0		1.3	1.5					79
							20		0.5	1	0.4			0.5					
							40		0.15	1	0.15			0.15					
2N6489	TO-220		40		500†	45	5		15	4	1.3			5		5		1	5A
							20	150	5	4	3.5			15					
2N6490	TO-220		60		500†	65	5		15	4	1.3			5		5		1	5A
							20	150	5	4	3.5			15					
2N6491	TO-220		80		500†	85	5		15	4	1.3			5		5		1	5A
							20	150	5	4	3.5			15					
MJE2901T	TO-220		60				25	100	3	2									5A
MJE2955T	TO-220		60		1 mA	70	20	70	4	4	1.1			4					5A
							5		10	4									
TIP42	TO-220		40		400*	40	15	75	3	4	1.5			6		3		0.5	5A
							30		0.3	4									
TIP42A	TO-220		60		400*	60	15	75	3	4	1.5			6		3		0.5	5A
							30		0.3	4									
TIP42B	TO-220		80		400*	80	15	75	3	4	1.5			6		3		0.5	5A
							30		0.3	4									
TIP42C	TO-220		100		400*	100	15	75	3	4	1.5			6		3		0.5	5A
							30		0.3	4									

POWER (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CEX}† (μA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (A)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (A)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (A)	Process No.
2N5193	TO-126		40		100	40	10 25	 100	4 1.5	2 2	0.6 1.2			1.5 4		2		1	5E
2N5194	TO-126		60		100	60	10 25	 100	4 1.5	2 2	0.6 1.2			1.5 4		2		1	5E
2N5195	TO-126		80		100	80	7 20	 80	4 1.5	2 2	0.6 1.2			1.5 4		2		1	5E
2N6107	TO-220		70		100†	75	5 30	 150	6.5 2	4 4	1.0 2.0			2 6.5	250	10		0.5	5E
2N6109	TO-220		50		100†	56	5 30	 150	6.5 2.5	4 4	1.0 2.0			2.5 6.5	250	10		0.5	5E
2N6110	TO-220 Lead Form + Clip		30		100†	37.5	5 30	 150	6.5 3	4 4	1.0 2.0			3 6.5	250	10		0.5	5E
2N6111	TO-220		30		100†	37.5	5 30	 150	6.5 3	4 4	1.0 2.0			3 6.5	250	10		0.5	5E
2N6124	TO-220		45		100	45	10 25	 100	4 1.5	2 2	0.6 1.4			1.5 4		2.5		1	5E
2N6125	TO-220		60		100	60	10 25	 100	4 1.5	2 2	0.6 1.4			1.5 4		2.5		1	5E
2N6126	TO-220		80		100	80	7 20	 80	4 1.5	2 2	0.6 1.4			1.5 4		2.5		1	5E
2N6132	TO-220		40		100	40	7 20	 100	7 2.5	4 4	1.4			7		2.5		1	5E
2N6133	TO-220		60		100	60	7 20	 100	7 2.5	4 4	1.4			7		2.5		1	5E
2N6134	TO-220		80		100	60	5 20	 100	7 2.5	4 4	2.0			7		2.5		1	5E
MJE371	TO-220		40				40		1	1									5E
2N4918	TO-126		40		100	40	10 20 40	100	1 0.5 0.05	1 1 1	0.6		1.3	1	100	3		0.25	5F
2N4919	TO-126		60		100	60	10 20 40	 100	1 0.5 0.05	1 1 1	0.6		1.3	1	100	3		0.25	5F
2N4920	TO-126		80		100	80	10 20 40	 100	1 0.5 0.05	1 1 1	0.6		1.3	1	100	3		0.25	5F

POWER (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CEX}† (μA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (A)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (A)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (A)	Process No.
2N6475	TO-220		100		100	100	15 2	150	1.5 4.0	4 2.5	1.2			1.5	250	10		0.5	5F
2N6476	TO-220		120		100	120	15 2	150	1.5 4.0	4 2.5	1.2			1.5	250	10		0.5	5F
MJE370	TO-220		30				25		0.2	1									5F
TIP30	TO-220		40		200*	40	15 40	75	1 0.2	4 4	0.7			1		3		0.2	5F
TIP30A	TO-220		60		200*	60	15 40	75	1 0.2	4 4	0.7			1		3		0.2	5F
TIP30B	TO-220		80		200*	80	15 40	75	1 0.2	4 4	0.7			1		3		0.2	5F
TIP30C	TO-220		100		200*	100	15 40	75	1 0.2	4 4	0.7			1		3		0.2	5F
TIP32	TO-220		40		200*	40	10 25	50	3 1	4 4	1.2			3		3		0.5	5F
TIP32A	TO-220		60		200*	60	10 25	50	3 1	4 4	1.2			3		3		0.5	5F
TIP32B	TO-220		80		200*	80	10 25	50	3 1	4 4	1.2			3		3		0.5	5F
TIP32C	TO-220		100		200*	100	10 25	50	3 1	4 4	1.2			3		3		0.5	5F
TIP62	TO-220		40		200*	40	15 40	100	0.5 0.05	4 4	0.7			0.5		3		0.05	5F
TIP62A	TO-220		60		200*	60	15 40	100	0.5 0.05	4 4	0.7			0.5		3		0.05	5F
TIP62B	TO-220		80		200*	80	15 40	100	0.5 0.05	4 4	0.7			0.5		3		0.05	5F
TIP62C	TO-220		100		200*	100	15 40	100	0.5 0.05	4 4	0.7			0.5		3		0.05	5F
D43C1	TO-202 (56)		30		1 μA	1	10 25		1A 200	1 1	0.5		1.3	1A	30				5P
D43C2	TO-202 (56)		30		1 μA	30	20 40	 120	1A 200	1 1	0.5		1.3	1A	30				5P
D43C3	TO-202 (56)		30		1 μA	30	20 40		1A 200	1 1	0.5		1.3	1A	30				5P

POWER (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CEX}† (µA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (A)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (A)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (A)	Process No.
D43C4	TO-202 (56)		45		1 µA	45	10		1A	1	0.5		1.3	1A	30				5P
							25		200	1									
D43C5	TO-202 (56)		45		1 µA	45	20		1A	1	0.5		1.3	1A	30				5P
							40	120	200	1									
D43C6	TO-202 (56)		45		1 µA	45	20		2A	1	0.5		1.3	1A	30				5P
							40		200	1									
D45C1	TO-220		30		10*	40	10		1	1	0.5		1.3	1	125	3		0.02	5P
							25		0.2	1									
D45C2	TO-220		30		10*	40	20		1	1	0.5		1.3	1	125	3		0.02	5P
							40	120	0.2	1									
D45C3	TO-220		30		10*	40	20		2	1	0.5		1.3	1	125	3		0.02	5P
							40		0.2	1									
D45C4	TO-220		45		10*	55	10		1	1	0.5		1.3	1	125	3		0.02	5P
							25		0.2	1									
D45C5	TO-220		45		10*	55	20		1	1	0.5		1.3	1	125	3		0.02	5P
							40	120	0.2	1									
D45C6	TO-220		45		10*	55	20		2	1	0.5		1.3	1	125	3		0.02	5P
							40		0.2	1									
D45C7	TO-220		60		10*	70	10		1	1	0.5		1.3	1	125	3		0.02	5P
							25		0.2	1									
D45C8	TO-220		60		10*	70	20		1	1	0.5		1.3	1	125	3		0.02	5P
							40	120	0.2	1									
D45C9	TO-220		60		10*	70	20		2	1	0.5		1.3	1	125	3		0.02	5P
							40		0.2	1									
D45C10	TO-220		80		10*	90	10		1	1	0.5		1.3	1	125	3		0.02	5P
D45C11	TO-220		80		10*	90	20		1	1	0.5		1.3	1	125	3		0.02	5P
							40	120	0.2	1									
D45C12	TO-220		80		10*	90	20		2	1	0.5		1.3	1	125	3		0.02	5P
							40		0.2	1									
MJE230	TO-126		40				40	200	0.2	1	0.3			0.5	70	50		0.1	5P
							20		2	1	0.8		1.8	2					
MJE231	TO-126		40				40	200	0.2	1	0.3			0.5	70	50		0.1	5P
							20		2	1	0.8		1.8	2					
MJE232	TO-126		40				25		0.2	1	0.3			0.5	70	50		0.1	5P
							10		1	1			1.8	2					
MJE233	TO-126		60				40	200	0.2	1	0.3			0.5	70	50		0.1	5P
							20		2	1	0.8		1.8	2					

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CEX}† (μA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (A)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (A)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (A)	Process No.
MJE234	TO-126		60				40	150	0.2	1	0.3			0.5	70	50		0.1	5P
							20		1	1	0.6			1					
													1.8	2					
MJE235	TO-126		60				25		0.2	1	0.3			0.5	70	50		0.1	5P
							10		1	1			1.8	2					
MJE250	TO-126						40	200	0.2	1	0.3			0.5	70	40		0.1	5P
							15		2	1	0.8		1.8	2					
MJE251	TO-126		80				40	120	0.2	1	0.3			0.5	70	40		0.1	5P
							20		1	1	0.6			1					
													1.8	2					
MJE252	TO-126		80				25		0.2	1	0.3			0.5	70	40		0.1	5P
							10		1	1			1.8	2					
MJE253	TO-126		100				40	120	0.2	1	0.3			0.5	70	40		0.1	5P
									1	1	0.8		1.8	2					
MJE254	TO-126		100				25		0.2	1	0.3			0.5	70	40		0.1	5P
							10		1	1			1.8	2					
D45H1	TO-220		30		10	30	20		4	1	1.0		1.5	8					5Q
							35		2	1									
D45H2	TO-220		30		10	30	40		4	1	1.0		1.5	8					5Q
							60		2	1									
D45H4	TO-220		45		10	45	20		4	1	1.0		1.5	8					5Q
							35		2	1									
D45H5	TO-220		45		10	45	40		4	1	1.0		1.5	8					5Q
							60		2	1									
D45H7	TO-220		60		10	60	20		4	1	1.0		1.5	8					5Q
							35		2	1									
D45H8	TO-220		60		10	60	40		4	1	1.0		1.5	8					5Q
							60		2	1									
D45H10	TO-220		80		10	80	20		4	1	1.0		1.5	8					5Q
							35		2	1									
D45H11	TO-220		80		10	80	40		4	1	1.0		1.5	8					5Q
							60		2	1									
MJE210	TO-126		25				70		0.5	1	0.3			0.5	120	65		0.1	5R
							45	180	2	1	0.75			2					
							10		5	2									

DARLINGTON

Type No.	Case Style	V_{CBO} (V) Min	V_{CES}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CEX}† (µA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (A)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (A)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (A)	Process No.
D41K1	TO-202		30*	13	0.5	30	10,000		0.2	5	1.5		2.5	1.5		100		0.02	61
	(55)						1000		1.5	5									
D41K2	TO-202		50*	13	0.5	50	10,000		0.2	5	1.5		2.5	1.5		100		0.02	61
	(55)						1000		1.5	5									
D41K3	TO-202		30*	13	0.5	30	10,000		0.2	5	1.5		2.5	1		100		0.02	61
	(55)						1000		1.5	5									
D41K4	TO-202		50*	13	0.5	50	10,000		0.2	5	1.5		2.5	1		100		0.02	61
	(55)						1000		1.5	5									
MPSA62	TO-92		20*		0.1	15	20,000		10	5	1.0			10				0.01	61
	(92)																		
MPSA63	TO-92		30*		0.1	30	10,000		100	5	1.5			100		125		0.01	61
	(92)						5000		10	5									
MPSA64	TO-92		30*		0.1	30	20,000		100	5	1.5			100		125		0.01	61
	(92)						10,000		10	5									
MPSA65	TO-92		30*		0.1	30	50,000		0.01	5	1.5					100		0.01	61
	(92)						20,000		0.1	5									
MPSA66	TO-92		30*		0.1	30	75,000		0.01	5	1.5					100		0.01	61
	(92)						40,000		0.1	5									
NSDU95	TO-202	50		10			25,000		0.2	5	1.5			1		50		0.02	61
	(55)						15,000		0.5	5									
							4000		1	5									
NSDU95A	TO-202	60		10			25,000		0.2	5	1.5			1		50		0.02	61
	(55)						15,000		0.5	5									
							4000		1	5									
2N6034	TO-126		40		500	40	100		4	3	2.0			2	200	25		0.75	5J
							750	15,000	2	3									
							500		0.05	3	3.0		4.0	4					
2N6035	TO-126		60		500	60	100		4	3	2.0			2	200	25		0.75	5J
							750	15,000	2	3									
							500		0.5	3	3.0		4.0	4					
2N6036	TO-126		80		500	80	100		4	3	2.0			2	200	25		0.75	5J
2N6040	TO-220		60		500†	60	1000	20,000	4	4	2.0			4	300				5J
							100		8	4									
2N6041	TO-220		80		500†	80	1000	20,000	4	4	2.0			4	300				5J
							100		8	4									
MJE700	TO-126		60		200	60	750		1.5	3	2.5			1.5		1		1.5	5J
MJE701	TO-126		60		200	60	750	2	3	2.8				2		1		1.5	5J
MJE702	TO-126		80		200	80	750		1.5	3	2.5			1.5		1		1.5	5J
MJE703	TO-126		80		200	80	750		2	3	2.8			2		1		1.5	5J

DARLINGTON (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CES}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CEX}† (μA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (A)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (A)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (A)	Process No.
TIP115	TO-220		60		1 mA	60	500		2	4	2.5			2					5J
							1000		1	4									
TIP116	TO-220		80		1 mA	80	500		2	4	2.5			2					5J
							1000		1	4									
TIP117	TO-220		100		1 mA	100	500		2	4	2.5			2					5J
							1000		1	4									
TIP125	TO-220		60		200	60	1000		3	3	4.0			5					5J
							1000		0.5	3	2.0			3					
TIP126	TO-220		80		200	80	1000		3	3	4.0			5					5J
							1000		0.5	3	2.0			3					
TIP127	TO-220		100		200	100	1000		3	3	4.0			5					5J
							1000		0.5	3	2.0			3					
2N6042	TO-220		100		500†	100	1000	20,000	4	4	2.0			4	300				5K
							100		8	4									
SE9400	TO-220		60				750		1	3	2.0			4					5K
							1000		4	3									
							100		7.5	3	2.5			7.5		1		4	
SE9401	TO-220		80				750		1	3	2.0			4		1		4	5K
							1000		4	3									
							100		7.5	3	2.5			7.5					
SE9402	TO-220		100				750		1	3	2.0			4		1		4	5K
							1000		4	3									
							100		7.5	3	2.5			7.5					
TIP105	TO-220		60				1000	20,000	3	4	2.0			3.0					5K
							200		8	4	2.5			8.0					
TIP106	TO-220		80				1000	20,000	3	4	2.0			3					5K
							200		8	4	2.5			8					
TIP107	TO-220		100				1000	20,000	3	4	2.0			3					5K
							200		8	4	2.5			8					
TIP135	TO-220		60		200	60	1000	15,000	4	4	3.0			6	200				5K
							500		1	4	2.0			4					
TIP136	TO-220		80		200	80	1000	15,000	4	4	3.0			6	200				5K
							500		1	4	2.0			4					
TIP137	TO-220		100		200	100	1000	15,000	4	4	3.0			6	200				5K
							500		1	4	2.0			4					

Section 3

Junction Field Effect Transistors

3

N-Channel JFETs

SWITCHES/CHOPPERS

Type No.	Case Style	BV_{GSS} BV_{GDO} (V) Min	@ I_G (µA)	I_{GSS} * I_{DGO} (nA) Max	@ V_{DG} (V)	$I_{D(off)}$ (nA) Max	@ V_{DS} (V)	V_{GS} (V)	V_P (V) Min	V_P (V) Max	@ V_{DS} (V)	I_D (nA)	I_{DSS} (mA) Min	I_{DSS} (mA) Max	@ V_{DS} (V)	$r_{ds(on)}$ (Ω) Max	@ I_D (mA)	C_{iss} (pF) Max	@ V_{DS} (V)	V_{GS} (V)	C_{rss} (pF) Max	@ V_{DS} (V)	V_{GS} (V)	t_{on} (ns) Max	t_{off} (ns) Max	Process No.	Pkg. No.
2N3824	TO-72	50	1	0.1	30	0.1	15	−8		8	15	0.1				250		6	15	0	3	0	−8			55	25
2N3966	TO-72	30	1	1	20	0.1	10	−7	4	6	10	10	2		20	220		6	20	0	1.5	0	−7			50	25
2N3970	TO-18	40	1	0.25*	20	0.25	20	−12	4	10	20	1	50	150	20	30	1	25	20	0	6	0	−12	20	30	51	02
2N3971	TO-18	40	1	0.25*	20	0.25	20	−12	2	5	20	1	25	75	20	60	1	25	20	0	6	0	−12	t30	60	51	02
2N3972	TO-18	40	1	0.25*	20	0.25	20	−12	0.5	3	20	1	5	30	20	100	1	25	20	0	6	0	−12	80	100	51	02
2N4091	TO-18	40	1	0.2*	20	0.2	20	−12	5	10	20	1	30		20	30	1	16	20	0	5	0	−20	25	40	51	02
2N4092	TO-18	40	1	0.2*	20	0.2	20	−8	2	7	20	1	15		20	50	1	16	20	0	5	0	−20	35	60	51	02
2N4093	TO-18	40	1	0.2*	20	0.2	20	−6	1	5	20	1	8		20	80	1	16	20	0	5	0	−20	60	80	51	02
2N4391	TO-18	40	1	0.1	20	0.1	20	−12	4	10	20	1	50	150	20	30	1	14	20	0	3.5	0	−12	20	35	51	02
2N4392	TO-18	40	1	0.1	20	0.1	20	−7	2	5	20	1	25	75	20	60	1	14	20	0	3.5	0	−7	20	55	51	02
2N4393	TO-18	40	1	0.1	20	0.1	20	−5	0.5	3	20	1	5	30	20	100	1	14	20	0	3.5	0	−5	20	80	51	02
2N4856	TO-18	40	1	0.25	20	0.25	15	−10	4	10	15	0.5	50		15	25		18	0	−10	8	0	−10	9	25	51	02
2N4856A	TO-18	40	1	0.25	20	0.25	15	−10	4	10	15	0.5	50		15	25		10	0	−10	4	0	−10	8	20	51	02
2N4857	TO-18	40	1	0.25	20	0.25	15	−10	2	6	15	0.5	20	100	15	40		18	0	−10	8	0	−10	10	50	51	02
2N4857A	TO-18	40	1	0.25	20	0.25	15	−10	2	6	15	0.5	20	100	15	40		10	0	−10	3.5	0	−10	10	40	51	02
2N4858	TO-18	40	1	0.25	20	0.25	15	−10	0.8	4	15	0.5	8	80	15	60		18	0	−10	8	0	−10	20	100	51	02
2N4858A	TO-18	40	1	0.25	20	0.25	15	−10	0.8	4	15	0.5	8	80	15	60		10	0	−10	3.5	0	−10	16	80	51	02
2N4859	TO-18	30	1	0.25	15	0.25	15	−10	4	10	15	0.5	50		15	25		18	0	−10	8	0	−10	9	25	51	02
2N4859A	TO-18	30	1	0.25	15	0.25	15	−10	4	10	15	0.5	50		15	25		10	0	−10	4	0	−10	8	20	51	02
2N4860	TO-18	30	1	0.25	15	0.25	15	−10	2	6	15	0.5	20	100	15	40		18	0	−10	8	0	−10	10	50	51	02
2N4860A	TO-18	30	1	0.25	15	0.25	15	−10	2	6	15	0.5	20	100	15	40		10	0	−10	3.5	0	−10	10	40	51	02
2N4861	TO-18	30	1	0.25	15	0.25	15	−10	0.8	4	15	0.5	8	80	15	60		18	0	−10	8	0	−10	20	100	51	02
2N4861A	TO-18	30	1	0.25	15	0.25	15	−10	0.8	4	15	0.5	8	80	15	60		10	0	−10	3.5	0	−10	16	80	51	02
2N5432	TO-52	25	1	0.2	15	0.2	5	−10	4	10	5	3	150		15	5	10	30	0	−10	15	0	−10	5	36	58	07
2N5433	TO-52	25	1	0.2	15	0.2	5	−10	3	9	5	3	100		15	7	10	30	0	−10	15	0	−10	5	36	58	07
2N5434	TO-52	25	1	0.2	15	0.2	5	−10	1	4	5	3	30		15	10	10	30	0	−10	15	0	−10	5	36	58	07
2N5555	TO-92	25	10	1	15	10	12	−10		(10)			15		15	150		5	15	0	1.2	0	−10	10	25	50	92
2N5638	TO-92	30	10	1	15	1	15	−12		(12)			50		20	30	1	10	0	−12	4	0	−12			51	92
2N5639	TO-92	30	10	1	15	1	15	−8		(8)			25		20	60	1	10	0	−12	4	0	−8			51	92
2N5640	TO-92	30	10	1	15	1	15	−6		(6)			5		20	100	1	10	0	−12	4	0	−6			51	92

SWITCHES/CHOPPERS (Continued)

N-Channel JFETs

Type No.	Case Style	BV_{GSS} BV_{GDO} (V) Min	@ I_G (μA)	I_{GSS} * I_{DGO} (nA) Max	@ V_{DG} (V)	$I_{D(off)}$ (nA) Max	@ V_{DS} (V)	V_{GS} (V)	V_P (V) Min	V_P (V) Max	@ V_{DS} (V)	I_D (nA)	I_{DSS} (mA) Min	I_{DSS} (mA) Max	@ V_{DS} (V)	$r_{ds(on)}$ (Ω) Max	@ I_D (mA)	C_{iss} (pF) Max	@ V_{DS} (V)	V_{GS} (V)	C_{rss} (pF) Max	@ V_{DS} (V)	V_{GS} (V)	t_{on} (ns) Max	t_{off} (ns) Max	Process No.	Pkg. No.
2N5653	TO-92	30	10	1	15	1	15	−12		(12)			40		20	50	1	10	0	−12	3.5	0	−12	9	15	51	92
2N5654	TO-92	25	10	1	15	10	15	−8		(8)			15		20	100	1	10	0	−12	3.5	0	−8	14	30	51	92
J108	TO-92	25	1	3	15	3	5	−10	3	10	5	1000	80		15	8	10	t30	0	−10	t15	0	−10	t5	t36	58	92
J109	TO-92	25	1	3	15	3	5	−10	2	6	5	1000	40		15	12	10	t30	0	−10	t15	0	−10	t5	t36	58	92
J110	TO-92	25	1	3	15	3	5	−10	0.5	4	5	1000	10		15	18	10	t30	0	−10	t15	0	−10	t5	t36	58	92
J111	TO-92	35	1	1	15	1	5	−10	3	10	5	1000	20		15	30	1	t10	0	−10	t5	0	−10	t13	t35	51	92
J112	TO-92	35	1	1	15	1	5	−10	1	5	5	1000	5		15	50	1	t10	0	−10	t5	0	−10	t13	t35	51	92
J113	TO-92	35	1	1	15	1	5	−10	0.5	3	5	1000	2		15	100	1	t10	0	−10	t5	0	−10	t13	t35	51	92
J114	TO-92	25	1	1	15	1	5	−10	3	10	5	1000	15		15	150	1	t4	0	−10	t2	0	−10	t6	t20	90	92
PN4091	TO-92	40	1	0.2*	20	0.2	20	−12	5	10	20	1	30		20	30		16	20	0	5	20	0	25	40	51	92
PN4092	TO-92	40	1	0.2*	20	0.2	20	−8	2	7	20	1	15		20	50		16	20	0	5	20	0	35	60	51	92
PN4093	TO-92	40	1	0.2*	20	0.2	20	−6	1	5	20	1	8		20	80		16	20	0	5	20	0	60	80	51	92
PN4391	TO-92	40	1	0.1	20	0.1	20	−12	4	10	20	1	50	150	20	30		14	20	0	3.5	0	−12	20	35	51	92
PN4392	TO-92	40	1	0.1	20	0.1	20	−7	2	5	20	1	25	75	20	60		14	20	0	3.5	0	−7	40	80	51	92
PN4393	TO-92	40	1	0.1	20	0.1	20	−5	0.5	3	20	1	5	30	20	100		14	20	0	3.5	0	−5	55	130	51	92
PN4856	TO-92	40	1	0.25	20	0.25	15	−10	4	10	15	0.5	50		15	25		18	0	−10	8	0	−10	9	25	51	92
PN4857	TO-92	40	1	0.25	20	0.25	15	−10	2	6	15	0.5	20	100	15	40		18	0	−10	8	0	−10	10	50	51	92
PN4858	TO-92	40	1	0.25	20	0.25	15	−10	0.8	4	15	0.5	8	80	15	60		18	0	−10	8	0	−10	20	100	51	92
PN4859	TO-92	30	1	0.25	15	0.25	15	−10	4	10	15	0.5	50		15	25		18	0	−10	8	0	−10	9	25	51	92
PN4860	TO-92	30	1	0.25	15	0.25	15	−10	2	6	15	0.5	20	100	15	40		18	0	−10	8	0	−10	10	50	51	92
PN4861	TO-92	30	1	0.25	15	0.25	15	−10	0.8	4	15	0.5	8	80	15	60		18	0	−10	8	0	−10	20	100	51	92
PN5432	TO-92	25	1	0.2	15	0.2	5	−10	4	10	5	3	150		15	5	10	30	0	−10	15	0	−10	5	36	58	92
PN5433	TO-92	25	1	0.2	15	0.2	5	−10	3	9	5	3	100		15	7	10	30	0	−10	15	0	−10	5	36	58	92
PN5434	TO-92	25	1	0.2	15	0.2	5	−10	1	4	5	3	30		15	10	10	30	0	−10	15	0	−10	5	36	58	92
TIS73	TO-92	30	1	2	15	2	15	−10	4	10	15	4	50		15	25		18	0	−10	8	0	−10	9	25	51	97
TIS74	TO-92	30	1	2	15	2	15	−10	2	6	15	4	20	100	15	40		18	0	−10	8	0	−10	10	50	51	97
TIS75	TO-92	30	1	2	15	2	15	−10	0.8	4	15	4	8	80	15	60		18	0	−10	8	0	−10	20	100	51	97
U1897	TO-92	40	1	0.2*	20				5	10	20	1	30		20	30	1	16	20	0	5	0	−20	25	40	51	92
U1898	TO-92	40	1	0.2*	20				2	7	20	1	15		20	50	1	16	20	0	5	0	−20	35	60	51	92
U1899	TO-92	40	1	0.2*	20				1	5	20	1	8		20	80	1	16	20	0	5	0	−20	60	80	51	92

t = typical value.

N-Channel JFETs

RF, VHF, UHF AMPLIFIERS

Type No.	Case Style	BV_{GSS} (V) Min	@ I_G (µA)	I_{GSS} (nA) Max	@V_{DG} (V)	V_p (V) Min	V_p (V) Max	@ V_{DS} (V)	I_D (nA)	I_{DSS} (mA) Min	I_{DSS} (mA) Max	@ V_{DS} (V)	R_e Y_{fs} (mmho) Min	@Freq (MHz)	$R_e(Y_{os})$ (µmho) Max	@ f (MHz)	C_{iss} (pF) Max	@V_{DS} (V)	V_{GS} (V)	C_{rss} (pF) Max	@V_{DS} (V)	V_{GS} (V)	NF (dB)@R_G = 1k Max	Freq (MHz)	Process No.	Pkg. No.
2N3819	TO-92	25	1	2	15		8	15	2	2	20	15	1.6	100			8	15	0	−4	15	0			50	94
2N3823	TO-72	30	1	0.5	20		8	15	0.5	4	20	15	3.2	200	200	200	6	15	0	−2	15	0	2.5	100	50	25
2N4223	TO-72	30	10	0.25	20	0.1	8	15	0.25	3	18	15	2.7	200	200	200	6	15	0	−2	15	0	5	200	50	25
2N4224	TO-72	30	10	0.5	20	0.1	8	15	0.5	2	20	15	1.7	200	200	200	6	15	0	2	15	0			50	25
2N4416	TO-72	30	1	0.1	20		6	15	1	5	15	15	4	400	100	400	4	15	0	0.8	15	0	4	400	50	25
2N4416A	TO-72	35	1	0.1	20	2.5	6	15	1	5	15	15	4	400	100	400	4	15	0	0.8	15	0	4	400	50	25
2N5078	TO-72	30	1	0.25	20	0.5	8	15		4	25	15	4	200	150	200	6	15	0	2	15	0	3	200	50	25
2N5245	TO-92	30	1	1	20	1	6	15	10	5	15	15	4	400	100	400	4.5	15	0	1	15	0	4	400	90	97
2N5246	TO-92	30	1	1	20	0.5	4	15	10	1.5	7	15	2.5	400	100	400	4.5	15	0	1	15	0			90	97
2N5247	TO-92	30	1	1	20	1.5	8	15	10	8	24	15	4	400	150	400	4.5	15	0	1	15	0			90	97
2N5248	TO-92	30	1	5	20	1	8	15	10	4	20	15	3	200	200	200	6	15	0	2	15	0			50	94
2N5397	TO-72	25	1	0.1	15	1	6	10	1	10	30	10	5.5	450	200	450	5	10	10 mA	1.2	10	10 mA	3.5	450	90	29
2N5398	TO-72	25	1	0.1	15	1	6	10	1	5	40	10	5.0	450	400	450	5.5	10	0	1.3	10	0	3.2	450	90	29
2N5484	TO-92	25	1	1	20	0.3	3	15	10	1	5	15	2.5	100	75	100	5	15	0	1	15	0	3	100	50	92
2N5485	TO-92	25	1	1	20	1	4	15	10	4	10	15	3	400	100	400	5	15	0	1	15	0	4	400	50	92
2N5486	TO-92	25	1	1	20	2	6	15	10	8	20	15	3.5	400	100	400	5	15	0	1	15	0	4	400	50	92
2N5668	TO-92	25	10	2	15	0.2	4	14	10	1	5	15	1	100	50	100	7	15	0	3	15	0	2.5	100	50	92
2N5669	TO-92	25	10	2	15	1	6	15	10	4	10	15	1.6	100	100	100	7	15	0	3	15	0	2.5	100	50	92
2N5670	TO-92	25	10	2	15	2	8	15	10	8	20	15	2.5	100	150	100	7	15	0	3	15	0	2.5	100	50	92
2N5949	TO-92	300	1	1	15	3	7	15	100	12	18	15	3.0	100	75	100	6	15	0	2	15	0	5	100	50	97
2N5950	TO-92	30	1	1	15	2.5	6	15	100	10	15	15	3.0	100	75	100	6	15	0	2	15	0	5	100	50	97
2N5951	TO-92	30	1	1	15	2	5	15	100	7	13	15	3.0	100	75	100	6	15	0	2	15	0	5	100	50	97
2N5952	TO-92	30	1	1	15	1.3	3.5	15	100	4	8	15	1.0	100	75	100	6	15	0	2	15	0	5	100	50	97
2N5953	TO-92	30	1	1	15	0.8	3	15	100	2.5	5	15	1.0	100	50	100	6	15	0	2	15	0	5	100	50	97
J300	TO-92	25	1	0.5	15	1	6	10	1	6	30	10	4.5	0.001	200	0.001	5.5	10	5 mA	1.7	10	5 mA	t2	100	90	92
J304	TO-92	30	1	0.1	20	2	6	15	1	5	15	15	t4.2	400	t80	100	t3	15	0	t.8	15	0	t4	400	50	92
J305	TO-92	30	1	0.1	20	0.5	3	15	1	1	8	15	t3.0	400	t80	100	t3	15	0	t.8	15	0	t4	400	50	92
J308	TO-92	25	1	1	15	1	6.5	10	1	12	60	10	8	0.001	200	0.001	7.5	0	−10	2.5	0	−10	t1.5	100	92	92
J309	TO-92	25	1	1	15	1	4.0	10	1	12	30	10	10	0.001	200	0.001	7.5	0	−10	2.5	0	−10	t1.5	100	92	92
J310	TO-92	25	1	1	15	2	6.5	10	1	24	60	10	8	0.001	200	0.001	7.5	0	−10	2.5	0	−10	t1.5	100	92	92

RF, VHF, UHF AMPLIFIERS (Continued)

Type No.	Case Style	BV_{GSS} (V) @ Min	I_G (μA)	I_{GSS} (nA) @ Max	V_{DG} (V)	V_p (V) Min	Max	@ V_{DS} (V)	I_D (nA)	I_{DSS} (mA) @ Min	Max	V_{DS} (V)	$R_e\|Y_{fs}\|$ (mmho) @ Min	Freq (MHz)	$R_e(Y_{os})$ (μmho) @ Max	f (MHz)	C_{iss} (pF) @ Max	V_{DS} (V)	V_{GS} (V)	C_{rss} (pF) @ Max	V_{DS} (V)	V_{GS} (V)	NF (dB) @ R_G = 1k Max	Freq (MHz)	Process No.	Pkg. No.
MPF102	TO-92	25	1	2	15		8	15	2	2	20	15	1.6	100	100	200	7	15	0	3	15	0			50	92
MPF106	TO-92	25	1	1	20	0.5	4	15	0.5	4	10	15	2.5	0.001			5	15	0	2	15	0	4	400	50	92
MPF107	TO-92	25	1	1	20	2	6	15	0.5	8	20	15	4	0.001			5	15	0	1.2	15	0	4	400	50	92
MPF108	TO-92	25	10	1	15	0.5	8	15	10	1.5	24	15	1.6	100	200	100	6.5	15	0	2.5	15	0	3	100	50	92
MPF256	TO-92	25	10	5	15	0.5	7.5	15	200μ	3	18	15	6	0.001									2.0	100	90	92
MPF820	TO-92	25	10	5	15		5.0	15	200μ	10		15		0.001									4.0	100	51	92
PN4223	TO-92	30	1	0.25	20	0.1	8	15	1	3	18	15	2.7	200	200	200	6	15	0	2	15	0	5	200	50	92
PN4224	TO-92	30	1	0.5	20	0.1	8	15	5	2	20	15	1.7	200	200	200	6	15	0	2	15	0			50	92
PN4416	TO-92	30	1	0.1	20		6	15	1	5	15	15	4	400	100	400	4	15	0	0.8	15	0	4	400	50	92
U308	TO-52	25	1	0.15	15	1	6	10	1	12	60	10	10	0.001	150	100	5	0	10 mA	2.5	0	10 mA	t3	450	92	07
U309	TO-52	25	1	0.15	15	1	4	10	1	12	30	10	10	0.001	150	100	5	0	10 mA	2.5	0	10 mA	t3	450	92	07
U310	TO-52	25	1	0.15	15	2.5	6	10	1	24	60	10	10	0.001	150	100	5	10	10 mA	2.5	10	10 mA	t3	450	92	07
U312	TO-52	25	1	0.1	15	1	6	10	1	10	30	10	6	0.001			3.8	10	10 mA	1.2	10	10 mA	t3.5	450	90	07

t = typical value.

*V_{DS} = 15 Vdc, R_S = 50 ohms.

LOW FREQUENCY—LOW NOISE AMPLIFIERS

Type No.	Case Style	BV_{GSS} (V) Min	I_G (μA)	I_{GSS} (nA) Max	V_{DG} (V)	$V_{GS(off)}$ (V) Min	Max	V_{DS} (V)	I_D (nA)	I_{DSS} (mA) Min	Max	V_{DS} (V)	g_{fs} ($R_e\|Y_{fs}\|$) (mmho) Min	Max	V_{DS} (V)	f (MHz)	G_{oss} (μmho) Max	V_{DS} (V)	C_{iss} (pF) Max	V_{DS} (V)	V_{GS} (V)	C_{rss} (pF) Max	V_{DS} (V)	e_n nV/$\sqrt{Hz}$ @ f Max	(Hz)	Process No.	Pkg. No.
2N4393	TO-18	40	1.0	0.1	20	0.5	3.0	20	1.0	5	30	20	t12		20	0.001			14	20	0	3.5	5 (GS)	t8	10	51	02
2N5556	TO-72	30	10	0.1	15	0.2	4.0	15	1.0	0.5	2.5	15	1.5	6.5	15	0.001	20	15	6	15	0	3	15	35	10	50	25
2N5557	TO-72	30	10	0.1	15	0.8	5.0	15	1.0	2	5.0	15	1.5	6.5	15	0.001	20	15	6	15	0	3	15	35	10	50	25
2N5558	TO-72	30	10	0.1	15	1.5	6.0	15	1.0	4	10	15	1.5	6.5	15	0.001	20	15	6	15	0	3	15	35	10	50	25
NF5101	TO-72	40	1	0.2	15	0.5	1.1	15	1.0	1	12	15	3.5		15	0.001	25	15	t12	15	0	t4	15	3.5	1000	51	25
NF5102	TO-72	40	1	0.2	15	0.7	1.6	15	1.0	4	20	15	7.5		15	0.001	25	15	t12	15	0	t4	15	3.5	1000	51	25
NF5103	TO-72	40	1	0.2	15	1.2	2.7	15	1.0	10	40	15	7.5		15	0.001	25	15	t12	15	0	t4	15	3.5	1000	51	25

t = typical value

N-Channel JFETs

LOW FREQUENCY—LOW NOISE AMPLIFIERS (Continued)

Type No.	Case Style	BV_{GSS} (V) Min	I_G (μA)	I_{GSS} (nA) Max	V_{DG} (V)	$V_{GS(off)}$ (V) Min	Max	V_{DS} (V)	I_D (nA)	I_{DSS} (mA) Min	Max	V_{DS} (V)	g_{fs} ($R_e\|Y_{fs}$) (mmho) Min	Max	V_{DS} (V)	f (MHz)	G_{oss} (μmho) Max	V_{DS} (V)	C_{iss} (pF) Max	V_{DS} (V)	V_{GS} (V)	C_{rss} (pF) Max	V_{DS} (V)	e_n nV/$\sqrt{Hz}$@f Max	(Hz)	Process No.	Pkg. No.
PF5101	TO-92	40	1	0.2	15	0.5	1.1	15	1.0	1	12	15	3.5		15	0.001	25	15	t12	15	0	t4	15	3.5	1000	51	92
PF5102	TO-92	40	1	0.2	15	0.7	1.6	15	1.0	4	20	15	7.5		15	0.001	25	15	t12	15	0	t4	15	3.5	1000	51	92
PF5103	TO-92	40	1	0.2	15	1.2	2.7	15	1.0	10	40	15	7.5		15	0.001	25	15	t12	15	0	t4	15	3.5	1000	51	92
PN4393	TO-92	40	1.0	0.1	20	0.5	3.0	20	1.0	5	30	20	t12		20	0.001			14	20	0	3.5	5 (GS)	t8	10	51	92

t = typical value

ULTRA LOW INPUT CURRENT AMPS

Type No.	Case Style	BV_{GSS} (V) Min	@ I_G (μA)	I_{GSS} (pA) Max	@V_{DG} (V)	V_P (V) Min	Max	@ V_{DS} (V)	I_D (nA)	I_{DSS} (μA) Min	Max	@ V_{DS} (V)	G_{fs} (μmho) Min	Max	@ V_{DS} (V)	G_{oss} (μmho) Max	V_{DS} (V)	C_{iss} (pF) Max	@V_{DS} (V)	V_{GS} (V)	C_{rss} (pF) Max	@V_{DS} (V)	V_{GS} (V)	Process No.	Pkg. No.
2N4117	TO-72	40	1	10	20	0.6	1.8	10	1	30	90	10	20	210	10	3	10	3	10	0	1.5	10	0	53	25
2N4117A	TO-72	40	1	1	20	0.6	1.8	10	1	30	90	10	70	210	10	3	10	3	10	0	1.5	10	0	53	25
2N4118	TO-72	40	1	10	20	1	3	10	1	80	240	10	80	250	10	5	10	3	10	0	1.5	10	0	53	25
2N4118A	TO-72	40	1	1	20	1	3	10	1	80	240	10	80	250	10	5	10	3	10	0	1.5	10	0	53	25
2N4119	TO-72	40	1	10	20	2	6	10	1	200	600	10	100	330	10	10	10	3	10	0	1.5	10	0	53	25
2N4119A	TO-72	40	1	1	20	2	6	10	1	200	600	10	100	330	10	10	10	3	10	0	1.5	10	0	53	25
NF5301	TO-72	30	1	1	15	0.6	3	10	1	30	500	10	70	300	10			3	10	0	1.5	10	0	53	25
NF5301-1	TO-72	30	1	1	15	0.6	1.8	10	1	30	500	10	70	300	10			3	10	0	1.5	10	0	53	25
NF5301-2	TO-72	30	1	1	15	1.7	3	10	1	30	500	10	70	300	10			3	10	0	1.5	10	0	53	25
NF5301-3	TO-72	30	1	1	15	1.0	2.4	10	1	30	500	10	70	300	10			3	10	0	1.5	10	0	53	25
PF5301	TO-92	30	1	1	15	0.6	3	10	1	30	500	10	70	300	10			3	10	0	1.5	10	0	53	92
PF5301-1	TO-92	30	1	1	15	0.6	1.8	10	1	30	500	10	70	300	10			3	10	0	1.5	10	0	53	92
PF5301-2	TO-92	30	1	1	15	1.7	3	10	1	30	500	10	70	300	10			3	10	0	1.5	10	0	53	92
PF5301-3	TO-92	30	1	1	15	1.0	3.4	10	1	30	500	10	70	300	10			3	10	0	1.5	10	0	53	92
PN4117	TO-92	40	1	10	20	0.6	2.8	10	1	30	90	10	20	210	10	3	10	3	10	0	1.5	10	0	53	92
PN4117A	TO-92	40	1	1	20	0.6	2.8	10	1	30	90	10	70	210	10	3	10	3	10	0	1.5	10	0	53	92
PN4118	TO-92	40	1	10	20	1	3	10	1	80	240	10	80	250	10	5	10	3	10	0	1.5	10	0	53	92
PN4118A	TO-92	40	1	1	20	1	3	10	1	80	240	10	80	250	10	5	10	3	10	0	1.5	10	0	53	92
PN4119	TO-92	40	1	10	20	2	6	10	1	200	600	10	100	330	10	10	10	3	10	0	1.5	10	0	53	92
PN4119A	TO-92	40	1	1	20	2	6	10	1	200	600	10	100	330	10	10	10	3	10	0	1.5	10	0	53	92

N-Channel JFETs

GENERAL PURPOSE AMPS

Type No.	Case Style	BV_{GSS} *BV_{GDO} (V) Min	@ I_G (µA)	I_{GSS} (nA) Max	@V_{DG} (V)	V_p (V) Min	V_p (V) Max	@ V_{DS} (V)	I_D (nA)	I_{DSS} (mA) Min	I_{DSS} (mA) Max	@ V_{DS} (V)	G_{fs} (mmho) Min	G_{fs} (mmho) Max	@ V_{DS} (V)	G_{oss} (µmho) Max	@V_{DS} (V)	C_{iss} (pF) Max	@V_{DS} (V)	V_{GS} (V)	C_{rss} (pF) Max	@V_{DS} (V)	V_{GS} (V)	e_n $\left(\frac{NV}{\sqrt{Hz}}\right)$ Max	@Freq (Hz)	Process No.	Pkg. No.
2N3369	TO-18	40	1	5	30		6.5	20	1000	0.5	2.5	30	0.6	2.5	30	30	30	20	8	0	3	30	0			52	02
2N3370	TO-18	40	1	5	30		3.2	20	1000	0.1	0.6	30	0.3	2.5	30	15	30	20	8	0	3	30	0			52	02
2N3458	TO-18	50	1	0.25	30		7.8	20	1000	3	15	20	2.5	10	20	35	30	18	0	−10	5	30	0	225	20	52	02
2N3459	TO-18	50	1	0.25	30		3.4	20	1000	0.8	4	20	1.5	6	20	20	30	18	0	−6	5	30	0	155	20	52	02
2N3460	TO-18	50	1	0.25	30		1.8	20	1000	0.2	1	20	0.8	4.5	20	5	30	18	0	−4	5	30	0	155	20	52	02
2N3684	TO-72	50	1	0.1	30	2	5	20	1	2.5	7.5	20	2	3	20	50	20	4	20	0	1.2	20	0	150	100	52	25
2N3685	TO-72	50	1	0.1	30	1	3.5	20	1	1	3	20	1.5	2.5	20	25	20	4	20	0	1.2	20	0	150	100	52	25
2N3686	TO-72	50	1	0.1	30	0.6	2	20	1	0.4	1.2	20	1	2	20	10	20	4	20	0	1.2	20	0	150	100	52	25
2N3687	TO-72	50	1	0.1	30	0.3	1.2	20	1	0.1	0.5	20	0.5	1.5	20	5	20	4	20	0	1.2	20	0	150	100	52	25
2N3821	TO-72	50	1	0.1	30		4	15	0.5	0.5	2.5	15	1.5	4.5	15	10	15	6	15	0	3	15	0	200	10	55	25
2N3822	TO-72	50	1	0.1	30		6	15	0.5	2	10	15	3	6.5	15	20	15	6	15	0	3	15	0	200	10	55	25
2N3967	TO-72	30	1	0.1	20	2	5	20	1	2.5	10	20	2.5		20	35	20¶	5	20	¶	1.3	20	■	84	100	55	25
2N3967A	TO-72	30	1	0.1	20	2	5	20	1	2.5	10	20	2.5		20	35	20¶	5	20	¶	1.3	20	■	160	10	55	25
2N3968	TO-72	30	1	0.1	20		3	20	1	1	5	20	2		20	15	20**	5	20	**	1.3	20	†	84	100	55	25
2N3968A	TO-72	30	1	0.1	20		3	20	1	1	5	20	2		20	15	20**	5	20	**	1.3	20	†	160	10	55	25
2N3969	TO-72	30	1	0.1	20		1.7	20	1	0.4	2	20	1.3		20	5	20††	5	20	††	1.3	20	¶	84	100	55	25
2N3969A	TO-72	30	1	0.1	20		1.7	20	1	0.4	2	20	1.3		20	5	20††	5	20	††	1.3	20	¶	160	10	55	25
2N4220	TO-72	30	10	0.1	15		4	15	0.1	0.5	3	15	1	4	15	10	15	6	15	0	2	15	0			55	25
2N4220A	TO-72	30	10	0.1	15		4	15	0.1	0.5	3	15	1	4	15	10	15	6	15	0	2	15	0	115	100	55	25
2N4221	TO-72	30	10	0.1	15		6	15	0.1	2	6	15	2	5	15	20	15	6	15	0	2	15	0			55	25
2N4221A	TO-72	30	10	0.1	15		6	15	0.1	2	6	15	2	5	15	20	15	6	15	0	2	15	0	115	100	55	25
2N4222	TO-72	30	10	0.1	15		8	15	0.1	5	15	15	2.5	6	15	40	15	6	15	0	2	15	0			55	25
2N4222A	TO-72	30	10	0.1	15		8	15	0.1	5	15	15	2.5	6	15	40	15	6	15	0	2	15	0	115	100	55	25
2N4338	TO-18	50	1	0.1	30	0.3	1	15	100	0.2	0.6	15	0.6	1.8	15	5	15	7	15	0	3	15	0	68	1000	52	02
2N4339	TO-18	50	1	0.1	30	0.6	1.8	15	100	0.5	1.5	15	0.8	2.4	15	15	15	7	15	0	3	15	0	68	1000	52	02
2N4340	TO-18	50	1	0.1	30	1	3	15	100	1.2	3.6	15	1.3	3	15	30	15	7	15	0	3	15	0	68	1000	52	02
2N4341	TO-18	50	1	0.1	30	2	6	15	100	3	9	15	2	4	15	60	15	7	15	0	3	15	0	68	1000	55	02
2N5103	TO-72	25	10	0.1	15	0.5	4	15	1	1	8	15	2	8	15	100	15	5	15	0	1	15	0	100	10	50	25
2N5104	TO-72	25	1	0.1	15	0.5	4	15	1	2	6	15	3.5	7.5	15	100	15	5	15	0	1	15	0	50	10	50	25

■ I_D = 1 mA; † I_D = 500 µA; †† I_D = 40 µA; ** I_D = 100 µA; ¶ I_D = 250 µA.
t = typical value.

N-Channel JFETs

GENERAL PURPOSE AMPS (Continued)

Type No.	Case Style	BV_{GSS} *BV_{GDO} (V) Min	@ I_G (µA)	I_{GSS} (nA) Max	@ V_{DG} (V)	V_p (V) Min	V_p (V) Max	@ V_{DS} (V)	I_D (nA)	I_{DSS} (mA) Min	I_{DSS} (mA) Max	@ V_{DS} (V)	G_{fs} (mmho) Min	G_{fs} (mmho) Max	@ V_{DS} (V)	G_{oss} (µmho) Max	@ V_{DS} (V)	C_{iss} (pF) Max	@ V_{DS} (V)	V_{GS} (V)	C_{rss} (pF) Max	@ V_{DS} (V)	V_{GS} (V)	e_n $\left(\frac{NV}{\sqrt{Hz}}\right)$ Max	@ Freq (Hz)	Process No.	Pkg. No.
2N5105	TO-72	25	1	0.1	15	0.5	4	15	1	5	15	15	5	10	15	100	15	5	15	0	1	15	0			50	25
2N5358	TO-72	40	1	0.1	20	0.5	3	15	100	0.5	1	15	1	3	15	10	15	6	15	0	2	15	0	115	100	55	25
2N5359	TO-72	40	1	0.1	20	0.8	4	15	100	0.6	1.6	15	1.2	3.6	15	10	15	6	15	0	2	15	0	115	100	55	25
2N5360	TO-72	40	1	0.1	20	0.8	4	15	100	1.5	3.0	15	1.4	4.2	15	20	15	6	15	0	2	15	0	115	100	55	25
2N5361	TO-72	40	1	0.1	20	1	6	15	100	2.5	5	15	1.5	4.5	15	20	15	6	15	0	2	15	0	115	100	55	25
2N5362	TO-72	40	1	0.1	20	2	7	15	100	4	8	15	2	5.5	15	40	15	6	15	0	2	15	0	115	100	55	25
2N5363	TO-72	40	1	0.1	20	2.5	8	15	100	7	14	15	2.5	6	15	40	15	6	15	0	2	15	0	115	100	55	25
2N5364	TO-72	40	1	0.1	20	2.5	8	15	100	9	18	15	2.7	6.5	15	60	15	6	15	0	2	15	0	115	100	55	25
2N5457	TO-92	25	1	1	15	0.5	6	15	10	1	5	15	2	5	15	50	15	7	15	0	3	15	0			55	92
2N5458	TO-92	25	1	1	15	1	7	15	10	2	9	15	1.5	5.5	15	50	15	7	15	0	3	15	0			55	92
2N5459	TO-92	25	1	1	15	2	8	15	10	4	16	15	2	6	15	50	15	7	15	0	3	15	0			55	92
2N5556	TO-72	30	1	0.1	15	0.2	4	15	1	0.5	2.5	15	1.5	6.5	15	20	15	6	15	0	3	15	0	35	10	50	25
2N5557	TO-72	30	1	0.1	15	0.8	5	15	1	2	5	15	1.5	6.5	15	20	15	6	15	0	3	15	0	35	10	50	25
2N5558	TO-72	30	1	0.1	15	1.5	6	15	1	4	10	15	1.5	6.5	15	20	15	6	15	0	3	15	0	35	10	50	25
J201	TO-92	40	1	0.1	20	0.3	1.5	20	10	0.2	1	20	0.5		20	t1	20	t5	20	0	t2	20	0	t10	1000	52	92
J202	TO-92	40	1	0.1	20	0.8	4	20	10	0.9	4.5	20	1		20	t3.5	20	t5	20	0	t2	20	0	t10	1000	52	92
J203	TO-92	40	1	0.1	20	2	10	20	10	4	20	20	1.5		20	t10	20	t5	20	0	t2	20	0	t10	1000	52	92
J210	TO-92	25	1	0.1	15	1	3	15	1	2	15	15	4	12	15	150	15	t5	15	0	t1.5	15	0	t10	1000	90	92
J211	TO-92	25	1	0.1	15	2.5	4.5	15	1	7	20	15	7	12	15	200	15	t5	15	0	t1.5	15	0	t10	1000	90	92
J212	TO-92	25	1	0.1	15	4	6	15	1	15	40	15	7	12	15	200	15	t5	15	0	t1.5	15	0	t10	1000	90	92
MPF103	TO-92	25	1	1	15		6	15	1	1	5	15	1	5	15	50	15	7	15	0	3	15	0			55	92
MPF104	TO-92	25	1	1	15		7	15	1	2	9	15	1.5	5.5	15	50	15	7	15	0	3	15	0			55	92
MPF105	TO-92	25	1	1	15		8	15	1	4	16	15	2	6	15	50	15	7	15	0	3	15	0			55	92
MPF109	TO-92	25	10	1	15	0.2	8	15	10	0.5	24	15	0.8	6	15	75	15	7	15	0	3	15	0	115	1000	55	92
MPF110	TO-92	20	10	100	10	0.5	10	10	1	0.5	20	10	0.5		10											50	92
MPF111	TO-92	20	10	100	10	0.5	10	10	1000	0.5	20	10	0.5		10	200	10									50	92
MPF112	TO-92	25	10	100	10	0.5	10	10	1000	1	25	10	1	7.5	10											55	92
PN3684	TO-92	50	1	0.1	30	2	5	20	1	2.5	7.5	20	2	3	20	50	20	4	20	0	1.2	20	0	150	20	52	92
PN3685	TO-92	50	1	0.1	30	1	3.5	20	1	1	3	20	1.5	2.5	20	25	20	4	20	0	1.2	20	0	150	20	52	92
PN3686	TO-92	50	1	0.1	30	0.6	2	20	1	0.4	1.2	20	1	2	20	10	20	4	20	0	1.2	20	0	150	20	52	92

GENERAL PURPOSE AMPS (Continued)

Type No.	Case Style	BV_{GSS} *BV_{GDO} (V) Min	@ I_G (μA)	I_{GSS} (nA) Max	@V_{DG} (V)	V_p (V) Min	V_p (V) Max	@ V_{DS} (V)	I_D (nA)	I_{DSS} (mA) Min	I_{DSS} (mA) Max	@ V_{DS} (V)	G_{fs} (mmho) Min	G_{fs} (mmho) Max	@ V_{DS} (V)	G_{oss} (μmho) Max	@V_{DS} (V)	C_{iss} (pF) Max	@V_{DS} (V)	V_{GS} (V)	C_{rss} (pF) Max	@V_{DS} (V)	V_{GS} (V)	e_n $\left(\frac{NV}{\sqrt{Hz}}\right)$ Max	@ Freq (Hz)	Process No.	Pkg. No.
PN3687	TO-92	50	1	0.1	30	0.3	1.2	20	1	0.1	0.5	20	0.5	1.5	20	5	20	4	20	0	1.2	20	0	150	20	52	92
PN4220	TO-92	30	10	0.1	15		4	15	1	0.5	3	15	1	4	15	10	15	6	15	0	2	15	0			55	92
PN4221	TO-92	30	10	0.1	15		6	15	1	2	6	15	2	5	15	20	15	6	15	0	2	15	0			55	92
PN4222	TO-92	30	10	0.1	15		8	15	1	5	15	15	2.5	6	15	40	15	6	15	0	2	15	0			55	92
PN4302	TO-92	30	1	1	10		4	20	10	0.5	5	20	1		20	50	20	6	20	0	3	20	0	100	1000	52	92
PN4303	TO-92	30	1	1	10		6	20	10	4	10	20	2		20	50	20	6	20	0	3	20	0	100	1000	52	92
PN4304	TO-92	30	1	1	10		10	20	10	0.5	15	20	1		20	50	20	6	20	0	3	20	0	125	1000	52	92
PN5163	TO-92	25	1	10	15	0.4	8	15	1000	1	40	15	2	9	15	200	15	12	15	0	3	15	0	50	1000	50	92
TIS58	TO-92	25	1	4	15	0.5	5	15	20	2.5	8	15	1.3	4	15			6	15	2 mA	3	15	2 mA			50	94
TIS59	TO-92	25	1	4	15	1	9	15	20	6	25	15	1.3		15			6	15	2 mA	3	15	2 mA			50	94

■ I_D = 1 mA; † I_D = 500 μA; †† I_D = 40 μA; ** I_D = 100 μA; ¶ I_D = 250 μA.
t = typical value.

N-Channel JFETs

GENERAL PURPOSE DUAL JFETs

Type No.	Case Style	Operating Conditions For These Characteristics: Op. Char. V_{DG} (V)	Op. Char. I_D (μA)	$\lvert V_{GS1-2}\rvert$ V_{OS} (mV) Max	Drift (μV/°C) ΔV_{GS} Max	I_G (pA) Max	G_{fs} μmhos Min	G_{fs} μmhos Max	G_{oss} (μmho) Max	CMRR (dB) Min	V_{gs} (V) Min	V_{gs} (V) Max	V_p (V) Min	V_p (V) Max	I_{DSS} (mA) Min	I_{DSS} (mA) Max	G_{fs} (mmho) Min	G_{fs} (mmho) Max	G_{oss} (μmho) Max	I_{GSS} (pA) Max	@ V_{DG} (V)	C_{iss} (pF) Max	C_{rss} (pF) Max	BV (V) Min	e_n (nV/√Hz) Max	@ f (Hz)	I_{DSS} Match %	G_{fs} Match %	G_{oss1-2} (μmho)	I_{G1}-I_{G2} 125°C (nA)	Process No.	Pkg. No.
2N3921	TO-71	10	700	5	10	250	1500		20					−3.0	1	10	1.5	7.5	35	1000	30	18	6	50	100	1000		5			83	12
2N3922	TO-71	10	700	5	25	250	1500		20					−3.0	1	10	1.5	7.5	35	1000	30	18	6	50	100	1000		5			83	12
2N3934	TO-71	10	200	5	10	100	300		5				See 2N3954-6 as an improved replacement																			12
2N3935	TO-71	10	200	5	25	100	300		5				See 2N3954-6 as an improved replacement																			12
2N3954A	TO-71	20	200	5	5	50					0.5	4	1	4.5	0.5	5	1	3	35	100	30	4	1.2	50	150	100	5	3		10	83	12
2N3954	TO-71	20	200	5	10	50					0.5	4	1	4.5	0.5	5	1	3	35	100	30	4	1.2	50	150	100	5	3		10	83	12
2N3955A	TO-71	20	200	5	15	50					0.5	4	1	4.5	0.5	5	1	3	35	100	30	4	1.2	50	150	100	5	3		10	83	12
2N3955	TO-71	20	200	10	25	50					0.5	4	1	4.5	0.5	5	1	3	35	100	30	4	1.2	50	150	100	5	5		10	83	12
2N3956	TO-71	20	200	15	50	50					0.5	4	1	4.5	0.5	5	1	3	35	100	30	4	1.2	50	150	100	5	5		10	83	12
2N3957	TO-71	20	200	20	75	50					0.5	4	1	4.5	0.5	5	1	3	35	100	30	4	1.2	50	150	100	10	10		10	83	12
2N3958	TO-71	20	200	25	100	50					0.5	4	1	4.5	0.5	5	1	3	35	100	30	4	1.2	50	150	100	15	15		10	83	12
2N4082	TO-71	10	200	15	10	100	300		10				See 2N3954-6 as an improved replacement																			12
2N4083	TO-71	10	200	15	25	100	300		10				See 2N3954-6 as an improved replacement																			12
2N4084	TO-71	10	700	15	10	250	1500		20		0.5	4		3	1	10	1.5	7.5	35	1000	30	18	6	50	100	1000		5			83	12
2N4085	TO-71	10	700	15	25	250	1500		20					3	1	10	1.5	7.5	35	1000	30	18	6	50	100	1000		5			83	12
2N5045	TO-71	15	200	5.0	67								0.5	4.5	0.5	8	1.5	6	25	250	30	8	4	50	200	10					83	12
2N5046	TO-71	15	200	10	133								0.5	4.5	0.5	8	1.5	6	25	250	30	8	4	50	200	10					83	12
2N5047	TO-71	15	200	15	200								0.5	4.5	0.5	8	1.5	6	25	250	30	8	4	50	200	10		20	3		83	12
2N5196	TO-71	20	200	5	5	15	700	1500	4		0.2	3.8	0.7	4.5	0.7	7	1	4	50	25	30	6	2	50	20	1000	5	3	1	5	83	12
2N5197	TO-71	20	200	5	10	15	700	1500	4		0.2	3.8	0.7	4.5	0.7	7	1	4	50	25	30	6	2	50	20	1000	5	3	1	5	83	12
2N5198	TO-71	20	200	10	20	15	700	1500	4		0.2	3.8	0.7	4.5	0.7	7	1	4	50	25	30	6	2	50	20	1000	5	5	1	5	83	12
2N5199	TO-71	20	200	15	40	17	700	1500	4		0.2	3.8	0.7	4.5	0.7	7	1	4	50	25	30	6	2	50	20	1000	5	5	1	5	83	12
2N5452	TO-71	20	200	5	5				1		0.2	4.2	1	4.5	0.5	5	1	3	3	100	30	4	1.2	50	20	1000	5	3	0.25		83	12
2N5453	TO-71	20	200	10	10				1		0.2	4.2	1	4.5	0.5	5	1	3	3	100	30	4	1.2	50	20	1000	5	3	0.25		83	12
2N5454	TO-71	20	200	15	25				1		0.2	4.2	1	4.5	0.5	5	1	3	3	100	30	4	1.2	50	20	1000	5	5	0.25		83	12
2N5545	TO-71	15	200	5	10	50							0.5	4.5	0.5	8	1.5	6	25	100	30	6	2	50	180	10	5	3	1	5	83	12
2N5546	TO-71	15	200	10	20	50							0.5	4.5	0.5	8	1.5	6	25	100	30	6	2	50	200	10	10	5	2	5	83	12
2N5547	TO-71	15	200	15	40	50							0.5	4.5	0.5	8	1.5	6	25	100	30	6	2	50			10	10	3	5	83	12
2N5561	TO-71	10	700	5	5		2000	3000	4		0.2	2.7†	0.8	3	1	10				100	30	15	4	50	50	10	5	3	0.3	10	98	12
2N5562	TO-71	10	700	10	10		2000	3000	4		0.2	2.7†	0.8	3	1	10				100	30	15	4	50	50	10	5	3	0.4	10	98	12
2N5563	TO-71	10	700	15	25		2000	3000	4		0.2	2.7†	0.8	3	1	10				100	30	15	4	50	50	10	5	3	0.5	10	98	12
J401	8-Pin Mini-DIP	10	200	5	10	100	1000	1600	2	95		2.3	0.5	2.5	0.5	10	2	7	20	100	30	8	3	50	20	10					98	60
J402		10	200	10	10	100	1000	1600	2	95		2.3	0.5	2.5	0.5	10	2	7	20	100	30	8	3	50	20	10					98	60
J403		10	200	10	25	100	1000	1600	2	95		2.3	0.5	2.5	0.5	10	2	7	20	100	30	8	3	50	20	10					98	60
J404		10	200	15	25	100	1000	1600	2	95		2.3	0.5	2.5	0.5	10	2	7	20	100	30	8	3	50	20	10					98	60
J405		10	200	20	40	100	1000	1600	2	90		2.3	0.5	2.5	0.5	10	2	7	20	100	30	8	3	50	20	10					98	60
J406		10	200	40	80	100	1000	1600	2			2.3	0.5	2.5	0.5	10	2	7	20	100	30	8	3	50	20	10					98	60
J410	8-Pin	20	200	10	10	250	600	1200	5		0.3	4	0.5	3.5	0.5	6	1	4	20	250	20	4.5	1.2	40	50	100					83	60

GENERAL PURPOSE DUAL JFETs (Continued)

Type No.	Case Style	Op. Char. V_{DG} (V)	I_D (µA)	V_{GS1-2} V_{OS} (mV) Max	Drift (µV/°C) ΔV_{GS} Max	I_G (pA) Max	G_{fs} µmhos Min	G_{fs} µmhos Max	G_{oss} (µmho) Max	CMRR (dB) Min	V_{gs} (V) Min	V_{gs} (V) Max	V_p (V) Min	V_p (V) Max	I_{DSS} (mA) Min	I_{DSS} (mA) Max	G_{fs} (mmho) Min	G_{fs} (mmho) Max	G_{oss} (µmho) Max	I_{GSS} (pA) Max	@ V_{DG} (V)	C_{iss} (pF) Max	C_{rss} (pF) Max	BV (V) Min	e_n (nV/√Hz) Max	@ f (Hz)	I_{DSS} Match %	G_{fs} Match %	G_{oss1-2} (µmho)	I_{G1}-I_{G2} 125°C (nA)	Process No.	Pkg. No.
J411	Mini-	20	200	25	25	250	600	1200	5		0.3	4	0.5	3.5	0.5	6	1	4	20	250	20	4.5	1.2	40	50	100					83	60
J412	DIP	20	200	40	80	250	600	1200	5		0.3	4	0.5	3.5	0.5	6	1	4	20	250	20	4.5	1.2	40	50	100					83	60
NPD8301	8-Pin	20	200	5	10	100	700	1200	5	70	0.3	4	0.5	3.5	0.5	6	1	4	20	100	20	4.5	1.2	40	50	100					83	67
NPD8302	Mini-	20	200	10	15	100	700	1200	5		0.3	4	0.5	3.5	0.5	6	1	4	20	100	20	4.5	1.2	40	50	100					83	67
NPD8303	DIP	20	200	15	25	100	700	1200	5		0.3	4	0.5	3.5	0.5	6	1	4	20	100	20	4.5	1.2	40	50	100					83	67
U231	TO-71	20	200	5	10	50	600		10		0.3	4	See 2N3954 as an improved replacement																		83	12
U232	TO-71	20	200	10	25	50	600		10		0.3	4	See 2N3955 as an improved replacement																		83	12
U233	TO-71	20	200	15	50	50	600		10		0.3	4	See 2N3956 as an improved replacement																		83	12
U234	TO-71	20	200	20	75	50	600		10		0.3	4	See 2N3957 as an improved replacement																		83	12
U235	TO-71	20	200	25	100	50	600		10		0.3	4	See 2N3958 as an improved replacement																		83	12
U401	TO-71	10	200	5	10	15	1000	1600	2	95		2.3	0.5	2.5	0.5	10	2	7	20	25	30	8	3	50	20	10					98	12
U402	TO-71	10	200	10	10	15	1000	1600	2	95		2.3	0.5	2.5	0.5	10	2	7	20	25	30	8	3	50	20	10					98	12
U403	TO-71	10	200	10	25	15	1000	1600	2	95		2.3	0.5	2.5	0.5	10	2	7	20	25	30	8	3	50	20	10					98	12
U404	TO-71	10	200	15	25	15	1000	1600	2	95		2.3	0.5	2.5	0.5	10	2	7	20	25	30	8	3	50	20	10					98	12
U405	TO-71	10	200	20	40	15	1000	1600	2	90		2.3	0.5	2.5	0.5	10	2	7	20	25	30	8	3	50	20	10					98	12
U406	TO-71	10	200	40	80	15	1000	1600	2			2.3	0.5	2.5	0.5	10	2	7	20	25	30	8	3	50	20	10					98	12

† I_D = 100 µA for V_{GS} for 2N5561/2/3 only.

LOW FREQUENCY—LOW NOISE DUAL JFETs

Type No.	Case Style	Op. Char. V_{DG} (V)	I_D (µA)	V_{GS1-2} V_{OS} (mV) Max	Drift (µV/°C) ΔV_{GS} Max	I_G (pA) Max	G_{fs} µmhos Min	G_{fs} µmhos Max	G_{oss} (µmho) Max	CMRR (dB) Min	V_{gs} (V) Min	V_{gs} (V) Max	V_p (V) Min	V_p (V) Max	I_{DSS} (mA) Min	I_{DSS} (mA) Max	G_{fs} (mmho) Min	G_{fs} (mmho) Max	G_{oss} (µmho) Max	I_{GSS} (pA) Max	@ V_{DG} (V)	C_{iss} (pF) Max	C_{rss} (pF) Max	BV (V) Min	e_n (nV/√Hz) Max	@ f (Hz)	I_{DSS} Match %	G_{fs} Match %	G_{oss1-2} (µmho)	I_{G1}-I_{G2} 125°C (nA)	Process No.	Pkg. No.
2N5515	TO-71	20	200	5	5	100	500	1000	1	100	0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	30	10	5	3	0.1	10	95	12
2N5516	TO-71	20	200	5	10	100	500	1000	1	100	0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	30	10	5	3	0.1	10	95	12
2N5517	TO-71	20	200	10	20	100	500	1000	1	90	0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	30	10	5	5	0.1	10	95	12
2N5518	TO-71	20	200	15	40	100	500	1000	1		0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	30	10	5	5	0.1	10	95	12
2N5519	TO-71	20	200	15	80	100	500	1000	1		0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	30	10	10	10	0.1	10	95	12
2N5520	TO-71	20	200	5	5	100	500	1000	1	100	0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	15	10	5	3	0.1	10	95	12
2N5521	TO-71	20	200	5	10	100	500	1000	1	100	0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	15	10	5	3	0.1	10	95	12
2N5522	TO-71	20	200	10	20	100	500	1000	1	90	0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	15	10	5	5	0.1	10	95	12
2N5523	TO-71	20	200	15	40	100	500	1000	1		0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	15	10	5	5	0.1	10	95	12
2N5524	TO-71	20	200	15	80	100	500	1000	1		0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	15	10	10	10	0.1	10	95	12
2N6483	TO-71	20	200	5	5	100	500	1500	1	100	0.2	3.8	0.7	4	0.5	7.5	1	4	10	200	30	20	3.5	50	10	10	5	3	0.1	10	95	12
2N6484	TO-71	20	200	10	10	100	500	1500	1	100	0.2	3.8	0.7	4	0.5	7.5	1	4	10	200	30	20	3.5	50	10	10	5	3	0.1	10	95	12
2N6485	TO-71	20	200	15	25	100	500	1500	1	90	0.2	3.8	0.7	4	0.5	7.5	1	4	10	200	30	20	3.5	50	10	10	5	5	0.1	10	95	12

N-Channel JFETs

WIDE BAND—LOW NOISE DUAL JFETs

Type No.	Case Style	Operating Conditions For These Characteristics: Op. Char. V_{DG} (V)	I_D (μA)	$\lvert V_{GS1\text{-}2}\rvert$ V_{OS} (mV) Max	Drift (μV/°C) ΔV_{GS} Max	I_G (pA) Max	G_{fs} μmhos Min	G_{fs} μmhos Max	G_{oss} (μmho) Max	CMRR (dB) Min	V_{gs} (V) Min	V_{gs} (V) Max	V_p (V) Min	V_p (V) Max	I_{DSS} (mA) Min	I_{DSS} (mA) Max	G_{fs} (mmho) Min	G_{fs} (mmho) Max	G_{oss} (μmho) Max	I_{GSS} (pA) Max	@ V_{DG} (V)	C_{iss} (pF) Max	C_{rss} (pF) Max	BV (V) Min	e_n (nV/$\sqrt{Hz}$) Max	@f (Hz)	I_{DSS} Match %	G_{fs} Match %	$G_{oss1\text{-}2}$ (μmho)	$I_{G1}\text{-}I_{G2}$ 125°C (nA)	Process No.	Pkg. No.
2N5564	TO-71	15	2000	5	10		7500		45				0.5	3	5	30				100	20	12	3	40	50	10	5	5			96	12
2N5565	TO-71	15	2000	10	25		7500		45				0.5	3	5	30				100	20	12	3	40	50	10	5	10			96	12
2N5566	TO-71	15	2000	20	50		7500		45				0.5	3	5	30				100	20	12	3	40	50	10	5	10			96	12
2N5911	TO-78	10	5000	10	20	100	5000	10,000	100		0.3	4	1	5	7	40				100	15	5	1.2	25	20	10,000	5	5	20	20	93	24
2N5912	TO-78	10	5000	15	40	100	5000	10,000	100		0.3	4	1	5	7	40				100	15	5	1.2	25	20	10,000	5	5	20	20	93	24
NPD5564	8-Pin	15	2000	5	10		7500		45				0.5	3	5	30				100	20	12	3	40	50	10	5	5			96	67
NPD5565	Mini-	15	2000	10	25		7500		45				0.5	3	5	30				100	20	12	3	40	50	10	5	10			96	67
NPD5566	DIP	15	2000	20	50		7500		45				0.5	3	5	30				100	20	12	3	40	50	10	5	10			96	67
U257	TO-78	10	5000	100			5000	10,000	150				1	5	5	40				100	15	5	1.2	25	30	10,000	15	15	20		93	24

LOW LEAKAGE—HIGH CMRR—WIDE BAND DUAL JFETs

Type No.	Case Style	Operating Conditions For These Characteristics: Op. Char. V_{DG} (V)	I_D (μA)	$\lvert V_{GS1\text{-}2}\rvert$ V_{OS} (mV) Max	Drift (μV/°C) ΔV_{GS} Max	I_{G}(pA) @ V_{DG} 35V	G_{fs} μmhos Min	G_{fs} μmhos Max	G_{oss} (μmho) Max	CMRR (dB) Min	V_{gs} (V) Min	V_{gs} (V) Max	V_p (V) Min	V_p (V) Max	I_{DSS} (mA) Min	I_{DSS} (mA) Max	G_{fs} (mmho) Min	G_{fs} (mmho) Max	G_{oss} (μmho) Max	I_{GSS} (pA) Max	@ V_{DG} (V)	C_{iss} (pF) Max	C_{rss} (pF) Max	BV (V) Min	e_n (nV/$\sqrt{Hz}$) Max	@f (Hz)	I_{DSS} Match %	G_{fs} Match %	$G_{oss1\text{-}2}$ (μmho)	$I_{G1}\text{-}I_{G2}$ 125°C (nA)	Process No.	Pkg. No.
NDF9406	TO-71	20	200	5	5	5	700	1800	1	120	0.1	4	0.5	4	0.5	10				50	30	5	0.02	50	30	10	5	3	0.1	1	94	12
NDF9407	TO-71	20	200	5	10	5	700	1800	1	120	0.1	4	0.5	4	0.5	10				50	30	5	0.02	50	30	10	5	3	0.1	1	94	12
NDF9408	TO-71	20	200	10	10	5	700	1800	1	110	0.1	4	0.5	4	0.5	10				50	30	5	0.02	50	30	10	5	5	0.1	1	94	12
NDF9409	TO-71	20	200	15	10	5	700	1800	1	110	0.1	4	0.5	4	0.5	10				50	30	5	0.02	50	30	10	5	5	0.1	1	94	12
NDF9410	TO-71	20	200	25	25	5	700	1800	1	100	0.1	4	0.5	4	0.5	10				50	30	5	0.02	50	30	10	10	10	0.1	1	94	12

ULTRA LOW LEAKAGE DUALS

Type No.	Case Style	Operating Conditions For These Characteristics: Oper. Cond. V_{DG} (V)	Oper. Cond. I_D (μA)	V_{GS1-2} V_{OS} (mV) Max	ΔV_{GS} Drift (μV/°C) Max	I_G (pA) Max	G_{fs} (mmho) Min	G_{oss} (μmho) Max	V_{GS} (V) Max	V_p (V) Min	V_p (V) Max	I_{DSS} (mA) Min	I_{DSS} (mA) Max	G_{fs} (mmho) Min	G_{fs} (mmho) Max	G_{oss} (μmho) Max	I_{GSS} (pA) Max	@ V_{GS} (V)	C_{iss} (pF) Max	C_{rss} (pF) Max	BV_{GSS} (V) Min	I_{G1}-I_{G2} @ 125°C (nA) Max	Process No.	Pkg. No.
2N5902	TO-78	10	30	5	5	3	50 μ	1	4	0.6	4.5	30 μ	0.5	70 μ	0.25	5	5	20	3	1.5	40	2	84	24
2N5903	TO-78	10	30	5	10	3	50 μ	1	4	0.6	4.5	30 μ	0.5	70 μ	0.25	5	5	20	3	1.5	40	2	84	24
2N5904	TO-78	10	30	10	20	3	50 μ	1	4	0.6	4.5	30 μ	0.5	70 μ	0.25	5	5	20	3	1.5	40	2	84	24
2N5905	TO-78	10	30	15	40	3	50 μ	1	4	0.6	4.5	30 μ	0.5	70 μ	0.25	4	5	20	3	1.5	40	2	84	24
2N5906	TO-78	10	30	5	5	1	50 μ	1	4	0.6	4.5	30 μ	0.5	70 μ	0.25	5	2	20	3	1.5	40	0.2	84	24
2N5907	TO-78	10	30	5	10	1	50 μ	1	4	0.6	4.5	30 μ	0.5	70 μ	0.25	5	2	20	3	1.5	40	0.2	84	24
2N5908	TO-78	10	30	10	20	1	50 μ	1	4	0.6	4.5	30 μ	0.5	70 μ	0.25	5	2	20	3	1.5	40	0.2	84	24
2N5909	TO-78	10	30	15	40	1	50 μ	1	4	0.6	4.5	30 μ	0.5	70 μ	0.25	5	2	20	3	1.5	40	0.2	84	24
U421	TO-78	Process In Development																					86	24
U422	TO-78																						86	24
U423	TO-78																						86	24
U424	TO-78																						86	24
U425	TO-78																						86	24
U426	TO-78																						86	24

P-Channel JFETs

SWITCHES

Type No.	Case Style	BV_{GSS} BV_{GDO} (V) Min	@ I_G (µA)	I_{GSS} (nA) Max	@ V_{DG} (V)	$I_{D(off)}$ (nA) Max	@ V_{DS} (V)	V_{GS} (V)	V_p (V) Min	V_p (V) Max	@ V_{DS} (V)	I_D (µA)	I_{DSS} (mA) Min	I_{DSS} (mA) Max	@ V_{DS} (V)	r_{ds} (Ω) Max	@ I_D (mA)	C_{iss} (pF) Max	@ V_{DS} (V)	V_{GS} (V)	C_{rss} (pF) Max	@ V_{DS} (V)	V_{GS} (V)	t_{on} (ns) Max	t_{off} (ns) Max	Process No.	Pkg. No.
2N5018	TO-18	30	1	2	15	10	−15	12		10	−15	1	10		20	75		45	−15	0	10	0	12	35	65	88	11
2N5019	TO-18	30	1	2	15	10	−15	7		5	−15	1	5		20	150		45	−15	0	10	0	7	90	125	88	11
2N5114	TO-18	30	1	0.5	20	0.5	−15	12	5	10	−15	0.001	30	90	18	75	1	25	−15	0	7	0	12	16	21	88	11
2N5115	TO-18	30	1	0.5	20	0.5	−15	7	3	6	−15	0.001	16	60	15	100	1	25	−15	0	7	0	7	30	38	88	11
2N5116	TO-18	30	1	0.5	20	0.5	−15	5	1	4	−15	0.001	5	25	15	150	1	25	−15	0	7	0	5	42	60	88	11
J174	TO-92	30	1	1	20	1	−15	10	5	10	−15	0.01	20	100	15	85	1	11	0	10	5.5	0	10	2	5	88	94
J175	TO-92	30	1	1	20	1	−15	10	3	6	−15	0.01	7	60	15	125	0.5	11	0	10	5.5	0	10	5	10	88	94
J176	TO-92	30	1	1	20	1	−15	10	1	4	−15	0.01	2	25	15	250	0.25	11	0	10	5.5	0	10	15	15	88	94
J177	TO-92	30	1	1	20	1	−15	10	0.8	2.25	−15	0.01	1.5	20	15	300	0.1	11	0	10	5.5	0	10	20	20	88	94
P1086	TO-92	30	1	2	15	10	−15	12		10	−15	1	10		20	75	1	45	−15	0	10	0	12	35	65	88	92
P1087	TO-92	30	1	2	15	10	−15	7		5	−15	1	5		20	150	1	45	−15	0	10	0	7	90	125	88	92

AMPLIFIERS

P-Channel JFETs

Type No.	Case Style	BV_{GSS} BV_{GDO} (V) Min	@ I_G (μA)	I_{GSS} (nA) Max	@V_{DG} (V)	V_p (V) Min	V_p (V) Max	@ V_{DS} (V)	I_D (μA)	I_{DSS} (mA) Min	I_{DSS} (mA) Max	@ V_{DS} (V)	G_{fs} (mmho) Min	G_{fs} (mmho) Max	@ V_{DS} (V)	G_{oss} (μmho) Max	V_{DS} (V)	C_{iss} (pF) Max	V_{DS} (V)	V_{GS} (V)	C_{rss} (pF) Max	V_{DS} (V)	V_{GS} (V)	e_n $\left(\frac{NV}{\sqrt{Hz}}\right)$ Max	@ Freq (Hz)	Process No.	Pkg. No.
2N2608	TO-18	30	1	10	30	1	4	−5	1	0.9	4.5	5	1		5			17	−5	1				125	1000	89	11
2N2609	TO-18	30	1	30	30	1	4	−5	1	2	10	5	2.5		5			30	−5	1				125	1000	88	11
2N3329	TO-72	20	10	10	10		5	−15	10	1	3	10	1	2	10/1 mA	20	10	20	−10	1				125	1000	89	23
2N3330	TO-72	20	10	10	10		6	−15	10	2	6	10	1.5	3	10/2 mA	40	10	20	−10	1				125	1000	89	23
2N3331	TO-72	20	10	10	10		8	−15	10	5	15	10	2	4	10/5 mA	100	10	20	−10	1				155	1000	89	23
2N3332	TO-72	20	10	10	10		6	−15	10	1	6	10	1	2.2	10/1 mA	20	10	20	−10	1				65	1000	89	23
2N3820	TO-92	20	10	20	10		8.0	−10	10	0.3	15	10	0.8	5	10	200	10	32	−10	0	16	−10	0			89	94
2N4381	TO-18	25	1	1	15	1	5	−15	1	3	12	15	2	6	15	75	15	20	−15	0	5	−15	0	20	1000	89	11
2N5020	TO-18	25	1	1	15	0.3	1.5	−15	1	0.3	1.2	15	1	3.5	15	20	15	25	−15	0	7	−15	0	30	1000	89	11
2N5021	TO-18	25	1	1	15	0.5	2.5	−15	1	1	3.5	15	1.5	6	15	20	15	25	−15	0	7	−15	0	30	1000	89	11
2N5460	TO-92	40	10	5	20	0.75	6	−15	1	1	5	15	1	4	15	50	15	7	−15	0	2	−15	0	115	100	89	92
2N5461	TO-92	40	10	5	20	1	7.5	−15	1	2	9	15	1.5	5	15	50	15	7	−15	0	2	−15	0	115	100	89	92
2N5462	TO-92	40	10	5	20	1.8	9	−15	1	4	16	15	2	6	15	50	15	7	−15	0	2	−15	0	115	100	89	92
J270	TO-92	30	1	0.2	20	0.5	2.0	−15	0.001	2	15	15	6.0	15	15	200	15	t20	−15	0	t5	−15	0	t10	1000	88	94
J271	TO-92	30	1	0.2	20	1.5	4.5	−15	0.001	6	50	15	8.0	18		500	15	t20	−15	0	t5	−15	0	t10	1000	88	94
PN4342	TO-92	25	10	10	15		5.5	−10	1	4	12	10	2	6	10	75	10	20	−10	0	5	−10	0	80	100	89	92
PN4360	TO-92	20	10	10	15	0.7	10	−10	1	3	30	10	2	8	10	100	10	20	−10	0	5	−10	0	190	100	89	92
PN5033	TO-92	20	10	10	15	0.3	2.5	−10	1	0.3	3.5	10	1	5	10	20	10	25	−10	0	7	−10	0	100	1000	89	92

t = typical value.

Section 4

Selection Guides

4

Choose The Proper FET

National Semiconductor utilizes 17 different FET geometries to cover, without compromise, the full spectrum of applications. Detailed data on each process, along with a list of all part numbers manufactured from each process, is to be found in Section 9.

To further simplify the selection procedure, the FET Family Tree is included for quick identification. After narrowing down the process types, it is suggested that the process sheets and specific part number characteristics be consulted.

FET FAMILY TREE

N-CHANNEL SINGLES

GENERAL PURPOSE AMP

- P50 – g_{fs} 3–7 mmhos, I_{DSS} 1–20 mA
- P52 – g_{fs} 0.5–3 mmhos, I_{DSS} 0.1–10 mA
- P55 – g_{fs} 0.8–5 mmhos, I_{DSS} 0.5–17 mA

RF/VHF/UHF

- P50 – G_{ps} 12 dB @ 400 MHz, g_{fs} 5.5 mmhos
- P90 – G_{pt} 11 dB @ 450 MHz, g_{fs} 8 mmhos
- P92 – G_{pg} 12 dB @ 450 MHz, g_{fs} 19 mmhos

ULTRA-LOW LEAKAGE AMP

- P50 – I_{GSS} 5 pA @ 20V, g_{fs} 3–7 mmhos
- P53 – I_{GSS} 0.3 pA @ 20V, g_{fs} 0.08–0.3 mmhos

LOW FREQ-LOW NOISE AMP

- P50 – e_n 8 nV/$\sqrt{Hz}$ @ 10 Hz, C_{is} 3 pF
- P51 – e_n 6 nV/$\sqrt{Hz}$ @ 10 Hz, g_{fs} 20 mmhos

SWITCH/CHOPPER

- P50 – r_{DS} 100–500 ohms, $I_{D(OFF)}$ 5 pA
- P51 – r_{DS} 20–100 ohms, $I_{D(OFF)}$ 15 pA
- P58 – r_{DS} 3–20 ohms, $I_{D(OFF)}$ 50 pA

P-CHANNEL SINGLES

GENERAL PURPOSE AMP

- P88 – g_{fs} 4–17 mmhos, I_{DSS} 5–90 mA
- P89 – g_{fs} 1–4 mmhos, I_{DSS} 0.3–20 mA

SWITCH/CHOPPER

- P88 – r_{DS} 50–200 ohms, $I_{D(OFF)}$ 50 pA
- P89 – r_{DS} 450 ohms, $I_{D(OFF)}$ 20 pA

N-CHANNEL DUALS

GENERAL PURPOSE

- P83 – I_G 3 pA @ 20V, g_{fs} 0.85 mmho @ 0.2 mA
- P94 – I_G 1 pA @ 35V, CMRR 125 dB

ULTRA-LOW INPUT CUR

- P84 – 1 pA @ 25V, g_{fs} 175 μmho
- P86 – I_G 0.1 pA, g_{fs} 500 μmho

WIDE BAND-LOW NOISE

- P93 – g_{fs} 6 mmhos @ 5 mA, C_{is} 4.2 pF
- P96 – g_{fs} 9 mmhos @ 2 mA, C_{is} 10 pF

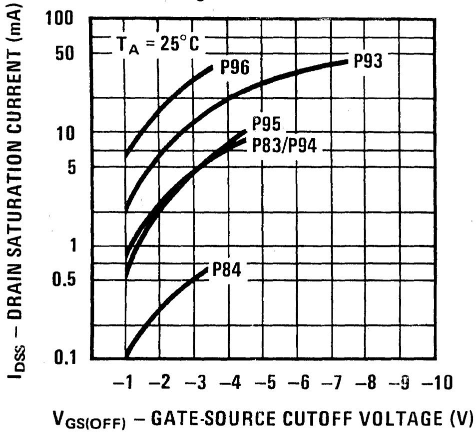
LOW FREQ-LOW NOISE

- P95 – e_n 8 nV/$\sqrt{Hz}$ @ 10 Hz, g_{fs} 1–4 mmhos
- P96 – e_n 7 nV/$\sqrt{Hz}$ @ 10 Hz, g_{fs} 10–22 mmhos

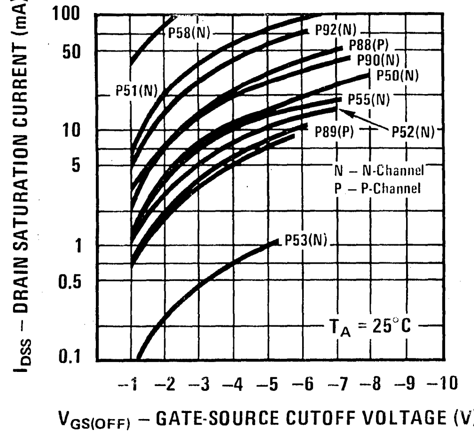
All values are typical

FET Process Comparison Curves

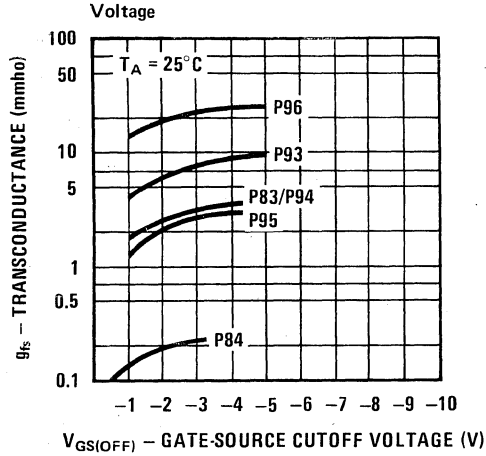
Dual FET Drain Saturation Current vs Cutoff Voltage



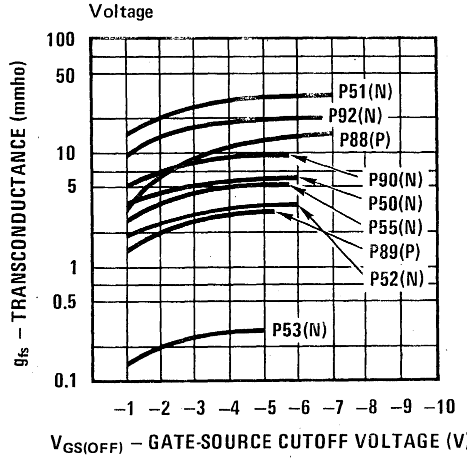
Single FET Drain Saturation Current vs Cutoff Voltage



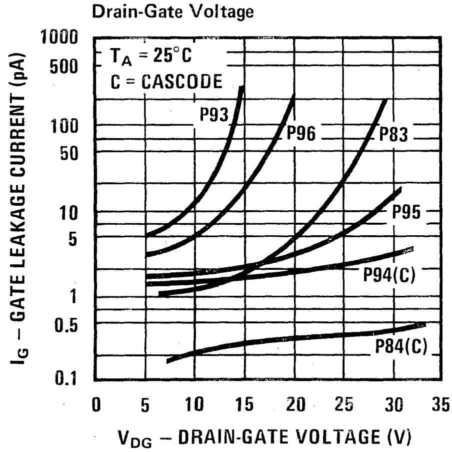
Dual FET Transconductance vs Cutoff Voltage



Single FET Transconductance vs Cutoff Voltage

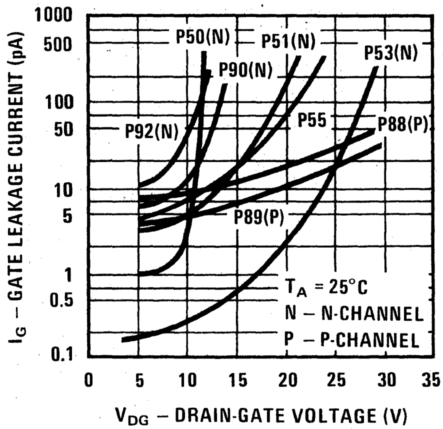


Dual FET Gate Leakage Current vs Drain-Gate Voltage

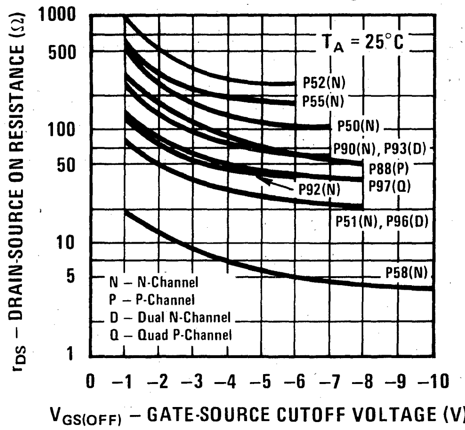


FET Process Comparison Curves (Continued)

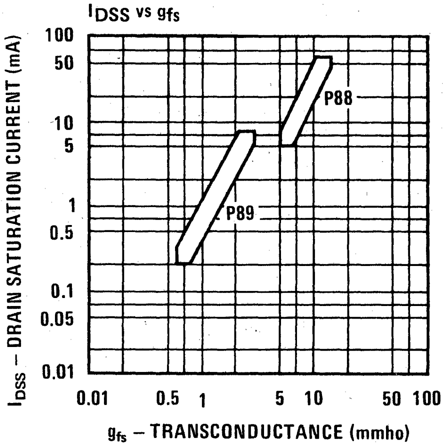
Single FET Gate Leakage Current vs Drain-Gate Voltage



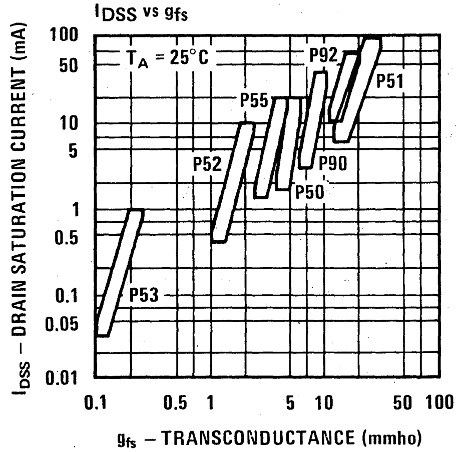
ON Resistance vs Cutoff Voltage



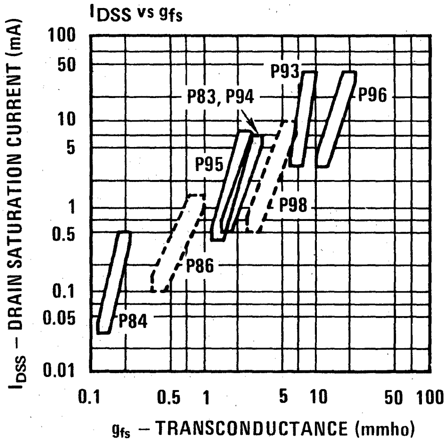
Single P-Channel FET Process Distribution
I_{DSS} vs g_{fs}



Single N-Channel FET Process Distribution
I_{DSS} vs g_{fs}



Monolithic Dual FET Process Distribution
I_{DSS} vs g_{fs}



FET Application Guide

National Semiconductor manufactures a broad line of silicon Junction Field Effect Transistors (JFETs). National's JFETs provide excellent performance in many areas such as RF amplifiers, analog switching, low input current amplifiers, low noise high impedance amplifiers and outstanding matched duals for operational amplifiers input applications.

The following FET guides enable the user to determine when to use FETs and where to look for the best choice.

POPULAR PRODUCT TYPES	2N4416, 2N5485, 6 PN4416, PN4302–4	2N4856–61, 2N4391–3 PN4856–61, PN4391–3	2N4338–41, 2N3684–7	2N4117–9, 2N3452–4 2N4117A–19A	2N3821–2, 2N4221–2 2N5457–9	2N5432–4	2N5196–9, 2N5545–7 2N3954–8	2N5902–9	U421–U426	2N5018–21, P1086–7E 2N5114–6	2N2608–9, 2N5460–62	2N5397, J300	U308–10, J308–10	2N5911–12	NDF9401–10	2N5515–24, 2N6483–5	2N5564–6	2N5561–63
PROCESS DESIGNATION	**50**	**51**	**52**	**53**	**55**	**58**	**83**	**84**	**86**	**88**	**89**	**90**	**92**	**93**	**94**	**95**	**96**	**98**
Low Current Amplifier			S	P	S		P	P	P		P				P	P		P
Low Freq Ampli ≤ 100 Hz			S		S		P			S	S				P	P		P
High Freq Ampli > 100 MHz	P											P	P	P			P	
General Purpose Amplifier	P		P		P						P							
Low Noise Amp (10 Hz $\overline{e}_n$)	S	S			S	S	P								P	P	P	P
Low Noise Amp > 50 MHz	P				S							P	P	P			P	
High Frequency Mixer	P											P	P					
Dual Diff Pair							P	P	P					P	P	S	P	P
AGC Amplifier	P				P													
Electrometer Preamp				P				P	P						P			S
Microvolt Amplifier				P				P	P						P			P
Low Leakage Diode				P														
Diff/Angle Ended Inp. Stag.							P	P	P					P	P		P	P
Active Filter	P		S		P						S							
Oscillator	P		S		P						S	P	P					
Voltage Variable Resistor	P	P	S		P					P	P							P
Hybrid Chips	P	P		P	P		P	P	P	P	P				P			
Analog/Digital Switch		P				P				P							S	S
Multiplexing	P	P			S	S				P								
Choppers		P				P				P							P	
Nixie Drivers																		
Reed Relay Replacement						P												
Sub pA Dual Diff Pair								P	P									
Sample-Hold	P	P			S				S	P								P
Buffer Interface to CMOS										P	P							
Matched Switch							S							S	S		P	P
HF ≥ 400 MHz Prime												P	P					
Current Limiter		P								P								
Current Source			P	S	P						S							

P — Prime Choice S — Secondary (Alternate) Choice

FET Application Guide (Continued)

ADVANTAGES OF USING FIELD-EFFECT TRANSISTORS

APPLICATION	ADVANTAGES	FINAL ASSEMBLY WHERE USED
DC Amplifiers	High Z_{in} Low drift duals Low noise	Transducers, military guidance systems, control systems, temp indicators, multimeters
Low frequency amplifiers	Small coupling capacitors Low noise, distortion High input impedance	Sound detection, microphones, inductive transducers, hearing aids, high impedance transducers
Operational amplifiers	Summing point essentially zero. Low device noise. Less loading of transducers	Control systems, potted op amps, test equipment, medical electronics
Medium and high frequency amplifiers	Low cross modulation Low device noise	FM tuners, communication received scope inputs, most instrumentation equipment, high impedance inputs
Mixers — 100 MHz and up	Low mixing noise Low cross modulation	FM tuners, communication receivers
Oscillators	Low drift	Transmitters, receivers, organ
Logic gates	Virtually infinite fan in Simplified circuitry Zero storage time Symmetrical	Guidance controls, computer market mini military teaching aids, traffic control, telemetry
Choppers	Zero offset Low leakage currents Simplified circuitry Eliminates input transformers	Op amp modules guidance controls instrumentation equipment
AD Converters Multiplex switching (arrays) and sample hold	Improved isolation of input and output. Zero offset. Symmetrical. Low resistance Simplified circuitry	Control system, DVM's and any read-out equipment, medical electronics
Relay contact replacement	Solid state reliability Zero offset, High isolation Symmetrical No inductive spring No contact bounce High repetition rate	Test equipment, airborne equipment instrumentation market
Voltage variable resistor	Symmetrical Solid state reliability Functions as variable resistor. Low noise. High isolation Improved resolution	Organ, tone controls, control ckts to input operational amplifiers
Current limiters Sources	Two lead simplicity Wide selection range Low voltage operation	Hybrid circuits, amplifiers, power supply protection, timing ckts, voltage regulators

Important Parameters by Application

LISTED IN APPROXIMATE ORDER OF IMPORTANCE

Low Frequency Amplifier	Source Follower	Electrometer Amplifier	Low Drift Amplifier	Low Noise Amplifier	High Frequency Amplifier	Oscillator	Differential Amplifier	Analog and Digital Switch
y_{fs}	y_{fs}	I_G	I_{DZ}	e_n	$Re(y_{fs})$	y_{fs}	$\|V_{GS1}-V_{GS2}\|$	$R_{DS(ON)}$
I_{DSS}	I_G	y_{fs}	y_{fs} @ I_{DZ}	I_G	$Re(y_{is})$	I_{DSS}	$\frac{\Delta\|V_{GS1}-V_{GS2}\|}{\Delta T}$	$I_{D(off)}$
$V_{GS(off)}$	C_{rss}	I_{DZ}	V_{GS} @ I_{DZ}	i_n	NF	C_{rss}	$\|I_{G1}-I_{G2}\|$	C_{iss}
C_{iss}	C_{iss}	e_n	I_G	y_{fs}	C_{rss}	C_{iss}	I_G	C_{rss}
C_{rss}	I_{DSS}	g_{os}	BV_{GSS}	I_{DSS}	$Re(y_{os})$	$V_{GS(off)}$	y_{fs}	$V_{GS(off)}$
e_n	$V_{GS(off)}$			$V_{GS(off)}$	I_{DSS}	BV_{GSS}	y_{fs1}/y_{fs2}	BV_{GSS}
BV_{GSS}	BV_{GSS}				$V_{GS(off)}$		$\|y_{os1}-y_{os2}\|$	
							CMRR	
							$V_{GS(off)}$	

JFET Cross Reference Guide

Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type	Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
2N2386-5	P	TO-5		2N5462-5	8971	TO-92	2N3966	N	TO-72	2N3966		5029	TO-72
2N2386A	P	TO-5		2N5462-5	8971	TO-92	2N3967	N	TO-72	2N3967		5225	TO-72
2N2497	P	TO-5		2N3329-5	8923	TO-72	2N3967A	N	TO-72	2N3967A		5525	TO-72
2N2498	P	TO-5		2N3330-5	8923	TO-72	2N3968	N	TO-72	2N3968		5525	TO-72
2N2499	P	TO-5		2N3331-5	8923	TO-72	2N3968A	N	TO-72	2N3968A		5525	TO-72
2N2500	P	TO-5		2N3332-5	8923	TO-72	2N3969	N	TO-72	2N3969		5525	TO-72
2N2606	P	TO-18		2N5020	8911	TO-18	2N3969A	N	TO-72	2N3969A		5525	TO-72
2N2607	P	TO-18		2N5020	8911	TO-18	2N3970	N	TO-18	2N3970		5102	TO-18
2N2608	P	TO-18	2N2608		8911	TO-18	2N3971	N	TO-18	2N3971		5102	TO-18
2N2609	P	TO-18	2N2609		8911	TO-18	2N3972	N	TO-18	2N3972		5102	TO-18
2N2843	P	TO-18		2N5020	8911	TO-18	2N3993	P	TO-72		2N5116	8811	TO-72
2N2844	P	TO-18		2N5020	8911	TO-18	2N3993A	P	TO-72		2N5116	8811	TO-72
2N3066	N	TO-18		2N4340	5202	TO-18	2N3994	P	TO-72		2N5116	8811	TO-72
2N3067	N	TO-18		2N4338	5202	TO-18	2N3994A	P	TO-72		2N5116	8811	TO-72
2N3068	N	TO-18		2N4338	5202	TO-18	2N4084	N	TO-71	2N4084		8312	TO-71
2N3069	N	TO-18	2N3069		5202	TO-18	2N4085	N	TO-71	2N4085		8312	TO-71
2N3070	N	TO-18	2N3071		5202	TO-18	2N4091	N	TO-18	2N4091		5102	TO-18
2N3071	N	TO-18	2N3071		5202	TO-18	2N4092	N	TO-18	2N4092		5102	TO-18
2N3084	N	TO-5		2N4340-5	5202	TO-18	2N4093	N	TO-18	2N4093		5102	TO-18
2N3085	N	TO-18		2N4340	5202	TO-18	2N4117	N	TO-72	2N4117		5325	TO-72
2N3086	N	TO-5		2N4340	5202	TO-18	2N4117A	N	TO-72	2N4117A		5325	TO-72
2N3087	N	TO-18		2N4340	5202	TO-18	2N4118	N	TO-72	2N4118		5325	TO-72
2N3088	N	TO-5		2N4339-5	5202	TO-18	2N4118A	N	TO-72	2N4118A		5325	TO-72
2N3088A	N	TO-5		2N4339-5	5202	TO-18	2N4119	N	TO-72	2N4119		5325	TO-72
2N3089	N	TO-18		2N4339	5202	TO-18	2N4119A	N	TO-72	2N4119A		5325	TO-72
2N3089A	N	TO-18		2N4339	5202	TO-18	2N4139	N	TO-18		2N5363	5525	TO-72
2N3329	P	TO-72	2N3329		8923	TO-72	2N4220	N	TO-72	2N4220		5525	TO-72
2N3330	P	TO-72	2N3330		8923	TO-72	2N4220A	N	TO-72	2N4220A		5525	TO-72
2N3331	P	TO-72	2N3331		8923	TO-72	2N4221	N	TO-72	2N4221		5525	TO-72
2N3332	P	TO-72	2N3332		8923	TO-72	2N4221A	N	TO-72	2N4221A		5525	TO-72
2N3365	N	TO-18		2N4340	5202	TO-18	2N4222	N	TO-72	2N4222		5525	TO-72
2N3368	N	TO-18	2N3368		5202	TO-18	2N4222A	N	TO-72	2N4222A		5525	TO-72
2N3369	N	TO-18	2N3369		5202	TO-18	2N4223	N	TO-72	2N4223		5025	TO-72
2N3370	N	TO-18	2N3370		5202	TO-18	2N4224	N	TO-72	2N4224		5025	TO-72
2N3376	P	TO-72		2N3329	8923	TO-72	2N4302	N	TO-106	PN4302-18		5272	TO-92
2N3378	P	TO-72		2N3330	8923	TO-72	2N4303	N	TO-106	PN4303-18		5272	TO-92
2N3380	P	TO-72		2N3331	8923	TO-72	2N4304	N	TO-106	PN4304-18		5272	TO-92
2N3382	P	TO-72		2N5116	8811	TO-72	2N4338	N	TO-18	2N4338		5202	TO-18
2N3384	P	TO-72		2N5115	8811	TO-72	2N4339	N	TO-18	2N4339		5202	TO-18
2N3386	P	TO-72		2N5114	8811	TO-72	2N4340	N	TO-18	2N4340		5202	TO-18
2N3436	N	TO-18		2N4222	5525	TO-72	2N4341	N	TO-18	2N4341		5202	TO-18
2N3437	N	TO-18		2N3968	5525	TO-72	2N4342	P	TO-106	PN4342-18		8971	TO-92
2N3438	N	TO-18		2N5358	5525	TO-72	2N4360	P	TO-106	PN4360-18		8971	TO-92
2N3453	N	TO-72		2N4119	5325	TO-72	2N4381	P	TO-18	2N4318		8971	TO-92
2N3454	N	TO-72		2N4117	5325	TO-72	2N4382	P	TO-18	2N5115		8811	TO-18
2N3457	N	TO-72		2N4117	5325	TO-72	2N4391	N	TO-18	2N4391		5102	TO-18
2N3458	N	TO-18	2N3458		5202	TO-18	2N4392	N	TO-18	2N4392		5102	TO-16
2N3459	N	TO-18	2N3459		5202	TO-18	2N4393	N	TO-18	2N4393		5102	TO-18
2N3460	N	TO-18	2N3460		5202	TO-18	2N4416	N	TO-72	2N4416		5025	TO-72
2N3578	P	TO-18		2N2608	8911	TO-18	2N4416A	N	TO-72	2N4416A		5025	TO-72
2N3684	N	TO-72	2N3684		5225	TO-72	2N4445	N	TO-18		2N5432	5807	TO-52
2N3684A	N	TO-72		2N3684	5225	TO-72	2N4446	N	TO-18		2N5433	5807	TO-52
2N3685	N	TO-72	2N3685		5225	TO-72	2N4447	N	TO-18		2N5432	5807	TO-52
2N3685A	N	TO-72		2N3685	5225	TO-72	2N4448	N	TO-18		2N5433	5807	TO-52
2N3686	N	TO-72	2N3686		5225	TO-72	2N4856	N	TO-18	2N4856		5102	TO-18
2N3686A	N	TO-72		2N3686A	5225	TO-72	2N4856A	N	TO-18	2N4856A		5102	TO-18
2N3687	N	TO-72	2N3687		5225	TO-72	2N4857	N	TO-18	2N4857		5102	TO-18
2N3687A	N	TO-72		2N3687	5225	TO-72	2N4857A	N	TO-18	2N4857A		5102	TO-18
2N3819	N	TO-92	2N3819		5074	TO-92	2N4858	N	TO-18	2N4858		5102	TO-18
2N3820	P	TO-92	2N3820		8974	TO-92	2N4858A	N	TO-18	2N4858A		5102	TO-18
2N3821	N	TO-72	2N3821		5525	TO-72	2N4859	N	TO-18	2N4859		5102	TO-18
2N3822	N	TO-72	2N3822		5525	TO-72	2N4859A	N	TO-18	2N4859A		5102	TO-18
2N3823	N	TO-72	2N3823		5025	TO-72	2N4860	N	TO-18	2N4860		5102	TO-18
2N3824	N	TO-72	2N3824		5525	TO-72	2N4860A	N	TO-18	2N4860A		5102	TO-18
2N3909	P	TO-72		2N3820	8974	TO-92	2N4861	N	TO-18	2N4861		5102	TO-18
2N3909A	P	TO-72		2N5462	8971	TO-92	2N4861A	N	TO-18	2N4861A		5102	TO-18
2N3921	N	TO-71		2N3921	8312	TO-71	2N4867	N	TO-72		2N4339	5202	TO-18
2N3922	N	TO-71	2N3922		8312	TO-71	2N4868	N	TO-72		2N3459	5202	TO-18
2N3954	N	TO-71	2N3954		8312	TO-71	2N4869	N	TO-72		2N4341	5702	TO-18
2N3955	N	TO-71	2N3955		8312	TO-71	2N4977	N	TO-18		2N5432	5807	TO-52
2N3955A	N	TO-71	2N3955A		8312	TO-71	2N4978	N	TO-18		2N5433	5807	TO-52
2N3956	N	TO-71	2N3956		8312	TO-71	2N4979	N	TO-18		2N5434	5807	TO-52
2N3957	N	TO-71	2N3957		8312	TO-71	2N5018	P	TO-18	2N5018		8811	TO-18
2N3958	N	TO-71	2N3958		8312	TO-71	2N5019	P	TO-18	2N5019		8811	TO-18

Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type	Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
2N5020	P	TO-18	2N5020		8811	TO-18	2N5668	N	TO-92	2N5668		5072	TO-92
2N5021	P	TO-18	2N5021		8971	TO-92	2N5669	N	TO-92	2N5669		5072	TO-92
2N5033	P	TO-106	PN5033-18		8971	TO-92	2N5670	N	TO-92	2N5670		5072	TO-92
2N5045	N	TO-71	2N5045		8312	TO-71	2N5717	N	TO-92		PN3686	5272	TO-92
2N5046	N	TO-71	2N5046		8312	TO-71	2N5718	N	TO-92		PN4302	5272	TO-92
2N5047	N	TO-71	2N5047		8312	TO-71	2N5801	N	TO-92		J210	9072	TO-92
2N5078	N	TO-72	2N5078		5025	TO-72	2N5802	N	TO-92		J212	9072	TO-92
2N5103	N	TO-72	2N5103		5025	TO-72	2N5902	N	TO-78	2N5902		8424	TO-78
2N5104	N	TO-72	2N5104		5025	TO-72	2N5903	N	TO-78	2N5903		8424	TO-78
2N5105	N	TO-72	2N5105		5025	TO-72	2N5904	N	TO-78	2N5904		8424	TO-78
2N5114	P	TO-18	2N5114		8811	TO-18	2N5905	N	TO-78	2N5905		8424	TO-78
2N5115	P	TO-18	2N5115		8811	TO-18	2N5906	N	TO-78	2N5906		8424	TO-78
2N5116	P	TO-18	2N5116		8811	TO-18	2N5907	N	TO-78	2N5907		8424	TO-78
2N5158	N	TO-18		2N5433	8807	TO-52	2N5908	N	TO-78	2N5908		8424	TO-78
2N5159	N	TO-18		2N5432	5807	TO-52	2N5909	N	TO-78	2N5908		8424	TO-78
2N5163	N	TO-106	PN5163-18		5072	TO-18	2N5911	N	TO-78	2N5911		9324	TO-78
2N5196	N	TO-71	2N5196		8312	TO-18	2N5912	N	TO-78	2N5912		9324	TO-78
2N5197	N	TO-71	2N5197		8312	TO-18	2N5949	N	TO-106	2N5949-18		5077	TO-92
2N5198	N	TO-71	2N5198		8312	TO-18	2N5950	N	TO-106	2N5950-18		5077	TO-92
2N5199	N	TO-71	2N5199		8312	TO-18	2N5951	N	TO-106	2N5951-18		5077	TO-92
2N5245	N	TO-106	2N5245-18		9077	TO-92	2N5952	N	TO-106	2N5952-18		5077	TO-92
2N5246	N	TO-106	2N5246-18		9077	TO-92	2N5953	N	TO-106	2N5953-18		5077	TO-92
2N5247	N	TO-106	2N5247-18		9077	TO-92	2N6483	N	TO-71	2N6483		9512	TO-71
2N5248	N	TO-92	2N5248		5074	TO-92	2N6484	N	TO-71	2N6484		9512	TO-71
2N5358	N	TO-72	2N5358		5525	TO-72	2N6485	N	TO-71	2N6485		9512	TO-71
2N5359	N	TO-72	2N5359		5525	TO-72	2SK11	N	TO-72		2N3459	5202	TO-18
2N5360	N	TO-72	2N5360		5525	TO-72	2SK12	N	TO-72		2N4340	5202	TO-18
2N5361	N	TO-72	2N5361		5525	TO-72	2SK13	N	TO-72		2N4340	5202	TO-18
2N5362	N	TO-72	2N5362		5525	TO-72	2SK15	N	TO-72		2N4340	5202	TO-18
2N5363	N	TO-72	2N5363		5525	TO-72	2SK19	N	TO-106		2N5485-18	5072	TO-92
2N5364	N	TO-72	2N5364		5525	TO-72	2SK30	N	TO-92		PN4304	5272	TO-92
2N5397	N	TO-72	2N5397		9025	TO-72	2SK37	N	B-69		2N5484	5072	TO-92
2N5398	N	TO-72	2N5398		9025	TO-72	2SK48	N	TO-72		2N3686	5225	TO-72
2N5432	N	TO-18	2N5432		5807	TO-72	2SK68	N	TO-92		PF5101	5172	TO-92
2N5433	N	TO-18	2N5433		5807	TO-72	3SK22	N	TO-72		2N5078	5025	TO-72
2N5434	N	TO-18	2N5434		5807	TO-72	3SK23	N	TO-72		2N5397	9025	TO-72
2N5452	N	TO-71	2N5452		8312	TO-71	3SK28	N	TO-72		2N5078	5025	TO-72
2N5453	N	TO-71	2N5453		8312	TO-71	A5T3821	N	TO-92	2N3821		5525	TO-72
2N5454	N	TO-71	2N5454		8312	TO-71	A5T3822	N	TO-92	2N3822		5525	TO-72
2N5457	N	TO-92	2N5457		5572	TO-92	A5T3823	N	TO-92	2N3823		5029	TO-72
2N5458	N	TO-92	2N5458		5572	TO-92	A5T3824	N	TO-92	2N3824		5525	TO-72
2N5459	N	TO-92	2N5459		5572	TO-92	A5T5460	P	TO-92	2N5460		8971	TO-92
2N5460	P	TO-92	2N5460		8971	TO-92	A5T5461	P	TO-92	2N5461		8971	TO-92
2N5461	P	TO-92	2N5461		8971	TO-92	A5T5462	P	TO-92	2N5462		8971	TO-92
2N5462	P	TO-92	2N5462		8971	TO-92	BC264A	N	TO-92	BC264A		5077	TO-92
2N5471	P	TO-72		2N5020	8911	TO-18	BC264B	N	TO-92	BC264B		5077	TO-92
2N5472	P	TO-72		2N5020	8911	TO-18	BC264C	N	TO-92	BC264C		5077	TO-92
2N5473	P	TO-72		2N5020	8911	TO-18	BC264D	N	TO-92	BC264D		5077	TO-92
2N5474	P	TO-72		2N5020	8911	TO-18	BF244A	N	TO-92	BF244A		5074	TO-92
2N5475	P	TO-72		2N5020	8911	TO-18	BF244B	N	TO-92	BF244B		5074	TO-92
2N5476	P	TO-72		2N5020	8911	TO-18	BF244C	N	TO-92	BF244C		5074	TO-92
2N5484	N	TO-92	2N5484		5072	TO-92	BF245A	N	TO-92	BF245A		5077	TO-92
2N5485	N	TO-92	2N5485		5072	TO-92	BF245B	N	TO-92	BF245B		5077	TO-92
2N5486	N	TO-92	2N5486		5072	TO-92	BF245C	N	TO-92	BF245C		5077	TO-92
2N5515	N	TO-71	2N5515		9512	TO-71	BF246A	N	TO-92	BF246A		5174	TO-92
2N5516	N	TO-71	2N5516		9512	TO-71	BF246B	N	TO-92	BF246B		5174	TO-92
2N5517	N	TO-71	2N5517		9512	TO-71	BF246C	N	TO-92	BF246C		5174	TO-92
2N5518	N	TO-71	2N5518		9512	TO-71	BF247A	N	TO-92	BF247A		5177	TO-92
2N5519	N	TO-71	2N5519		9512	TO-71	BF247B	N	TO-92	BF247B		5177	TO-92
2N5520	N	TO-71	2N5520		9512	TO-71	BF247C	N	TO-92	BF247C		5177	TO-92
2N5521	N	TO-71	2N5521		9512	TO-71	BF256A	N	TO-92	BF256A		5077	TO-92
2N5522	N	TO-71	2N5522		9512	TO-71	BF256B	N	TO-92	BF256B		5077	TO-92
2N5523	N	TO-71	2N5523		9512	TO-71	BF256C	N	TO-92	BF256C		5077	TO-92
2N5524	N	TO-71	2N5524		9512	TO-71	BFW10	N	TO-72		2N4224	5025	TO-72
2N5545	N	TO-71	2N5545		8312	TO-71	BFW11	N	TO-72		2N5558	5025	TO-72
2N5546	N	TO-71	2N5546		8312	TO-71	BFW61	N	TO-72		2N4224	5025	TO-72
2N5547	N	TO-71	2N5547		8312	TO-71	BSV78	N	TO-18		2N4856	5102	TO-18
2N5549	N	TO-72		2N5397	9025	TO-72	BSV79	N	TO-18		2N4857	5102	TO-18
2N5555	N	TO-92	2N5555		5072	TO-92	BSV80	N	TO-18		2N4858	5102	TO-18
2N5556	N	TO-72	2N5556		5025	TO-72	E101	N	TO-106	J201-18		5272	TO-92
2N5557	N	TO-72	2N5557		5025	TO-72	E102	N	TO-106	J202-18		5272	TO-92
2N5558	N	TO-72	2N5558		5025	TO-72	E103	N	TO-106	J203-18		5272	TO-92
2N5561	N	TO-71	2N5561		9812	TO-71	E106	N	TO-106		J108-18	5872	TO-92
2N5562	N	TO-71	2N5562		9812	TO-71	E107	N	TO-106		J108-18	5872	TO-92
2N5563	N	TO-71	2N5563		9812	TO-71	E108	N	TO-106	J108-18		5872	TO-92
2N5564	N	TO-71	2N5564		9612	TO-71	E109	N	TO-106	J109-18		5872	TO-92
2N5565	N	TO-71	2N5565		9612	TO-71	E110	N	TO-106	J110-18		5872	TO-92
2N5566	N	TO-71	2N5566		9612	TO-71	E111	N	TO-106	J111-18		5172	TO-92
2N5592	N	TO-72		PN5163-18	5072	TO-92	E112	N	TO-106	J112-18		5172	TO-92
2N5593	N	TO-72		PN5163-18	5072	TO-92	E113	N	TO-106	J113-18		5172	TO-92
2N5594	N	TO-72		PN5163-18	5072	TO-92	E114	N	TO-106	J114-18		9072	TO-92
2N5638	N	TO-92	2N5638		5172	TO-92	E174	N	TO-106	J174-18		8874	TO-92
2N5639	N	TO-92	2N5639		5172	TO-92	E175	N	TO-106	J175-18		8874	TO-92
2N5640	N	TO-92	2N5640		5172	TO-92	E176	N	TO-106	J176-18		8874	TO-92
2N5653	N	TO-92	2N5653		5172	TO-92	E177	N	TO-106	J177-18		8874	TO-92
2N5654	N	TO-92	2N5654		5172	TO-92	E201	N	TO-106	J201-18		5272	TO-92

Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type	Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
E202	N	TO-106	J202-18		5272	TO-92	J309	N	TO-92	J309		9272	TO-92
E203	N	TO-106	J203-18		5272	TO-92	J310	N	TO-92	J310		9272	TO-92
E204	N	TO-106		PN4220-18	5572	TO-92	J3970	N	TO-92		PN4391	5172	TO-92
E210	N	TO-106	J210-18		9072	TO-92	J3971	N	TO-92		PN4392	5172	TO-92
E211	N	TO-106	J211-18		9072	TO-92	J3972	N	TO-92		PN4393	5172	TO-92
E212	N	TO-106	J212-18		9072	TO-92	J401	N	MiniDip	J401		9860	MiniDip
E230	N	TO-106		PN3821-18	5272	TO-92	J402	N	MiniDip	J402		9860	MiniDip
E231	N	TO-106		PN3684-18	5272	TO-92	J403	N	MiniDip	J403		9860	MiniDip
E232	N	TO-106		J203-18	5272	TO-92	J404	N	MiniDip	J404		9860	MiniDip
E270	P	TO-106	J270-18		8874	TO-92	J405	N	MiniDip	J405		9860	MiniDip
E271	P	TO-106	J271-18		8874	TO-92	J406	N	MiniDip	J406		9860	MiniDip
E300	N	TO-106	J300-18		9072	TO-92	J410	N	MiniDip	J410		8360	MiniDip
E304	N	TO-106	J304-18		5072	TO-92	J411	N	MiniDip	J411		8360	MiniDip
E305	N	TO-106	J305-18		5072	TO-92	J412	N	MiniDip	J412		8360	MiniDip
E308	N	TO-106	J308-18		9272	TO-92	J4091	N	TO-92	PN4091		5172	TO-92
E309	N	TO-106	J309-18		9272	TO-92	J4092	N	TO-92	PN4092		5172	TO-92
E310	N	TO-106	J310-18		9272	TO-92	J4093	N	TO-92	PN4093		5172	TO-92
E311	N	TO-106	J309		9272	TO-92	J4220	N	TO-92	PN4220		5572	TO-92
E312	N	TO-106		J310-18	9272	TO-92	J4221	N	TO-92	PN4221		5572	TO-92
E430	N	TO-71		2N5566	9612	TO-71	J4222	N	TO-92	PN4222		5572	TO-92
ESM4091	N	FO-18	2N4091		5102	TO-18	J4223	N	TO-92	PN4223		5072	TO-92
ESM4093	N	FO-18	2N4091		5102	TO-18	J4224	N	TO-92	PN4224		5072	TO-92
ESM4302	N	FO-18	PN4302-18		5272	TO-92	J4302	N	TO-92	PN4302		5272	TO-92
ESM4303	N	FO-18	PN4303-18		5272	TO-92	J4303	N	TO-92	PN4303		5272	TO-92
ESM4304	N	FO-18	PN4304-18		5272	TO-92	J4304	N	TO-92	PN4304		5272	TO-92
FT0654A	N			2N3824	5525	TO-72	J4338	N	TO-92		PN3687	5272	TO-92
FT0654B	N			2N3824	5525	TO-72	J4339	N	TO-92		PN3686	5272	TO-92
FT0654C	N			2N4221	5202	TO-18	J4391	N	TO-92	PN4391		5172	TO-92
FT3820	P	TO-18	2N3820-18		8974	TO-92	J4392	N	TO-92	PN4392		5172	TO-92
GET5457	N		2N5457		5572	TO-92	J4393	N	TO-92	PN4393		5172	TO-92
GET5458	N		2N5458		5572	TO-92	J4416	N	TO-92	PN4416		5072	TO-92
GET5459	N		2N5459		5572	TO-92	J4856	N	TO-92	PN4856		5172	TO-92
IMF3954	N	TO-71		2N3954	8312	TO-71	J4857	N	TO-92	PN4857		5172	TO-92
IMF3954A	N	TO-71		2N3954A	8312	TO-71	J4858	N	TO-92	PN4858		5172	TO-92
IMF3955	N	TO-71		2N3955	8312	TO-71	J4859	N	TO-92	PN4859		5172	TO-92
IMF3956	N	TO-71		2N3956	8312	TO-71	J4860	N	TO-92	PN4860		5172	TO-92
IMF3957	N	TO-71		2N3957	8312	TO-71	J4861	N	TO-92	PN4861		5172	TO-92
IMF3958	N	TO-71		2N3758	8312	TO-71	J5103	N	TO-92		J305	5072	TO-92
IMF6485	N	TO-71		2N6485	9512	TO-71	J5104	N	TO-92		J305	5072	TO-92
IT101	P	TO-18		2N5114	8811	TO-18	J5105	N	TO-92		J304	5072	TO-92
IT108	N			2N5486	5072	TO-92	K114-18	N			J114	9072	TO-92
ITE3066	N	TO-106		2N4340	5202	TO-18	K210-18	N		J210-18		9072	TO-92
ITE3067	N	TO-106		2N4338	5202	TO-18	K211-18	N		J211-18		9072	TO-92
ITE3068	N	TO-106		2N4338	5202	TO-18	K212-18	N		J212-18		9072	TO-92
ITE4117	N	TO-106	PN4117-18		5372	TO-92	K300-18	N		J300-18		9072	TO-92
ITE4118	N	TO-106	PN4118-18		5372	TO-92	K304-18	N		J304-18		5072	TO-92
ITE4119	N	TO-106	PN4119-18		5372	TO-92	K305-18	N		J305-18		5072	TO-92
ITE4338	N	TO-106		2N4338	5202	TO-18	K308-18	N		J308-18		9272	TO-92
ITE4339	N	TO-106		2N4339	5202	TO-18	K309-18	N		J308-18		9272	TO-92
ITE4340	N	TO-106		2N4340	5202	TO-18	K310-18	N		J310-18		9272	TO-92
ITE4341	N	TO-106		2N4391	5202	TO-18	KE510	N	TO-106		J111	5172	TO-92
ITE4391	N	TO-106	PN4391-18		5172	TO-92	KE511	N	TO-106		J111	5172	TO-92
ITE4392	N	TO-106	PN4392-18		5172	TO-92	KE3684	N	TO-106	PN3684-18		5272	TO-92
ITE4393	N	TO-106	PN4393-18		5172	TO-92	KE3685	N	TO-106	PN3685-18		5272	TO-92
ITE4416	N	TO-106	PN4416-18		5072	TO-92	KE3686	N	TO-106	PN3686-18		5272	TO-92
ITE4867	N	TO-106		PN3686-18	5272	TO-92	KE3687	N	TO-106	PN3687-18		5272	TO-92
ITE4868	N	TO-106		PN3685-18	5272	TO-92	KE3823	N	TO-106		PN4224-18	5072	TO-92
J108	N	TO-92	J108		5872	TO-92	KE3970	N	TO-106		PN4391-18	5172	TO-92
J109	N	TO-92	J109		5872	TO-92	KE3971	N	TO-106		PN4392-18	5172	TO-92
J110	N	TO-92	J110		5872	TO-92	KE3972	N	TO-106		PN4393-18	5172	TO-92
J111	N	TO-92	J111		5172	TO-92	KE4091	N	TO-106	PN4091-18		5172	TO-92
J111A	N	TO-92		PN4091	5172	TO-92	KE4092	N	TO-106	PN4092-18		5172	TO-92
J112	N	TO-92	J112		5172	TO-92	KE4093	N	TO-106	PN4093-18		5172	TO-92
J112A	N	TO-92		PN4092	5172	TO-92	KE4220	N	TO-106	PN4220-18		5572	TO-92
J113	N	TO-92	J113		5172	TO-92	KE4221	N	TO-106	PN4221-18		5572	TO-92
J113A	N	TO-92		PN4093	5172	TO-92	KE4222	N	TO-106	PN4222-18		5572	TO-92
J114	N	TO-92	J114		9072	TO-92	KE4223	N	TO-106	PN4223-18		5072	TO-92
J174	N	TO-92	J174		8874	TO-92	KE4224	N	TO-106	PN4224-18		5072	TO-92
J175	P	TO-92	J175		8874	TO-92	KE4391	N	TO-106	PN4391-18		5172	TO-92
J176	P	TO-92	J176		8874	TO-92	KE4392	N	TO-106	PN4392-18		5172	TO-92
J177	P	TO-92	J177		8874	TO-92	KE4393	N	TO-106	PN4393-18		5172	TO-92
J201	N	TO-92	J201		5272	TO-92	KE4416	N	TO-106	PN4416-18		5072	TO-92
J202	N	TO-92	J202		5274	TO-92	KE4856	N	TO-106	PN4856-18		5172	TO-92
J203	N	TO-92	J203		5272	TO-92	KE4857	N	TO-106	PN4857-18		5172	TO-92
J210	N	TO-92	J210		9072	TO-92	KE4858	N	TO-106	PN4858-18		5172	TO-92
J211	N	TO-92	J211		9072	TO-92	KE4859	N	TO-106	PN4859-18		5172	TO-92
J212	N	TO-92	J212		9072	TO-92	KE4860	N	TO-106	PN4860-18		5172	TO-92
J230	N	TO-92		J202	5272	TO-92	KE4861	N	TO-106	PN4861-18		5172	TO-92
J231	N	TO-92		J202	5272	TO-92	KE5103	N	TO-106		J305-18	5072	TO-92
J232	N	TO-92		J203	5272	TO-92	KE5104	N	TO-106		J305-18	5072	TO-92
J270	P	TO-92	J270		8874	TO-92	KE5105	N	TO-106		J304-18	5072	TO-92
J271	P	TO-92	J271		8874	TO-92	KK4416-18	N		PN4416-18		5072	TO-92
J300	N	TO-92	J300		9072	TO-92	MFE2000	N	TO-72		2N4416	5025	TO-72
J304	N	TO-92	J304		5072	TO-92	MFE2001	N	TO-72		2N4416	5025	TO-72
J305	N	TO-92	J305		5072	TO-92	MFE2004	N	TO-18		2N4093	5102	TO-18
J308	N	TO-92	J308		9272	TO-92	MFE2005	N	TO-18		2N4092	5102	TO-18

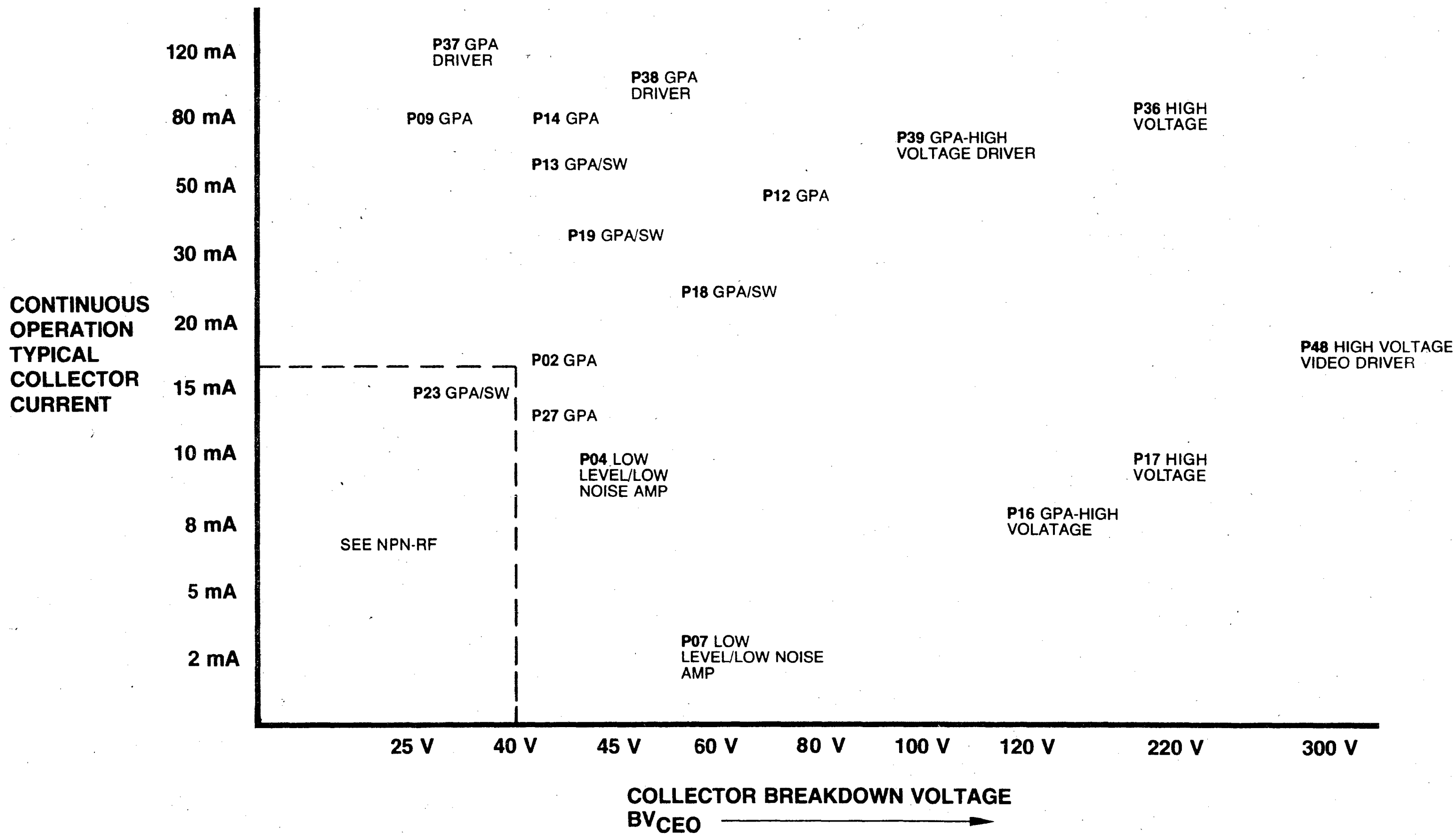
Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
MFE2006	N	TO-18		2N4091	5102	TO-18
MFE2007	N	TO-18		2N4857	5102	TO-18
MFE2008	N	TO-18		2N4391	5102	TO-18
MFE2009	N	TO-18		2N4856	5102	TO-18
MFE2010	N	TO-18		2N4856	5102	TO-18
MFE2011	N	TO-18		2N5433	5807	TO-52
MFE2012	N	TO-18		2N5433	5807	TO-52
MFE4007	P	TO-72		2N5020	8911	TO-18
MFE4008	P	TO-72		2N2608	8911	TO-18
MFE4009	P	TO-72		2N3329	8923	TO-72
MFE4010	P	TO-72		2N3330	8923	TO-72
MFE4011	P	TO-72		2N3331	8923	TO-72
MPF102	N	TO-92	MPF102		5072	TO-92
MPF103	N	TO-92	MPF103		5572	TO-92
MPF104	N	TO-92	MPF104		5072	TO-92
MPF105	N	TO-92	MPF105		5572	TO-92
MPF106	N	TO-92	MPF106		5072	TO-92
MPF107	N	TO-92	MPF107		5072	TO-92
MPF108	N	TO-92	MPF108		5072	TO-92
MPF109	N	TO-92	MPF109		5572	TO-92
MPF110	N	TO-92	MPF110		5072	TO-92
MPF111	N	TO-92	MPF111		5072	TO-92
MPF112	N	TO-92	MPF112		5072	TO-92
MPF161	P	TO-92		2N5461	8971	TO-92
MPF256	N	TO-92	MPF256		9072	TO-92
MPF820	N	TO-92	MPF820		9272	TO-92
MPF970	P	TO-92		P1086	8871	TO-92
MPF971	P	TO-92		P1087	8871	TO-92
MPF4391	N	TO-92	PN4391		5172	TO-92
MPF4392	N	TO-92	PN4392		5172	TO-92
MPF4393	N	TO-92	PN4393		5172	TO-92
NDF9401	N	TO-78		NDF9406	9412	TO-71
NDF9402	N	TO-78		NDF9407	9412	TO-71
NDF9403	N	TO-78		NDF9408	9412	TO-71
NDF9404	N	TO-78		NDF9409	9412	TO-71
NDF9405	N	TO-78		NDF9410	9412	TO-71
NDF9406	N	TO-71	NDF9406		9412	TO-71
NDF9407	N	TO-71	NDF9407		9412	TO-71
NDF9408	N	TO-71	NDF9408		9412	TO-71
NDF9409	N	TO-71	NDF9409		9412	TO-71
NDF9410	N	TO-71	NDF9410		9412	TO-71
NF500	N	TO-72		2N4224	5025	TO-72
NF501	N	TO-72		2N4224	5025	TO-72
NF506	N	TO-72		2N3823	5025	TO-72
NF510	N	TO-18		2N4092	5102	TO-18
NF511	N	TO-18		2N4092	5102	TO-18
NF520	N	TO-72		2N4224	5025	TO-72
NF521	N	TO-72		2N4220	5525	TO-72
NF522	N	TO-72		2N4224	5025	TO-72
NF523	N	TO-72		2N4220	5525	TO-72
NF530	N	TO-18		2N3822	5525	TO-72
NF531	N	TO-18		2N3821	5525	TO-72
NF532	N	TO-18		2N3822	5525	TO-72
NF533	N	TO-18		2N3821	5525	TO-72
NF3819	N	TO-18	2N3819-18		5074	TO-92
NF4302	N	TO-18	PN4302-18		5272	TO-92
NF4303	N	TO-18	PN4303-18		5272	TO-92
NF4304	N	TO-18	PN4304-18		5272	TO-92
NF4445	N	TO-18		2N5432	5807	TO-52
NF4446	N	TO-18		2N5433	5807	TO-52
NF4447	N	TO-18		2N5432	5807	TO-52
NF4448	N	TO-18		2N4856	5807	TO-52
NF5101	N	TO-72	NF5101		5125	TO-72
NF5102	N	TO-72	NF5102		5125	TO-72
NF5103	N	TO-72	NF5103		5125	TO-72
NF5163	N	TO-18	PN5163-18		5072	TO-72
NF5457	N	TO-18	2N5457-18		5572	TO-92
NF5458	N	TO-18	2N5458-18		5572	TO-92
NF5459	N	TO-18	2N5459-18		5572	TO-92
NF5484	N	TO-18	2N5484-18		5072	TO-92
NF5485	N	TO-18	2N5485-18		5072	TO-92
NF5486	N	TO-18	2N5486-18		5072	TO-92
NF5555	N	TO-72	2N5555-18		5072	TO-92
NF5638	N	TO-18	2N5638-18		5172	TO-92
NF5639	N	TO-18	2N5639-18		5172	TO-92
NF5640	N	TO-18	2N5640-18		5172	TO-92
NF5653	N	TO-18	2N5653-18		5172	TO-92
NF5654	N	TO-18	2N5654-18		5172	TO-92
P1086E	P	TO-106	P1086-18		8871	TO-92
P1087E	P	TO-106	P1087-18		8871	TO-92
PF510	P	TO-18		PN4392-18	5172	TO-92
PF511	P	TO-18		PN4392-18	5172	TO-92
PF5101	N	TO-92	PF5101		5172	TO-92
PF5102	N	TO-92	PF5102		5172	TO-92
PF5103	N	TO-92	PF5103		5172	TO-92
PN3684	N	TO-92	PN3684		5272	TO-92

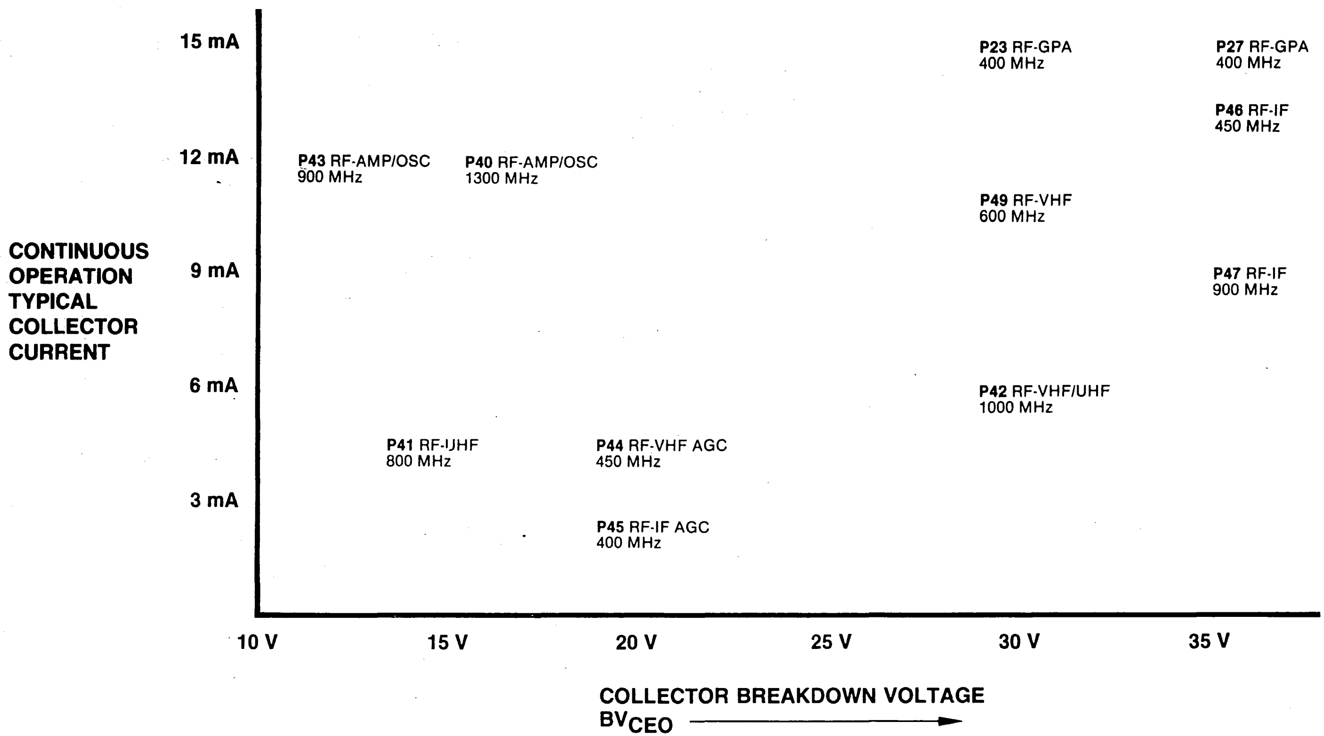
Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
PN3685	N	TO-92	PN3685		5272	TO-92
PN3686	N	TO-92	PN3686		5272	TO-92
PN3687	N	TO-92	PN3687		5272	TO-92
PN4091	N	TO-92	PN4091		5172	TO-92
PN4092	N	TO-92	PN4092		5172	TO-92
PN4093	N	TO-92	PN4093		5172	TO-92
PN4220	N	TO-92	PN4220		5572	TO-92
PN4221	N	TO-92	PN4221		5572	TO-92
PN4222	N	TO-92	PN4222		5572	TO-92
PN4223	N	TO-92	PN4223		5072	TO-92
PN4224	N	TO-92	PN4224		5072	TO-92
PN4302	N	TO-92	PN4302		5272	TO-92
PN4303	N	TO-92	PN4303		5272	TO-92
PN4304	N	TO-92	PN4304		5272	TO-92
PN4342	N	TO-92	PN4342		8971	TO-92
PN4360	N	TO-92	PN4360		8971	TO-92
PN4391	N	TO-92	PN4391		5172	TO-92
PN4392	N	TO-92	PN4392		5172	TO-92
PN4393	N	TO-92	PN4393		5172	TO-92
PN4416	N	TO-92	PN4416		5072	TO-92
PN4856	N	TO-92	PN4856		5172	TO-92
PN4857	N	TO-92	PN4857		5172	TO-92
PN4858	N	TO-92	PN4858		5172	TO-92
PN4859	N	TO-92	PN4859		5172	TO-92
PN4860	N	TO-92	PN4860		5172	TO-92
PN4861	N	TO-92	PN4861		5172	TO-92
PN5033	N	TO-92	PN5033		8971	TO-92
PN5163	N	TO-92	PN5163		5072	TO-92
SU2000	N	TO-71		2N3822	5525	TO-72
SU2020	N	TO-71		2N5196	8312	TO-71
SU2021	N	TO-71		2N5196	8312	TO-71
SU2022	N	TO-71		2N5196	8312	TO-71
SU2023	N	TO-71		2N5196	8312	TO-71
SU2024	N	TO-71		2N5196	8312	TO-71
SU2025	N	TO-71		2N5196	8312	TO-71
SU2026	N	TO-71		2N5196	8312	TO-71
SU2027	N	TO-71		2N5196	8312	TO-71
SU2028	N	TO-71		2N5196	8312	TO-71
SU2029	N	TO-71		2N5196	8312	TO-71
SU2030	N	TO-71		2N4082	8312	TO-71
SU2033	N	TO-71		2N5561	8312	TO-71
SU2034	N	TO-71		2N5561	8312	TO-71
SU2035	N	TO-71		2N5561	8312	TO-71
SU2076	N	TO-71		2N5561	8312	TO-71
SU2077	N	TO-71		2N5561	8312	TO-71
SU2078	N	TO-71		2N3955	8312	TO-71
SU2079	N	TO-71		2N3956	8312	TO-71
SU2080	N	TO-71		U404	9812	TO-71
SU2081	N	TO-71		U404	9812	TO-71
SU2098	N	TO-71		2N3954	8312	TO-71
SU2098A	N	TO-71		2N3954	8312	TO-71
SU2098B	N	TO-71		2N3954A	8312	TO-71
SU2099	N	TO-71		2N3955A	8312	TO-71
SU2099A	N	TO-71		2N3955A	8312	TO-71
SU2365	N	TO-71		U401	9812	TO-71
SU2365A	N	TO-71		U401	9812	TO-71
SU2366	N	TO-71		U402	9812	TO-71
SU2366A	N	TO-71		U402	9812	TO-71
SU2367	N	TO-71		U403	9812	TO-71
SU2367A	N	TO-71		U403	9812	TO-71
SU2368	N	TO-71		U404	9812	TO-71
SU2368A	N	TO-71		U404	9812	TO-71
SU2369	N	TO-71		U405	9812	TO-71
SU2369A	N	TO-71		U405	9812	TO-71
SU2652M	N	MiniDip		J401	9860	MiniDip
SU2653M	N	MiniDip		J401	9860	MiniDip
SU2654M	N	MiniDip		J401	9860	MiniDip
SU2655M	N	MiniDip		J402	9860	MiniDip
SU2656M	N	MiniDip		J404	9860	MiniDip
TD5452	N	TO-18/8		2N5452	8312	TO-71
TD5453	N	TO-18/8		2N5453	8312	TO-71
TD5454	N	TO-18/8		2N5454	8312	TO-71
TD5902	N	TO-18/8	2N5902		8424	TO-78
TD5902A	N	TO-18/8		2N5902	8424	TO-78
TD5903	N	TO-18/8	2N5903		8424	TO-78
TD5903A	N	TO-18/8		2N5903	8424	TO-78
TD5904	N	TO-18/8	2N5904		8424	TO-78
TD5904A	N	TO-18/8		2N5904	8424	TO-78
TD5905	N	TO-18/8	2N5905		8424	TO-78
TD5905A	N	TO-18/8		2N5905	8424	TO-78
TD5906	N	TO-18/8	2N5906		8424	TO-78
TD5906A	N	TO-18/8		2N5906	8424	TO-78
TD5907	N	TO-18/8	2N5907		8424	TO-78
TD5907A	N	TO-18/8		2N5907	8424	TO-78
TD5908	N	TO-18/8	2N5908		8424	TO-78
TD5908A	N	TO-18/8		2N5908	8424	TO-78

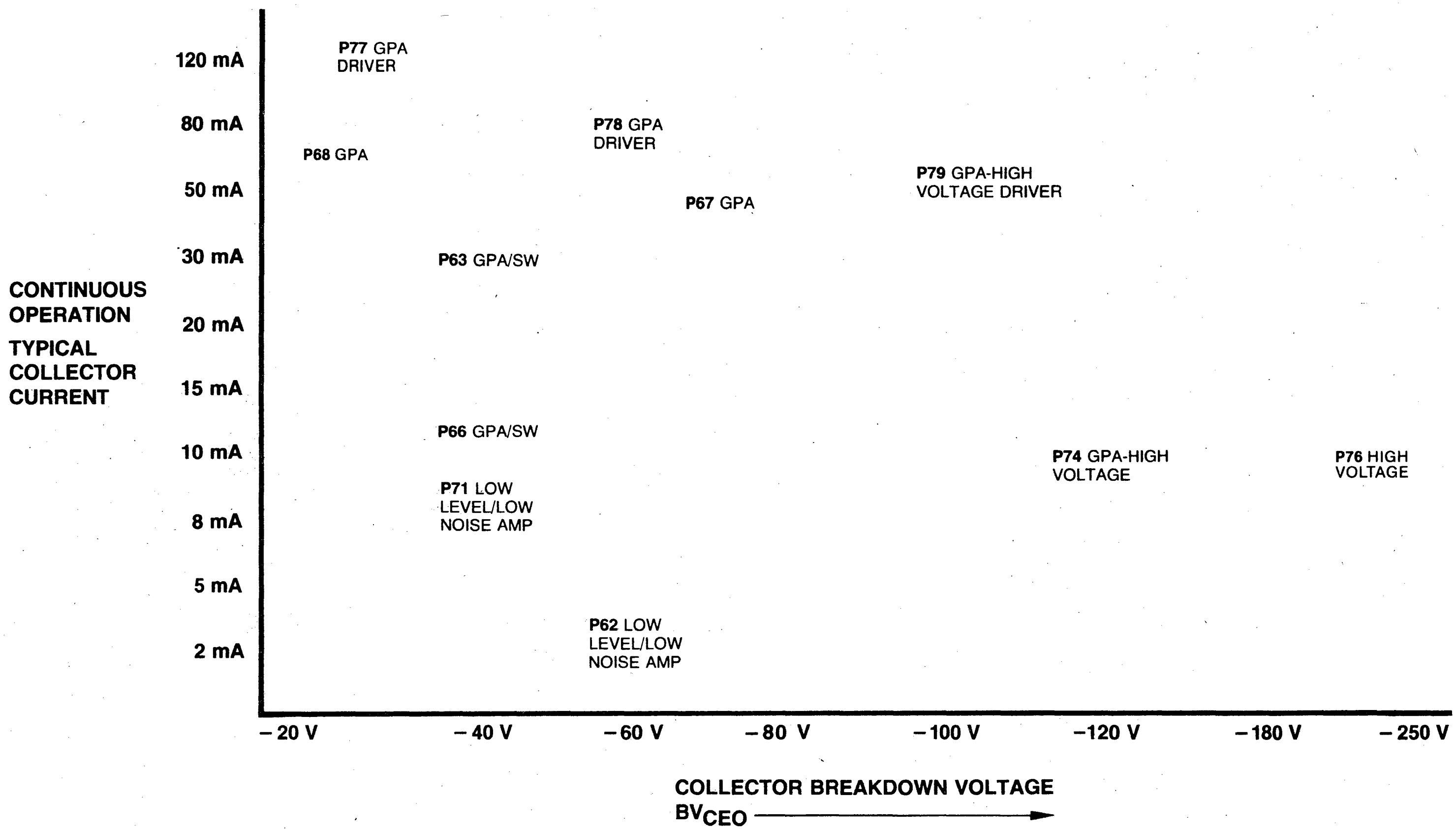
Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type	Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
TD5909	N	TO-18/8	2N5909		8424	TO-78	U312	N	TO-18	U312		9007	TO-52
TD5909A	N	TO-18/8		2N5909	8424	TO-78	U316	N	B-69	U309		9207	TO-52
TD5910	N	TO-18/8	2N5910		8424	TO-78	U317	N	B-69	U310		9207	TO-52
TD5910A	N	TO-18/8		2N5910	8424	TO-78	U320	N	TO-5		2N5433	5807	TO-52
TD5911	N	TO-18/8	2N5911		9324	TO-78	U321	N	TO-5		2N5433	5807	TO-52
TD5911A	N	TO-18/8		2N5911	9324	TO-78	U322	N	TO-5		2N5432	5807	TO-52
TD5912	N	TO-18/8	2N5912		9324	TO-78	U401	N	TO-71	U401		9812	TO-71
TD5912A	N	TO-18/8		2N5912	9324	TO-78	U402	N	TO-71	U402		9812	TO-71
TIS25	N	TO-5/6		U401	9812	TO-71	U403	N	TO-71	U403		9812	TO-71
TIS26	N	TO-5/6		U402	9812	TO-71	U404	N	TO-71	U404		9812	TO-71
TIS27	N	TO-5/6		U403	9812	TO-71	U405	N	TO-71	U405		9812	TO-71
TIS34	N	TO-92		2N5486	5072	TO-92	U406	N	TO-71	U406		9812	TO-71
TIS41	N	TO-18		2N4859	5172	TO-92	U440	N	TO-71		2N5911	9324	TO-78
TIS42	N	TO-92		PN4392	5172	TO-92	U441	N	TO-71		2N5912	9324	TO-78
TIS58	N	TO-92	TIS58		5074	TO-92	U1837E	N	TO-106		2N5486-18	5072	TO-92
TIS59	N	TO-92	TIS59		5074	TO-92	U1897	N	TO-106	U1897		5172	TO-92
TIS73	N	TO-18	TIS73		5177	TO-92	U1897E	N	TO-106		U1897-18	5172	TO-92
TIS74	N	TO-18	TIS74		5177	TO-92	U1898	N	TO-106	U1898		5172	TO-92
TIS75	N	TO-18	TIS75		5177	TO-92	U1898E	N	TO-106		U1898-18	5172	TO-92
TIS88A	N	TO-18		2N5486	5072	TO-92	U1899	N	TO-106	U1899		5172	TO-92
TP5114	P	TO-18	2N5114		8811	TO-18	U1899E	N	TO-106		U1899-18	5172	TO-92
TP5115	P	TO-18	2N5115		8811	TO-18	U1994	N	TO-106		PN4416-18	5072	TO-92
TP5116	P	TO-18	2N5116		8811	TO-18	U1994E	N	TO-106		PN4416-18	5072	TO-92
U110	P	TO-18		2N5020	8911	TO-18	U2047	N	TO-92		PN4416	5072	TO-92
U112	P	TO-18		2N4318	8911	TO-18	U2047E	N	TO-106		PN4416-18	5072	TO-92
U146	P	TO-18		2N5020	8911	TO-18	UC155	N	TO-72		2N4416	5025	TO-72
U147	P	TO-18		2N5020	8911	TO-18	UC200	N	TO-72		2N4393	5102	TO-18
U148	P	TO-18		2N2608	8911	TO-18	UC201	N	TO-72		2N4416	5025	TO-72
U149	P	TO-18		2N2609	8811	TO-18	UC210	N	TO-72		2N3822	5525	TO-72
U183	N	TO-72		2N3823	5025	TO-72	UC220	N	TO-72		2N4220	5525	TO-72
U184	N	TO-72		2N4416	5025	TO-72	UC241	N	TO-72		2N3822	5525	TO-72
U197	N	TO-18		2N4338	5202	TO-18	UC250	N	TO-18		2N4391	5102	TO-18
U198	N	TO-18		2N4340	5202	TO-18	UC251	N	TO-18		2N4392	5102	TO-18
U199	N	TO-18		2N4341	5202	TO-18	UC400	P	TO-72		2N2609	8811	TO-18
U200	N	TO-18		2N4393	5102	TO-18	UC401	P	TO-72		2N5019	8811	TO-18
U201	N	TO-18		2N4392	5102	TO-18	UC410	P	TO-72		2N2609	8811	TO-18
U202	N	TO-18		2N4391	5102	TO-18	UC420	P	TO-72		2N3329	8923	TO-72
U231	N	TO-71	U231		8312	TO-71	UC588	N	TO-106		PN4416-18	5072	TO-92
U232	N	TO-71	U232		8312	TO-71	UC703	N	TO-72		2N3822	5525	TO-72
U233	N	TO-71	U233		8312	TO-71	UC705	N	TO-72		2N3824	5525	TO-72
U234	N	TO-71	U234		8312	TO-71	UC707	N	TO-18		2N4391	5102	TO-18
U235	N	TO-71	U235		8312	TO-71	UC714	N	TO-72		2N4416	5025	TO-72
U257	N	TO-78	U257		9324	TO-78	UC734	N	TO-72		2N4416	5025	TO-72
U300	P	TO-18		2N5114	8811	TO-18	UC734E	N	TO-106		PN4416-18	5072	TO-92
U301	P	TO-18		2N5145	8811	TO-18	UC755	N	TO-18		2N4391	5102	TO-18
U304	P	TO-18		2N5114	8811	TO-18	UC756	N	TO-18		2N4224	5025	TO-72
U305	P	TO-18		2N5116	8811	TO-18	UC805	P	TO-72		2N3331	8923	TO-72
U308	N	TO-52	U308		9207	TO-52	UC807	P	TO-72		2N4861	5102	TO-18
U309	N	TO-52	U309		9207	TO-52	UC814	P	TO-72		2N3331	8923	TO-72
U310	N	TO-52	U310		9207	TO-52	UC851	P	TO-18		2N2608	8911	TO-18

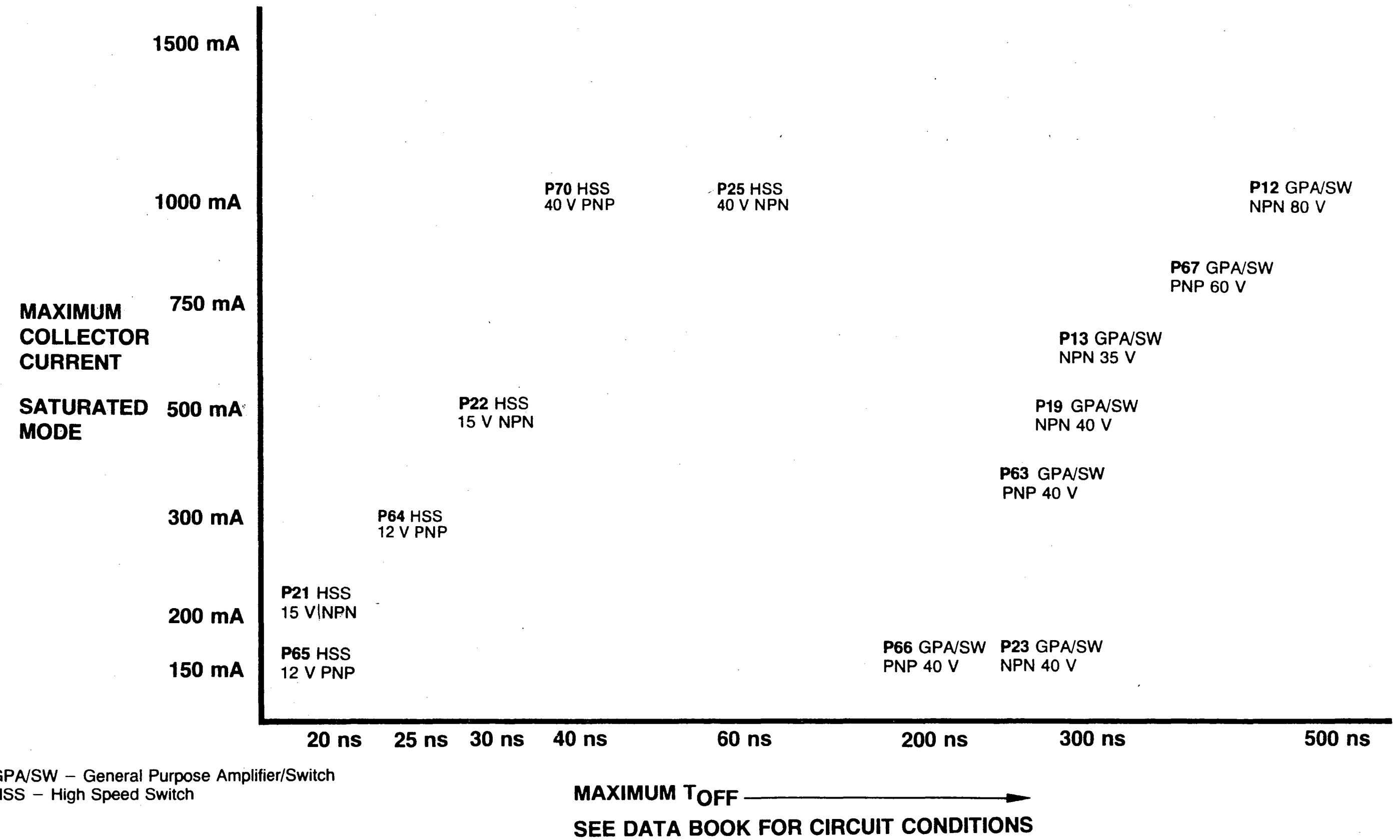
RF Selector Guide

	BIPOLARS									JFETs		
	40	41	42	43	44	45	46	47	49	50	90	92
Preamplifiers												
> 500 MHz		•										
> 500 MHz with AGC												
200–500 MHz	•	•	•							•		•
200–500 MHz with AGC					•							
50–250 MHz			•		•			•		•	•	•
50–250 MHz with AGC					•							
20–120 MHz					•	•			•	•	•	
Mixers												
Input > 500 MHz		•										
Input 200–500 MHz	•		•					•		•	•	•
Input 50–250 MHz	•		•		•			•	•	•	•	
Input 20–120 MHz							•	•	•	•	•	
Loc Osc												
> 500 MHz Mech. Tuned			•	•								
> 500 MHz Varactor	•		•									
200–500 MHz Mech. Tuned				•				•				
200–500 MHz Varactor	•		•					•				
50–250 MHz				•				•				
20–120 MHz				•				•				
IF Amps												
< 75 MHz			•			•	•	•	•	•	•	
< 15 MHz				•			•	•		•		
< 75 MHz with AGC					•	•						
< 15 MHz with AGC					•							
< 75 MHz Last Stage							•	•	•			
< 15 MHz Last Stage							•		•	•		
Special Uses												
200–500 MHz < 1.0 mA Bias	•		•									
50–250 MHz < 1.0 mA Bias	•		•					•				
200–500 MHz 5–15 mA Linear IF	•											
50–250 MHz 5–15 mA Linear IF								•				•
< 120 MHz/15 mA Wideband RF								•				•
VHF Freq. Generator and/or Multiplier to 75 mW Levels	•			•								


CONTINUOUS
OPERATION
TYPICAL
COLLECTOR
CURRENT
120 mA
80 mA
50 mA
30 mA
20 mA
15 mA
10 mA
8 mA
5 mA
2 mA
P37 GPA
DRIVER
P38 GPA
DRIVER
P09 GPA
P14 GPA
P36 HIGH
VOLTAGE
P39 GPA-HIGH
VOLTAGE DRIVER
P13 GPA/SW
P12 GPA
P19 GPA/SW
P18 GPA/SW
P48 HIGH VOLTAGE
VIDEO DRIVER
P02 GPA
P23 GPA/SW
P27 GPA
P04 LOW
LEVEL/LOW
NOISE AMP
P17 HIGH
VOLTAGE
P16 GPA-HIGH
VOLATAGE
SEE NPN-RF
P07 LOW
LEVEL/LOW NOISE
AMP
25 V
40 V
45 V
60 V
80 V
100 V
120 V
220 V
300 V
COLLECTOR BREAKDOWN VOLTAGE
BVCEO


CONTINUOUS OPERATION TYPICAL COLLECTOR CURRENT
15 mA
12 mA
9 mA
6 mA
3 mA
10 V
15 V
20 V
25 V
30 V
35 V
COLLECTOR BREAKDOWN VOLTAGE BV_{CEO}
P43 RF-AMP/OSC 900 MHz
P40 RF-AMP/OSC 1300 MHz
P41 RF-UHF 800 MHz
P44 RF-VHF AGC 450 MHz
P45 RF-IF AGC 400 MHz
P23 RF-GPA 400 MHz
P49 RF-VHF 600 MHz
P42 RF-VHF/UHF 1000 MHz
P27 RF-GPA 400 MHz
P46 RF-IF 450 MHz
P47 RF-IF 900 MHz


120 mA
80 mA
50 mA
30 mA
20 mA
15 mA
10 mA
8 mA
5 mA
2 mA
CONTINUOUS OPERATION
TYPICAL COLLECTOR CURRENT
P77 GPA DRIVER
P68 GPA
P78 GPA DRIVER
P67 GPA
P79 GPA-HIGH VOLTAGE DRIVER
P63 GPA/SW
P66 GPA/SW
P71 LOW LEVEL/LOW NOISE AMP
P62 LOW LEVEL/LOW NOISE AMP
P74 GPA-HIGH VOLTAGE
P76 HIGH VOLTAGE
– 20 V
– 40 V
– 60 V
– 80 V
– 100 V
–120 V
– 180 V
– 250 V
COLLECTOR BREAKDOWN VOLTAGE
BVCEO



GPA/SW – General Purpose Amplifier/Switch
HSS – High Speed Switch

TO-237 Type Power Transistor Selection Guide

Part Number NPN	PNP	I_C (A)	V_{CEO} (V)	h_{FE} Min	Max	@ I_C(mA)	V_{CE} (V)	Max $V_{CE\,(SAT)}$ (V)	@ I_C(mA)	P_D (W)	f_T (MHz)	Process (NPN/PNP)
92PE869	92PE870	0.1	250	50		25	20			*	60	17/76
92PE871	92PE872	0.1	300	50		25	20				60	17/76
2N6711/ 92PE487		0.1	160	30		30	10	1	30		50	48
2N6733/ 92PU391		0.1	200	40		10	10	2	20		50	48
2N6712/ 92PE488		0.1	250	30		30	10	1	30	*	50	48
2N6734/ 92PU392		0.1	250	40		10	10	2	20		50	48
2N6773/ 92PE489		0.1	300	30		30	10	1	30		50	48
2N6735/ 92PU393		0.1	300	40		10	10	2	20	*	50	48
2N6719/ 92PU10		0.1	300	40		30	10	0.75	30		50	48
TN2219		0.5	30	100	300	150	10	0.4	150		250	19
				30		500	10					
TN2218A		0.5	40	40	120	150	10	0.3	150		250	19
				25		500	10					
TN2219A	TN2905	0.5	40	100	300	150	10	0.3/ 0.4	150	*	300	19/63
	TN2904A	0.5	60	40	120	150	10	0.4	150		200	63
				40		500	10					
	TN2905A	0.5	60	100	300	150	10	0.4	150		200	63
				50		500	10					
TN3053	TN4037	1	40	50	250	150	10	1.4	150		100	12/63
2N6737		1	45	60	150	100	1	0.4	300		300	25
				40		300				*		
TN3726		1	50	60	150	100	1	0.4	300		300	25
				40		300						
TN2102	TN4036	1	65	40	120	150	10	0.5/ 0.65	150		60	12/67
				25		500	10					
TN3019		1	80	100	300	150	10	0.2	150	*	100	12
TN3020		1	80	40	120	150	10	0.2	150		100	12
	TN4033	1	80	100	300	100	5	0.15	150		150	67
2N6720/ 92PU36		1	150	30	300	100	10	0.5	100		10	36
2N6721/ 92PU36A		1	200	0		00	10	0.5	00		10	36
2N6722/ 92PU36B		1	250							*	10	36
2N6723/ 92PU36C		1	300								10	36
TN3724		1.5	30	60	150	100	1	0.2	100		300	25
				40		300	1	0.32	300			

*All TO-237: 850 mW, free air ($T_A = 25°C$)
2.0W, collector lead at 25°C
1W-1.2W mounted flush in PC board

TO-237 Type Power Transistor Selection Guide (Continued)

Part Number NPN	Part Number PNP	I_C (A)	V_{CEO} (V)	h_{FE} Min	h_{FE} Max	@ I_C(mA)	@ V_{CE} (V)	Max $V_{CE\,(SAT)}$ (V)	@ I_C(mA)	P_D (W)	f_T (MHz)	Process (NPN/PNP)
2N6714/	2N6726/	2	30	60		100	1	0.5	1000		50	37/77
92PU01	92PU51			55		1000	1					
2N6715/	2N6727/	2	40	60		100	1	0.5	1000		50	37/77
92PU01A	92PU51A			55		1000	1					
2N6724/		2	40	25k		200	5	1	200	*	100	05
92PU45				4k		1000	5	1.5	1000			
2N6705/	2N6708/	2	45	40		500	2	0.5	500		50	38/78
92PE37A	92PE77A											
2N6725		2	50	25k		200	5	1	200		100	05
92PU45A				4k		1000	5	1.5	1000			
2N6706/	2N6709/	2	60	40		500	2	0.5	500		50	38/78
92PE37B	92PE77B											
2N6716/	2N6728/	2	60	20		500	1	0.35	250		50	38/78
92PU05	92PU55											
2N6731/	2N6732/	2	80	100	300	350	2	0.35	350	*	50	39/79
92PU100	92PU200											
2N6707/	2N6710/	2	80	40		500	2	0.5	500		50	39/79
92PE37C	92PE77C											
2N6717/	2N6720/	2	80	20		500	1	0.35	250		50	39/79
92PU06	92PU56											

Pinout: 92PE ECB
92PU, TN EBC

*All TO-237: 850 mW, free air ($T_A = 25°C$)
2.0W, collector lead at 25°C
1W-1.2W mounted flush in PC board

TO-202 Type Power Transistor Selection Guide

Part Number NPN	Part Number PNP	I_C (A)	V_{CEO} (V)	h_{FE} Min	h_{FE} Max	@ I_C(A)	@ V_{CE} (V)	Max $V_{CE(SAT)}$ (V)	@ I_C(A)	P_D (W)	f_T (MHz)	Process (NPN/PNP)
NSD457		0.1	160	25		0.03	10	1	0.03	1.75	50	48
NSE457		0.1	160	25		0.03	10	1	0.03	1.75	50	48
NSD458		0.1	250	25		0.03	10	1	0.03	1.75	50	48
NSE458		0.1	250	25		0.03	10	1	0.03	1.75	50	48
D40N1		0.1	250	30	90	0.02	10			1.67	50	48
D40N2		0.1	250	60	180	0.02	10			1.67	50	48
NSD131		0.1	250	30	90	0.03	10	1	0.02	1.75		48
NSD132		0.1	250	60	180	0.03	10	1	0.02	1.75		48
NSE869	NSE870	0.1	250	50		25m	20			1.8	60	17/76
NSD871	NSE872	0.1	300	50		25m	20			1.8	60	17/76
D40N3		0.1	300	30	90	0.02	10			1.67	50	48
D40N4		0.1	300	60	180	0.02	10			1.67	50	48
NSD133		0.1	300	30	90	0.03	10	1	0.02	1.75	50	48
NSD134		0.1	300	60	180	0.03	10	1	0.02	1.75	50	48
NSD459		0.1	300	25		0.03	10	1	0.03	1.75	50	48
NSE459		0.1	300	25		0.03	10	1	0.03	1.75	50	48
NSDU10		0.1	300	40		0.03	10	1.5	0.02	1.75	60	48
D40N5		0.1	375	20		0.02	10			1.67	50	48
NSD135		0.1	375	30	90	0.03	10	1	0.02	1.75	50	48
D40C1		0.5	30	10k	60k	0.2	5	1.5	0.5	1.33	75	05
D40C2		0.5	30	40k		0.2	5	1.5	0.5	1.33	75	05
D40C3		0.5	30	90k		0.2	5	1.5	0.5	1.33	75	05
D40C4		0.5	40	10k	60k	0.2	5	1.5	0.5	1.33	75	05
D40C5		0.5	40	40k		0.2	5	1.5	0.5	1.33	75	05
D40C7		0.5	50	10k	60k	0.2	5	1.5	0.5	1.33	75	05
D40C8		0.5	50	40k		0.2	5	1.5	0.5	1.33	75	05
D40P1		0.5	120	40		0.08	10	1	0.1	1.67	50	36
D40P3		0.5	180	40		0.08	10	1	0.1	1.67	50	36
D40P5		0.5	225	40		0.08	10	1	0.1	1.67	50	36
D40D1	D41D1	1	30	50	150	0.1	2	0.5	0.5	1.67	200	38/78
D40D2	D41D2	1	30	120	300	0.1	2	0.5	0.5	1.67	200	38/78
D40D3		1	30	290		0.1	2			1.67	200	38
D40D4	D41D4	1	45	50	150	0.1	2	0.5	0.5	1.67	200	38/78
D40D5	D41D5	1	45	120	360	0.1	2	0.5	0.5	1.67	200	38/78
NSD102	NSD202	1	45	50	150	0.1	5	0.2	0.1	1.75	60	38/78
NSD103	NSD203	1	45	120	360	0.1	5	0.2	0.1	1.75	60	38/78
D40D7	D41D7	1	60	50	150	0.1	2	1	0.5	1.67	200	38/78
D40D8	D41D8	1	60	120	360	0.1	2	1	0.5	1.67	200	38/78
2N6551	2N6554	1	60	80	250	0.05	1	0.5	0.25	2.0	75	38/78
D40D10	D41D10	1	75	50	150	0.1	2	1	0.5	1.67	200	38/78
D40D11	D41D11	1	75	120	360	0.1	2	1	0.5	1.67	200	38/78
D40D13	D41D13	1	75	50	150	0.1	2	1	0.5	1.67	200	38/78
D40D14	D41D14	1	75	120	360	0.1	2	1	0.5	1.67	200	38/78
2N6552	2N6555	1	80	80	250	0.05	1	0.5	0.25		75	39/79
NSD104	NSD204	1	80	50	150	0.1	5	0.2	0.1	1.75	60	39/79
NSD105	NSD205	1	80	120	360	0.1	5	0.2	0.1	1.75	60	39/79
NSD106	NSD206	1	100	50	150	0.1	5	0.2	0.1	1.75	60	39/79
2N6553	2N6556	1	100	80	250	0.05	1	0.5	0.25		75	39/79
NSD36		1	150	30	300	0.1	10	0.5	0.1	1.75	10	36
NSD36A		1	200	30	300	0.1	10	0.5	0.1	1.75	10	36
NSD36B		1	250	30	300	0.1	10	0.5	0.1	1.75	10	36
NSD36C		1	300	30	300	0.1	10	0.5	0.1	1.75	10	36

TO-202 Type Power Transistor Selection Guide (Continued)

Part Number NPN	Part Number PNP	I_C (A)	V_{CEO} (V)	h_{FE} Min	h_{FE} Max	@ I_C(A)	@ V_{CE} (V)	Max $V_{CE(SAT)}$ (V)	@ I_C(A)	P_D (W)	f_T (MHz)	Process (NPN/PNP)
NSDU01	NSDU51	2	30	60		0.1	1	0.5	1	1.75	50	37/77
NSD151		2	30	10k	250k	0.1	5	1.5	0.1	1.75	100	05
NSD153		2	30	5k		0.1	5	1.5	0.1	1.75	100	05
D40E1	D41E1	2	30	50		0.1	2	1	1	1.3		37/77
D40K1	D41K1	2	30	10k		0.2	5	1.5	1.5	1.67	75	05/61
D40K3	D41K3	2	30	10k		0.2	5	1.5	1.0	1.67	75	05/61
NSDU01A	NSDU51A	2	40	60		0.1	1	0.5	1	1.75	50	37/77
NSDU02	NSDU52	2	40	50	300	0.15	10	0.4	0.15	1.75	50	37/77
2N6548		2	40	15k		0.2	5	1.5	1	1.75	100	05
2N6549		2	40	25k		0.2	5	1.5	1	1.75	100	05
NSDU45		2	40	25k	150k	0.2	5	1	0.2	1.75	100	05
NSD152		2	40	10k	250k	0.1	5	1.5	1	1.75	100	05
NSD154		2	40	5k		0.1	5	1.5	1	1.75	100	05
D40K2	D41K2	2	50	10k		0.2	5	1.5	1.5	1.67	75	05/61
D40K4	D41K4	2	50	10k		0.2	5	1.5	1.0	1.67	75	05/61
NSDU45A		2	50	25k	150k	0.2	5	1	0.2	1.75	100	05
NSDU05	NSDU55	2	60	80		0.05	1	0.5	0.25	1.75	50	38/78
D40E5	D41E5	2	60	50		0.1	2	1	1	1.3		38/78
NSDU06	NSDU56	2	80	80		0.05	1	0.5	0.25	1.75	50	39/79
D40E7	D41E7	2	80	50		0.1	2	1	1	1.3		38/78
NSDU07	NDSU57	2	100	80		0.05	1	0.5	0.25	1.75	50	39/79
D42C1	D43C1	3	30	25		0.2	1	0.5	1	2.1	50	4P/5P
D42C2	D43C2	3	30	100	220	0.2	1	0.5	1	2.1	50	4P/5P
D42C3	D43C3	3	30	40	120	0.2	1	0.5	1	2.1	50	4P/5P
D42C4	D43C4	3	45	25		0.2	1	0.5	1	2.1	50	4P/5P
D42C5	D43C5	3	45	100	220	0.2	1	0.5	1	2.1	50	4P/5P
D42C6	D43C6	3	45	40	120	0.2	1	0.5	1	2.1	50	4P/5P
D42C7	D43C7	3	60	25		0.2	1	0.5	1	2.1	50	4P/5P
D42C8	D43C8	3	60	100	220	0.2	1	0.5	1	2.1	50	4P/5P
D42C9	D43C9	3	60	40	120	0.2	1	0.5	1	2.1	50	4P/5P
D42C10	D43C10	3	80	25		0.2	1	0.5	1	2.1	50	4P/5P
D42C11	D43C11	3	80	100	220	0.2	1	0.5	1	2.1	50	4P/5P
D42C12	D43C12	3	80	40	120	0.2	1	0.5	1	2.1	50	4P/5P

Pinout: EBC, NSDU, NSD, D40, D41
BCE, NSE, D42, D43

TO-126 Type Power Transistor Selection Guide

Part Number NPN	PNP	I_C (A)	V_{CEO} (V)	h_{FE} Min	Max	@ I_C(A)	V_{CE} (V)	Max $V_{CE\,(SAT)}$ (V)	@ I_C(A)	P_D (W)	f_T (MHz)	Process (NPN/PNP)
MJE3440		0.3	250	40	160	0.02	10	0.5	0.05	15	15	36
MJE3439		0.3	350	40	160	0.02	10	0.5	0.05	15	15	36
MJE341		0.5	150	25	200	0.05	10	1	0.05	20	15	36
MJE344		0.5	200	30	300	0.05	10	1	0.05	30	15	36
2N5655		0.5	250	30	250	0.1	10	1	0.1	20	10	36
MJE340		0.5	300	30	240	0.05	10			20		36
2N5656		0.5	300	30	250	0.1	10	1	0.1	20	10	36
2N5657		0.5	350	30	250	0.1	10	1	0.1	20	10	36
2N4921	2N4918	1	40	20	100	0.5	1	0.6	1	30	3	4H/5F
2N4922	2N4919	1	60	20	100	0.5	1	0.6	1	30	3	4H/5F
2N4923	2N4920	1	80	20	100	0.5	1	0.6	1	30	3	4H/5F
MJE720	MJE710	1.5	40	40		0.15	1	0.15	0.15	20		37/77
BD345	BD344	1.5	60	40	250	0.2	1	0.4	0.2	20	50	38/78
MJE721	MJE711	1.5	60	40		0.15	1	0.15	0.15	20		38/78
BD349	BD348	1.5	80	50	250	0.25	1	0.5	0.25	20	50	39/79
MJE722	MJE712	1.5	80	40		0.15	1	0.15	0.15	20		39/79
MJE520	MJE370	3	30	25		1	1			25		4F/5F
MJE180	MJE170	3	40	50	250	0.1	1	0.3	0.5	12.5	50	37/77
MJE181	MJE171	3	60	50	250	0.1	1	0.3	0.5	12.5	50	38/78
MJE182	MJE172	3	80	50	250	0.1	1	0.3	0.5	12.5	50	39/79
MJE220	MJE230	4	40	20		2	1	0.8	2	15	50	4P/5P
MJE221	MJE231	4	40	20		1	1	0.6	1	15	50	4P/5P
MJE222	MJE232	4	40	25		1	1	0.3	0.5	15	50	4P/5P
MJE521	MJE371	4	40	40		0.1	1			40		4F/5F
2N5190	2N5193	4	40	25	100	1.5	2	0.6	1.5	40	2	4E/5E
2N6037	2N6034	4	40	750	15k	2	3	2	2	40		4J/5J
2N5191	2N5194	4	60	25	100	1.5	2	0.6	1.5	40	2	4E/5E
MJE223	MJE233	4	60	20		2	1	0.8	2	15	50	4P/5P
MJE224	MJE234	4	60	20		1	1	0.6	1	15	50	4P/5P
MJE225	MJE235	4	60	25		1	1	0.3	0.5	15	50	4P/5P
MJE800	MJE700	4	60	750		1.5	3	2.5	1.5	40		4J/5J
MJE801	MJE701	4	60	750		2	3	2.8	2	40		4J/5J
2N6038	2N6035	4	60	750	15k	2	3	2	2	40		4J/5J
MJE240	MJE250	4	80	15		2	1	0.8	2	15	40	4P/5P
MJE241	MJE251	4	80	20		1	1	0.6	1	15	40	4P/5P
MJE242	MJE252	4	80	10		1	1	0.3	0.5	15	40	4P/5P
MJE802	MJE702	4	80	750		1.5	3	2.5	1.5	40		4J/5J
MJE803	MJE703	4	80	750		2	3	2.8	2	40		4J/5J
2N5192	2N5195	4	80	20	80	1.5	2	0.6	1.5	40	2	4E/5E
2N6039	2N6036	4	80	750	15k	2	3	2	2	40		4J/5J
MJE243	MJE253	4	100	20		1	1	0.6	1	15	40	4P/5P
MJE244	MJE254	4	100	10		1	1	0.3	0.5	15	40	4P/5P
MJE200	MJE210	5	25	45	180	2	1	0.75	2	15	65	4R/5R

Pinout: ECB

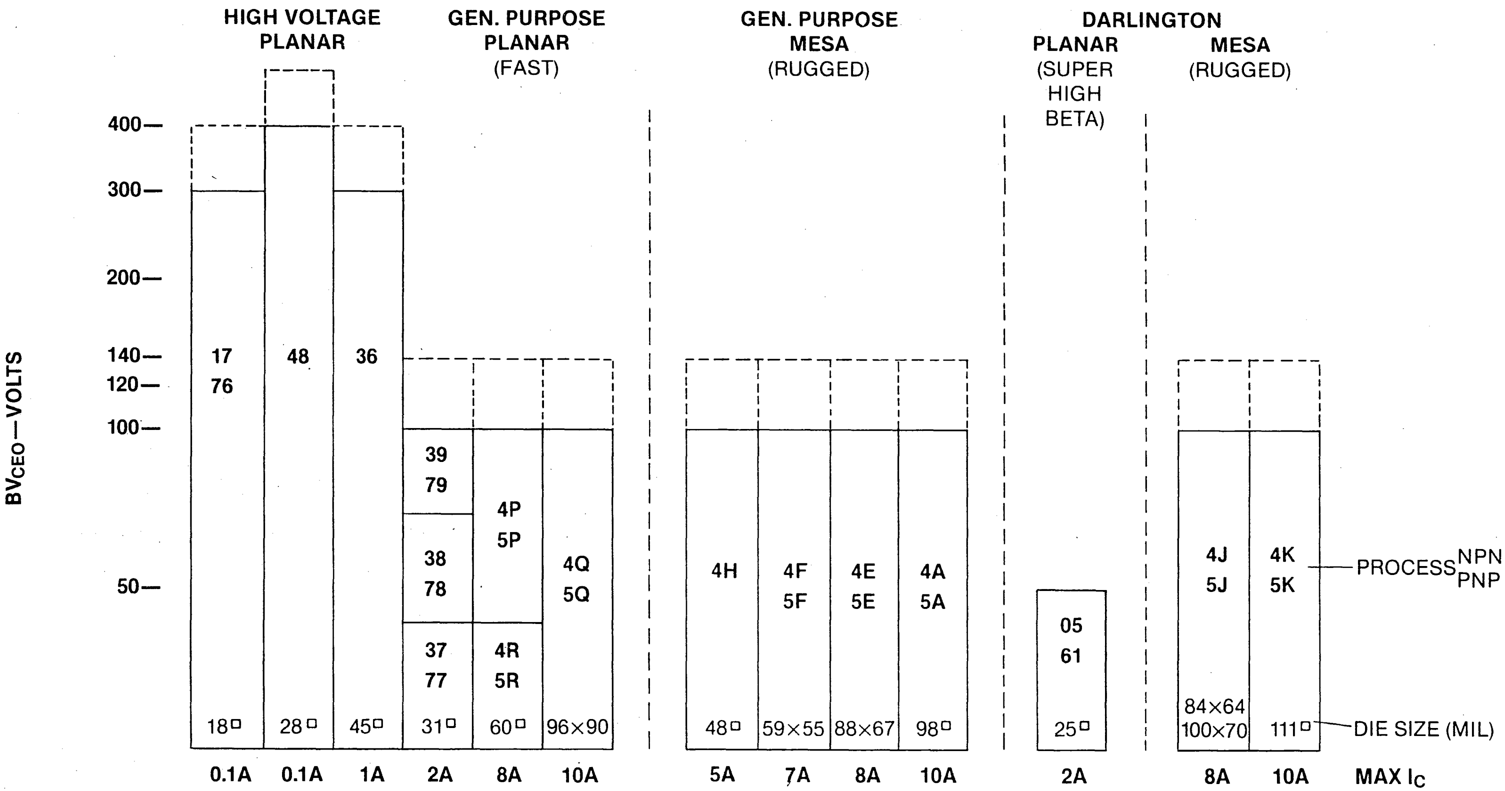
TO-220 Type Power Transistor Selection Guide

Part Number NPN	PNP	I_C (A)	V_{CEO} (V)	h_{FE} Min	Max	@ I_C(A)	V_{CE} (V)	Max $V_{CE\,(SAT)}$ (V)	@ I_C(A)	P_D (W)	f_T (MHz)	Process (NPN/PNP)
TIP61	TIP62	0.5	40	15	100	0.5	4	0.7	0.5	20	3	4F/5F
TIP61A	TIP62A	0.5	60	15	100	0.5	4	0.7	0.5	20	3	4F/5F
TIP61B	TIP62B	0.5	80	15	100	0.5	4	0.7	0.5	20	3	4F/5F
TIP61C	TIP62C	0.5	100	15	100	0.5	4	0.7	0.5	20	3	4F/5F
TIP29	TIP30	1	40	15	75	1	4	0.7	1	30	3	4F/5F
TIP29A	TIP30A	1	60	15	75	1	4	0.7	1	30	3	4F/5F
TIP29B	TIP30B	1	80	15	75	1	4	0.7	1	30	3	4F/5F
TIP29C	TIP30C	1	100	15	75	1	4	0.7	1	30	3	4F/5F
TIP110	TIP115	2	60	1000		1	4	2.5	2	50	1	4J/5J
TIP111	TIP116	2	80	1000		1	4	2.5	2	50	1	4J/5J
TIP112	TIP117	2	100	1000		1	4	2.5	2	50	1	4J/5J
TIP31	TIP32	3	40	10	50	3	4	1.2	3	40	3	4F/5F
TIP31A	TIP32A	3	60	10	50	3	4	1.2	3	40	3	4F/5F
TIP31B	TIP32B	3	80	10	50	3	4	1.2	3	40	3	4F/5F
TIP31C	TIP32C	3	100	10	50	3	4	0.2	3	40	3	4F/5F
D44C1	D45C1	3	30	25		0.2	1	0.5	1	30	50	4P/5P
D44C2	D45C2	3	30	40	120	0.2	1	0.5	1	30	50	4P/5P
D44C3	D45C3	3	30	40	120	0.2	1	0.5	1	30	50	4P/5P
2N5296		4	40	30	120	1	4	1	1	36	2	4E
D44C4	D45C4	3	45	25		0.2	1	0.5	1	30	50	4P/5P
D44C5	D45C5	3	45	40	120	0.2	1	0.5	1	30	50	4P/5P
D44C6	D45C6	3	45	40	120	0.2	1	0.5	1	30	50	4P/5P
2N6121	2N6124	4	45	25	100	1.5	2	0.6	1.5	40	2.5	4E/5E
D44C7	D45C7	3	60	25		0.2	1	0.5	1	30	50	4P/5P
D44C8	D45C8	3	60	40	120	0.2	1	0.5	1	30	50	4P/5P
D44C9	D45C9	3	60	40	120	0.2	1	0.5	1	30	50	4P/5P
2N5298		4	60	20	80	1.5	4	1	1.5	36	2	4E
2N6122	2N6125	4	60	25	100	1.5	2	0.6	1.5	40	2.5	4E/5E
2N5294		4	70	30	120	0.5	4	1	0.5	36	2	4E
D44C10	D45C10	3	80	25		0.2	1	0.5	1	30	50	4P/5P
D44C11	D45C11	3	80	100	220	0.2	1	0.5	1	30	50	4P/5P
D44C12	D45C12	3	80	40	120	0.2	1	0.5	1	30	50	4P/5P
2N6123	2N6126	4	80	20	80	1.5	2	0.6	1.5	40	2.5	4E/5E
MJE105T	MJE205T	5	50	25	100	2	2			65		4A/5A
TIP120	TIP125	5	60	1000		3	3	2	3	65	1	4J/5K
TIP121	TIP126	5	80	1000		3	3	2	3	65	1	4K/5K
TIP122	TIP127	5	100	1000		3	3	2	3	65	1	4K/5K
TIP41	TIP42	6	40	15	75	3	4	1.5	6	65	3	4A/5A
TIP41A	TIP42A	6	60	15	75	3	4	1.5	6	65	3	4A/5A
TIP130	TIP135	6	60	1000	15,000	4	4	2	4	65	1	4K/5K
TIP41B	TIP42B	6	80	15	75	3	4	1.5	6	65	3	4A/5A
TIP131	TIP136	6	80	1000	15,000	4	4	2	4	65	1	4K/5K
TIP41C	TIP42C	6	100	15	75	3	4	1.5	6	65	3	4A/5A
TIP132	TIP137	6	100	1000	15,000	4	4	2	4	65	1	4K/5K
2N6288	2N6111	7	30	30	150	3	4	1	3	40	4	4E/5E
2N5494		7	40	20	100	2	4	1	0.2	50	0.8	4E
2N5494		7	40	20	100	3	4	1	0.3	50	0.8	4E
2N6129	2N6132	7	40	20	100	2.5	4	1.4	7	50	2.5	4E/5E
2N6290	2N6109	7	50	30	150	2.5	4	1	2.5	40	4	4E/5E
2N5492		7	55	20	100	2.5	4	1	0.25	50	0.8	4E

TO-220 Type Power Transistor Selection Guide (Continued)

Part Number NPN	Part Number PNP	I_C (A)	V_{CEO} (V)	h_{FE} Min	h_{FE} Max	@ I_C(A)	@ V_{CE} (V)	Max $V_{CE\,(SAT)}$ (V)	@ I_C(A)	P_D (W)	f_T (MHz)	Process (NPN/PNP)
2N6130	2N6133	7	60	20	100	2.5	4	1.4	7	50	2.4	4E/5E
2N5496		7	70	20	100	3.5	4	1	0.35	50	0.8	4E
2N6292	2N6107	7	70	30	150	2	4	1	2	40	4	4E/5E
2N6131	2N6134	7	80	20	100	2.5	4	2	7	50	2.5	4E/5E
2N6386		8	40	1000	20,000	3	3	2	3	40	20	4J
BD347	BD346	8	60	40	140	2	2.5	0.6	4	60	4	4A/5A
D44H1	D45H1	10	30	35		2	1	1	8	50	50	4Q/5Q
D44H2	D45H2	10	30	60		2	1	1	8	50	50	4Q/5Q
D44H4	D45H4	10	45	35		2	1	1	8	50	50	4Q/5Q
D44H5	D45H5	10	45	60		2	1	1	8	50	50	4Q/5Q
2N6099		10	60	20	80	4	4	2.5	10	75	0.8	4A
D44H7	D45H7	10	60	35		2	1	1	8	50	50	4Q/5Q
D44H8	D45H8	10	60	60		2	1	1	8	50	50	4Q/5Q
SE9300	SE9400	10	60	1000		4	3	2	4	70	1	4K/5K
2N6101		10	70	20	80	5	4	2.5	10	75	0.8	4A
D44H10	D45H10	10	80	35		2	1	1	8	50	50	4Q/5Q
D44H11	D45H11	10	80	60		2	1	1	8	50	50	4Q/5Q
MJE2801T	MJE2901T	10	60	25	100	3	2			60		4A/5A
MJE3055T	MJE2955T	10	60	20	70	4	4	1.1	4	60	2	4A/5A
TIP100	TIP105	10	60	1000		3	4	2	3	60		4K/5K
TIP101	TIP106	10	80	1000		3	4	2	3	60		4K/5K
TIP102	TIP107	10	100	1000		3	4	2	3	60		4K/5K
SE9301	SE9401	10	80	1000		4	3	2	4	70	1	4K/5K
SE9302	SE9402	10	100	1000		4	3	2	4	70	1	4K/5K
2N6486	2N6489	15	40	20	150	5	4	1.3	5	75	5	4A/5A
2N6487	2N6490	15	60	20	150	5	4	1.3	5	75	5	4A/5A
2N6488	2N6491	15	80	20	150	5	4	1.3	5	75	5	4A/5A

Pinout: BCE



DISSIPATION (WATTS)

Package	0.1A	0.1A	1A	2A	8A	10A	5A	7A	8A	10A	2A	8A	10A
TO-92 (Note 1)		0.6		0.6							0.6		
TO-237 (Note 2)	2	2	2	2							2		
TO-202 (Note 3)	8	10	15	10	15						10		
TO-126 (Note 3)			25	15	30		30	30	40			40	
TO-220 (Note 3)					40	60		40	50	60		50	60

Notes: 1) $T_A = 25°C$ 2) $T_{COLL\ LEAD} = 25°C$, will do 1–1.2 W in PC board 3) $T_C = 25°C$

Substitution Guide for Non-Listed Power Part Types

Industry Part No.	Package	NSC Part No.	Package	Industry Part No.	Package	NSC Part No.	Package
2N2102	TO-39	TN2102	TO-237	2N6411	TO-126 (rev)	MJE210	TO-126
2N2218A	TO-18	TN2218A	TO-237	2N6412	TO-126 (rev)	MJE180	TO-126
2N2219A	TO-18	TN2219A	TO-237	2N6413	TO-126 (rev)	MJE181	TO-126
2N2905	TO-18	TN2905	TO-237	2N6414	TO-126 (rev)	MJE170	TO-126
2N3019	TO-39	TN3019	TO-237	2N6415	TO-126 (rev)	MJE171	TO-126
2N3020	TO-39	TN3020	TO-237	2N6416	TO-126 (rev)	MJE241	TO-126
2N3053	TO-39	TN3053	TO-237	2N6417	TO-126 (rev)	MJE243	TO-126
2N3054	TO-66	NSP3054	TO-220	2N6418	TO-126 (rev)	MJE251	TO-126
2N3724	TO-39	TN3724	TO-237	2N6419	TO-126 (rev)	MJE253	TO-126
2N3725	TO-39	TN3725	TO-237	2N6465	TO-66	TIP41C	TO-220
2N3735	TO-39	TN3735	TO-237	2N6530	TO-220	TIP101	TO-220
2N3740	TO-66	NSP3740	TO-220	2N6531	TO-220	TIP102	TO-220
2N3741	TO-66	NSP3741	TO-220	BD575	Mot Case 199	NSP575	TO-220
2N4033	TO-39	TN4033	TO-237	BD576	Mot Case 199	NSP576	TO-220
2N4037	TO-39	TN4037	TO-237	BD577	Mot Case 199	NSP577	TO-220
2N4063	TO-37	MJE3439	TO-126	BD578	Mot Case 199	NSP578	TO-220
2N4064	TO-37	MJE3440	TO-126	BD579	Mot Case 199	NSP579	TO-220
2N5974	TO-127	NSP5974	TO-220	BD579	Mot Case 199	NSP578	TO-220
2N5975	TO-127	NSP5975	TO-220	BD580	Mot Case 199	NSP580	TO-220
2N5976	TO-127	NSP5976	TO-220	BD581	Mot Case 199	NSP581	TO-220
2N5977	TO-127	NSP5977	TO-220	BD582	Mot Case 199	NSP582	TO-220
2N5978	TO-127	NSP5978	TO-220	BD585	Mot Case 199	NSP585	TO-220
2N5979	TO-127	NSP5979	TO-220	BD586	Mot Case 199	NSP586	TO-220
2N5980	Mot Case 90	2N6489	TO-220	BD587	Mot Case 199	NSP587	TO-220
2N5981	Mot Case 90	MJE2955T	TO-220	BD588	Mot Case 199	NSP588	TO-220
2N5982	Mot Case 90	2N6491	TO-220	BD589	Mot Case 199	NSP589	TO-220
2N5983	Mot Case 90	MJE3055T	TO-220	BD590	Mot Case 199	NSP590	TO-220
2N5984	Mot Case 90	MJE3055T	TO-220	BD595	Mot Case 199	NSP595	TO-220
2N5985	Mot Case 90	2N6488	TO-220	BD596	Mot Case 199	NSP596	TO-220
2N6021	TO-220	2N6126	TO-220	BD597	Mot Case 199	NSP597	TO-220
2N6022	TO-220	2N6126	TO-220	BD601	Mot Case 199	NSP601	TO-220
2N6023	TO-220	2N6124	TO-220	BD602	Mot Case 199	NSP602	TO-220
2N6024	TO-220	2N6124	TO-220	BD603	Mot Case 199	NSP603	TO-220
2N6025	TO-220	2N6125	TO-220	BD604	Mot Case 199	NSP604	TO-220
2N6026	TO-220	2N6125	TO-220	BD605	Mot Case 199	NSP605	TO-220
2N6040	Mot Case 199	TIP125	TO-220	BD606	Mot Case 199	NSP606	TO-220
2N6041	Mot Case 199	TIP126	TO-220	BD607	Mot Case 199	NSP607	TO-220
2N6042	Mot Case 199	TIP127	TO-220	BD608	Mot Case 199	NSP608	TO-220
2N6043	Mot Case 199	TIP120	TO-220	BD609	Mot Case 199	NSP609	TO-220
2N6044	Mot Case 199	TIP121	TO-220	BD610	Mot Case 199	NSP610	TO-220
2N6045	Mot Case 199	TIP122	TO-220	BD695	Mot Case 199	NSP695	TO-220
2N6098	TO-220	2N6099	TO-220	BD695A	Mot Case 199	NSP695A	TO-220
2N6100	TO-220	2N6101	TO-220	BD700	Mot Case 199	NSP700	TO-220
2N6101	TO-220	2N6101	TO-220	BD700A	Mot Case 199	NSP700A	TO-220
2N6102	TO-220	2N6102	TO-220	BD701	Mot Case 199	NSP701	TO-220
2N6103	TO-220	2N6103	TO-220	BD702	Mot Case 199	NSP702	TO-220
2N6106	TO-220	2N6107	TO-220	D45E1	TO-220	TIP125	TO-220
2N6108	TO-220	2N6109	TO-220	D45E2	TO-220	TIP125	TO-220
2N6109	TO-220	2N6109	TO-220	D45E3	TO-220	TIP126	TO-220
2N6110	TO-220	2N6111	TO-220	FT2955	TO-220	MJE2955T	TO-220
2N6111	TO-220	2N6111	TO-220	FT3055	TO-220	MJE3055T	TO-220
2N6175	Plastic TO-5	2N5656	TO-126	MJE29	Mot Case 199	TIP29	TO-220
2N6176	Plastic TO-5	2N5656	TO-126	MJE29A	Mot Case 199	TIP29A	TO-220
2N6177	Plastic TO-5	2N5657	TO-126	MJE29B	Mot Case 199	TIP29B	TO-220
2N6178	Plastic TO-5	MJE182	TO-126	MJE29C	Mot Case 199	TIP29C	TO-220
2N6179	Plastic TO-5	MJE181	TO-126	MJE30	Mot Case 199	TIP30	TO-220
2N6180	Plastic TO-5	MJE172	TO-126	MJE30A	Mot Case 199	TIP30A	TO-220
2N6181	Plastic TO-5	MJE171	TO-126	MJE30B	Mot Case 199	TIP30B	TO-220
2N6406	TO-126 (rev)	MJE171	TO-126	MJE30C	Mot Case 199	TIP30C	TO-220
2N6407	TO-126 (rev)	MJE172	TO-126	MJE33	Mot Case 199	TIP41	TO-220
2N6408	TO-126 (rev)	MJE181	TO-126	MJE33A	Mot Case 199	TIP41A	TO-220
2N6409	TO-126 (rev)	MJE182	TO-126	MJE33B	Mot Case 199	TIP41B	TO-220
2N6410	TO-126 (rev)	MJE200	TO-126	MJE33C	Mot Case 199	TIP41C	TO-220

Substitution Guide for Non-Listed Power Part Types (Continued)

Industry Part No.	Package	NSC Part No.	Package	Industry Part No.	Package	NSC Part No.	Package
MJE34	Mot Case 199	TIP42	TO-220	MJE3371	TO-126 (rev)	MJE371	TO-126
MJE34A	Mot Case 199	TIP42A	TO-220	MJE3520	TO-126 (rev)	MJE520	TO-126
MJE34B	Mot Case 199	TIP42B	TO-220	MJE3521	TO-126 (rev)	MJE521	TO-126
MJE34C	Mot Case 199	TIP42C	TO-220	MJE4918		TIP30	
MJE41	Mot Case 199	TIP41	TO-220	MJE4919		TIP30A	
MJE41A	Mot Case 199	TIP41A	TO-220	MJE4920		TIP30B	
MJE41B	Mot Case 199	TIP41B	TO-220	MJE4921		TIP29	
MJE41C	Mot Case 199	TIP41C	TO-220	MJE4922		TIP29A	
MJE42	Mot Case 199	TIP42	TO-220	MJE4923		TIP29B	
MJE42A	Mot Case 199	TIP42A	TO-220	MJE5190		2N6121	
MJE42B	Mot Case 199	TIP42B	TO-220	MJE5191		2N6122	
MJE42C	Mot Case 199	TIP42C	TO-220	MJE5192		2N6123	
MJE105K	Mot Case 199	TIP42A	TO-220	MJE5193		2N6124	
MJE105	Mot Case 199	MJE105T	TO-220	MJE5194		2N6125	
MJE170	TO-126	MJE170	TO-126	MJE5195		2N6126	
MJE171	TO-126	MJE171	TO-126	MJE5974	Mot Case 199	NSP5974	TO-220
MJE172	TO-126	MJE172	TO-126	MJE5975	Mot Case 199	NSP5975	TO-220
MJE180	TO-126	MJE180	TO-126	MJE5976	Mot Case 199	NSP5976	TO-220
MJE181	TO-126	MJE181	TO-126	MJE5977	Mot Case 199	NSP5977	TO-220
MJE182	TO-126	MJE182	TO-126	MJE5978	Mot Case 199	NSP5978	TO-220
MJE200	TO-126	MJE200	TO-126	MJE5979	Mot Case 199	NSP5979	TO-220
MJE205	Mot Case 199	MJE205T	TO-220	MJE5980	Mot Case 199	NSP5980	TO-220
MJE205K	Mot Case 199	TIP41A	TO-220	MJE5981	Mot Case 199	NSP5981	TO-220
MJE345	TO-126	MJE3439	TO-126	MJE5982	Mot Case 199	NSP5982	TO-220
MJE370K	Mot Case 199	NSP370	TO-220	MJE5983	Mot Case 199	NSP5983	TO-220
MJE371K	Mot Case 199	NSP371	TO-220	MJE5984	Mot Case 199	NSP5984	TO-220
MJE482	TO-126	2N5190	TO-126	MJE5985	Mot Case 199	NSP5985	TO-220
MJE483	TO-126	2N5191	TO-126	MPSU01	Mot 152	NSDU01	TO-202
MJE484	TO-126	2N5192	TO-126	MPSU01	Mot 152	92PU01	TO-237
MJE492	TO-126	2N5193	TO-126	MPSU01A	Mot 152	NSDU01A	TO-202
MJE493	TO-126	2N5194	TO-126	MPSU01A	Mot 152	92PU01A	TO-237
MJE494	TO-126	2N5195	TO-126	MPSU02	Mot 152	NSDU02	TO-202
MJE520K	Mot Case 199	TIP31	TO-220	MPSU02	Mot 152	TN2219A	TO-237
MJE521K	Mot Case 199	TIP31	TO-220	MPSU03	Mot 152	92PU391	TO-237
MJE2010	Mot Case 199	NSP2010	TO-220	MPSU04	Mot 152	92PU319	TO-237
MJE2011	Mot Case 199	NSP2011	TO-220	MPSU05	Mot 152	NSDU05	TO-202
MJE2020	Mot Case 199	NSP2020	TO-220	MPSU05	Mot 152	92PU05	TO-237
MJE2021	Mot Case 199	NSP2021	TO-220	MPSU06	Mot 152	NSDU06	TO-202
MJE2090	Mot Case 199	NSP2090	TO-220	MPSU06	Mot 152	92PU06	TO-237
MJE2091	Mot Case 199	NSP2091	TO-220	MPSU07	Mot 152	NSDU07	TO-202
MJE2092	Mot Case 199	NSP2092	TO-220	MPSU07	Mot 152	92PU07	TO-237
MJE2093	Mot Case 199	NSP2093	TO-220	MPSU10	Mot 152	NSDU10	TO-202
MJE2100	Mot Case 199	NSP2100	TO-220	MPSU10	Mot 152	92PU10	TO-237
MJE2101	Mot Case 199	NSP2101	TO-220	MPSU31	Mot 152	TN2102	TO-237
MJE2102	Mot Case 199	NSP2102	TO-220	MPSU45	Mot 152	NSDU45	TO-202
MJE2103	Mot Case 199	NSP2103	TO-220	MPSU45	Mot 152	92PU45	TO-237
MJE2150	TO-126 (rev)	MJE210	TO-126	MPSU45A	Mot 152	NSDU45A	TO-202
MJE2370	Mot Case 199	NSP2370	TO-220	MPSU45A	Mot 152	92PU45A	TO-237
MJE2371	Mot Case 199	TIP32A	TO-220	MPSU51	Mot 152	NSDU51	TO-202
MJE2480	Mot Case 199	TIP31	TO-220	MPSU51	Mot 152	92PU51	TO-237
MJE2481	Mot Case 199	TIP32A	TO-220	MPSU51A	Mot 152	NSDU51A	TO-202
MJE2482	Mot Case 199	TIP41	TO-220	MPSU52	Mot 152	NSPU52	TO-202
MJE2483	Mot Case 199	TIP41A	TO-220	MPSU52	Mot 152	92PU51A	TO-237
MJE2490	Mot Case 199	NSP2490	TO-220	MPSU55	Mot 152	NSDU55	TO-202
MJE2491	Mot Case 199	NSP2491	TO-220	MPSU55	Mot 152	92PU55	TO-237
MJE2520	Mot Case 199	NSP2520	TO-220	MPSU56	Mot 152	NSDU56	TO-202
MJE2801K	Mot Case 199	NSP2801T	TO-220	MPSU56	Mot 152	92PU56	TO-237
MJE2901K	Mot Case 199	MJE2901T	TO-220	MPSU57	Mot 152	NSDU57	TO-202
MJE2955K	Mot Case 199	MJE2955T	TO-220	MPSU57	Mot 152	92PU57	TO-237
MJE2955	Mot Case 90	MJE2955T	TO-220	RCA1C05	TO-220	2N6130	TO-220
MJE3055K	Mot Case 199	MJE3055T	TO-220	RCA1C06	TO-220	2N6133	TO-220
MJE3055	Mot Case 90	MJE3055T	TO-220	RCA1C07	TO-220	MJE3055T	TO-220
MJE3370	TO-126 (rev)	MJE370	TO-126	RCA1C08	TO-220	MJE2955T	TO-220

Substitution Guide for Non-Listed Power Part Types (Continued)

Industry Part No.	Package	NSC Part No.	Package	Industry Part No.	Package	NSC Part No.	Package
RCA1C09	TO-220	MJE3055T	TO-220	RCP704B	TO-202	2N6554	TO-202
RCA1C10	TO-220	2N6292	TO-220	RCP705	TO-202	2N6551	TO-202
RCA1C11	TO-220	2N6107	TO-220	RCP705B	TO-202	2N6551	TO-202
RCA1C14	TO-220	2N6290	TO-220	RCP706	TO-202	2N6554	TO-202
RCA1C15	TO-220	2N6388	TO-220	RCP706B	TO-202	2N6554	TO-202
RCA29	TO-220	TIP29	TO-220	RCP707	TO-202	2N6551	TO-202
RCA29A	TO-220	TIP29A	TO-220	RCP707B	TO-202	2N6551	TO-202
RCA29B	TO-220	TIP29B	TO-220	TIP33	TO-220	TIP41	TO-220
RCA29C	TO-220	TIP29C	TO-220	TIP33A	TO-220	TIP41A	TO-220
RCA30	TO-220	TIP30	TO-220	TIP33B	TO-220	TIP41B	TO-220
RCA30A	TO-220	TIP30A	TO-220	TIP33C	TO-220	TIP41C	TO-220
RCA30B	TO-220	TIP30B	TO-220	TIP34	TO-220	TIP42	TO-220
RCA30C	TO-220	TIP30C	TO-220	TIP34A	TO-220	TIP42A	TO-220
RCA31	TO-220	TIP31	TO-220	TIP34B	TO-220	TIP42B	TO-220
RCA31A	TO-220	TIP31A	TO-220	TIP34C	TO-220	TIP42C	TO-220
RCA31B	TO-220	TIP31B	TO-220	TIP73	TO-220	2N6486	TO-220
RCA31C	TO-220	TIP31C	TO-220	TIP73A	TO-220	2N6487	TO-220
RCA32	TO-220	TIP32	TO-220	TIP73B	TO-220	2N6488	TO-220
RCA32A	TO-220	TIP32A	TO-220	TIP74	TO-220	2N6489	TO-220
RCA32B	TO-220	TIP32B	TO-220	TIP74A	TO-220	2N6490	TO-220
RCA32C	TO-220	TIP32C	TO-220	TIP74B	TO-220	2N6491	TO-220
RCA41	TO-220	TIP41	TO-220	TIP2955	TO-220	MJE2955T	TO-220
RCA41A	TO-220	TIP41A	TO-220	TIP3055	TO-220	MJE3055T	TO-220
RCA41B	TO-220	TIP41B	TO-220	40513	TO-220	MJE3055T	TO-220
RCA41C	TO-220	TIP41C	TO-220	40514	TO-220	MJE3055T	TO-220
RCA42	TO-220	TIP42	TO-220	40613	TO-220	TIP31	TO-220
RCA42A	TO-220	TIP42A	TO-220	40618	TO-220	TIP31	TO-220
RCA42B	TO-220	TIP42B	TO-220	40621	TO-220	TIP31	TO-220
RCA42C	TO-220	TIP42C	TO-220	40622	TO-220	TIP31	TO-220
RCA120	TO-220	TIP120	TO-220	40624	TO-220	TIP41A	TO-220
RCA121	TO-220	TIP121	TO-220	40627	TO-220	TIP41A	TO-220
RCA122	TO-220	TIP122	TO-220	40629	TO-220	TIP31	TO-220
RCA125	TO-220	TIP125	TO-220	40630	TO-220	TIP31	TO-220
RCA126	TO-220	TIP126	TO-220	40631	TO-220	TIP31A	TO-220
RCA3054	TO-220	2N6122	TO-220	40632	TO-220	TIP41A	TO-220
RCA3055	TO-220	2N6487	TO-220	40871	TO-220	TIP41C	TO-220
RCP115	TO-202	2N6591	TO-202	40872	TO-220	TIP42C	TO-220
RCP117	TO-202	2N6591	TO-202	40873	TO-220	TIP41B	TO-220
RCP131A	TO-202	2N6592	TO-202	40874	TO-220	TIP41B	TO-220
RCP131B	TO-202	2N6593	TO-202	40875	TO-220	TIP41C	TO-220
RCP133A	TO-202	2N6592	TO-202	40876	TO-220	TIP41A	TO-220
RCP133B	TO-202	2N6593	TO-202	41500	TO-220	TIP29	TO-220
RCP135	TO-202	2N6553	TO-202	41501	TO-220	TIP30	TO-220
RCP137	TO-202	2N6553	TO-202	41504	TO-220	TIP31	TO-220
RCP700A	TO-202	2N6554	TO-202	2SA496	TO-126	2N4918	TO-126
RCP700B	TO-202	2N6554	TO-202	2SA505	TO-126	2N4919	TO-126
RCP700C	TO-202	2N6555	TO-202	2SA623	TO-202	D41E1	TO-202
RCP700D	TO-202	2N6556	TO-202	2SA624	TO-202	D41E5	TO-202
RCP701A	TO-202	2N6551	TO-202	2SA633	TO-202	D41E1	TO-202
RCP701B	TO-202	2N6551	TO-202	2SA634	TO-202	D41E5	TO-202
RCP701C	TO-202	2N6552	TO-202	2SA635	TO-202	D41D7	TO-202
RCP701D	TO-202	2N6553	TO-202	2SA636	TO-202	2N6556	TO-202
RCP702A	TO-202	2N6554	TO-202	2SA645	TO-202	D41D10	TO-202
RCP702B	TO-202	2N6554	TO-202	2SA646	TO-202	2N6556	TO-202
RCP702C	TO-202	2N6555	TO-202	2SA647	TO-202	2N6556	TO-202
RCP702D	TO-202	2N6556	TO-202	2SA681	TO-126	MJE253	TO-126
RCP703A	TO-202	2N6551	TO-202	2SA682	TO-126	MJE253	TO-126
RCP703B	TO-202	2N6551	TO-202	2SA699	TO-202	D41E5	TO-202
RCP703C	TO-202	2N6552	TO-202	2SA700	TO-220	TIP30	TO-220
RCP703D	TO-202	2N6553	TO-202	2SA703	TO-220	D41E1	TO-202
RCP704	TO-202	2N6554	TO-202				

Section 5

Pro Electron Series

5

PRO ELECTRON SERIES (Bipolar—see page 5-37 for JFET)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} h_{fe} 1 kHz* Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BC107	TO-18	50	45	6	15*	50	40 125 40	 500* 	0.01 2 0.01	5 5 5	0.6 0.2	 0.55	 0.7*	100 10 2	4.5	150		10		10	1	04
BC107A	TO-18	50	45	6	15*	50	125	260*	2	5	0.6 0.2	 0.55	 0.7*	100 10 2	4.5	150		10		10	1	04
BC107B	TO-18	50	45	6	15*	50	40 240	 500*	0.01 2	5 5	0.6 0.2	 0.55	 0.7*	100 10 2	4.5	150		10		10	1	04
BC108	TO-18	30	20	5	15*	30	40 125	 900*	0.01 2	5 5	0.6 0.2	 0.55	 0.7*	100 10 2	4.5	150		10		10	1	04
BC108A	TO-18	30	20	5	15*	30	40 125	 260*	0.01 2	5 5	0.6 0.2	 0.55	 0.7*	100 100 2	4.5	150		10		10	1	04
BC108B	TO-18	30	20	5	15*	30	40 240	 500*	0.01 2	5 5	0.6 0.2	 0.55	 0.7*	100 10 2	4.5	150		10		10	1	04
BC108C	TO-18	30	20	5	15*	30	40 450	 900*	0.01 2	5 5	0.6 0.2	 0.55	 0.7*	100 10 2	4.5	150		10		10	1	04
BC109	TO-18	30	20	5	15*	30	100 240	 900*	0.01 2	5 5	0.6 0.2	 0.55	 0.7*	100 10 2	4.5	150		10		4	1	04
BC109B	TO-18	30	20	5	15*	30	100 240	 500*	0.01 2	5 5	0.6 0.2	 0.55	 0.7*	100 10 2	4.5	150		10		4	1	04
BC109C	TO-18	30	20	5	15*	30	100 450	 900*	0.01 2	5 5	0.6 0.2	 0.55	 0.7*	100 10 2	4.5	150		10		4	1	04
BC140	TO-39	80*	40	7	100*	60	40	250	100	1	1.0		1.8*	1A	25	50		50	850		2	14
BC140-6	TO-39	80*	40	7	100*	60	40	100	100	1	1.0		1.8*	1A	25	50		50	850		2	14
BC140-10	TO-39	80*	40	7	100*	60	63	160	100	1	1.0		1.8*	1A	25	50		50	850		2	14
BC140-16	TO-39	80*	40	7	100*	60	100	250	100	1	1.0		1.8*	1A	25	50		50	850		2	14
BC141	TO-39	100*	60	7	100*	60	40	250	100	1	1.0		1.8*	1A	25	50		50	850		2	14
BC141-6	TO-39	100*	60	7	100*	60	40	100	100	1	1.0		1.8*	1A	25	50		50	850		2	14
BC141-10	TO-39	100*	60	7	100*	60	63	160	100	1	1.0		1.8*	1A	25	50		50	850		2	14

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BC143	TO-5	60	60	5	50	40	20		200	2	1.5		1.5	500 200	20	60		50				63
BC146-1	TO-92 (94)	20	20	4	50	40	100 80	 200	2 0.2	1 0.2	1.5		1.5	500 200	20	60		50				04
BC146-2	TO-92 (94)	20	20	4	50	40	140 140	 350	2 0.2	1 0.2	1.5		1.5	500 200	20	60		50				04
BC146-3	TO-92 (94)	20	20	4	50	40	280 280	 550	2 0.2	1 0.2	1.5		1.5	500 200	20	60		50				04
BC160	TO-39	40*	5	40	100	40	40	250	100	1	1.0		1.7*	1A	30	50		50	650		2	67
BC160-6	TO-39	40*	5	40	100	40	40	100	100	1	1.0		1.7*	1A	30	50		50	650		2	67
BC160-10	TO-39	40*	5	40	100	40	63	160	100	1	1.0		1.7*	1A	30	50		50	650		2	67
BC160-16	TO-39	40*	5	40	100	40	100	250	100	1	1.0		1.7*	1A	30	50		50	650		2	67
BC161	TO-39	60*	5	60	100	60	40	250	100	1	1.0		1.7*	1A	30	50		50	650		2	67
BC161-6	TO-39	60*	5	60	100	60	40	100	100	1	1.0		1.7*	1A	30	50		50	650		2	67
BC161-10	TO-39	60*	5	60	100	60	63	160	100	1	1.0		1.7*	1A	30	50		50	650		2	67
BC161-16	TO-39	60*	5	60	100	60	100	250	100	1	1.0		1.7*	1A	30	50		50	650		2	67
BC167	TO-92 (94)	60*	45	6	15*	50	110 125	 500*	2 2	5 5	0.2 0.6	 0.55	 0.7*	10 100 2	4.5	150		10		10	1	04
BC167A	TO-92 (94)	60*	45	6	15*	50	110 125	260*	2 2	5 5	0.2 0.6	 0.55	 0.7*	10 100 2	4.5	150		10		10	1	04
BC167B	TO-92 (94)	60*	45	6	15*	50	110 240	500*	2 2	5 5	0.2 0.6	 0.55	 0.7*	10 100 2	4.5	150		10		10	1	04
BC168	TO-92 (94)		20	5	15*	30	110 125	 900*	2 2	5 5	0.2 0.6	 0.55	 0.70*	10 100 2	4.5	150		10		10	1	04
BC168A	TO-92 (94)		20	5	15*	30	110 125	 260*	2 2	5 5	0.2 0.6	 0.55	 0.70*	10 100 2	4.5	150		10		10	1	04
BC168B	TO-92 (94)		20	5	15*	30	110 240	 500*	2 2	5 5	0.2 0.6	 0.55	 0.70*	10 100 2	4.5	150		10		10	1	04

TEST CONDITIONS:

(1) I_C = 200 µA, V_{CE} = 5V, f = 1 kHz. **(2)** I_C = 100 mA, V_{CC} = 20V, $I_B^1 = I_B^2$ = 5 mA. **(3)** I_C = 200 µA, V_{CE} = 2V, f = 1 kHz. **(4)** I_C = 100 mA, V_{CC} = 10V, $I_B^1 = I_B^2$ = 10 mA. **(5)** I_C = 10 mA, V_{CC} = 3V, $I_B^1 = I_B^2$ = 1 mA. **(6)** I_C = 100 µA, V_{CE} = 5V, f = 1 kHz. **(7)** I_C = 1 mA, V_{CE} = 10V, f = 200 kHz. **(8)** I_C = 1 mA, V_{CE} = 5V, f = 1 kHz. **(9)** I_C = 150 mA, V_{CC} = 6V, $I_B^1 = I_B^2$ = 15 mA. **(10)** I_C = 10 µA, V_{CE} = 5V, f = WB.

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} h_{fe} 1 kHz* Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BC168C	TO-92 (94)		20	5	15*	30	110 450	 900*	2 2	5 5	0.2 0.6	 0.55	 0.70*	10 100 2	4.5	150		10		10	1	04
BC169	TO-92 (94)		20	5	15*	30	110 240	 900*	2 2	5 5	0.2 0.6	 0.55	 0.70*	10 100 2	4.5	150		10		4	1	04
BC169B	TO-92 (94)		20	5	15*	30	110 240	 500*	2 2	5 5	0.2 0.6	 0.55	 0.70*	10 100 2	4.5	150		10		4	1	04
BC169C	TO-92 (94)		20	5	15*	30	110 450	 900*	2 2	5 5	0.2 0.6	 0.55	 0.70*	10 100 2	4.5	150		10		4	1	04
BC177	TO-18	50	45	5	100	20	110 125	 500*	2 2	5 5	0.18		0.78 0.75* 1.0*	10 2 100	4.5	150		10		10	1	71
BC177A	TO-18	50	45	5	100	20	110 125	 260*	2 2	5 5	0.18		0.78 0.75* 1.0*	10 2 100	4.5	150		10		10	1	71
BC177B	TO-18	50	45	5	100	20	110 240	 500*	2 2	5 5	0.18		0.78 0.75* 1.0*	10 2 100	4.5	150		10		10	1	71
BC177VI	TO-18	50	45	5	100	20	110 75	 150*	2 2	5 5	0.18		0.78 0.75* 1.0*	10 2 100	4.5	150		10		10	1	71
BC178	TO-18	30	25	5	100	20	110 125	 900*	2 2	5 5	0.18		0.78 0.75* 1.0*	10 2 100	4.5	150		10		10	1	71
BC178A	TO-18	30	25	5	100	20	110 125	 260*	2 2	5 5	0.18		0.78 0.75* 1.0*	10 2 100	4.5	150		10		10	1	71
BC178B	TO-18	30	25	5	100	20	110 240	 500*	2 2	5 5	0.18		0.78 0.75* 1.0*	10 2 100	4.5	150		10		10	1	71
BC179	TO-18	25	20	5	100	20	110 125	 900*	2 2	5 5	0.18		0.78 0.75* 1.0*	10 2 100	4.5	150		10		4	1	71
BC179A	TO-18	25	20	5	100	20	110 125	 260*	2 2	5 5	0.18		0.78 0.75* 1.0*	10 2 100	4.5	150		10		4	1	71

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	V_{BE} Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BC179B	TO-18	25	20	5	100	20	110 240	 500*	2 2	5 5	0.18		0.78 0.75* 1.0*	10 2 100	4.5	150		10		4	1	71
BC182	TO-92 (97)	60	50	5	15	50	40 80 125	 500*	0.01 100 2	5 5 5	0.6 0.25	 0.55	1.2 0.70*	100 10 2	5	150		10		10	1	04
BC182A	TO-92 (97)	60	50	5	15	50	40 80 125	 260*	0.01 100 2	5 5 5	0.6 0.25	 0.55	1.2 0.70*	100 10 2	5	150		10		10	1	04
BC182B	TO-92 (97)	60	50	5	15	50	40 80 240	 500*	0.01 100 2	5 5 5	0.6 0.25	 0.55	1.2 0.70*	100 10 2	5	150		10		10	1	04
BC182L	TO-92 (94)	60	50	5	15	50	40 80 125	 500*	0.01 100 2	5 5 5	0.6 0.25	 0.55	1.2 0.70*	100 10 2	5	150		10		10	1	04
BC182LA	TO-92 (94)	60	50	5	15	50	40 80 125	 260*	0.01 100 2	5 5 5	0.6 0.25	 0.55	1.2 0.70*	100 10 2	5	150		10		10	1	04
BC182LB	TO-92 (94)	60	50	5	15	50	40 80 240	 500*	0.01 100 2	5 5 5	0.6 0.25	 0.55	1.2 0.70*	100 10 2	5	150		10		10	1	04
BC183	TO-92 (97)	45	30	5	15	30	40 80 125	 900*	0.01 100 2	5 5 5	0.6 0.25	 0.55	1.2 0.70*	100 10 2	5	150		10		10	1	04
BC183A	TO-92 (97)	45	30	5	15	30	40 80 125	 260*	0.01 100 2	5 5 5	0.6 0.25	 0.55	1.2 0.70*	100 10 2	5	150		10		10	1	04
BC183B	TO-92 (97)	45	30	5	15	30	40 80 240	 500*	0.01 100 2	5 5 5	0.6 0.25	 0.55	1.2 0.70*	100 10 2	5	150		10		10	1	04
BC183C	TO-92 (97)	45	30	5	15	30	40 80 450	 900*	0.01 100 2	5 5 5	0.6 0.25	 0.55	1.2 0.70*	100 10 2	5	150		10		10	1	04

TEST CONDITIONS:

(1) I_C = 200 μA, V_{CE} = 5V, f = 1 kHz. **(2)** I_C = 100 mA, V_{CC} = 20V, $I_{B}^{1} = I_{B}^{2}$ = 5 mA. **(3)** I_C = 200 μA, V_{CE} = 2V, f = 1 kHz. **(4)** I_C = 100 mA, V_{CC} = 10V, $I_{B}^{1} = I_{B}^{2}$ = 10 mA. **(5)** I_C = 10 mA, V_{CC} = 3V, $I_{B}^{1} = I_{B}^{2}$ = 1 mA. **(6)** I_C = 100 μA, V_{CE} = 5V, f = 1 kHz. **(7)** I_C = 1 mA, V_{CE} = 10V, f = 200 kHz. **(8)** I_C = 1 mA, V_{CE} = 5V, f = 1 kHz. **(9)** I_C = 150 mA, V_{CC} = 6V, $I_{B}^{1} = I_{B}^{2}$ = 15 mA. **(10)** I_C = 10 μA, V_{CE} = 5V, f = WB.

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BC183L	TO-92	45	30	5	15	30	40		0.01	5	0.6		1.2	100	5	150		10		10	1	04
	(94)						80		100	5	0.25			10								
							125	900*	2	5		0.55	0.70*	2								
BC183LA	TO-92	45	30	5	15	30	40		0.01	5	0.6		1.2	100	5	150		10		10	1	04
	(94)						80		100	5	0.25			10								
							125	260*	2	5		0.55	0.70*	2								
BC183LB	TO-92	45	30	5	15	30	40		0.01	5	0.6		1.2	100	5	150		10		10	1	04
	(94)						80		100	5	0.25			10								
							240	500*	2	5		0.55	0.70*	2								
BC183LC	TO-92	45	30	5	15	30	40		0.01	5	0.6		1.2	100	5	150		10		10	1	04
	(94)						80		100	5	0.25			10								
							450	900*	2	5		0.55	0.70*	2								
BC184	TO-92	45	30	5	15	30	100		0.01	5	0.6		1.2	100	5	150		10		4	1	04
	(97)						130		100	5	0.25			10								
							240	900*	2	5		0.55	0.70*	2								
BC184B	TO-92	45	30	5	15	30	100		0.01	5	0.6		1.2	100	5	150		10		4	1	04
	(97)						130		100	5	0.25			10								
							240	500*	2	5		0.55	0.70*	2								
BC184C	TO-92	45	30	50	15	30	100		0.01	5	0.6		1.2	100	5	150		10		4	1	04
	(97)						130		100	5	0.25			10								
							450	900*	2	5		0.55	0.70*	2								
BC184L	TO-92	45	30	50	15	30	100		0.01	5	0.6		1.2	100	5	150		10		4	1	04
	(94)						130		100	5	0.25			10								
							240	900*	2	5		0.55	0.70*	2								
BC184LB	TO-92	45	30	50	15	30	100		0.01	5	0.6		1.2	100	5	150		10		4	1	04
	(94)						130		100	5	0.25			10								
							240	500*	2	5		0.55	0.70*	2								
BC184LC	TO-92	45	30	50	15	30	100		0.01	5	0.6		1.2	100	5	150		10		4	1	04
	(94)						130		100	5	0.25			10								
							450	900*	2	5		0.55	0.70*	2								
BC204	TO-92	50	45	5	50	45	50	450	2	5	0.3			10						10	1	71
	(92)																					
BC207	TO-92	50	45	5	15	40	110	450	2	5	0.25			10	6					10	1	04
	(92)										0.6			100								
BC212	TO-92	60	50	5	15	30					0.6		1.1	100	10	200		10		10	1	63
	(97)										0.25			10								
							60	400*	2	5		0.6	0.72*	2								

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BC212A	TO-92	60	50	5	15	30					0.6		1.1	100	10	200		10		10	1	63
	(97)										0.25			10								
							100	300*	2	5		0.6	0.72*	2								
BC212B	TO-92	60	50	5	15	30			0.01		0.6		1.1	100	10	200		10		10	1	63
	(97)								100		0.25			10								
							200	400*	2	5		0.6	0.72*	2								
BC212L	TO-92	60	50	5	15	30	40		0.01	5	0.6		1.1	100	10	200		10		10	1	63
	(94)						60	300	2	5	0.25			10								
							60*		2	5		0.6	0.72*	2								
BC212LA	TO-92	60	50	5	15	30	40		0.01	5	0.6		1.1	100	10	200		10		10	1	63
	(94)						60		2	5	0.25			10								
							100	300*	2	5		0.6	0.72*	2								
BC212LB	TO-92	60	50	5	15	30	40		0.01	5	0.6		1.1	100	10	200		10		10	1	63
	(94)						60		2	5	0.25			10								
							200	400*	2	5		0.6	0.72*	2								
BC213	TO-92	45	30	5	15	30	40		0.01	5	0.6		1.1	100	10	200		10		10	1	63
	(97)						60		2	5	0.25			10								
							80	600*	2	5		0.6	0.72*	2								
BC213A	TO-92	45	30	5	15	30	40		0.01	5	0.6		1.1	100	10	200		10		10	1	63
	(97)						60		2	5	0.25			10								
							100	300*	2	5		0.6	0.72*	2								
BC213B	TO-92	45	30	5	15	30	40		0.01	5	0.6		1.1	100	10	200		10		10	1	63
	(97)						60		2	5	0.25			10								
							200	400*	2	5		0.6	0.72*	2								
BC213C	TO-92	45	30	5	15	30	40		0.01	5	0.6		1.1	100	10	200		10		10	1	63
	(97)						60		2	5	0.25			10								
							350	600*	2	5		0.6	0.72*	2								
BC213L	TO-92	45	30	5	15	30	40		0.01	5	0.6		1.1	100	10	200		10		10	1	63
	(94)						80	400	2	5	0.25			10								
							80*		2	5		0.6	0.72*	2								
BC213LA	TO-92	45	30	5	15	30	40		0.01	5	0.6		1.1	100	10	200		10		10	1	63
	(94)						80		2	5	0.25			10								
							100	300*	2	5		0.6	0.72*	2								

TEST CONDITIONS:

(1) I_C = 200 μA, V_{CE} = 5V, f = 1 kHz. **(2)** I_C = 100 mA, V_{CC} = 20V, $I_B{}^1 = I_B{}^2$ = 5 mA. **(3)** I_C = 200 μA, V_{CE} = 2V, f = 1 kHz. **(4)** I_C = 100 mA, V_{CC} = 10V, $I_B{}^1 = I_B{}^2$ = 10 mA. **(5)** I_C = 10 mA, V_{CC} = 3V, $I_B{}^1 = I_B{}^2$ = 1 mA. **(6)** I_C = 100 μA, V_{CE} = 5V, f = 1 kHz. **(7)** I_C = 1 mA, V_{CE} = 10V, f = 200 kHz. **(8)** I_C = 1 mA, V_{CE} = 5V, f = 1 kHz. **(9)** I_C = 150 mA, V_{CC} = 6V, $I_B{}^1 = I_B{}^2$ = 15 mA. **(10)** I_C = 10 μA, V_{CE} = 5V, f = WB.

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	(V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BC213LB	TO-92 (94)	45	30	5	15	30	40		0.01	5	0.6		1.1	100	10	200		10		10	1	63
							80		2	5	0.25			10								
							200	400*	2	5		0.6	0.72*	2								
BC213LC	TO-92 (94)	45	30	5	15	30	40		0.01	5	0.6		1.1	100	10	200		10		10	1	63
							80		2	5	0.25			10								
							350	600*	2	5		0.6	0.72*	2								
BC214	TO-92 (97)	45	30	5	15	30	40		0.01	5	0.6		1.1	100	10	200		10		2	1	63
							80		2	5	0.25			10								
							140	600*	2	5		0.6	0.72*	2								
BC214A	TO-92 (97)	45	30	5	15	30	40		0.01	5	0.6		1.1	100	10	200		10		2	1	63
							80		2	5	0.25			10								
							100	300*	2	5		0.6	0.72*	2								
BC214B	TO-92 (97)	45	30	5	15	30	40		0.01	5	0.6		1.1	100	10	200		10		2	1	63
							80		2	5	0.25			10								
							200	400*	2	5		0.6	0.72*	2								
BC214C	TO-92 (97)	45	30	5	15	30	40		0.01	5	0.6		1.1	100	10	200		10		2	1	63
							80		2	5	0.25			10								
							350	600*	2	5		0.6	0.72*	2								
BC214L	TO-92 (94)	45	30	5	15	30	100		0.01	5	0.6		1.1	100	10	200		10		2	1	63
							140	400	2	5	0.25			10								
							120		100	5		0.6	0.72*	2								
							140*		2	5												
BC214LB	TO-92 (94)	45	30	5	15	30	100		0.01	5	0.6		1.1	100	10	200		10		2	1	63
							140		2	5	0.25			10								
							120		100	5		0.6	0.72*	2								
							200	400*	2	5												
BC214LC	TO-92 (94)	45	30	5	15	30	100		0.01	5	0.6		1.1	100	10	200		10		2	1	63
							140		2	5	0.25			10								
							120		100	5		0.6	0.72*	2								
							350	600*	2	5												
BC237-92	TO-92 (97)	50	45	6	50	20	100		0.01	5	0.25		0.77*	10	4.5					10	1	04
							140		2	5			0.6	100								
							120		100	5												
							125	500*	2	5		0.55	0.70*	2								
BC237A-92	TO-92 (97)	50	45	6	50	20	100		0.01	5	0.25		0.77*	10	4.5					10	1	04
							140		2	5			0.6	100								
							120		100	5												
							125	500*	2	5		0.55	0.70*	2								

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BC237B-92	TO-92 (97)	50	45	6	50	20	100		0.01	5	0.25		0.77*	10	4.5					10	1	04
							140		2	5			0.6	100								
							120		100	5												
							240	500*	2	5		0.55	0.70*	2								
BC238-92	TO-92 (97)	30	20	5	50	20	100		0.01	5	0.25		0.77*	10	4.5					10	1	04
							140		2	5			0.6	100								
							120		100	5												
							125	900*	2	5		0.55	0.70*	2								
BC238A-92	TO-92 (97)	30	20	5	50	20	100		0.01	5	0.25		0.77*	10	4.5					10	1	04
							140		2	5			0.6	100								
							120		100	5												
							125	260*	2	5		0.55	0.70*	2								
BC238B-92	TO-92 (97)	30	20	5	50	20	100		0.01	5	0.25		0.77*	10	4.5					10	1	04
							140		2	5			0.6	100								
							120		100	5												
							240	500*	2	5		0.55	0.70*	2								
BC238C-92	TO-92 (97)	30	20	5	50	20	100		0.01	5	0.25		0.77*	10	4.5					10	1	04
							140		2	5			0.6	100								
							120		100	5												
							450	900*	2	5		0.55	0.70*	2								
BC239-92	TO-92 (97)	30	20	5	50	20	100		0.01	5	0.25		0.77*	10	4.5					4	1	04
							140		2	5			0.6	100								
							120		100	5												
							240	900*	2	5		0.55	0.70	2								
BC239B-92	TO-92 (97)	30	20	5	50	20	100		0.01	5	0.25		0.77*	10	4.5					4	1	04
							140		2	5			0.6	100								
							120		100	5												
							240	500*	2	5		0.55	0.70	2								
BC239C-92	TO-92 (97)	30	20	5	50	20	100		0.01	5	0.25		0.77*	10	4.5					4	1	04
							140		2	5			0.6	100								
							120		100	5												
							450	900*	2	5		0.55	0.70	2								
BC261A	TO-18		45		50	45	100		0.01	5	0.25		0.9	10	4.5					6	3	71
							140		2	5	0.6			100								
							120		100	5												
							125	260*	2	5												

TEST CONDITIONS:

(1) $I_C = 200\ \mu A$, $V_{CE} = 5V$, f = 1 kHz. **(2)** $I_C = 100$ mA, $V_{CC} = 20V$, $I_B^1 = I_B^2 = 5$ mA. **(3)** $I_C = 200\ \mu A$, $V_{CE} = 2V$, f = 1 kHz. **(4)** $I_C = 100$ mA, $V_{CC} = 10V$, $I_B^1 = I_B^2 = 10$ mA. **(5)** $I_C = 10$ mA, $V_{CC} = 3V$, $I_B^1 = I_B^2 = 1$ mA. **(6)** $I_C = 100\ \mu A$, $V_{CE} = 5V$, f = 1 kHz. **(7)** $I_C = 1$ mA, $V_{CE} = 10V$, f = 200 kHz. **(8)** $I_C = 1$ mA, $V_{CE} = 5V$, f = 1 kHz. **(9)** $I_C = 150$ mA, $V_{CC} = 6V$, $I_B^1 = I_B^2 = 15$ mA. **(10)** $I_C = 10\ \mu A$, $V_{CE} = 5V$, f = WB.

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} h_{fe} 1 kHz* Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BC261B	TO-18		45		50	45	100		0.01	5	0.25		0.9	10						6	3	71
							140		2	5	0.6			100								
							120		100	5												
							240	500*	2	5												
BC262A	TO-18		20	5	50	20	100		0.01	5	0.25		0.9	10						6	3	71
							140		2	5												
							120		100	5												
							125	260*	2	5	0.6			100								
BC262B	TO-18		20	5	50	20	100		0.01	5	0.25		0.9	10						6	3	71
							140		2	5												
							120		100	5												
							240	500*	2	5	0.6			100								
BC263A	TO-18		20	5	50	20	100		0.01	5	0.25		0.9	10						2.5	3	71
							140		2	5												
							120		100	5												
							125	260*	2	5	0.6			100								
BC263B	TO-18		20	5	50	20	100		0.01	5	0.25		0.9	10						2.5	3	71
							140		2	5												
							120		100	5												
							240	500*	2	5	0.6			100								
BC307-92	TO-92 (97)	50	45	5	100	20	100		0.01	5	0.18		0.78	10						10	1	71
							140		2	5			1.0*	100								
							120		100	5												
							75	500*	2	5			0.75*	2								
BC307A-92	TO-92 (97)	50	45	5	100	20	100		0.01	5	0.18		0.78	10						10	1	71
							140		2	5			1.0*	100								
							120		100	5												
							125	260*	2	5			0.75*	2								
BC307B-92	TO-92 (97)	50	45	5	100	20	100		0.01	5	0.18		0.78	10						10	1	71
							140		2	5			1.0*	100								
							120		100	5												
							240	500*	2	5			0.75*	2								
BC308-92	TO-92 (97)	30	25	5	100	20	100		0.01	5	0.18		0.78	10						10	1	71
							140		2	5			1.0*	100								
							120		100	5												
							125	900*	2	5			0.75*	2								
BC308A-92	TO-92 (97)	30	25	5	100	20	100		0.01	5	0.18		0.78	10						10	1	71
							140		2	5			1.0*	100								
							120		100	5												
							125	260*	2	5			0.75*	2								

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} h_{fe} 1 kHz* Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BC308B-92	TO-92 (97)	30	25	5	100	20	100		0.01	5	0.18		0.78	10						10	1	71
							140	400	2	5			1.0*	100								
							120		100	5												
							240	500*	2	5			0.75*	2								
BC308C-92	TO-92 (97)	30	25	5	100	20	100		0.01	5	0.18		0.78	10						10	1	71
							140	400	2	5			1.0*	100								
							120		100	5												
							450	900*	2	5			0.75*	2								
BC309-92	TO-92 (97)	25	20	5	100	20	100		0.01	5	0.18		0.78	10						4	1	71
							140	400	2	5			1.0	100								
							120		100	5												
							125	900*	2	5			0.75	2								
BC309B-92	TO-92 (97)	25	20	5	100	20	100		0.01	5	0.18		0.78	10						4	1	71
							140		2	5			1.0	100								
							120		100	5												
							240	500*	2	5			0.75	2								
BC309C-92	TO-92 (97)	25	20	5	100	20	100		0.01	5	0.8		0.78	10						4	1	71
							140	400	2	5			1.0	100								
							120		100	5												
							450	900*	2	5			0.75*	2								
BC317	TO-92 (92)	50	45	6	30	20	110	450	2	5	0.2		0.77*	10	4					6	1	04
							125	500*	2	5	0.5			100								
												0.57	0.72*	2								
BC317A	TO-92 (92)	50	45	6	30	20	110	220	2	5	0.2		0.77*	10	4					6	1	04
							125	260*	2	5	0.5			100								
												0.57	0.72*	2								
BC317B	TO-92 (92)	50	45	6	30	20	200	450	2	5	0.2		0.77*	10	4					6	1	04
							240	500*	2	5	0.5			100								
												0.57	0.72*	2								
BC318	TO-92 (92)	30	20	5	30	20	110	800	2	5	0.2		0.77*	10	4					6	1	04
							125	900*	2	5	0.5			100								
												0.57	0.72*	2								
BC318A	TO-92 (92)	30	20	5	30	20	110	220	2	5	0.2		0.77*	10	4					6	1	04
							125	260*	2	5	0.5			100								
												0.57	0.72*	2								

TEST CONDITIONS:
(1) I_C = 200 μA, V_{CE} = 5V, f = 1 kHz. **(2)** I_C = 100 mA, V_{CC} = 20V, $I_B{}^1 = I_B{}^2$ = 5 mA. **(3)** I_C = 200 μA, V_{CE} = 2V, f = 1 kHz. **(4)** I_C = 100 mA, V_{CC} = 10V, $I_B{}^1 = I_B{}^2$ = 10 mA. **(5)** I_C = 10 mA, V_{CC} = 3V, $I_B{}^1 = I_B{}^2$ = 1 mA. **(6)** I_C = 100 μA, V_{CE} = 5V, f = 1 kHz. **(7)** I_C = 1 mA, V_{CE} = 10V, f = 200 kHz. **(8)** I_C = 1 mA, V_{CE} = 5V, f = 1 kHz. **(9)** I_C = 150 mA, V_{CC} = 6V, $I_B{}^1 = I_B{}^2$ = 15 mA. **(10)** I_C = 10 μA, V_{CE} = 5V, f = WB.

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} h_{fe} 1 kHz* Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BC318B	TO-92	30	20	5	30	20	200	450	2	5	0.2		0.77*	10	4					6	1	04
	(92)						240	500*	2	5	0.5			100								
												0.57	0.72*	2								
BC318C	TO-92	30	20	5	30	20	100		0.01	5	0.2*		0.77*	10	4					6	1	04
	(92)						450	800	2	5	0.5			100								
							450	900*	2	5		0.57	0.72*	2								
BC319	TO-92	30	20	5	30	20	40		0.01	5	0.2		0.77*	10	4					4	1	04
	(92)						200	800	2	5	0.5			100								
							240	900*	2	5		0.57	0.72*	2								
BC319B	TO-92	30	20	5	30	20	200	450	2	5	0.2		0.77*	10	4					4	1	04
	(92)						240	500*	2	5	0.5			100								
												0.57	0.72*	2								
BC319C	TO-92	30	20	5	30	20	100		0.01	5	0.2		0.77*	10	4					4	1	04
	(92)						420	800	2	5	0.5			100								
							450	900*	2	5		0.57	0.72*	2								
BC327	TO-92	50†	45	5	100†	45	40		300	1	0.7			500	4					4	1	67
	(97)						100	600	100	1			12*	300								
BC327-10	TO-92	50†	45	5	100†	45	40		300	1	0.7			500	4					4	1	67
	(97)						63	160	100	1			1.2*	300								
BC327-16	TO-92	50†	45	5	100†	45	40		300	1	0.7			500	4					4	1	67
	(97)						100	250	100	1			1.2*	300								
BC327-25	TO-92	50†	45	5	100†	45	40		300	1	0.7			500	4					4	1	67
	(97)						160	400	100	1			1.2*	300								
BC328	TO-92	30†	25	5	100†	25	40		300	1	0.7			500	4					4	1	67
	(97)						100	600	100	1			1.2	300								
BC328-10	TO-92	30†	25	5	100†	25	40		300	1	0.7			500	4					4	1	67
	(97)						63	160	100	1			1.2	300								
BC328-16	TO-92	30†	25	5	100†	25	40		300	1	0.7			500	4					4	1	67
	(97)						100	250	100	1			1.2	300								
BC328-25	TO-92	30†	25	5	100†	25	40		300	1	0.7			500	4					4	1	67
	(97)						160	400	100	1			1.2	300								
BC337	TO-92	50†	45	5	100†	45	40		300	1	0.7			500	4					4	1	14
	(97)						100	600	100	1			1.2*	300								
BC337-10	TO-92	50†	45	5	100†	45	40		300	1	0.7			500	4					4	1	14
	(97)						63	160	100	1			1.2*	300								
BC337-16	TO-92	50†	45	5	100†	45	40		300	1	0.7			500	4					4	1	14
	(97)						100	250	100	1			1.2*	300								
BC337-25	TO-92	50†	45	5	100†	45	40		300	1	0.7			500	4					4	1	14
	(97)						160	400	100	1			1.2*	300								

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BC338	TO-92	$30^\dagger$	25	5	$100^\dagger$	25	40		300	1	0.7			500	4					4	1	14
	(97)						100	600	100	1			1.2*	300								
BC338-10	TO-92	$30^\dagger$	25	5	$100^\dagger$	25	40		300	1	0.7			500	4					4	1	14
	(97)						63	160	100	1			1.2*	300								
BC338-16	TO-92	$30^\dagger$	25	5	$100^\dagger$	25	40		300	1	0.7			500	4					4	1	14
	(97)						100	250	100	1			1.2*	300								
BC338-25	TO-92	$30^\dagger$	25	5	$100^\dagger$	25	40		300	1	0.7			500	4					4	1	14
	(97)						160	400	100	1			1.2*	300								
BC415	TO-92	45	35	5	15	30	40		0.01	5	0.25			10						2	10	71
	(97)						120	800	2	5	0.6			100								
BC415A	TO-92	45	35	5	15	30	40		0.01	5	0.25			10						2	10	71
	(97)						120	220	2	5	0.6			100								
BC415B	TO-92	45	35	5	15	30	100		0.01	5	0.25			10						2	10	71
	(97)						180	460	2	5	0.6			100								
BC415C	TO-92	45	35	5	15	30	100		0.01	5	0.25			10						2	10	71
	(97)						380	800	2	5	0.6			100								
BC485	TO-92	45	45	5	100	30	15		1A	5	0.5		1.2	500	4					4	1	14
	(97)						40		10	2			1.2*	300								
							60	400	100	2												
BC485A	TO-92	45	45	5	100	30	15		1A	5	0.5		1.2	500	4					4	1	14
	(97)						40		10	2			1.2*	300								
							100	250	100	2												
BC485B	TO-92	45	45	5	100	30	15		1A	5	0.5		1.2	500	4					4	1	14
	(97)						40		10	2			1.2*	300								
							160	400	100	2												
BC485L	TO-92	45	45	5	100	30	15		1A	5	0.5		1.2	500	4					4	1	14
	(97)						40		10	2			1.2*	300								
							60	150	100	2												
BC547	TO-92	50	45	6	10	20					0.25		0.77*	10	4.5					10	1	04
	(97)										0.6			100								
							125	500*	2	5		0.55	0.70*	2								
BC547A	TO-92	50	45	6	10	20					0.25		0.77*	10	4.5					10	1	04
	(97)										0.6			100								
							125	260*	2	5		0.55	0.70*	2								

TEST CONDITIONS:

(1) I_C = 200 μA, V_{CE} = 5V, f = 1 kHz. **(2)** I_C = 100 mA, V_{CC} = 20V, $I_{B1} = I_{B2}$ = 5 mA. **(3)** I_C = 200 μA, V_{CE} = 2V, f = 1 kHz. **(4)** I_C = 100 mA, V_{CC} = 10V, $I_{B1} = I_{B2}$ = 10 mA. **(5)** I_C = 10 mA, V_{CC} = 3V, $I_{B1} = I_{B2}$ = 1 mA. **(6)** I_C = 100 μA, V_{CE} = 5V, f = 1 kHz. **(7)** I_C = 1 mA, V_{CE} = 10V, f = 200 kHz. **(8)** I_C = 1 mA, V_{CE} = 5V, f = 1 kHz. **(9)** I_C = 150 mA, V_{CC} = 6V, $I_{B1} = I_{B2}$ = 15 mA. **(10)** I_C = 10 μA, V_{CE} = 5V, f = WB.

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} h_{fe} 1 kHz* Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BC547B	TO-92 (97)	50	45	6	10	20	240	500*	2	5	0.25 0.6	0.55	0.77* 0.70*	10 100 2	4.5					10	1	04
BC547C	TO-92 (97)	50	45	6	10	20	450	900*	2	5	0.25 0.6	0.55	0.77* 0.70*	10 100 2	4.5					10	1	04
BC548	TO-92 (97)	30	20	5	10	20	125	900*	2	5	0.25 0.6	0.55	0.77* 0.70*	10 100 2	4.5					10	1	04
BC548A	TO-92 (97)	30	20	5	10	20	125	260*	2	5	0.25 0.6	0.55	0.77* 0.70*	10 100 2	4.5					10	1	04
BC548B	TO-92 (97)	30	20	5	10	20	240	500*	2	5	0.25 0.6	0.55	0.77* 0.70*	10 100 2	4.5					10	1	04
BC548C	TO-92 (97)	30	20	5	10	20	450	900*	2	5	0.25 0.6	0.55	0.77* 0.70*	10 100 2	4.5					10	1	04
BC549	TO-92 (97)	30	20	5	10	20	240	900*	2	5	0.25 0.6	0.55	0.77* 0.70	10 100 2	4.5					4	1	04
BC549B	TO-92 (97)	30	20	5	10	20	240	500*	2	5	0.25 0.6	0.55	0.77* 0.70	10 100 2	4.5					4	1	04
BC549C	TO-92 (97)	30	20	5	10	20	450	900*	2	5	0.25	0.55	0.77* 0.70	10 100 2	4.5					4	1	04
BC550	TO-92 (97)	50	45	5	10	45	240	900*	2	5	0.25 0.6	0.55	0.77* 0.70	10 100 2						3	1	04
BC550B	TO-92 (97)	50	45	5	10	45	240	500*	2	5	0.25 0.6	0.55	0.77* 0.70	10 100 2						3	1	04
BC550C	TO-92 (97)	50	45	5	10	45	450	900*	2	5	0.25 0.6	0.55	0.77* 0.70	10 100 2						3	1	04
BC557	TO-92 (97)	50	45	5	100	20	75	260*	2	5	0.3 0.65	0.6	0.82* 0.75*	10 100 2						10	1	71

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} h_{fe} 1 kHz* Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BC557A	TO-92	50	45	5	100	20					0.3		0.82*	10						10	1	71
	(97)										0.65			100								
							125	260*	2	5		0.6	0.75*	2								
BC557B	TO-92	50	45	5	100	20					0.3		0.82*	10						10	1	71
	(97)										0.65			100								
							240	500*	2	5		0.6	0.75*	2								
BC558	TO-92	30	25	5	100	20					0.3		0.82*	10						10	1	71
	(97)										0.65			100								
							75	500*	2	5		0.6	0.75	2								
BC558A	TO-92	30	25	5	100	20					0.3		0.82*	10						10	1	71
	(97)										0.65			100								
							125	260*	2	5		0.6	0.75	2								
BC558B	TO-92	30	25	5	100	20					0.3		0.82*	10						10	1	71
	(97)										0.65			100								
							240	500*	2	5		0.6	0.75	2								
BC558C	TO-92	30	25	5	100	20					0.3		0.82*	10						10	1	71
	(97)										0.65			100								
							450	900*	2	5		0.6	0.75	2								
BC559	TO-92	25	20	5	100	20					0.3		0.82*	10						4	1	71
	(97)										0.65			100								
							125	500*	2	5		0.6	0.75*	2								
BC559A	TO-92	25	20	5	100	20					0.3		0.82*	10						4	1	71
	(97)										0.65			100								
							125	260*	2	5		0.6	0.75*	2								
BC559B	TO-92	25	20	5	100	20					0.3		0.82*	10						4	1	71
	(97)										0.65			100								
							240	500*	2	5		0.6	0.75*	2								
BC559C	TO-92	25	20	5	100	20					0.3		0.82*	10						4	1	71
	(97)										0.65			100								
							450	900*	2	5		0.6	0.75*	2								
BC560	TO-92	50	45	5	100	45					0.3		0.82*	10						2	1	71
	(97)										0.65			100								
							125	500*	2	5		0.6	0.75*	2								

TEST CONDITIONS:

(1) I_C = 200 μA, V_{CE} = 5V, f = 1 kHz. **(2)** I_C = 100 mA, V_{CC} = 20V, $I_B^1 = I_B^2$ = 5 mA. **(3)** I_C = 200 μA, V_{CE} = 2V, f = 1 kHz. **(4)** I_C = 100 mA, V_{CC} = 10V, $I_B^1 = I_B^2$ = 10 mA. **(5)** I_C = 10 mA, V_{CC} = 3V, $I_B^1 = I_B^2$ = 1 mA. **(6)** I_C = 100 μA, V_{CE} = 5V, f = 1 kHz. **(7)** I_C = 1 mA, V_{CE} = 10V, f = 200 kHz. **(8)** I_C = 1 mA, V_{CE} = 5V, f = 1 kHz. **(9)** I_C = 150 mA, V_{CC} = 6V, $I_B^1 = I_B^2$ = 15 mA. **(10)** I_C = 10 μA, V_{CE} = 5V, f = WB.

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BC560A	TO-92 (97)	50	45	5	100	45	 125	 260*	 2	 5	0.3 0.65	 0.6	0.82* 0.75*	10 100 2						2	1	71
BC560B	TO-92 (97)	50	45	5	100	45	 240	 500*	 2	 5	0.3 0.65	 0.6	0.82* 0.75*	10 100 2						2	1	71
BC560C	TO-92 (97)	50	45	5	100	45	 450	 900*	 2	 5	0.3 0.65	 0.6	0.82* 0.75*	10 100 2						2	1	71
BCX58	TO-92 (97)		32	7	10	32	120 80 40	630 1000	2 10 100	5 1 1						125		10	800	6	3/4	04
BCX58-7	TO-92 (97)		32	7	10	32	120 80 40	220	2 10 100	5 1 1						125		10	800	6	3/4	04
BCX58-8	TO-92 (97)		32	7	10	32	20 180 120 45	 310 400	0.01 2 10 100	5 5 1 1						125		10	800	6	3/4	04
BCX58-9	TO-92 (97)		32	7	10	32	40 250 160 60	 460 630	0.01 2 10 100	5 5 1 1						125		10	800	6	3/4	04
BCX58-10	TO-92 (97)		32	7	10	32	100 380 240 60	 630 1000	0.01 2 10 100	5 5 1 1						125		10	800	6	3/4	04
BCX59	TO-92 (97)		45	7			120 80 40	630 1000	2 10 100	5 1 1	0.5		1.0	100		125		10	800		5	04
BCX59-7	TO-92 (97)		45	7			120 80 40	220	2 10 100	5 1 1	0.5		1.0	100		125		10	800		5	04
BCX59-8	TO-92 (97)		45	7			20 180 120 45	 310 400	0.01 2 10 100	5 5 1 1	0.5		1.0	100		125		10	800		5	04
BCX59-9	TO-92 (97)		45	7			40 250 160 60	 460 630	0.01 2 10 100	5 5 1 1	0.5		1.0	100		125		10	800		5	04

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BCX59-10	TO-92 (97)		45	7			100 380 240 60	 630 1000 	0.01 2 10 100	5 5 1 1	0.5		1.0	100		125		10	800		5	04
BCX78	TO-92 (97)		32	5			120 80 40	630 1000 	2 10 100	5 1 1	0.6		1.0	100								71
BCX78-7	TO-92 (97)		32	5			120 80 40	220 	2 10 100	5 1 1	0.6		1.0	100								71
BCX78-8	TO-92 (97)		32	5			30 180 120 45	 310 400 	0.01 2 10 100	5 5 1 1	0.6		1.0	100								71
BCX78-9	TO-92 (97)		32	5			40 250 160 60	 460 630 	0.01 2 10 100	5 5 1 1	0.6		1.0	100								71
BCX78-10	TO-92 (97)		32	5			100 380 240 60	 630 1000 	0.01 2 10 100	5 5 1 1	0.6		1.0	100								71
BCX79	TO-92 (97)		45	5			80 40 120	1000 630	10 100 2	1 1 5	0.6		1.0	100								71
BCX79-7	TO-92 (97)		45	5			120	220	2	5	0.6		1.0	100								71
BCX79-8	TO-92 (97)		45	5			120 45 30 180	400 310	10 100 0.01 2	1 1 5 5	0.6		1.0	100								71
BCX79-9	TO-92 (97)		45	5			160 60 40 250	630 460	10 100 0.01 2	1 1 5 5	0.6		1.0	100								71

TEST CONDITIONS:

(1) I_C = 200 µA, V_{CE} = 5V, f = 1 kHz. **(2)** I_C = 100 mA, V_{CC} = 20V, $I_B{}^1 = I_B{}^2$ = 5 mA. **(3)** I_C = 200 µA, V_{CE} = 2V, f = 1 kHz. **(4)** I_C = 100 mA, V_{CC} = 10V, $I_B{}^1 = I_B{}^2$ = 10 mA. **(5)** I_C = 10 mA, V_{CC} = 3V, $I_B{}^1 = I_B{}^2$ = 1 mA. **(6)** I_C = 100 µA, V_{CE} = 5V, f = 1 kHz. **(7)** I_C = 1 mA, V_{CE} = 10V, f = 200 kHz. **(8)** I_C = 1 mA, V_{CE} = 5V, f = 1 kHz. **(9)** I_C = 150 mA, V_{CC} = 6V, $I_B{}^1 = I_B{}^2$ = 15 mA. **(10)** I_C = 10 µA, V_{CE} = 5V, f = WB.

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} h_{fe} 1 kHz* Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BCX79-10	TO-92 (97)		45	5			240 60 100 380	1000 630	10 100 0.01 2	1 1 5 5	0.6		1.0	100								71
BCY56	TO-18	45	45	5	100	20	40 100 125 40	 450 500* 	10 2 2 0.01	5 5 5 5		0.6	0.7*	2						5	1	04
BCY57	TO-18	25	20	5	100	20	200 200 240 100	 800 900* 	10 2 2 0.01	5 5 5 5		0.6	0.7*	2						5	1	04
BCY58	TO-18		32	7	10†	32	40 80 125	 1000 700*	100 10 2	1 1 5	0.35 0.7	0.6 0.75 0.55	0.85 1.2 0.7*	10 100 2	6	125		10	800	6	4/1	04
BCY58-7	TO-18		32	7	10†	32	40 80 125	 1000 250*	100 10 2	1 1 5	0.35 0.7	0.6 0.75 0.55	0.85 1.2 0.7*	10 100 2	6	125		10	800	6	4/1	04
BCY58-8	TO-18		32	7	10†	32	40 80 175	 1000 350*	100 10 2	1 1 5	0.35 0.7	0.6 0.75 0.55	0.85 1.2 0.7*	10 100 2	6	125		10	800	6	4/1	04
BCY58-9	TO-18		32	7	10†	32	40 80 250	 1000 500*	100 10 2	1 1 5	0.35 0.7	0.6 0.75 0.55	0.85 1.2 0.7*	10 100 2	6	125		10	800	6	4/1	04
BCY58-10	TO-18		32	7	10†	32	40 80 350	 1000 700*	100 10 2	1 1 5	0.35 0.7	0.6 0.75 0.55	0.85 1.2 0.7*	10 100 2	6	125		10	800	6	4/1	04
BCY59	TO-18		45	7	10†	45	40 80 125	 1000 700*	100 10 2	1 1 5	0.35 0.7	0.6 0.55	0.85 0.75 0.7*	10 1.2 2	6 100	125		10	800	6	4/1	04
BCY59-7	TO-18		45	7	10†	45	40 80 125	 1000 250*	100 10 2	1 1 5	0.35 0.7	0.6 0.75 0.55	0.85 1.2 0.7*	10 100 2	6	125		10	800	6	4/1	04
BCY59-8	TO-18		45	7	10†	45	40 80 175	 1000 350*	100 10 2	1 1 5	0.35 0.7	0.6 0.75 0.55	0.85 1.2 0.7*	10 100 2	6 100	125		10	800	6	4/1	04
BCY59-9	TO-18		45	7	10†	45	40 80 250	 1000 500*	100 10 2	1 1 5	0.35 0.7	0.6 0.75 0.55	0.85 1.2 0.7*	10 100 2	6	125		10	800	6	4/1	04

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} h_{fe} 1 kHz* Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BCY59-10	TO-18		45	7	10†	45	40		100	1	0.35	0.6	0.85	10	6	125		10	800	6	4/1	04
							80	1000	10	1	0.7	0.75	1.2	100								
							350	700*	2	5		0.55	0.7*	2								
BCY70	TO-18	50	40	5	10	40	40		0.1	1	0.25	0.6	0.9	10	6	250		10	420	6	5/6	71
							45		1	1												
							50		10	1												
							15		50	1	0.5		1.2	50								
BCY71	TO-18	45	45	5	500	45	40		0.01	1	0.25	0.6	0.9	10	6	200		10		2	6	71
							80		0.1	1												
							90		1	1												
							100	600	10	1	0.5		1.2	50								
BCY71A	TO-18	45	45	5	500	45	40		0.01	1	0.25	0.6	0.9	10	6	300		10	420	2	6	71
							80		0.1	1												
							90		1	1												
							100	600	10	1	0.5		1.2	50								
BCY72	TO-18	25	25	5	500	20	40		1	1	0.25			10	6	200		10	420	6	5/6	71
							50		10	1	0.5		1.2	50								
BD135	TO-126	45	45	5	100	30	25		500	2	0.5		1.0*	500		50		50	420	6	5/6	37
							40	250	50	2												
BD135-6	TO-126	45	45	5	100	30	40	100	150	2	0.5			500		50		50				37
							25		500	2												
BD135-10	TO-126	45	45	5	100	30	63	160	150	2	0.5			500		50		50				37
							25		500	2												
BD135-16	TO-126	45	45	5	100	30	100	250	150	2	0.5			500		50		50				37
							25		500	2												
BD136	TO-126	45	45	5	100	30	40	250	150	2	0.5			500		50		50				77
							25		500	2												
BD136-6	TO-126	45	45	5	100	30	40	100	150	2	0.5			500		50		50				77
							25		500	2												
BD136-10	TO-126	45	45	5	100	30	63	160	150	2	0.5			500		50		50				77
							25		500	2												
BD136-16	TO-126	45	45	5	100	30	100	250	150	2	0.5			500		50		50				77
							25		500	2												
BD137	TO-126	60	60	5	100	30	40	160	150	2	0.5			500		50		50				38
							25		500	2												

TEST CONDITIONS:

(1) I_C = 200 μA, V_{CE} = 5V, f = 1 kHz. **(2)** I_C = 100 mA, V_{CC} = 20V, $I_B{}^1 = I_B{}^2$ = 5 mA. **(3)** I_C = 200 μA, V_{CE} = 2V, f = 1 kHz. **(4)** I_C = 100 mA, V_{CC} = 10V, $I_B{}^1 = I_B{}^2$ = 10 mA. **(5)** I_C = 10 mA, V_{CC} = 3V, $I_B{}^1 = I_B{}^2$ = 1 mA. **(6)** I_C = 100 μA, V_{CE} = 5V, f = 1 kHz. **(7)** I_C = 1 mA, V_{CE} = 10V, f = 200 kHz. **(8)** I_C = 1 mA, V_{CE} = 5V, f = 1 kHz. **(9)** I_C = 150 mA, V_{CC} = 6V, $I_B{}^1 = I_B{}^2$ = 15 mA. **(10)** I_C = 10 μA, V_{CE} = 5V, f = WB.

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max @	V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	Max @	I_C (mA) &	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max &	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	Max @	I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	Max @	I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BD137-6	TO-126	60	60	5	100	30	40	100	150	2	0.5			500		50		50				38
							25		500	2												
BD137-10	TO-126	60	60	5	100	30	63	160	150	2	0.5			500		50		50				38
							25		500	2												
BD138	TO-126	60	60	5	100	30	40	160	150	2	0.5			500		50		50				78
							25		500	2												
BD138-6	TO-126	60	60	5	100	30	40	100	150	2	0.5			500		50		50				78
							25		500	2												
BD138-10	TO-126	60	60	5	100	30	63	160	150	2	0.5			500		50		50				78
							25		500	2												
BD139	TO-126	80	80	5	100	30	25		500	2	0.5		1.0*	500		50		50	420	6	5/6	39
							40	160	50	2												
BD139-6	TO-126	80	80	5	100	30	25		500	2	0.5		1.0*	500		50		50				39
							40	100		2												
BD139-10	TO-126	80	80	5	100	30	25		500	2	0.5		1.0*	500		50		50				39
							40	160	50	2												
BD140	TO-126	80	80	5	100	30	25		500	2	0.5		1.0*	500		50		50	420	6	5/6	79
							40	160	50	2												
BD157	TO-126		250		100 μA	275	30	240	50	10												36
BD158	TO-126		300		100 μA	325	30	240	50	10												36
BD159	TO-126		350		100 μA	325	30	240	50	10												36
BD185	TO-126		30		100 μA	40	40		500	2	1.0		1.2*	2A								4F
							15		2A	2												
BD186	TO-126		30		100 μA	40	40		500	2	1.0		1.5*	2A								5F
							15		2A	2												
BD187	TO-126		45		100 μA	55	40		500	2	1.0		1.5*	2A								4F
							15		2A	2												
BD188	TO-126		45		100 μA	55	40		500	2	1.0		1.5*	2A								5F
							15		2A	2												
BD189	TO-126		60		100 μA	70	40		500	2	1.0		1.5*	2A								4F
							15		2A	2												
BD190	TO-126		60		100 μA	70	40		500	2	1.0		1.5*	2A								5F
							15		2A	2												
BD201	TO-220	60	45	5	10 μA	40	30		3A	2	1.0		1.5*	3A		3		300	420	6	5/6	4A
							30		1A	2												
							75	235	500	1												
BD202	TO-220	60	45	5	10 μA	40	30		3A	2	1.0		1.5*	3A		3		300	420	6	5/6	5A
							30		1A	2												
							75	235	500	1												

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BD203	TO-220	60	60	5			30		2	2	1.0			3A		3		300				4A
							30		1	2												
BD204	TO-220	60	60	5	10 μA	40	30		2A	2	1.0		1.5*	3A								5A
							30		1A	1												
BD220	TO-220		70				30	120	500	4	1.0		1.1*	500								4F
BD221	TO-220		40				30	120	1A	4	1.0		1.3*	1A								4F
BD222	TO-220		60				20	80	1.5A	4	1.0		1.5*	1.5A								4F
BD223	TO-220	70					30	120	300	4	1.0		1.1*	500								5F
BD224	TO-220		40				30	120	1A	4	1.0		1.3*	1A								5F
BD225	TO-220		60				20	80	1.5A	4	1.0		1.5*	1.5A								5F
BD233	TO-126	45	45		100 μA	45	25		1A	2	0.6		1.3*	1A		3		250	420	6	5/6	4F
							40		150	2												
BD234	TO-126	45	45		100 μA	45	25		1A	2	0.6		1.3*	1A		3		250	420	6	5/6	5F
							40		150	2												
BD235	TO-126	60	60		100 μA	60	25		1A	2	0.6		1.3*	1A		3		250	420	6	5/6	4F
							40		150	2												
BD236	TO-126	60	60		100 μA	60	25		1A	2	0.6		1.3*	1A		3		250	420	6	5/6	5F
							40		150	2												
BD237	TO-126	80	80		100 μA	80	25		1A	2	0.6		1.3*	1A		3		250	420	6	5/6	4F
							40		150	2												
BD238	TO-126		80		100 μA	80	25		1A	2	0.6		1.3*	1A		3		250	420	6	5/6	5F
							40		150	2												
BD239	TO-220		45		200 μA*	45	15		1A	4	0.7		1.3*	1A		3		200	420	6	5/6	4F
							40		200	4												
BD239A	TO-220		60		200 μA*	60	15		1A	4	0.7		1.3*	1A		3		200	420	6	5/6	4F
							40		200	4												
BD239B	TO-220		80		200 μA*	80	15		1A	4	0.7		1.3*	1A		3		200	420	6	5/6	4F
							40		200	4												
BD239C	TO-220		100		200 μA*	100	15		1A	4	0.7		1.3*	1A		3		200	420	6	5/6	4F
							40		200	4												
BD240	TO-220		45		200 μA*	45	15		1A	4	0.7		1.3*	1A		3		200	420	6	5/6	5F
							40		200	4												
BD240A	TO-220	80	60		200 μA*	60	15		1A	4	0.7		1.3*	1A		3		200	420	6	5/6	5F
							40		200	4												

TEST CONDITIONS:

(1) I_C = 200 μA, V_{CE} = 5V, f = 1 kHz. **(2)** I_C = 100 mA, V_{CC} = 20V, $I_{B^1} = I_{B^2}$ = 5 mA. **(3)** I_C = 200 μA, V_{CE} = 2V, f = 1 kHz. **(4)** I_C = 100 mA, V_{CC} = 10V, $I_{B^1} = I_{B^2}$ = 10 mA. **(5)** I_C = 10 mA, V_{CC} = 3V, $I_{B^1} = I_{B^2}$ = 1 mA. **(6)** I_C = 100 μA, V_{CE} = 5V, f = 1 kHz. **(7)** I_C = 1 mA, V_{CE} = 10V, f = 200 kHz. **(8)** I_C = 1 mA, V_{CE} = 5V, f = 1 kHz. **(9)** I_C = 150 mA, V_{CC} = 6V, $I_{B^1} = I_{B^2}$ = 15 mA. **(10)** I_C = 10 μA, V_{CE} = 5V, f = WB.

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BD240B	TO-220	80	80		200 µA*	80	15 40		1A 200	4 4	0.7		1.3*	1A		3		200	420	6	5/6	5F
BD240C	TO-220	80	100		200 µA*	100	15 40		1A 200	4 4	0.7		1.3*	1A		3		200	420	6	5/6	5F
BD241	TO-220	80	45		200 µA*	45	10 25		3A 1A	4 4	1.3		1.8*	3A		3		500	420	6	5/6	4F
BD241A	TO-220	80	60		200 µA*	60	10 25		3A 1A	4 4	1.3		1.8*	3A		3		500	420	6	5/6	4F
BD241B	TO-220	80	80		200 µA*	80	10 25		3A 1A	4 4	1.3		1.8*	3A		3		500	420	6	5/6	4F
BD241C	TO-220	80	100		200 µA*	100	10 25		3A 1A	4 4	1.3		1.8*	3A		3		500	420	6	5/6	4F
BD242	TO-220	80	45		200 µA*	45	10 25		3A 1A	4 4	1.2		1.8*	3A		3		500	420	6	5/6	5E
BD242A	TO-220	80	60		200 µA*	60	10 25		3A 1A	4 4	1.2		1.8*	3A		3		500	420	6	5/6	5E
BD242B	TO-220	80	80		200 µA*	80	10 25		3A 1A	4 4	1.2		1.8*	3A	3	3		500	420	6	5/6	5E
BD242C	TO-220	80	100		200 µA*	100	10 25		3A 1A	4 4	1.2		1.8*	3A		3		500	420	6	5/6	5E
BD243	TO-220		45		400 µA*	45	30 15		300 3A	4 4						3		500				4A
BD243A	TO-220		60		400 µA*	60	30 15		300 3A	4 4						3		500				4A
BD243B	TO-220		80		400 µA*	80	30 15		300 3A	4 4						3		500				4A
BD243C	TO-220		100		400 µA*	100	30 15		300 3A	4 4												4A
BD244	TO-220		45		400 µA*	45	30 15		300 3A	4 4												4A
BD244A	TO-220		60		400 µA*	60	30 15		300 3A	4 4												5A
BD244B	TO-220		80		400 µA*	80	30 15		300 3A	4 4						3		500				5A
BD244C	TO-220		100		400 µA*	100	30 15		300 3A	4 4						3		500				5A
BD344	TO-126	60	60	5	500	60	60 40	 250	50 200	1 1	0.4			200	20	50		50				78

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BD345	TO-126	60	60	5	500	60	60		50	1	0.4			200	20	50		50				38
							40	250	200	1												
BD346	TO-220		60		10 µA	60	40	140	2A	2.5					200	4		250				5A
							30		4A	2.5												
BD347	TO-220		60		10 µA	60	40	140	2A	2.5					200	4		250				4A
							30		4A	2.5												
BD348	TO-126	80	80	5	500	80	60		100	1	0.5			250	17	50		50				79
							50	250	250	1												
BD349	TO-126		80		500	80	60		100	1	0.5		1.5*	250	15	50		50				39
							50	250	250	1												
BD370A	TO-237	80	45		100	45	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	78
	(91)						40	400	100	1												
BD370A-10	TO-237	80	45		100	45	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	78
	(91)						63	160	100	1												
BD370A-16	TO-237	80	45		100	45	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	78
	(91)						100	250	100	1												
BD370A-25	TO-237	80	45		100	45	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	78
	(91)						160	400	100	1												
BD370B	TO-237	80	60		100	60	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	78
	(91)						40	400	100	1												
BD370B-10	TO-237	80	60		100	60	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	78
	(91)						63	160	100	1												
BD370B-16	TO-237	80	60		100	60	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	78
	(91)						100	250	100	1												
BD370B-25	TO-237	80	60		100	60	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	78
	(91)						160	400	100	1												
BD370C	TO-237	80	80		100	80	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	78
	(91)						40	400	100	1												
BD370-6	TO-237	80	80		100	80	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	78
	(91)						40	100	100	1												
BD370C-10	TO-237	80	80		100	80	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	78
	(91)						63	160	100	1												
BD370C-16	TO-237	80	80		100	80	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	78
	(91)						100	250	100	1												

TEST CONDITIONS:

(1) I_C = 200 µA, V_{CE} = 5V, f = 1 kHz. **(2)** I_C = 100 mA, V_{CC} = 20V, $I_B^1 = I_B^2$ = 5 mA. **(3)** I_C = 200 µA, V_{CE} = 2V, f = 1 kHz. **(4)** I_C = 100 mA, V_{CC} = 10V, $I_B^1 = I_B^2$ = 10 mA. **(5)** I_C = 10 mA, V_{CC} = 3V, $I_B^1 = I_B^2$ = 1 mA. **(6)** I_C = 100 µA, V_{CE} = 5V, f = 1 kHz. **(7)** I_C = 1 mA, V_{CE} = 10V, f = 200 kHz. **(8)** I_C = 1 mA, V_{CE} = 5V, f = 1 kHz. **(9)** I_C = 150 mA, V_{CC} = 6V, $I_B^1 = I_B^2$ = 15 mA. **(10)** I_C = 10 µA, V_{CE} = 5V, f = WB.

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BD370D	TO-237 (91)	80	100		100	80	25 40	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	79
BD370D-6	TO-237 (91)	80	100		100	80	25 40	 100	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	79
BD370D-10	TO-237 (91)	80	100		100	80	25 63	 160	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	79
BD371A	TO-237 (91)	80	45		100	45	25 40	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	38
BD371A-10	TO-237 (91)	80	45		100	45	25 63	 160	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	38
BD371A-16	TO-237 (91)	80	45		100	45	25 100	 250	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	38
BD371A-25	TO-237 (91)	80	45		100	45	25 180	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	38
BD371B	TO-237 (91)	80	60		100	60	25 40	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	38
BD371B-10	TO-237 (91)	80	60		100	60	25 63	 160	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	38
BD371B-16	TO-237 (91)	80	60		100	60	25 100	 250	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	38
BD371B-25	TO-237 (91)	80	60		100	60	25 160	 400	500 100	2	0.7		1.2*	1A	30	50		200	420	6	5/6	38
BD371C	TO-237 (91)	80	80		100	80	25 40	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	38
BD371C-6	TO-237 (91)	80	80		100	80	25 40	 100	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	38
BD371C-10	TO-237 (91)	80	80		100	80	25 63	 160	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	38
BD371C-16	TO-237 (91)	80	80		100	80	25 100	 250	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	38
BD371D	TO-237 (91)	80	100		100	100	25 40	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	39
BD371D-6	TO-327 (91)	80	100		100	100	25 40	 100	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	39
BD371D-10	TO-237 (91)	80	100		100	100	25 63	 160	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	39
BD372A	TO-237 (90)	80	45		100	45	25 40	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	78

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BD372A-10	TO-237	80	45		100	45	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	78
	(90)						63	160	100	1												
BD372A-16	TO-237	80	45		100	45	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	78
	(90)						100	250	100	1												
BD372A-25	TO-237	80	45		100	45	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	78
	(90)						160	400	100	1												
BD372B	TO-237	80	60		100	60	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	78
	(90)						40	400	100	1												
BD372B-10	TO-237	80	60		100	60	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	78
	(90)						63	160	100	1												
BD372B-16	TO-237	80	60		100	60	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	78
	(90)						100	250	100	1												
BD372B-25	TO-237	80	60		100	60	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	78
	(90)						160	400	100	1												
BD372C	TO-237	80	80		100	80	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	78
	(90)						40	400	100	1												
BD372C-6	TO-237	80	80		100	80	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	78
	(90)						40	100	100	1												
BD372C-10	TO-237	80	80		100	80	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	78
	(90)						63	160	100	1												
BD372C-16	TO-237	80	100		100	100	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	78
	(90)						100	250	100	1												
BD372D	TO-237	80	100		100	100	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	79
	(90)						40	400	100	1												
BD372D-6	TO-237	80	100		100	100	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	79
	(90)						40	100	100	1												
BD372D-10	TO-237	80	100		100	100	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	79
	(90)						63	160	100	1												
BD373A	TO-237	80	45		100	45	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	38
	(90)						40	400	100	1												
BD373A-10	TO-237	80	45		100	45	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	38
	(90)						63	160	100	1												
BD373A-16	TO-237	80	45		100	45	25		500	2	0.7		1.2*	1A	30	50		200	420	6	5/6	38
	(90)						100	250	100	1												

TEST CONDITIONS:
(1) I_C = 200 μA, V_{CE} = 5V, f = 1 kHz. **(2)** I_C = 100 mA, V_{CC} = 20V, $I_B^1 = I_B^2$ = 5 mA. **(3)** I_C = 200 μA, V_{CE} = 2V, f = 1 kHz. **(4)** I_C = 100 mA, V_{CC} = 10V, $I_B^1 = I_B^2$ = 10 mA. **(5)** I_C = 10 mA, V_{CC} = 3V, $I_B^1 = I_B^2$ = 1 mA. **(6)** I_C = 100 μA, V_{CE} = 5V, f = 1 kHz. **(7)** I_C = 1 mA, V_{CE} = 10V, f = 200 kHz. **(8)** I_C = 1 mA, V_{CE} = 5V, f = 1 kHz. **(9)** I_C = 150 mA, V_{CC} = 6V, $I_B^1 = I_B^2$ = 15 mA. **(10)** I_C = 10 μA, V_{CE} = 5V, f = WB.

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} h_{fe} 1 kHz* Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BD373A-25	TO-237 (90)	80	45		100	45	25 160	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	38
BD373B	TO-237 (90)	80	80		100	80	25 40	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	38
BD373B-10	TO-237 (90)	80	60		100	80	25 63	 160	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/8	38
BD373B-16	TO-237 (90)	80	60		100	60	25 100	 250	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/8	38
BD373B-25	TO-237 (90)	80	60		100	60	25 160	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	38
BD373C	TO-237 (90)	80	80		100	80	25 40	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	38
BD373C-6	TO-237 (90)	80	80		100	80	25 40	 100	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	38
BD373C-10	TO-237 (90)	80	80		100	80	25 63	 160	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	38
BD373C-16	TO-237 (90)	80	80		100	80	25 100	 250	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	38
BD373D	TO-237 (90)	80	100		100	100	25 40	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	39
BD373D-6	TO-237 (90)	80	100		100	100	25 40	 100	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	39
BD373D-10	TO-237 (90)	80	100		100	100	25 63	 160	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	5/6	39
BD375	TO-126	50	45		2 μA	45	20 40	 375	1A 150	2 2	1.0		1.5*	1A	30	50		200	420	6	5/6	38
BD375-6	TO-126	50	45		2 μA	45	20 40	 100	1A 150	2 2	1.0		1.5*	1A	30	50		200	420	6	5/6	38
BD375-10	TO-126	50	45		2 μA	45	20 63	 160	1A 150	2 2	1.0		1.5*	1A	30	50		200	420	6	5/6	38
BD375-16	TO-126	50	45		2 μA	45	20 100	 250	1A 150	2 2	1.0		1.5*	1A	30	50		200	420	6	5/6	38
BD375-25	TO-126	50	45		2 μA	45	20 150	 375	1A 150	2 2	1.0		1.5*	1A	30	50		200	420	6	5/6	38
BD376	TO-126	50	45		2 μA	45	20 40	 375	1A 150	2 2	1.0		1.5*	1A	30	50		200	420	6	5/6	78
BD376-6	TO-126	50	45		2 μA	45	20 40	 100	1A 150	2 2	1.0		1.5*	1A	30	50		200	420	6	5/6	78

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BD376-10	TO-126	50	45		2 μA	45	20		1A	2	1.0		1.5*	1A	30	50		200	420	6	5/6	78
							63	160	150	2												
BD376-16	TO-126	50	45		2 μA	45	20		1A	2	1.0		1.5*	1A	30	50		200	420	6	5/6	78
							100	200	150	2												
BD376-25	TO-126	50	45		2 μA	45	20		1A	2	1.0		1.5*	1A	30	50		200	420	6	5/6	78
							150	375	150	2												
BD377	TO-126	75	60		2 μA	60	20		1A	2	1.0		1.5*	1A	30	50		200	420	6	5/6	38
							40	375	150	2												
BD377-6	TO-126	75	60		2 μA	60	20		1A	2	1.0		1.5*	1A	30	50		200	420	6	5/6	38
							40	100	150	2												
BD377-10	TO-126	75	60		2 μA	60	20		1A	2	1.0		1.5*	1A	30	50		200	420	6	5/6	38
							63	160	150	2												
BD377-16	TO-126	75	60		2 μA	60	20		1A	2	1.0		1.5*	1A	30	50		200	420	6	5/6	38
							100	250	150	2												
BD377-25	TO-126	75	60		2 μA	60	20		1A	2	1.0		1.5*	1A	30	50		200	420	6	5/6	38
							150	375	150	2												
BD378	TO-126	75	60		2 μA	60	20		1A	2	1.0		1.5*	1A	30	50		200	420	6	5/6	78
							40	375	150	2												
BD378-6	TO-126	75	60		2 μA	60	20		1A	2	1.0		1.5*	1A	30	50		200	420	6	5/6	78
							40	100	150	2												
BD378-10	TO-126	75	60		2 μA	60	20		1A	2	1.0		1.5*	1A	30	50		200	420	6	5/6	78
							63	160	150	2												
BD378-16	TO-126	75	60		2 μA	60	20		1A	2	1.0		1.5*	1A	30	50		200	420	6	5/6	78
							100	250	150	2												
BD378-25	TO-126	75	60		2 μA	60	20		1A	2	1.0		1.5*	1A	30	50		200	420	6	5/6	78
							150	375	150	2												
BD379	TO-126	100	80		2 μA	80	20		1A	2	1.0		1.5*	1A	30	50		200	420	6	5/6	39
							40	375	150	2												
BD379-6	TO-126	100	80		2 μA	80	20		1A	2	1.0		1.5*	1A	30	50		200	420	6	5/6	39
							40	100	150	2												

TEST CONDITIONS:
(1) I_C = 200 μA, V_{CE} = 5V, f = 1 kHz. **(2)** I_C = 100 mA, V_{CC} = 20V, $I_B^1 = I_B^2$ = 5 mA. **(3)** I_C = 200 μA, V_{CE} = 2V, f = 1 kHz. **(4)** I_C = 100 mA, V_{CC} = 10V, $I_B^1 = I_B^2$ = 10 mA. **(5)** I_C = 10 mA, V_{CC} = 3V, $I_B^1 = I_B^2$ = 1 mA. **(6)** I_C = 100 μA, V_{CE} = 5V, f = 1 kHz. **(7)** I_C = 1 mA, V_{CE} = 10V, f = 200 kHz. **(8)** I_C = 1 mA, V_{CE} = 5V, f = 1 kHz. **(9)** I_C = 150 mA, V_{CC} = 6V, $I_B^1 = I_B^2$ = 15 mA. **(10)** I_C = 10 μA, V_{CE} = 5V, f = WB.

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BD379-10	TO-126	100	80		2 μA	80	20 63	 160	1A 150	2 2	1.0		1.5*	1A	30	50		200	420	6	5/6	39
BD379-16	TO-126	100	80		2 μA	80	20 100	 250	1A 150	2 2	1.0		1.5*	1A	30	50		200	420	6	5/6	39
BD379-25	TO-126	100	80		2 μA	80	20 150	 375	1A 150	2 2	1.0		1.5*	1A	30	50		200	420	6	5/6	39
BD380	TO-126	100	80		2 μA	80	20 40	 375	1A 150	2 2	1.0		1.5*	1A	30	50		200	420	6	5/6	79
BD380-6	TO-126	100	80		2 μA	80	20 40	 100	1A 150	2 2	1.0		1.5*	1A	30	50		200	420	6	5/6	79
BD380-10	TO-126	100	80		2 μA	80	20 63	 160	1A 150	2 2	1.0		1.5*	1A	30	50		200	420	6	5/6	79
BD380-16	TO-126	100	80		2 μA	80	20 100	 250	1A 150	2 2	1.0		1.5*	1A	30	50		200	420	6	5/6	79
BD380-25	TO-126	100	80		2 μA	80	20 150	 375	1A 150	2 2	1.0		1.5*	1A	30	50		200	420	6	5/6	79
BD433	TO-126	22†	22	5	100 μA	22	50 85 40	 475 	2A 500 10	1 1 5	0.5		1.1*	2A		3		250	420	6	5/6	4E
BD434	TO-126	22†	22	5	100 μA	22	50 85 40	 475 	2A 500 10	1 1 5	0.5		1.1*	2A	30	3		250	420	6	5/6	5E
BD435	TO-126	32†	32	5	100 μA	32	50 85 40	 475 	2A 500 10	1 1 5	0.5		1.1*	2A	30	3		250	420	6	5/6	4E
BD436	TO-126	32†	32	5	100 μA	32	50 85 40	 475 	2A 500 10	1 1 5	0.5		1.1*	2A	30	3		250	420	6	5/6	5E
BD437	TO-126	45†	45	5	100 μA	45	40 40 30	 236 	2A 500 10	1 1 5	0.6		1.2*	2A	30	3		250	420	6	5/6	4E
BD438	TO-126	45†	45	5	100 μA	45	40 40 30	 236 	2A 500 10	1 1 5	0.6		1.2*	2A	30	3		250	420	6	5/6	5E
BD439	TO-126	60†	60	5	100 μA	60	25 40 20	 236 	2A 500 10	1 1 5	0.8		1.5*	2A	30	3		250	420	6	5/6	4E

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	V_{BE} Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BD440	TO-126	60†	60	5	100 µA	60	25		2A	1	0.8		1.5*	2A	80	3		250	420	6	5/6	5E
							40	236	500	1												
							20		10	5												
BD441	TO-126	80†	80	5	100 µA	80	15		2A	1	0.8		1.5*	2A	30	3		250	420	6	5/6	4E
							40	236	500	1												
							15		10	5												
BD442	TO-126	80†	80	5	100 µA	80	15		2A	1	0.8		1.5*	2A	30	3		250	420	6	5/6	5E
							40	236	500	1												
							15		10	5												
BD533	TO-220	80†	45	5	100 µA	45	25		2A	2	0.8		1.5*	2A	30	3		250	420	6	5/6	4E
							40		500	2												
							20		10	5												
BD534	TO-220	80†	45	5	100 µA	45	25		2A	2	0.8		1.5*	2A	30	3		250	420	6	5/6	5E
							40		500	2												
							20		10	5												
BD535	TO-220	80†	60	5	100 µA	60	25		2A	2	0.8		1.5*	2A	30	3		250	420	6	5/6	4E
							40		500	2												
							20		10	5												
BD536	TO-220	80†	60	5	100 µA	60	25		2A	2	0.8		1.5*	2A	30	3		250	420	6	5/6	5E
							40		500	2												
							20		10	5												
BD537	TO-220	80†	80	5	100 µA	80	15		2A	2	0.8		1.5*	2A	30	3		250	420	6	5/6	4E
							40		500	2												
							15		10	5												
BD538	TO-220	80†	80	5	100 µA	80	15		2A	2	0.8		1.5*	2A	30	3		250	420	6	5/6	5E
							40		500	2												
							15		10	5												
BD633	TO-220	45	45	5	200 µA†	45	25		1A	2	0.6		1.3*	1A	30	3		250	420	6	5/6	4F
							40		25	2												
BD634	TO-220	45	45	5	200 µA†	45	25		1A	2	0.6		1.3*	1A	30	3		250	420	6	5/6	5F
							40		25	2												
BD635	TO-220	60	60	5	200 µA†	60	25		1A	2	0.6		1.3*	1A	30	3		250	420	6	5/6	4F
							40		25	2												

TEST CONDITIONS:

(1) I_C = 200 µA, V_{CE} = 5V, f = 1 kHz. **(2)** I_C = 100 mA, V_{CC} = 20V, $I_B^1 = I_B^2$ = 5 mA. **(3)** I_C = 200 µA, V_{CE} = 2V, f = 1 kHz. **(4)** I_C = 100 mA, V_{CC} = 10V, $I_B^1 = I_B^2$ = 10 mA. **(5)** I_C = 10 mA, V_{CC} = 3V, $I_B^1 = I_B^2$ = 1 mA. **(6)** I_C = 100 µA, V_{CE} = 5V, f = 1 kHz. **(7)** I_C = 1 mA, V_{CE} = 10V, f = 200 kHz. **(8)** I_C = 1 mA, V_{CE} = 5V, f = 1 kHz. **(9)** I_C = 150 mA, V_{CC} = 6V, $I_B^1 = I_B^2$ = 15 mA. **(10)** I_C = 10 µA, V_{CE} = 5V, f = WB.

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BD636	TO-220	60	60	5	200 μA†	60	25		1A	2	0.6		1.3*	1A	30	3		250	420	6	5/6	5F
							40		25	2												
BD637	TO-220	100	80	5	200 μA†	100	25		1A	2	0.6		1.3*	1A	30	3		250	420	6	5/6	4F
							40		25	2												
BD638	TO-220	100	80	5	200 μA†	100	25		1A	2	0.6		1.3	1A	30	3		250	420	6	5/6	5F
							40		25	2												
BD675	TO-126		45		200 μA	45	750		1.5A	3	2.5		2.5*	1.5A		1		1.5A				4J
BD675A	TO-126		45		200 μA	45	750		2A	3	2.8		2.5*	2A		1		1.5A				4J
BD676	TO-126		45		200 μA	45	750		1.5A	3V	2.5		2.5*	1.5A		1		1.5A				5J
BD676A	TO-126		45		200 μA	45	750		2A	3V	2.8		2.5*	2A		1		1.5A				5J
BD677	TO-126		60		200 μA	60	750		1.5A	3V	2.5		2.5*	1.5A		1		1.5A				4J
BD677A	TO-126		60		200 μA	60	750		2A	3V	2.8		2.5*	2A		1		1.5A				4J
BD678	TO-126		60		200 μA	60	750		1.5A	3V	2.5		2.5*	1.5A		1		1.5A				5J
BD678A	TO-126		60		200 μA	60	750		2A	3V	2.8		2.5*	2A		1		1.5A				5J
BD679	TO-126		80		200 μA	80	750		1.5A	3V	2.5		2.5*	1.5A		1		1.5A				4J
BD679A	TO-126		80		200 μA	80	750		2A	3V	2.8		2.5*	2A		1		1.5A				4J
BD680	TO-126		80		200 μA	80	750		1.5A	3V	2.5		2.5*	1.5A		1		1.5A				5J
BD680A	TO-126		80		200 μA	80	750		2A	3V	2.8		2.5*	2A		1		1.5A				5J
BD681	TO-126		100		200 μA	100	750		1.5A	3V	2.5		2.5*	1.5A		1		1.5A				4J
BD682	TO-126		100		200 μA	100	750		1.5A	3V	2.5		2.5*	1.5A		1		1.5A				5J
BD733	TO-220	25	25	5	200 μA†	25	50		2A	1	0.6		1.1*	2A		1		1.5A				4F
							40		20	4												
BD734	TO-220	25	25	5	200 μA†	25	50		2A	1	0.6		1.1*	2A		1		1.5A				5E
							40		20	4												
BD735	TO-220	35	35	5	200 μA†	35	40		2A	1	0.6		1.1*	2A		1		1.5A				4F
							40		20	4												
BD736	TO-220	35	35	5	200 μA†	35	40		2A	1	0.6		1.1*	2A		1		1.5A				5E
							40		20	4												
BD737	TO-220	45	45	5	200 μA†	45	40		2A	1	0.8		1.1*	2A		1		1.5A				4F
							40		20	4												
BD738	TO-220	45	45	5	200 μA†	45	40		2A	1	0.8		1.1*	2A		1		1.5A				5E
							40		20	4												
BD795	TO-220		45		100	45	40		1A	2	1.0		1.6*	3A		3		250				4E
							25		3A	2												
BD796	TO-220		45		100	45	40		1A	2	1.0		1.6*	2A		3		250				5E
							25		3A	2												
BD797	TO-220		60		100 μA	60	40		1A	2	1.0		1.6*	3A		3		250				4E
							25		3A	2												

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BD798	TO-220		60		100 µA	60	40		1A	2	1.0		1.6*	3A		3		250				5E
							25		3A	2												
BD799	TO-220		80		100 µA	80	30		1A	2	1.0		1.6*	3A		3		250				4E
							15		3A	2												
BD800	TO-220		80		100 µA	80	30		1A	2	1.0		1.6*	3A		3		250				5E
							15		3A	2												
BD801	TO-220		100		100 µA	100	30		1A	2	1.0		1.6*	3A		3		250				4E
							15		3A	2												
BD802	TO-220		100		100 µA	100	30		1A	2	1.0		1.6*	3A		3		250				5E
							15		3A	2												
BD895	TO-220		45		200 µA	45	750		3A	3			2.5*	3A		1		3A				4K
BD895A	TO-220		45		200 µA	45	750		4A	3			2.5*	4A		1		3A				4K
BD896	TO-220		45		200 µA	45	750		3A	3			2.5*	3A		1		3A				5K
BD896A	TO-220		45		200 µA	45	750		4A	3			2.5*	4A		1		3A				5K
BD897	TO-220		60		200 µA	60	750		3A	3			2.5*	3A		1		3A				4K
BD897A	TO-220		60		200 µA	60	750		4A	3			2.5*	4A		1		4A				4K
BD898	TO-220		60		200 µA	60	750		3A	3			2.5*	3A		1		3A				5K
BD898A	TO-220		60		200 µA	60	750		4A	3			2.5*	4A		1		4A				5K
BD899	TO-220		80		200 µA	80	750		3A	3			2.5*	3A		1		3A				4K
BD899A	TO-220		80		200 µA	80	750		4A	3			2.5*	4A		1		4A				4K
BD900	TO-220		80		200 µA	80	750		3A	3			2.5*	3A		1		3A				5K
BD900A	TO-220		80		200 µA	80	750		4A	3			2.5*	4A		1		4A				5K
BD901	TO-220		100		200 µA	100	750		3A	3			2.5*	3A		1		3A				4K
BD902	TO-220		100		200 µA	100	750		4A	3			2.5*	4A		1		4A				4K
BDX33	TO-220		45		1 mA	45	750		4A	3			2.5*	4A		20		1A				4K
BDX33A	TO-220		60		1 mA	60	750		4A	3			2.5*	4A		20		1A				4K
BDX33B	TO-220		80		1 mA	80	750		3A	3			2.5*	3A		20		1A				4K
BDX33C	TO-220		100		1 mA	100	750		3A	3			2.5*	3A		20		1A				4K
BDX33D	TO-220		120		1 mA	120	750		3A	3			2.5*	3A		20		1A				4K
BDX34	TO-220		45		1 mA	45	750		4A	3			2.5*	4A		20		1A				5K
BDX34A	TO-220		60		1 mA	60	750		4A	3			2.5*	4A		20		1A				5K
BDX34B	TO-220		80		1 mA	80	750		3A	3			2.5*	3A		20		1A				5K

TEST CONDITIONS:

(1) I_C = 200 µA, V_{CE} = 5V, f = 1 kHz. **(2)** I_C = 100 mA, V_{CC} = 20V, $I_B^1 = I_B^2$ = 5 mA. **(3)** I_C = 200 µA, V_{CE} = 2V, f = 1 kHz. **(4)** I_C = 100 mA, V_{CC} = 10V, $I_B^1 = I_B^2$ = 10 mA. **(5)** I_C = 10 mA, V_{CC} = 3V, $I_B^1 = I_B^2$ = 1 mA. **(6)** I_C = 100 µA, V_{CE} = 5V, f = 1 kHz. **(7)** I_C = 1 mA, V_{CE} = 10V, f = 200 kHz. **(8)** I_C = 1 mA, V_{CE} = 5V, f = 1 kHz. **(9)** I_C = 150 mA, V_{CC} = 6V, $I_B^1 = I_B^2$ = 15 mA. **(10)** I_C = 10 µA, V_{CE} = 5V, f = WB.

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BDX34C	TO-220		100		1 mA	100	750		3A	3			2.5*	3A		20		1A				5K
BDX34D	TO-220		120		1 mA	120	750		3A	3			2.5*	3A		20		1A				5K
BF167	TO-72 (28)	40	30	4	100†	30	26		4	10			0.84*	4								45
BF180	TO-72 (25)	30	20	3	100	20	13 6		2 12	10 7												41
BF181	TO-72 (25)	30	20	3	100	20	13 6		2 12	10 7												41
BF194	TO-92 (98)	Same as BF254, see page 5-33 for explanation																				46
BF195	TO-92 (98)	Same as BF255, see page 5-33 for explanation																				46
BF196	TO-92 (98)	Same as BF198, see below for explanation																				45
BF197	TO-92 (98)	Same as BF199, see below for explanation																				47
BF198	TO-92 (98)	40	30	4	100	40	26 6		4 12	10 7			0.85*	4								45
BF199	TO-92 (98)	40	25	4	100	40	36 6		7 12	10 7						1100 typ		7				47
BF200	TO-72 (25)	30	20	3	100	40	15 6		3 12	10 7												41
BF233-2	TO-92 (96)	30	30	4	100	10	40 6	70	1 12	10 7		0.65	0.74*	1	1.0	150		1				49
BF233-3	TO-92 (96)	30	30	4	100	10	60 6	100	1 12	10 7		0.65	0.74*	1	1.0	150		1				49
BF233-4	TO-92 (96)	30	30	4	100	10	90 6	150	1 12	10 7		0.65	0.74*	1	1.0	150		1				49
BF233-5	TO-92 (96)	30	30	4	100	10	140 6	220	1 12	10 7		0.65	0.74*	1	1.0	150		1				49
BF237	TO-92 (98)	45	30	4	100	20					0.25			10								47
BF238	TO-92 (98)	45	30	4	100	20					0.25			10								47
BF240	TO-92 (98)	40	40	4	100	20	67 6	222	1 12	10 7		0.65	0.74*	1	0.34			1		3.5	7	47
BF241	TO-92 (98)	40	40	4	100	20	36 6	125	1 12	10 7		0.65	0.74*	1	0.34			1		3.5	7	47

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BF254	TO-92	30	20	5	100	20	67	220	1	10		0.65	0.74*	1	0.34			1		3.5	7	46
	(98)						6		12	7												
BF255	TO-92	30	20	5	100	20	36	125	1	10		0.65	0.74*	1	0.34			1		3.5	7	46
	(98)						6		12	7												
BF257	TO-39	100	100	5	50	100	25		30	10	1.0	0.65	0.74*	30	0.34			1		3.5	7	48
							6		12	7												
BF258	TO-39	250	250	5	50	200	25		30	10	1.0	0.65	0.74*	30	0.34			1		3.5	7	48
							6		12	7												
BF259	TO-39	300	300	5	50	250	25		30	10	1.0	0.65	0.74*	30	0.34			1		3.5	7	48
							6		12	7												
BF457	TO-126	100	100	5	50	100	25		30	10	1.0	0.65	0.74*	30	0.34			1		3.5	7	48
							6		12	7												
BF458	TO-126	250	200	5	50	200	25		30	10	1.0	0.65	0.74*	30	0.34			1		3.5	7	48
							6		12	7												
BF459	TO-126	300	300	5	50	250	25		30	10	1.0	0.65	0.74*	30	0.34			1		3.5	7	48
							6		12	7												
BFX13	TO-18	20	15	5	50	15	10		100	2	0.2		0.78	1	6	150		10		10	8	66
							50	250	10	0.35	0.25	0.7	0.9	10								
							18		1	2	1.5		1.5	100								
BFX29	TO-5	20	15	5	50	50	40		150	10					12	100		50	150		9	63
							50		50	10	0.4		1.3	150								
							50		10	10			0.9	30								
							40		1	10												
							20		0.1	10												
BFX30	TO-5	65	65	5	50	50	10		150	0.4					12				290		4	63
							20		50	0.4			0.9	30								
							50	200	10	0.4			1.3	150								
							40		1	0.4												
BFX37	TO-18	60	60	6	20†	50	100		10	5	0.4		1.0	50	6	40		0.5		3	1	62
							100		1	5												
							0.85		0.1	5	0.25		0.9	10								
							70	300	0.01	5												
BFX65	TO-18	45	45	6	10*	40	100		10	5	0.25		0.9	10	6.5					3	1	62
							100		1	5												
							100		0.1	5												
							40		0.01	5												

TEST CONDITIONS:

(1) I_C = 200 μA, V_{CE} = 5V, f = 1 kHz. **(2)** I_C = 100 mA, V_{CC} = 20V, I_{B1} = I_{B2} = 5 mA. **(3)** I_C = 200 μA, V_{CE} = 2V, f = 1 kHz. **(4)** I_C = 100 mA, V_{CC} = 10V, I_{B1} = I_{B2} = 10 mA. **(5)** I_C = 10 mA, V_{CC} = 3V, I_{B1} = I_{B2} = 1 mA. **(6)** I_C = 100 μA, V_{CE} = 5V, f = 1 kHz. **(7)** I_C = 1 mA, V_{CE} = 10V, f = 200 kHz. **(8)** I_C = 1 mA, V_{CE} = 5V, f = 1 kHz. **(9)** I_C = 150 mA, V_{CC} = 6V, I_{B1} = I_{B2} = 15 mA. **(10)** I_C = 10 μA, V_{CE} = 5V, f = WB.

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	(V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BFX84	TO-39	45	45	6	500	100	15		1A	10	0.15		1.2	10	12	50		50	360		9	14
							20		500	10	0.35		1.3	150								
							30		150	10	1.0		1.5	500								
							20		10	10	1.6		2.0	1A								
BFX85	TO-39	45	45	6	50	80	15		1A	10	0.15		1.2	10	12	50		50	360		9	14
							30		500	10	0.35		1.3	150								
							70		150	10	1.0		1.5	500								
							50		10	10	1.6		2.0	1A								
BFX86	TO-39	45	45	6	50	30	15		1A	10	0.15		1.2	10	12	50		50	360		9	14
							30		500	10	0.35		1.3	150								
							70		150	10	1.0		1.5	500								
							50		10	10	1.6		2.0	1A								
BFX87	TO-5	45	50	6	50	40	25		500	10	0.4		1.3	150	12	100		50	150		9	63
							40		150	10			0.9	30								
							40		10	10												
							40		1	10												
BFX88	TO-5	45	40	6	50	30	25		500	10	0.4		1.3	150	12	100		50	150		9	63
							40		150	10			0.9	30								
							40		10	10												
							40		1	10												
BFY39	TO-18	45	25	5	50	30	35	400	10	10	1.0		1.0	10		150		10				23
BFY39-1	TO-18	45	25	5	50	30	35	110	10	10	1.0		1.0	10		150		10				23
BFY39-2	TO-18	45	25	5	50	30	100	200	10	10	1.0		1.0	10		150		10				23
BFY39-3	TO-18	45	25	5	50	30	180	400	10	10	1.0		1.0	10		150		10				23
BFY50	TO-18	80	35	6	500	80	20		10	10	0.1		1.2	10	12	60		50	360		9	14
							30		150	10												
							20		500	10												
							15		1A	10												
BFY51	TO-39	60	30	6	500	60	30		10	10	0.1		1.2	10	12	60		50	360		9	14
							40		150	10												
							25		500	10												
							15		1A	10												
BFY52	TO-39	40	20	6	500	60	30		10	10	0.1		1.2	10	12	60		50	360		9	14
							60		150	10												
							30		500	10												
							15		1A	10												
BFY56	TO-39	80	45	5	50	50	15		1	10	0.3		1.5	150	25	40		50				14
							20		500	10												
							30	150	150	1	1.2		2.5	1A								

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BFY72	TO-39	50	28	5	40*	20	15		0.1	10	0.25		1.2	150	8	50		50				19
							20		1	10												
							30		10	10												
							40	150	150	10												
							15		500	10	0.7		1.6	500								
BFY76	TO-18	45	45	6	20	30	30	200	0.01	5	0.35			1	6							
							80		0.5	5												
							140		1	5												
BSX21	TO-18		80		500	50	20		4	3			0.9	4		60		4				07
BSX45-6	TO-39	80*	40	7	10*	60	40	100	100	1	1.0			500	20	60		50				14
													2.0	1A								
BSX45-10	TO-39	80*	40	7	10*	60	63	160	100	1	1.0			500	20	60		50				14
													2.0	1A								
BSX45-16	TO-39	80*	40	7	10*	60	100	250	100	1	1.0			500	20	60		50				14
													2.0	1A								
BSX46-6	TO-39	100*	60	7	10*	60	40	100	100	1	1.0			500	25	60		50				12
													2.0	1A								
BSX46-10	TO-39	100*	60	7	10*	60	63	160	100	1	1.0			500	25	60		50				12
													2.0	1A								
BSX46-16	TO-39	100*	60	7	10*	60	100	250	100	1	1.0			500	25	60		50				12
													2.0	1A								
BSX48	TO-18	50	25	5	120	50	17		100	1	1.5		1.5	500	6	250		30				19
BSX88	TO-18	40	15	5	25	20	15		0.5	1	0.5	0.72	0.8	10	6	300		10				21
BSY38	TO-18	20	12	5	100	20	30	60	10	0.35	0.25	0.7	0.85	10	5	200		10	45		16	21
							15	45	100	1	0.6		1.5	100								
BSY39	TO-18	20	12	5	100	20	40	120	10	0.35	0.25	0.7	0.85	10	5	200		10	45		16	21
							20	70	100	1	0.6		1.5	100								
BSY51	TO-18	60	35	5	100	30	40	120	150	10	1.0		1.3	150	9	130		50				19
BSY52	TO-18	60	25	5	100	30	100	300	150	10	1.0		1.3	150	9	130		50				19
BSY53	TO-18	75	30	7	10	60	20		0.1	10	0.6		1.3	150	9	150		50				19
							35		10	10												
							40	120	150	10												
							20		500	10	2.0			500								

TEST CONDITIONS:

(1) I_C = 200 μA, V_{CE} = 5V, f = 1 kHz. **(2)** I_C = 100 mA, V_{CC} = 20V, $I_B^1 = I_B^2$ = 5 mA. **(3)** I_C = 200 μA, V_{CE} = 2V, f = 1 kHz. **(4)** I_C = 100 mA, V_{CC} = 10V, $I_B^1 = I_B^2$ = 10 mA. **(5)** I_C = 10 mA, V_{CC} = 3V, $I_B^1 = I_B^2$ = 1 mA. **(6)** I_C = 100 μA, V_{CE} = 5V, f = 1 kHz. **(7)** I_C = 1 mA, V_{CE} = 10V, f = 200 kHz. **(8)** I_C = 1 mA, V_{CE} = 5V, f = 1 kHz. **(9)** I_C = 150 mA, V_{CC} = 6V, $I_B^1 = I_B^2$ = 15 mA. **(10)** I_C = 10 μA, V_{CE} = 5V, f = WB.

PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BSY54	TO-18	75	30	7	10	60	35		0.1	10	0.6		1.3	150	9	150		50				19
							75		10	10												
							100	300	150	10												
							40		500	10	2.0			50								
BSY95A	TO-18	20	15	5	50	16	30		1	0.35	0.35	0.67	0.87	10	6	200		10				21
							50	200	10	0.35												

TEST CONDITIONS:

(1) $I_C = 200\ \mu A$, $V_{CE} = 5V$, f = 1 kHz. **(2)** $I_C = 100$ mA, $V_{CC} = 20V$, $I_B{}^1 = I_B{}^2 = 5$ mA. **(3)** $I_C = 200\ \mu A$, $V_{CE} = 2V$, f = 1 kHz. **(4)** $I_C = 100$ mA, $V_{CC} = 10V$, $I_B{}^1 = I_B{}^2 = 10$ mA. **(5)** $I_C = 10$ mA, $V_{CC} = 3V$, $I_B{}^1 = I_B{}^2 = 1$ mA. **(6)** $I_C = 100\ \mu A$, $V_{CE} = 5V$, f = 1 kHz. **(7)** $I_C = 1$ mA, $V_{CE} = 10V$, f = 200 kHz. **(8)** $I_C = 1$ mA, $V_{CE} = 5V$, f = 1 kHz. **(9)** $I_C = 150$ mA, $V_{CC} = 6V$, $I_B{}^1 = I_B{}^2 = 15$ mA. **(10)** $I_C = 10\ \mu A$, $V_{CE} = 5V$, f = WB.

PRO ELECTRON SERIES (JFET)

Type No.	Case Style	BV_{GSS} BV_{GDO} (V) Min	@ I_G (μA)	I_{GSS} I_{DGD} (nA) Max	@ V_{GD} (V)	V_P (V) Min	V_P (V) Max	@ V_{DS} (V)	I_D (nA)	V_{GS} (V) Min	V_{GS} (V) Max	@ V_{GS} (V)	I_D (μA)	I_{DSS} (mA) Min	I_{DSS} (mA) Max	@ V_{DS} (V)	$R_e(Y_{FS})$ (mmho) Min	$R_e(Y_{FS})$ (mmho) Max	@ f (MHz)	C_{iss} (pF) Typ	@ V_{DS} (V)	V_{GS} (V)	C_{rss} (pF) Typ	@ V_{DS} (V)	V_{GS} (V)	NF (dB) @ R_G = 1k Max	e_n* Typ	f (Hz)* (MHz)	Process No.	Pkg. No.
BF244A	TO-92	30	1	5	20	.5	8	15	10	.4	2.2	15	200	2	6.5	15	3	6.5	.001	4	20	−1	1.1	20	−1		1.5	100	50	74
BF244B	TO-92	30	1	5	20	.5	8	15	10	1.6	3.8	15	200	6	15	15	3	6.5	.001	4	20	−1	1.1	20	−1		1.5	100	50	74
BF244C	TO-92	30	1	5	20	.5	8	15	10	3.2	7.5	15	200	12	25	15	3	6.5	.001	4	20	−1	1.1	20	−1		1.5	100	50	74
BF245A	TO-92	30	1	5	20	.5	8	15	10	.4	2.2	15	200	2	6.5	15	3	6.5	.001	4	20	−1	1.1	20	−1				50	77
BF245B	TO-92	30	1	5	20	.5	8	15	10	1.6	3.8	15	200	6	15	15	3	6.5	.001	4	20	−1	1.1	20	−1				50	77
BF245C	TO-92	30	1	5	20	.5	8	15	10	3.2	7.5	15	200	12	25	15	3	6.5	.001	4	20	−1	1.1	20	−1				50	77
BF246A	TO-92	25	1	5	15	.6	14.5	15	10	1.5	4.0	15	200	30	80	15	8		.001	11	15	0	3.5	15	0				51	74
BF246B	TO-92	25	1	5	15	.6	14.5	15	10	3.0	7.0	15	200	60	140	15	8		.001	11	15	0	3.5	15	0				51	74
BF246C	TO-92	25	1	5	15	.6	14.5	15	10	5.5	12	15	200	110	250	15	8		.001	11	15	0	3.5	15	0				51	74
BF247A	TO-92	25	1	5	15	.6	14.5	15	10	1.5	4.0	15	200	30	80	15	8		.001	11	15	0	3.5	15	0				51	77
BF247B	TO-92	25	1	5	15	.6	14.5	15	10	3.0	7.0	15	200	60	140	15	8		.001	11	15	0	3.5	15	0				51	77
BF247C	TO-92	25	1	5	15	.6	14.5	15	10	5.5	12	15	200	110	250	15	8		.001	11	15	0	3.5	15	0				51	77
BF256A	TO-92	30	1	5	20					.5	7.5	15	200	3	7	15	4.5		.001				.7	20	−1		7.5	800	50	77
BF256B	TO-92	30	1	5	20					.5	7.5	15	200	6	13	15	4.5		.001				.7	20	−1		7.5	800	50	77
BF256C	TO-92	30	1	5	20					.5	7.5	15	200	11	18	15	4.5		.001				.7	20	−1		7.5	800	50	77
BC264A	TO-92	30	1	10	20	.5		15	10	.2	1.2	15	1000	2	4.5	15	2.5		.001	4.0	15	−1	1.2	15	−1		40*	10*	50	77
BC264B	TO-92	30	1	10	20	.5		15	10	.4	1.4	15	1500	3.5	6.5	15	3.0		.001	4.0	15	−1	1.2	15	−1		40*	10*	50	77
BC264C	TO-92	30	1	10	20	.5		15	10	.5	1.5	15	2500	5.0	8.0	15	3.5		.001	4.0	15	−1	1.2	15	−1		40*	10*	50	77
BC264D	TO-92	30	1	10	20	.5		15	10	.6	1.6	15	3500	7.0	12.0	15	4.0		.001	4.0	15	−1	1.2	15	−1		40*	10*	50	77

Section 6

6

Consumer Series

CONSUMER SERIES

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} h_{fe} 1 kHz* Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Condition	Process No.
CS9011	TO-92 (92)	20	18	3	50	18	28	198	1	5	1.0			1	3.5							27
CS9012	TO-92 (92)	25	25	3	500	18	64	350	50	1	1.0			250								60
CS9013	TO-92 (92)	25	25	3	500	18	64	350	50	1	1.0			250								09
CS9014	TO-92 (92)	20	18	3	50	18	60	600	1	5	0.5			1								04
CS9015	TO-92 (92)	20	18	3	50	18	60	600	1	5	0.5			1								71
CS9016	TO-92 (92)	20	20	3	50	18	28	146	1	5	3		1	10	1.6							44
CS9018	TO-92 (92)	20	12	2	50	15	28	146	1	5	0.6			10								43
ED1402	TO-92 (92)	35	30	4	10	10	110	810	2	5										10	1	07
ED1502	TO-92 (92)	25	20	4	10	10	36	210	1	10						250		5				46
ED1602	TO-92 (92)	35	30	4	10	10	70	475	2	5										10	1	62
ED1702	TO-92 (92)	30*	25	5	100*	20	40 106	 300	0.5A 100	1 1	0.4			500								37
ED1802	TO-92 (92)	30*	25	5	100*	20	40 106	 300	0.5A 100	1 1	0.4			500								77

	H_{FE} BINS												
	A	B	C	D	E	F	G	H	I	K	L	M	N
CS9011				28–45	39–60	54–80	72–108	97–146	132–198				
CS9012				64–91	78–112	96–135	118–166	144–202	180–350				
CS9013				64–91	78–112	96–135	118–166	144–202	180–350				
CS9014	60–150	100–300	200–600										
CS9015	60–150	100–300	200–600										
CS9016				28–45	39–60	54–80	72–108	97–146					
CS9018				28–45	39–60	54–80	72–108						
ED1402	110–165	150–225	202–318	290–450	410–810								
ED1502	36–55	48–75	66–100	84–127	105–210								
ED1602	70–105	90–140	125–190	170–260	223–475								
ED1702										106–150	132–188	170–233	213–300
ED1802										106–150	132–188	170–233	213–300

Note: Orders must contain at least two adjacent bins.

Section 7

NA/NB/NR Series

7

National Semiconductor

NA/NB TRANSISTOR SERIES SELECTION GUIDE

GENERAL DESCRIPTION

The NA series of transistors are complementary power series which provide minimum collector saturation voltages at low drive conditions and feature matched HFE, guaranteed V_{BE} (on), V_{BE} (sat), V_{CE} (sat), etc, for estimating circuit performance at limit conditions. They are ideal for use with the NB series in complementary audio power amplifier applications. In addition, the collector breakdown voltages range from 20 to 60 Volts, which allows great flexibility in other power applications, such as converters/inverters, servo amplifiers, etc. The NB series of transistors are complementary general-purpose devices which cover a wide range of applications from low-noise equalizer preamplifiers to 1.5 Amp class B drivers. This series provides low leakage, low V_{CE} (sat), high HFE and three different types of collector breakdown voltages (35, 50 and 65 Volts) for multi-purpose usage and total flexibility.

NA – APPLICATIONS

- 0.1 to 25 Watts fully complementary audio power amplifiers
- Converters/Inverters
- Power control circuits
- Switching/linear regulators
- High current switching circuits
- Servo amplifiers

NB – APPLICATIONS

- Low noise equalizer preamplifiers
- Class A general purpose amplifiers
- Class B drivers
- Oscillators
- Control/Switching circuits
- Display/line drivers
- Servo amplifiers

NA SERIES – – COMPLEMENTARY POWER TRANSISTORS

device types and ratings

PART # NPN	PART # PNP	AVAILABLE PACKAGES	V_{CE} (max) VOLTS	I_C (max) AMPS	HFE	DESCRIPTION
NA01	NA02	TO-92	20	0.8	Matched	0.8A complementary power transistors
NA11	NA12	TO-92	20	1.0	Matched	1.0A complementary power transistors
NA21	NA22	TO-92, TO-92 PLUS	20	1.5	Matched	1.5A complementary power transistors
NA31	NA32	TO-92 PLUS, TO-202	30	2.0	Matched	2.0A complementary power transistors
NA41	NA42	TO-126, TO-220	30	2.5	Guaranteed min	2.5A complementary power transistors
NA51	NA52	TO-126, TO-220	45	3.5	Guaranteed min	3.5A complementary power transistors
NA61	NA62	TO-126, TO-220	45	4.5	Guaranteed min	4.5A complementary power transistors
NA71	NA72	TO-126, TO-220	60	3.5	Guaranteed min	3.5A complementary power transistors

NB SERIES – – GENERAL PURPOSE COMPLEMENTARY TRANSISTORS

device types and ratings

PART # NPN	PART # PNP	AVAILABLE PACKAGES	V_{CE} (max) VOLTS	I_C (max) AMPS	V_{CE} (sat) max	V_{CE} (sat) Ic/Ib (mA)	DESCRIPTION
NB011	NB021	TO-92	35	0.03	0.3	10/0.5	30mA general purpose transistors
NB012	NB022	TO-92	50	0.03	0.3	10/0.5	30mA general purpose transistors
NB013	NB023	TO-92	35	0.03	0.3	10/0.5	30mA low noise transistors
NB014	NB024	TO-92	50	0.03	0.3	10/0.5	30mA low noise transistors
NB111	NB121	TO-92	35	0.1	0.3	40/0.8	100mA general purpose transistors
NB112	NB122	TO-92	50	0.1	0.3	40/0.8	100mA general purpose transistors
NB113	NB123	TO-92	65	0.1	0.3	40/0.8	100mA general purpose transistors
NB211	NB221	TO-92, TO-92 PLUS	35	0.5	0.4	100/2	500mA medium current drivers
NB212	NB222	TO-92, TO-92 PLUS	50	0.5	0.4	100/2	500mA medium current drivers
NB213	NB223	TO-92, TO-92 PLUS	65	0.5	0.4	100/2	500mA medium current drivers
NB311	NB321	TO-92, TO-92 PLUS, TO-202	35	1.5	0.5	300/10	1.5A complementary power drivers
NB312	NB322	TO-92, TO-92 PLUS, TO-202	50	1.5	0.5	300/10	1.5A complementary power drivers
NB313	NB323	TO-92, TO-92 PLUS, TO-202	65	1.5	0.5	300/10	1.5A complementary power drivers

COMPLEMENTARY AUDIO AMPLIFIER CROSS REFERENCE CHARTS

AUDIO OUTPUT POWER — — Battery operated "OTL" amplifiers

OPERATING CONDITIONS	(1) OUTPUT POWER minimum	@ 10% THD typical	RECOMMENDED OUTPUT DEVICES	RECOMMENDED DRIVER DEVICES
6 Volts/8Ω single-bootstrapping		380 mW	NA01 / NA02	NB111 / NB121
6 Volts/8Ω single-bootstrapping	380 mW	480 mW	NA11 / NA12	NB111 / NB121
6 Volts/4Ω single-bootstrapping	680 mW	850 mW	NA21 / NA22	NB111 / NB121
6 Volts/4Ω double-bootstrapping	920 mW	1.0 W	NA21 / NA22	NB111 / NB121
9 Volts/8Ω single-bootstrapping	800 mW	1.0 W	NA21 / NA22	NB111 / NB121
9 Volts/4Ω single-bootstrapping	1.4 W	1.8 W	NA21 / NA22	NB111 / NB121
9 Volts/4Ω double-bootstrapping	1.9 W	2.2 W	NA21 / NA22	NB111 / NB121
14 Volts/8Ω single-bootstrapping	2.0 W	2.3 W	NA21 / NA22	NB111 / NB121
14 Volts/4Ω single-bootstrapping	3.8 W	4.2 W	NA31 / NA32	NB211 / NB221

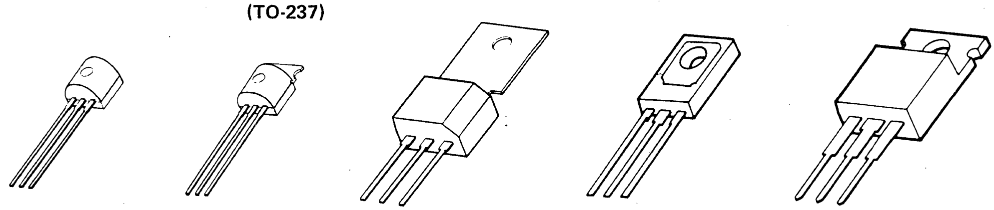
AUDIO OUTPUT POWER — — AC operated "OTL" amplifiers

OUTPUT POWER (min) @ 10% THD	LOAD IMPEDENCE	(2) REQUIRED SUPPLY VOLTAGE (min)	RECOMMENDED OUTPUT DEVICES	RECOMMENDED DRIVER DEVICES
3 Watts	8Ω	15	NA31 / NA32	NB211 / NB221
4 Watts	8Ω	17	NA31 / NA32	NB211 / NB221
6 Watts	8Ω	20	NA41 / NA42	NB211 / NB221
8 Watts	8Ω	23	NA51 / NA52	NB212 / NB222
12 Watts	8Ω	27	NA51 / NA52	NB312 / NB322
15 Watts	8Ω	32	NA71 / NA72	NB312 / NB322
18 Watts	8Ω	35	NA71 / NA72	NB313 / NB323
24 Watts	8Ω	40	NA71 / NA72	NB313 / NB323
3 Watts	4Ω	11	NA31 / NA32	NB211 / NB221
4 Watts	4Ω	13	NA31 / NA32	NB211 / NB221
6 Watts	4Ω	16	NA41 / NA42	NB211 / NB221
8 Watts	4Ω	18	NA51 / NA52	NB211 / NB221
12 Watts	4Ω	20	NA51 / NA52	NB311 / NB321
15 Watts	4Ω	23	NA61 / NA62	NB312 / NB322
18 Watts	4Ω	26	NA61 / NA62	NB312 / NB322
24 Watts	4Ω	30	NA61 / NA62	NB312 / NB322

NOTES: (1) Minimum Output Power levels shown are obtained by considering transistor parameter variations only, and do not include external component value tolerances.
(2) Voltage drops across emitter ballast resistors of the output devices are not included as part of the minimum required supply voltages; voltages specified are dc and under full load condition.
(3) Orders must allow for shipment of at least two adjacent HFE BIN ranges.

PACKAGE OUTLINES

TO-92 | TO-92 PLUS™ (TO-237) | TO-202 | TO-126 | TO-220



National Semiconductor

NA01(NPN) NA02(PNP) 800mA complementary power transistors

features

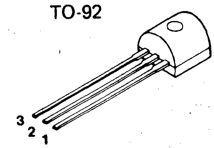
- 20 Volt/800 mA Amp rating
- Low V_{CE} (sat) and V_{BE} (sat) characteristics at I_C = 500 mA, I_B = 50 mA
- Guaranteed V_{BE} (on) characteristics at low current for stable biasing
- Matched HFE groupings for complementary applications
- "Epoxy B" packaging concept for excellent reliability

applications

- 0.2 to 1 Watt audio power amplifiers
- Medium power switching circuits
- Converter/Inverter circuits
- Circuits for toys

1 package and lead coding

TO-92



PACKAGE CODE TO-92	LEAD 1	2	3
E	E	B	C
F	E	C	B
H	C	B	E

2 maximum ratings

PARAMETER	SYMBOL	RATING	UNIT
Collector-Emitter Voltage	V_{CEO}	20	V_{DC}
Collector-Base Voltage	V_{CB}	25	V_{DC}
Emitter-Base Voltage	V_{EB}	5.0	V_{DC}
Collector Current (continuous)	I_C (max)	800	mA
Power Dissipation (T_A = 25°C)	P_D		
TO-92		0.6	W
Power Dissipation (T_C = 25°C)	P_D		
TO-92		1.0	W
Thermal Resistance			
TO-92	θ_{JA}	208	°C/W
	θ_{JC}	125	°C/W
Temperature, Junction and Storage	Tj, Tstg	–55 to + 150	°C

3 ordering information

NA0XXX

- POLARITY: "1" for NPN, "2" for PNP
- PACKAGE/LEAD CODE: refer to 1
- HFE GROUPING: refer to 5

4 electrical characteristics $T_C = 25°C$

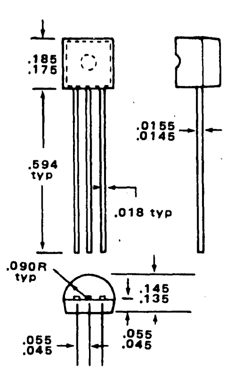
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
BV_{CEO}	Collector-Emitter Sustaining Voltage	I_C = 1 mA	20			V
BV_{CBO}	Collector-Base Breakdown Voltage	$I_C = 100 \mu A$	25			V
BV_{EBO}	Emitter-Base Breakdown Voltage	$I_E = 10 \mu A$	5			V
I_{CEO}	Collector-Emitter Leakage Current	V_{CE} = 15V			100	μA
I_{CBO}	Collector-Base Leakage Current	V_{CB} = 20V			1	μA
V_{BE} (on)	Base-Emitter Voltage	I_C = 10 mA, V_{CE} = 3V	630	680	730	mV
V_{BE} (sat)	Base-Emitter Saturation Voltage	I_C = 500 mA, I_B = 50 mA		0.95	1.5	V
V_{CE} (sat)	Collector-Emitter Saturation Voltage	I_C = 500 mA, I_B = 50 mA		0.2	0.5	V
Cob	Collector Output Capacitance	V_{CB} = 10V, f = 1 MHz				
	NPN types			4.5		pF
	PNP types			7.0		pF
ft	Current Gain Bandwidth Product	I_C = 100 mA, V_{CE} = 3V	50	200		MHz

5 HFE groupings

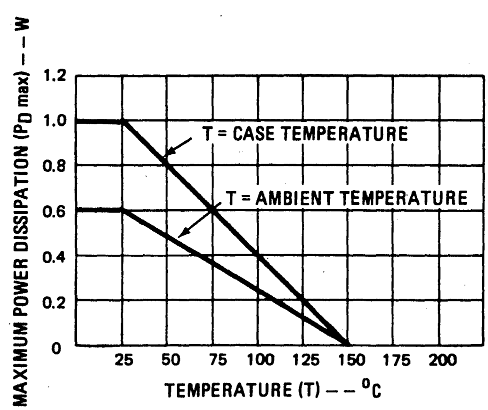
GROUPING	PARAMETER	CONDITIONS	MIN	TYP	MAX	RATIO
G	DC Current Gain	I_C = 100 mA, V_{CE} = 3V	68	85	110	1:1.6
H	DC Current Gain	I_C = 100 mA, V_{CE} = 3V	100	127	160	1:1.6
I	DC Current Gain	I_C = 100 mA, V_{CE} = 3V	140	180	240	1:1.6
J	DC Current Gain	I_C = 100 mA, V_{CE} = 3V	200	260	350	1:1.6
X	DC Current Gain	I_C = 100 mA, V_{CE} = 3V	30	58	110	1:3.5
Y	DC Current Gain	I_C = 100 mA, V_{CE} = 3V	100	190	350	1:3.5

6 physical dimensions

TO-92



7 max power dissipation

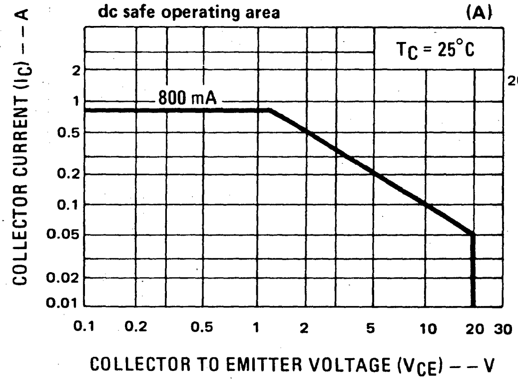


7

8 typical performance characteristics

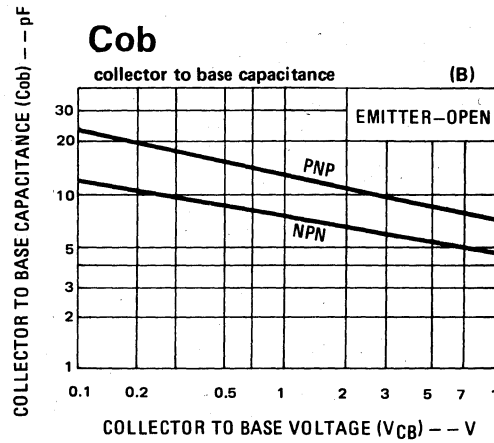
SOA

dc safe operating area (A)



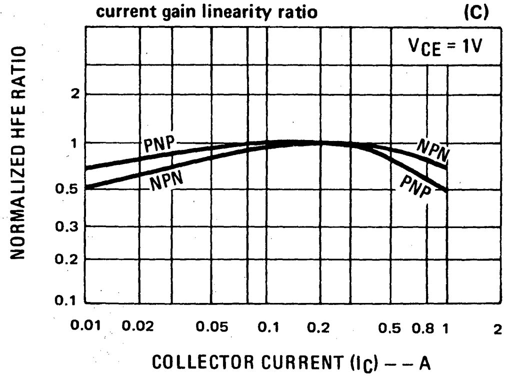
Cob

collector to base capacitance (B)



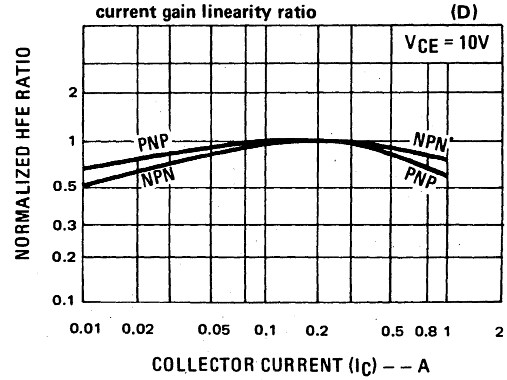
HFE1/HFE2

current gain linearity ratio (C)



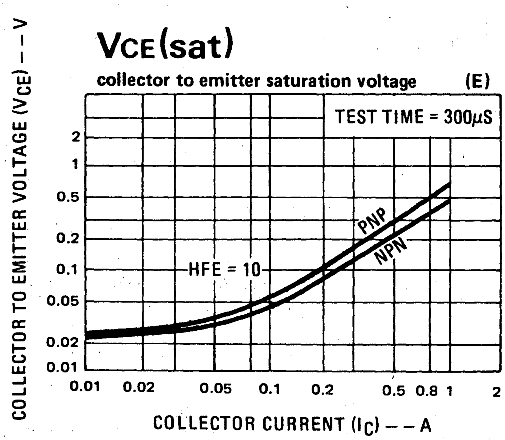
HFE1/HFE2

current gain linearity ratio (D)



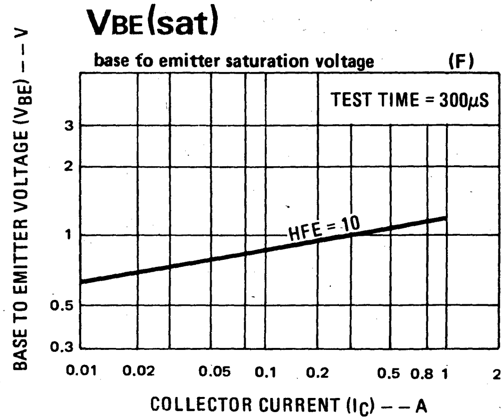
VCE(sat)

collector to emitter saturation voltage (E)

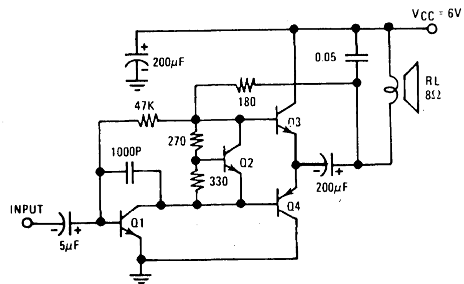


VBE(sat)

base to emitter saturation voltage (F)

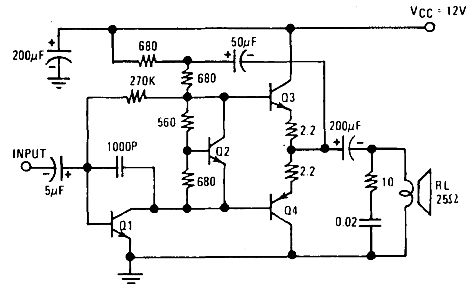


9 typical applications



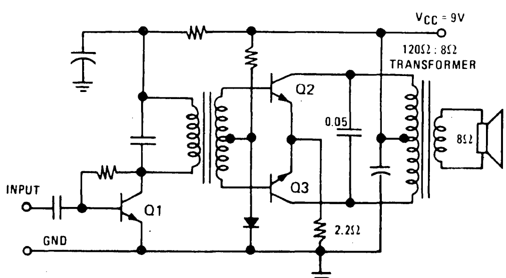
Q1 NB111EH/J Q3 NA01EG/J
Q2 NR001E Q4 NA01EG/J

Figure A. 380mW 6V/8Ω OTL Amplifier



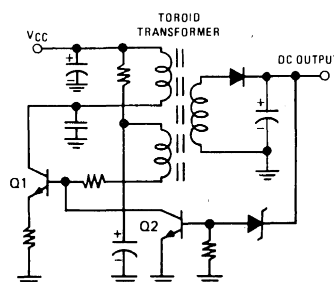
Q1 NB111EH/J Q3 NA01EG/J
Q2 NR001E Q4 NA01EG/J

Figure B. 650mW 12V/25Ω OTL Amplifier



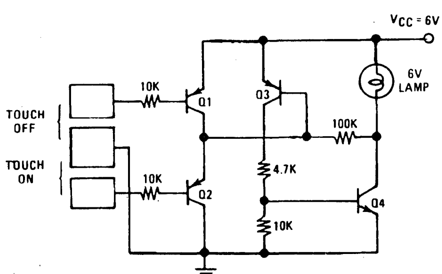
Q1 NB111EH/J Q2 NA01EG/J Q3 NA01EG/J

Figure C. 1.2W Audio Amplifier



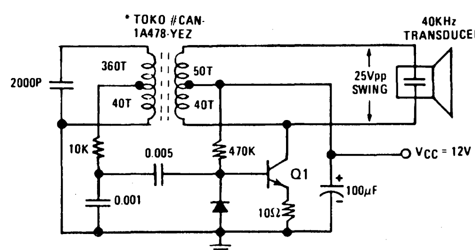
Q1 NA01EX Q2 NB111EY

Figure D. Typical Converter Circuit



Q1 NB021EY Q3 NB021EY
Q2 NB021EY Q4 NA01EX

Figure E. Touch-on/Touch-off Electronic Switch



Q1 NA01EX

Figure F. 40KHz Ultrasonic Transmitter

National Semiconductor

NA11 (NPN) NA12 (PNP) 1 Amp complementary power transistors

features

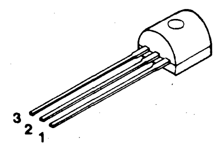
- 20 Volt/1 Amp rating
- Low V_{CE} (sat) and V_{BE} (sat) characteristics at I_C = 400 mA, I_B = 10 mA
- Guaranteed V_{BE} (on) characteristics at low current for stable biasing
- Matched HFE groupings for complementary applications
- "Epoxy B" packaging concept for excellent reliability

applications

- 0.2 to 1 Watt audio power amplifiers
- Medium power switching circuits
- Converter/Inverter circuits
- Circuits for toys

1 package and lead coding

TO-92



PACKAGE CODE TO-92	LEAD 1	2	3
E	E	B	C
F	E	C	B
H	C	B	E

2 maximum ratings

PARAMETER	SYMBOL	RATING	UNIT
Collector-Emitter Voltage	V_{CEO}	20	V_{DC}
Collector-Base Voltage	V_{CB}	25	V_{DC}
Emitter-Base Voltage	V_{EB}	5.0	V_{DC}
Collector Current (continuous)	I_C (max)	1.0	A
Power Dissipation (T_A = 25°C)	P_D		
TO-92		0.6	W
Power Dissipation (T_C = 25°C)	P_D		
TO-92		1.0	W
Thermal Resistance			
TO-92	θ_{JA}	208	°C/W
	θ_{JC}	125	°C/W
Temperature, Junction and Storage	T_j, T_{stg}	–55 to + 150	°C

3 ordering information

NA1XXX

- POLARITY: "1" for NPN, "2" for PNP
- PACKAGE/LEAD CODE: refer to 1
- HFE GROUPING: refer to 5

4 electrical characteristics $T_C = 25°C$

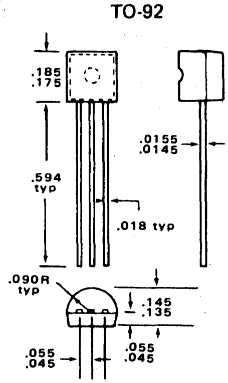
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
BV_{CEO}	Collector-Emitter Sustaining Voltage	$I_C = 1$ mA	20			V
BV_{CBO}	Collector-Base Breakdown Voltage	$I_C = 100\mu A$	25			V
BV_{EBO}	Emitter-Base Breakdown Voltage	$I_E = 10\mu A$	5			V
I_{CEO}	Collector-Emitter Leakage Current	$V_{CE} = 15V$			100	μA
I_{CBO}	Collector-Base Leakage Current	$V_{CB} = 20V$			1	μA
V_{BE} (on)	Base-Emitter Voltage	$I_C = 10$ mA, $V_{CE} = 3V$	630	680	730	mV
V_{BE} (sat)	Base-Emitter Saturation Voltage	$I_C = 400$ mA, $I_B = 10$ mA		0.9	1.0	V
V_{CE} (sat)	Collector-Emitter Saturation Voltage	$I_C = 400$ mA, $I_B = 10$ mA		0.3	0.5	V
Cob	Collector Output Capacitance	$V_{CB} = 10V$, f = 1 MHz				
	NPN types			4.5		pF
	PNP types			7.0		pF
ft	Current Gain Bandwidth Product	$I_C = 100$ mA, $V_{CE} = 3V$	50	200		MHz

5 HFE groupings

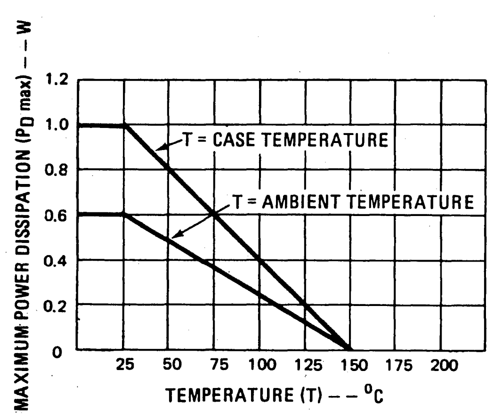
GROUPING	PARAMETER	CONDITIONS	MIN	TYP	MAX	RATIO
G	DC Current Gain	$I_C = 100$ mA, $V_{CE} = 3V$	68	85	110	1:1.6
H	DC Current Gain	$I_C = 100$ mA, $V_{CE} = 3V$	100	127	160	1:1.6
I	DC Current Gain	$I_C = 100$ mA, $V_{CE} = 3V$	140	180	240	1:1.6
J	DC Current Gain	$I_C = 100$ mA, $V_{CE} = 3V$	200	260	350	1:1.6
X	DC Current Gain	$I_C = 100$ mA, $V_{CE} = 3V$	30	58	110	1:3.5
Y	DC Current Gain	$I_C = 100$ mA, $V_{CE} = 3V$	100	190	350	1:3.5

6 physical dimensions

TO-92



7 max power dissipation

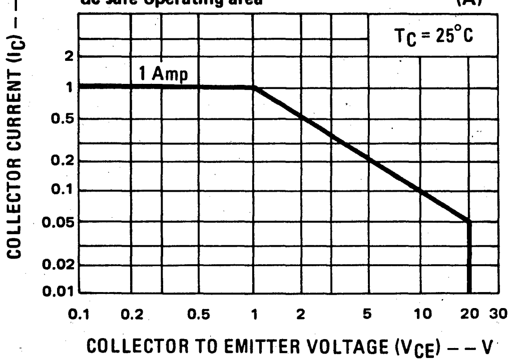


7

8 typical performance characteristics

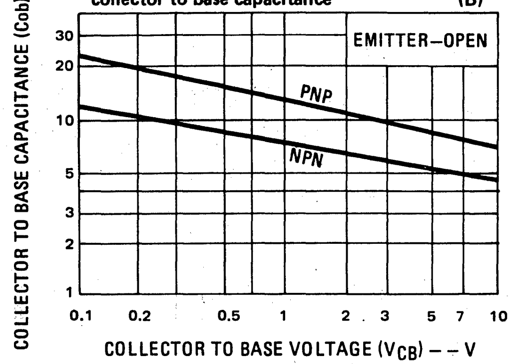
SOA

dc safe operating area (A)



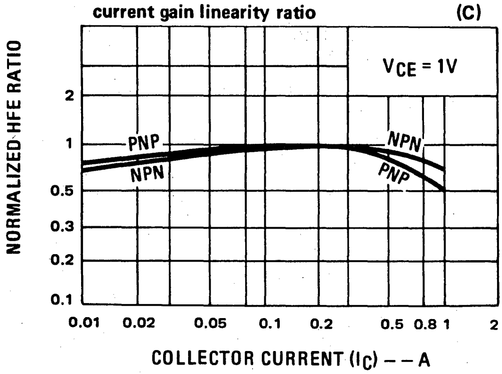
Cob

collector to base capacitance (B)



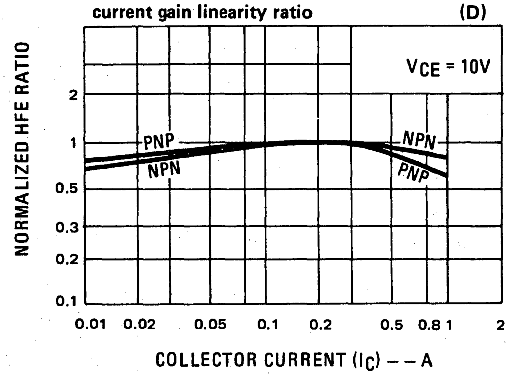
HFE1/HFE2

current gain linearity ratio (C)



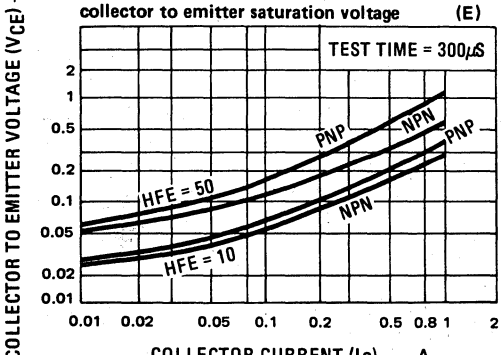
HFE1/HFE2

current gain linearity ratio (D)



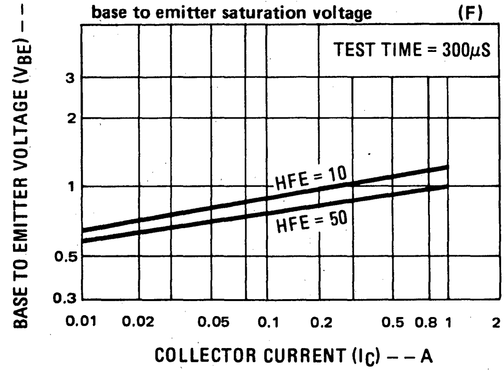
VCE(sat)

collector to emitter saturation voltage (E)

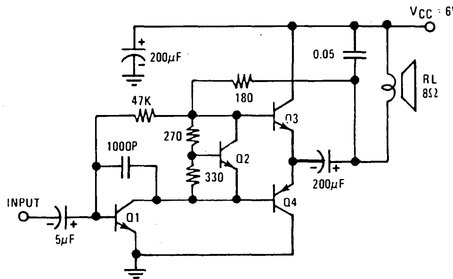


VBE(sat)

base to emitter saturation voltage (F)

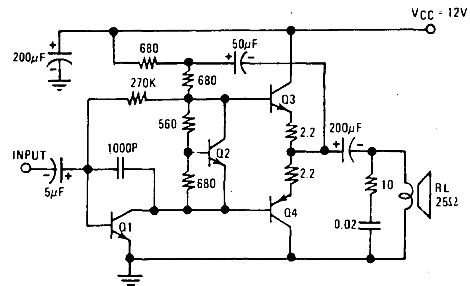


9 typical applications



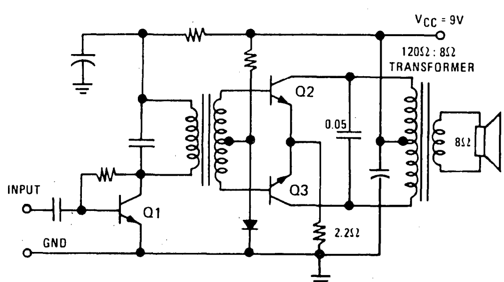
Q1 NB111EH/J Q3 NA11EG/J
Q2 NR001E Q4 NA12EG/J

Figure A. 380mW 6V/8Ω OTL Amplifier



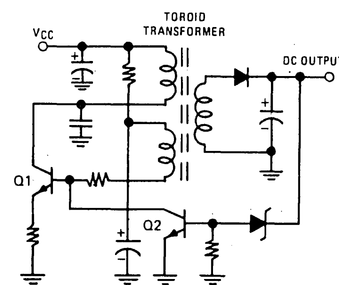
Q1 NB111EH/J Q3 NA11EG/J
Q2 NR001E Q4 NA12EG/J

Figure B. 650mW 12V/25Ω OTL Amplifier



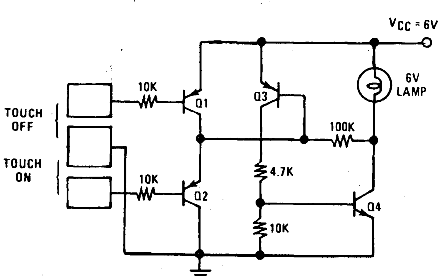
Q1 NB111EH/J Q2 NA11EG/J Q3 NA11EG/J

Figure C. 1.2W Audio Amplifier



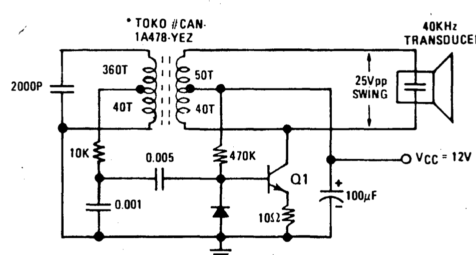
Q1 NA11EX Q2 NB111EY

Figure D. Typical Converter Circuit



Q1 NB021EY Q3 NB021EY
Q2 NB021EY Q4 NA11EX

Figure E. Touch-on/Touch-off Electronic Switch



Q1 NA11EX

Figure F. 40KHz Ultrasonic Transmitter

National Semiconductor

NA21 (NPN) NA22 (PNP) 1.5 Amp complementary power transistors

features

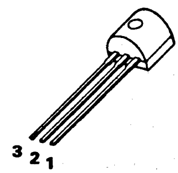
- 20 Volt/1.5 Amp rating
- 1.2 Watts practical power dissipation (TO-92 PLUS TM)
- Low V_{CE} (sat) and V_{BE} (sat) characteristics at $I_C = 700$ mA, $I_B = 14$ mA
- Guaranteed V_{BE} (on) characteristics at small current for stable biasing
- Matched HFE groupings for complementary applications
- "Epoxy B" packaging concept for excellent reliability

applications

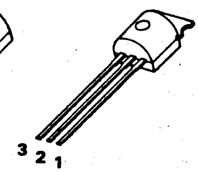
- 0.5 – 2 Watt audio power amplifiers
- Medium power switching circuits
- Converter/Inverter circuits
- Toy circuits

1 package and lead coding

TO-92



TO-92 PLUS TM



PACKAGE CODE		LEAD		
TO-92	TO-92 PLUS	1	2	3
E	X	E	B	C
F	Y	E	C	B
	Z	B	C	E
H		C	B	E

2 maximum ratings

PARAMETER	SYMBOL	RATING	UNIT
Collector-Emitter Voltage	V_{CE}	20	V_{DC}
Collector-Base Voltage	V_{CB}	25	V_{DC}
Emitter-Base Voltage	V_{EB}	5.0	V_{DC}
Collector Current (continuous)	I_C (max)	1.5	A
Power Dissipation ($T_A = 25°C$)	P_D		
TO-92		0.6	W
TO-92 PLUS		0.75	W
Power Dissipation ($T_C = 25°C$)	P_D		
TO-92		1.0	W
TO-92 PLUS		2.5	W
Thermal Resistance			
TO-92	$\theta_{JA} / \theta_{JC}$	208/125	°C/W
TO-92 PLUS	$\theta_{JA} / \theta_{JC}$	167/50	°C/W
Temperature, Junction and Storage	T_j, T_{stg}	–55 to + 150	°C

3 ordering information

N A 2 X X X

- POLARITY: "1" for NPN, "2" for PNP
- PACKAGE/LEAD CODE: refer to 1
- HFE GROUPING: refer to 5

4 electrical characteristics $T_C = 25°C$

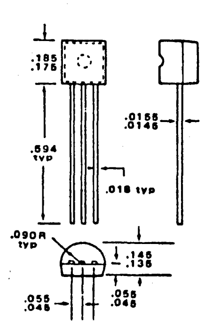
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
BV_{CEO}	Collector-Emitter Sustaining Voltage	$I_C = 1$ mA	20			V
BV_{CBO}	Collector-Base Breakdown Voltage	$I_C = 100\mu A$	25			V
BV_{EBO}	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$	5			V
I_{CEO}	Collector-Emitter Leakage Current	$V_{CE} = 15V$			100	μA
I_{CBO}	Collector-Base Leakage Current	$V_{CB} = 20V$			1	μA
V_{BE} (on)	Base-Emitter Voltage	$I_C = 10$ mA, $V_{CE} = 3V$	600	670	730	mV
V_{BE} (sat)	Base-Emitter Saturation Voltage	$I_C = 700$ mA, $I_B = 14$ mA		0.9	1.0	V
V_{CE} (sat)	Collector-Emitter Saturation Voltage	$I_C = 700$ mA, $I_B = 14$ mA				
	NPN types			0.35	0.5	V
	PNP types			0.65	1	V
C_{ob}	Collector Output Capacitance	$V_{CB} = 10V$, f = 1 MHz				
	NPN types			0.45		pF
	PNP types			0.7		pF
f_t	Current Gain Bandwidth Product	$I_C = 100$ mA, $V_{CE} = 3V$	50	200		MHz

5 HFE groupings

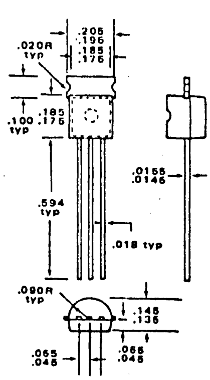
GROUPING	PARAMETER	CONDITIONS	MIN	TYP	MAX	RATIO
G	DC Current Gain	$I_C = 100$ mA, $V_{CE} = 3V$	68	85	110	1:1.6
H	DC Current Gain	$I_C = 100$ mA, $V_{CE} = 3V$	100	127	160	1:1.6
I	DC Current Gain	$I_C = 100$ mA, $V_{CE} = 3V$	140	180	240	1:1.6
J	DC Current Gain	$I_C = 100$ mA, $V_{CE} = 3V$	200	260	350	1:1.6
X	DC Current Gain	$I_C = 100$ mA, $V_{CE} = 3V$	30	58	110	1:3.5
Y	DC Current Gain	$I_C = 100$ mA, $V_{CE} = 3V$	100	190	350	1:3.5

6 physical dimensions

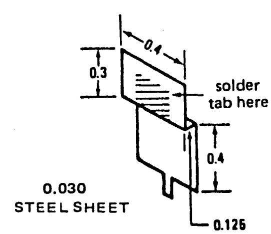
TO-92



TO-92 PLUS



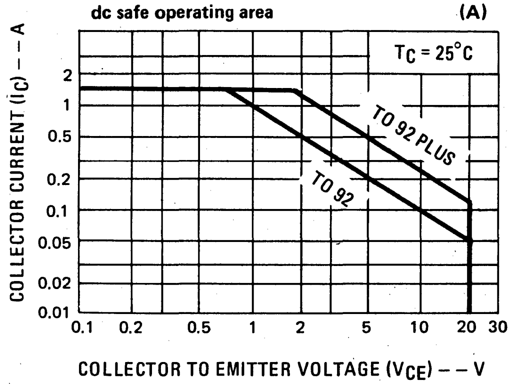
7 heatsink information



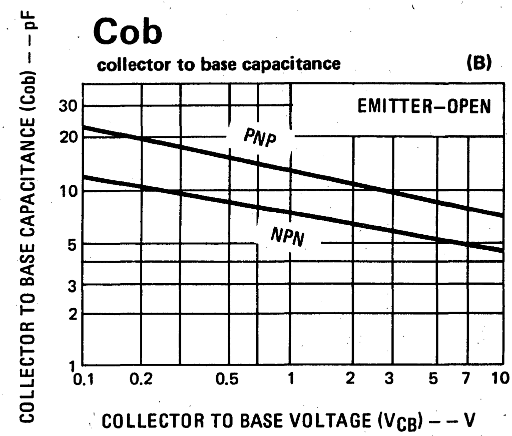
- TO-92 PLUS package with heat-sink shown on right permits 1.6 Watts power dissipation and combined Thermal Resistance $\theta_{JA} = 78°C/W$. If used without heatsink and PCB land area at collector lead > 1 sq. inch, $P_D = 1.2W$.

8 typical performance characteristics

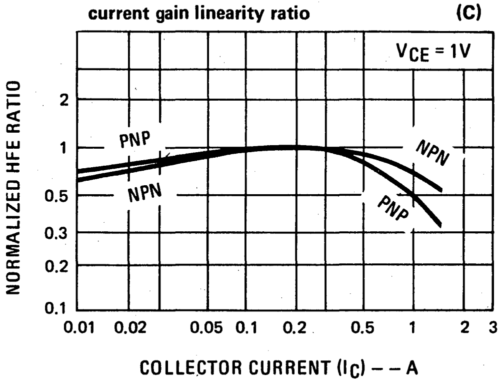
SOA
dc safe operating area (A)



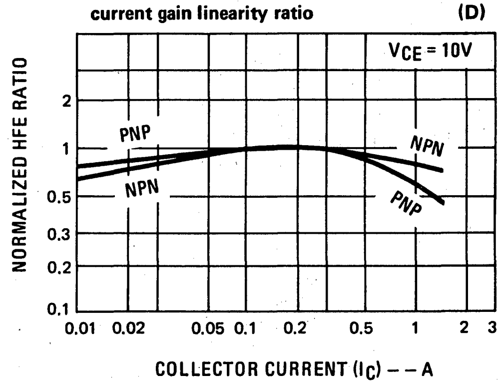
Cob
collector to base capacitance (B)



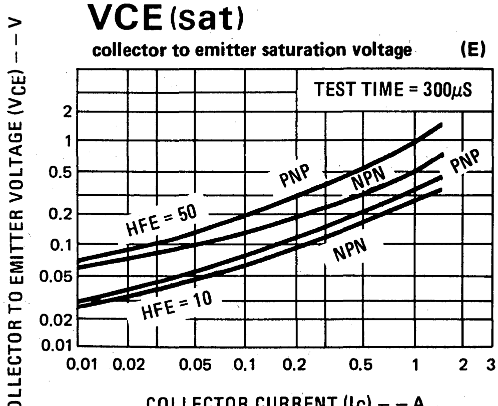
HFE1/HFE2
current gain linearity ratio (C)



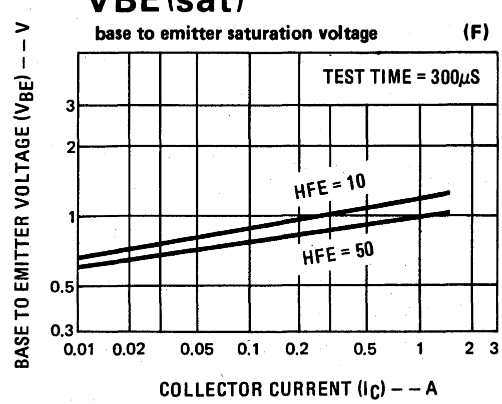
HFE1/HFE2
current gain linearity ratio (D)



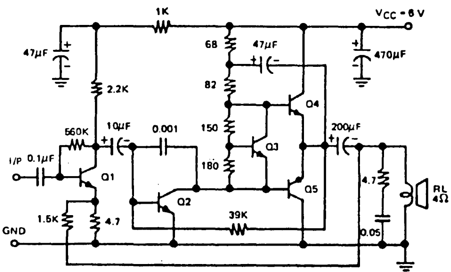
VCE(sat)
collector to emitter saturation voltage (E)



VBE(sat)
base to emitter saturation voltage (F)

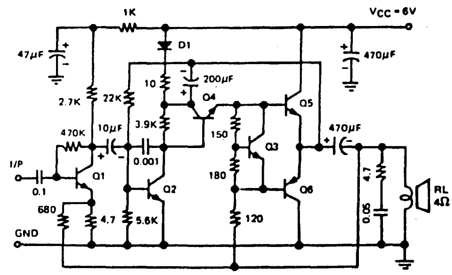


9 typical applications



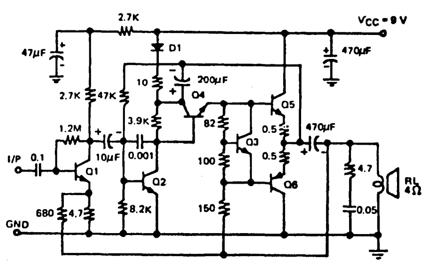
Q1 NB011EY Q3 NR001E Q5 NA22EG/J
Q2 NB111EH/J Q4 NA21EG/J

Figure A. 700mW 6V/4Ω OTL Amplifier



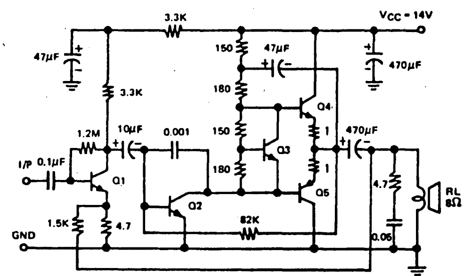
Q1 NB011EY Q3 NR001E Q5 NA21EG/J
Q2 NB011EY Q4 NB111EY Q6 NA22EG/J

Figure B. 950mW 6V/4Ω OTL Amplifier



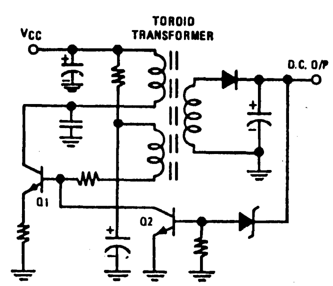
Q1 NB011EY Q3 NR001E Q5 NA21EG/J
Q2 NB011EY Q4 NB111EY Q6 NA22EG/J

Figure C. 2W 9V/4Ω OTL Amplifier



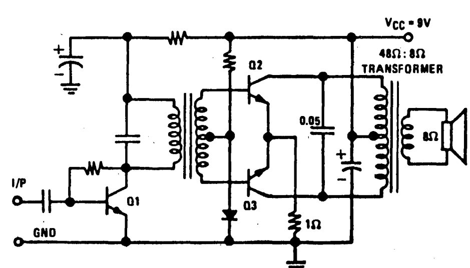
Q1 NB011EY Q3 NR001E Q5 NA22EG/J
Q2 NB111EH/J Q4 NA21EG/J

Figure D. 2.2W 14V/8Ω OTL Amplifier



Q1 NA21EX Q2 NB111EY

Figure E. Typical Convertor Circuit



Q1 NB111E Q2 NA21Y G/J Q3 NA21Y G/J

Figure F. 2W Audio Amplifier

7

National Semiconductor

NA31 (NPN) NA32 (PNP) 2 Amp complementary power transistors

features

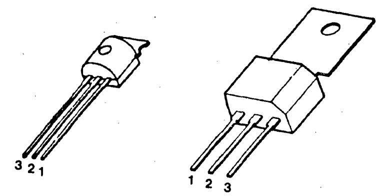
- 30 Volt/2 Amp rating
- 1.2 Watts practical power dissipation (TO-92 PLUS™)
- 1.75 Watts free air power dissipation (TO-202)
- Low $V_{CE(sat)}$ and $V_{BE(sat)}$ characteristics at I_C = 1.2A, I_B = 30 mA
- Matched HFE groupings for complementary applications
- "Epoxy B" packaging concept for excellent reliability

applications

- 4-Watt audio power amplifiers
- Medium power switching circuits
- Converter/Inverter circuits
- TV receivers

1 packages and lead coding

TO-92 PLUS ™ TO-202



PACKAGE CODE		LEAD		
TO-92 PLUS	TO-202	1	2	3
X	K	E	B	C
Y	L	E	C	B
Z	M	B	C	E

2 maximum ratings

PARAMETER	SYMBOL	RATING	UNIT
Collector-Emitter Voltage	V_{CEO}	30	V_{DC}
Collector-Base Voltage	V_{CB}	35	V_{DC}
Emitter-Base Voltage	V_{EB}	5.0	V_{DC}
Collector Current (continuous)	I_C (max)	2.0	A
Power Dissipation (T_A = 25°C)	P_D		
TO-92 PLUS		0.75	W
TO-202		1.75	W
Power Dissipation (T_C = 25°C)	P_D		
TO-92 PLUS		2.5	W
TO-202		10	W
Thermal Resistance			
TO-92 PLUS	θ_{JA}/θ_{JC}	167/ 50	°C/W
TO-202	θ_{JA}/θ_{JC}	72/ 12.5	°C/W
Temperature, Junction and Storage	T_j, T_{stg}	−55 to + 150	°C

3 ordering information

N A 3 X X X

- POLARITY: "1" for NPN, "2" for PNP
- PACKAGE/LEAD CODE: refer to 1
- HFE GROUPING: refer to 5

4 electrical characteristics $T_C = 25°C$

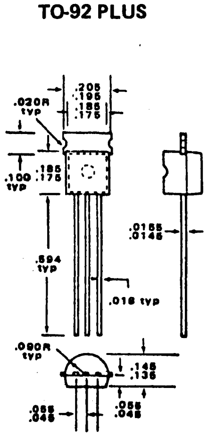
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
BV_{CEO}	Collector-Emitter Sustaining Voltage	$I_C = 1$ mA	30			V
BV_{CBO}	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$	35			V
BV_{EBO}	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$	5			V
I_{CEO}	Collector-Emitter Leakage Current	$V_{CE} = 25V$			100	μA
I_{CBO}	Collector-Base Leakage Current	$V_{CB} = 30V$			1	μA
$V_{BE(on)}$	Base-Emitter Voltage	$I_C = 15$ mA, $V_{CE} = 5V$	600	650	700	mV
$V_{BE(sat)}$	Base-Emitter Saturation Voltage	$I_C = 1.2A$, $I_B = 30$ mA		0.95	1.2	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_C = 1.2A$, $I_B = 30$ mA		0.5	1	V
$V_{BE(sat)}$	Base-Emitter Saturation Voltage	$I_C = 1.2A$, $I_B = 120$ mA		1.0	1.4	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_C = 1.2A$, $I_B = 120$ mA		0.25	0.5	V
C_{ob}	Collector Output Capcitance	$V_{CB} = 10V$, f = 1 MHz				
	NPN types			10		pF
	PNP types			17		pF
f_t	Current Gain Bandwidth Product	$I_C = 300$ mA, $V_{CE} = 5V$	20			MHz

5 HFE groupings

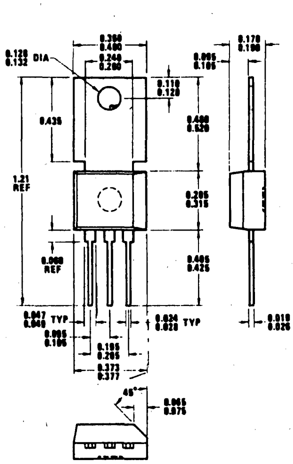
GROUPING	PARAMETER	CONDITIONS	MIN	TYP	MAX	RATIO
G	DC Current Gain	$I_C = 300$ mA, $V_{CE} = 5V$	68	85	110	1:1.6
H	DC Current Gain	$I_C = 300$ mA, $V_{CE} = 5V$	100	127	160	1:1.6
I	DC Current Gain	$I_C = 300$ mA, $V_{CE} = 5V$	140	180	240	1:1.6
J	DC Current Gain	$I_C = 300$ mA, $V_{CE} = 5V$	200	260	350	1:1.6
X	DC Current Gain	$I_C = 300$ mA, $V_{CE} = 5V$	30	58	110	1:3.5
Y	DC Current Gain	$I_C = 300$ mA, $V_{CE} = 5V$	100	190	350	1:3.5

6 physical dimensions

TO-92 PLUS

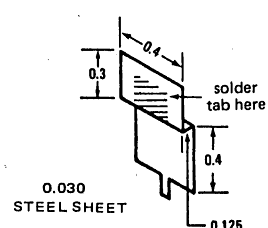


TO-202

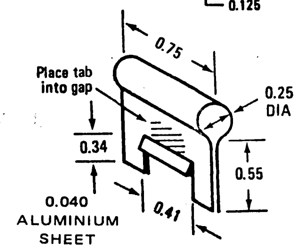


7 heatsink information

- TO-92 PLUS package with heatsink shown on right permits 1.6 Watts power dissipation and combined Thermal Resistance $\theta_{JA} = 78°C/W$. If used without heatsink and PCB land area at collector lead > 1 sq. inch, $P_D = 1.2W$.

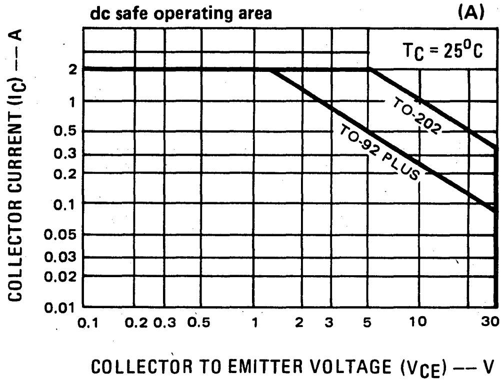


- TO-202 package with heatsink shown on right permits 3 Watts P_D and $\theta_{JA} = 42°C/W$.

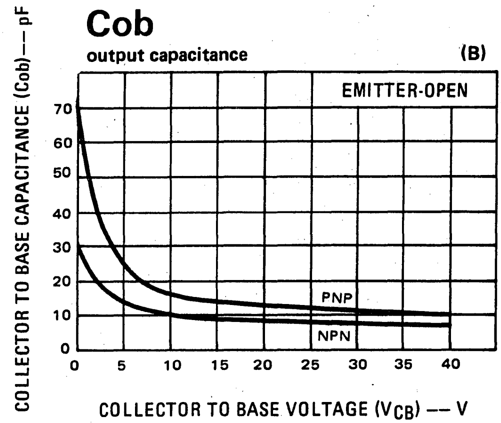


8 typical performance characteristics

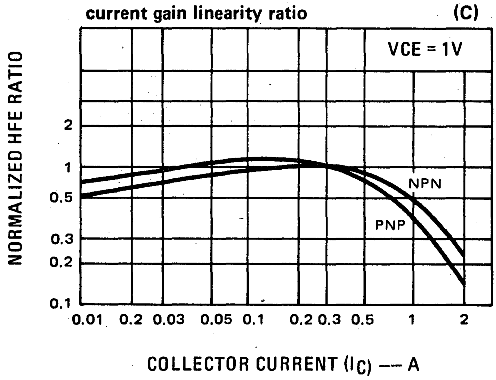
SOA
dc safe operating area (A)



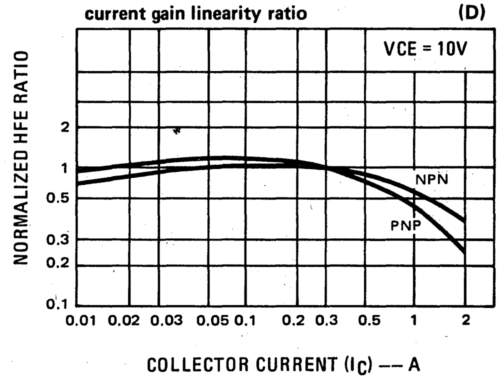
Cob
output capacitance (B)



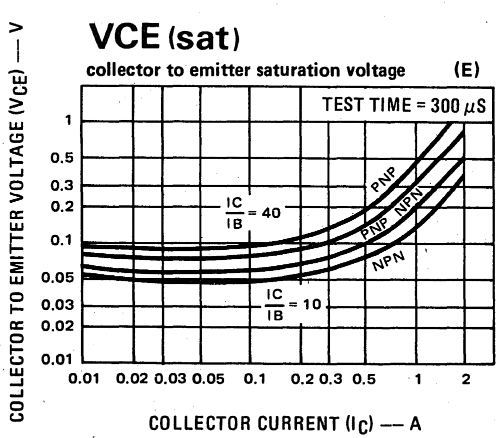
HFE1/HFE2
current gain linearity ratio (C)



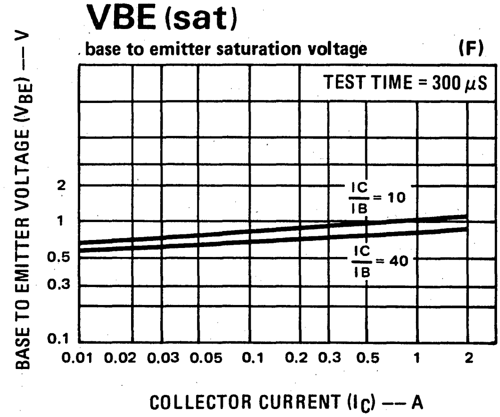
HFE1/HFE2
current gain linearity ratio (D)



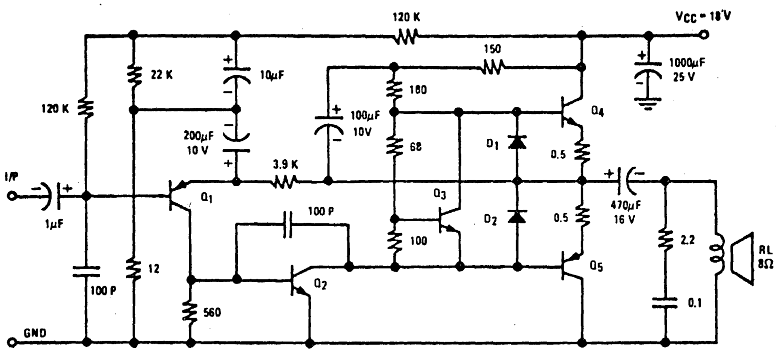
VCE (sat)
collector to emitter saturation voltage (E)



VBE (sat)
base to emitter saturation voltage (F)

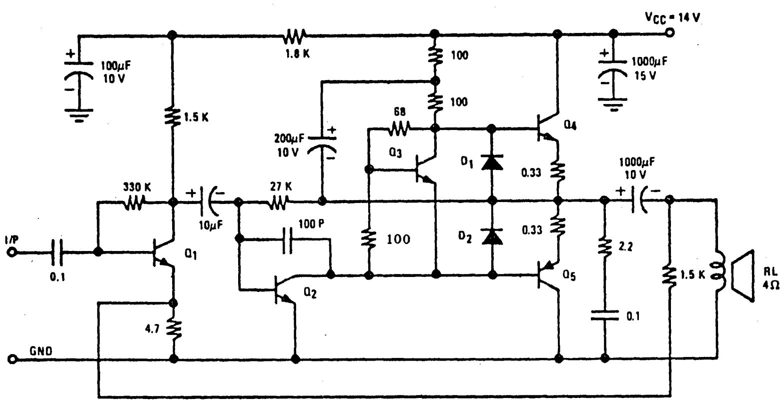


9 typical applications



Q1 NB021EY
Q2 NB211EY
Q3 NR001E
Q4 NA31YG/I
Q5 NA32YG/I

Figure A. 4 Watt/ 8 Ohm OTL Amplifier



Q1 NB011EU
Q2 NB211EH/J
Q3 NR001E
Q4 NA31YG/I
Q5 NA32YG/I

Figure B. 4 Watt/ 4 Ohm OTL Amplifer

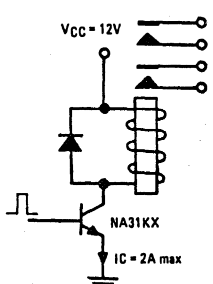


Figure C. Relay Driver

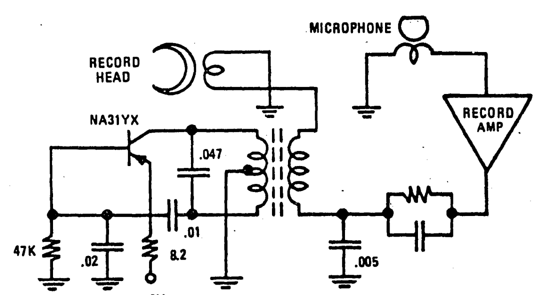


Figure D. Cassette Bias Oscillator

National Semiconductor

NA41 (NPN) NA42 (PNP) 2.5 Amp complementary power transistors

features

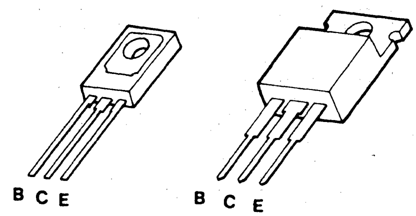
- 30 Volt/2.5 Amp rating
- Available in TO-126 and TO-220 packages
- Low V_{CE} (sat) and V_{BE} (sat) characteristics at I_C = 1.6 A, I_B = 40 mA
- Matched HFE groupings for complementary applications
- "Epoxy B" packaging concept for excellent reliability

applications

- 4 to 7 Watt, 4 or 8 Ohm audio power amplifiers
- High current switching circuits
- Converter/Inverter circuits
- TV receivers

1 packages and lead coding

TO-126 TO-220



PACKAGE CODE	
TO 126	TO 220
U	W

2 maximum ratings

PARAMETER	SYMBOL	RATING	UNIT
Collector-Emitter Voltage	V_{CE}	30	V_{DC}
Collector-Base Voltage	V_{CB}	35	V_{DC}
Emitter-Base Voltage	V_{EB}	4	V_{DC}
Collector Current (continuous)	I_C (max)	2.5	A
Power Dissipation (T_A = 25°C)	P_D		
TO-126		1.7	W
TO-220		1.8	W
Power Dissipation (T_C = 25°C)	P_D		
TO-126		25	W
TO-220		25	W
Thermal Resistance			
TO-126	θ_{JA}/θ_{JC}	73.5/5	°C/W
TO-220	θ_{JA}/θ_{JC}	69.4/5	°C/W
Temperature, Junction and Storage	Tj, Tstg	–55 to + 150	°C

3 ordering information

N A 4 X X X

- POLARITY: "1" for NPN, "2" for PNP
- PACKAGE/LEAD CODE: refer to [1]
- HFE GROUPING: refer to [5]

4 electrical characteristics $T_C = 25°C$

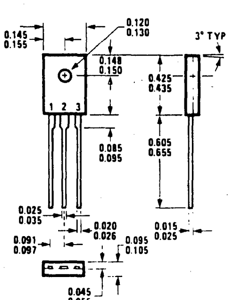
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
BV_{CER}	Collector-Emitter Sustaining Voltage	I_C = 10 mA, R = 1K	30			V
BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 100μA	35			V
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 100μA	4			V
I_{CER}	Collector-Emitter Leakage Current	V_{CE} = 20V, R = 1K			500	μA
I_{CBO}	Collector-Base Leakage Current	V_{CB} = 25V			200	μA
V_{BE} (on)	Base-Emitter Voltage	I_C = 10 mA, V_{CE} = 10V	510	590	670	mV
V_{BE} (sat)	Base-Emitter Saturation Voltage	I_C = 1.6A, I_B = 40 mA			1.2	V
V_{BE} (sat)	Base-Emitter Saturation Voltage	I_C = 1.6A, I_B = 160 mA			1.4	V
V_{CE} (sat)	Collector-Emitter Saturation Voltage	I_C = 1.6A, I_B = 40 mA			1.2	V
V_{CE} (sat)	Collector-Emitter Saturation Voltage	I_C = 1.6A, I_B = 160 mA			0.6	V
Cob	Collector Output Capacitance	V_{CB} = 10V, f = 1 MHz				
	NPN types			35		pF
	PNP types			65		pF

5 HFE groupings

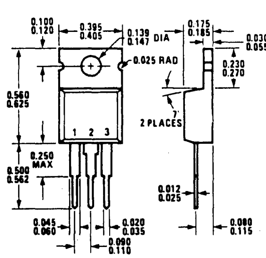
GROUPING	PARAMETER	CONDITIONS	MIN	TYP	MAX	RATIO
G	DC Current Gain	I_C = 300 mA, V_{CE} = 10V	68	85	110	1:1.6
H	DC Current Gain	I_C = 300 mA, V_{CE} = 10V	100	127	160	1:1.6
I	DC Current Gain	I_C = 300 mA, V_{CE} = 10V	140	180	240	1:1.6
X	DC Current Gain	I_C = 300 mA, V_{CE} = 10V	30	58	110	1:3.5
Y	DC Current Gain	I_C = 300 mA, V_{CE} = 10V	100	190	350	1:3.5

6 physical dimensions

TO-126



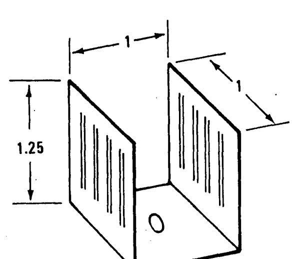
TO-220



7 heatsink information

The TO-126 and TO-220 packages used with heatsink shown below permits about 8.7 Watts Power Dissipation and θ_{CA} = 9.4°C/W.

0.05 inch aluminium sheet

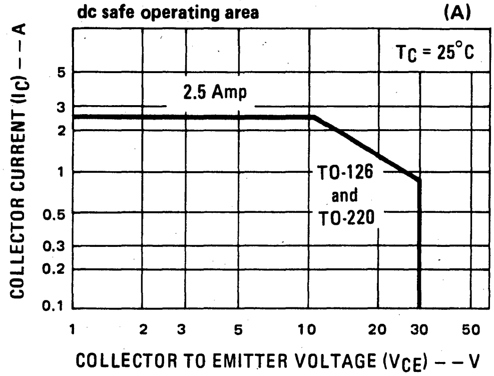


Mount transistor under heatsink and apply thermally conductive compound between contact surfaces.

8 typical performance characteristics

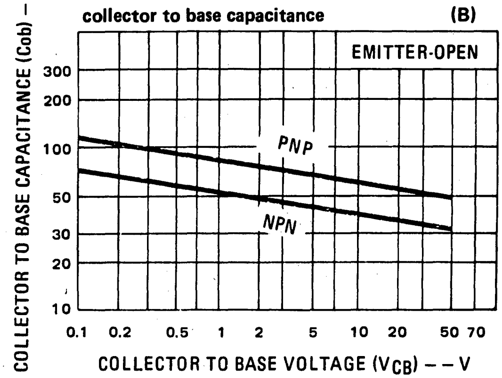
SOA

dc safe operating area (A)



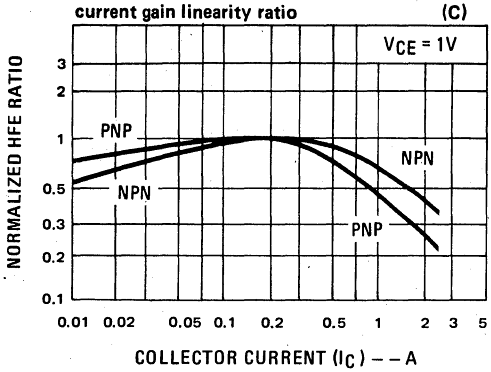
Cob

collector to base capacitance (B)



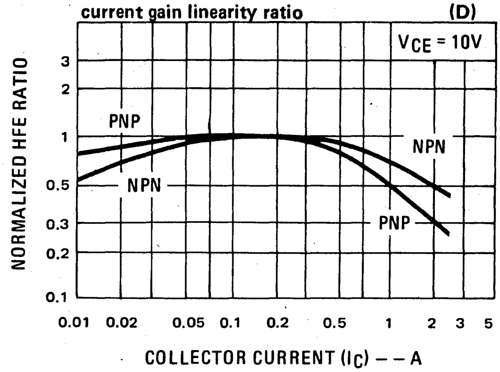
HFE1/HFE2

current gain linearity ratio (C)



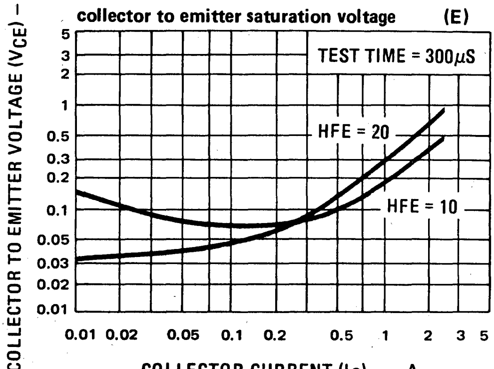
HFE1/HFE2

current gain linearity ratio (D)



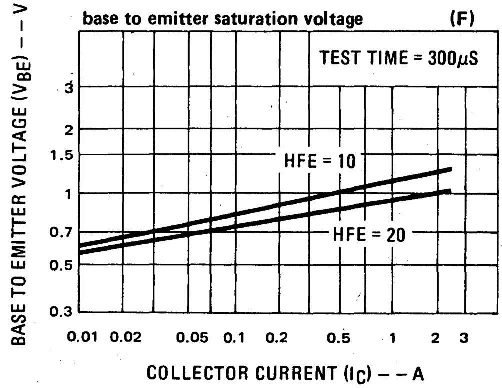
VCE(sat)

collector to emitter saturation voltage (E)

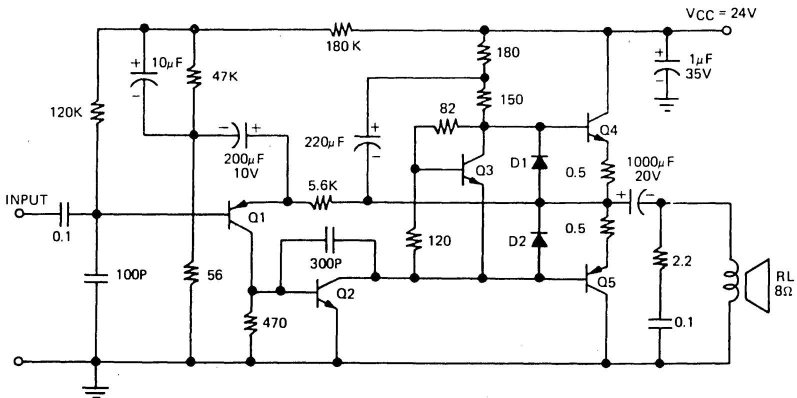


VBE(sat)

base to emitter saturation voltage (F)

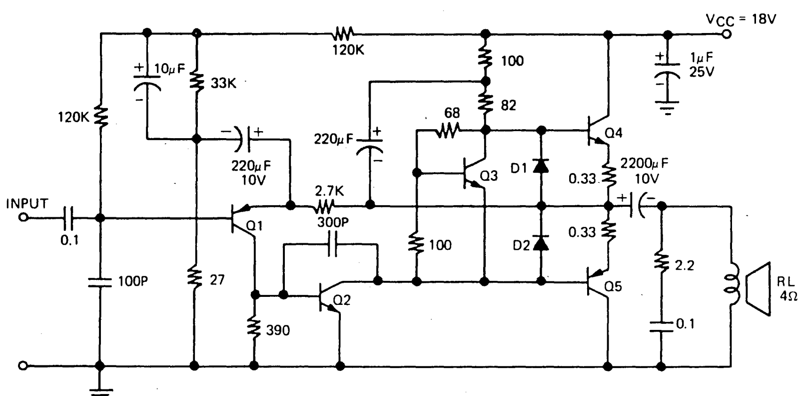


9 typical applications



Q1	NB021EY
Q2	NB211YY
Q3	NR001E
Q4	NA41U
Q5	NA42U

Figure A. 6 Watt, 8 Ohm OTL Amplifier



Q1	NB021EY
Q2	NB211YY
Q3	NR001E
Q4	NA41U
Q5	NA42U

Figure B. 6 Watt, 4 Ohm OTL Amplifier

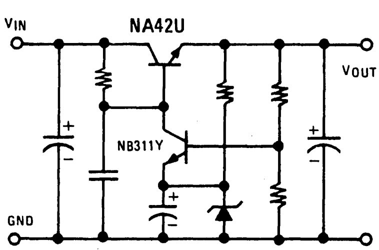


Figure C. Linear Regulator Circuit

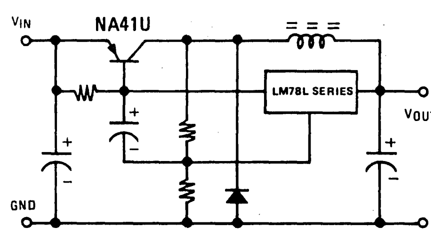


Figure D. Switching Regulator Circuit

National Semiconductor

NA51(NPN) NA52(PNP) 3.5 Amp complementary power transistors

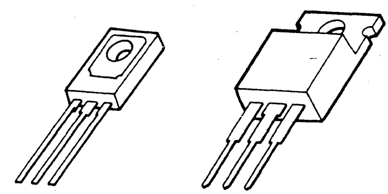
features

- 45 Volt/3.5 Amp rating
- Available in TO-126 and TO-220 packages
- Low V_{CE} (sat) and V_{BE} (sat) characteristics at I_C = 2A, I_B = 80 mA
- Guaranteed V_{CE} (sat) and V_{BE} (sat) at I_C = 3A, I_B = 160 mA for improved short-circuit protection design in audio amplifier
- "Epoxy B" packaging concept for excellent reliability

applications

- 6 to 14 Watt, 4 or 8 Ohm audio power amplifier
- High current switching circuits
- Converter/Inverter circuits
- TV receivers

1 packages and lead coding



PACKAGE CODE	
TO 126	TO 220
U	W

2 maximum ratings

PARAMETER	SYMBOL	RATING	UNIT
Collector-Emitter Voltage	V_{CE}	45	V_{DC}
Collector-Base Voltage	V_{CB}	50	V_{DC}
Emitter-Base Voltage	V_{EB}	4	V_{DC}
Collector Current (continuous)	I_C (max)	3.5	A
Power Dissipation (T_A = 25°C)	P_D		
TO-126		1.8	W
TO-220		2.0	W
Power Dissipation (T_C = 25°C)	P_D		
TO-126		30	W
TO-220		30	W
Thermal Resistance			
TO-126	θ_{JA}/θ_{JC}	69.4/4.17	°C/W
TO-220	θ_{JA}/θ_{JC}	62.5/4.17	°C/W
Temperature, Junction and Storage	Tj, Tstg	–55 to + 150	°C

3 ordering information

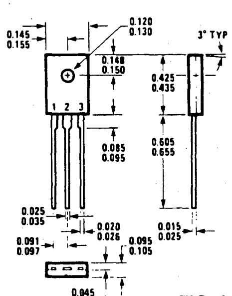
NA5XX

- POLARITY: "1" for NPN, "2" for PNP
- PACKAGE/LEAD CODE: refer to 1

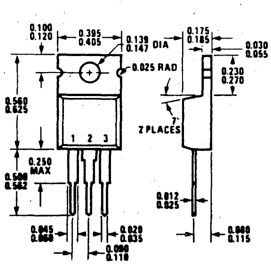
4 electrical characteristics $T_C = 25°C$

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
BV_{CER}	Collector-Emitter Sustaining Voltage	I_C = 10 mA, R = 1K	45			V
BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 100μA	50			V
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 100μA	4			V
I_{CER}	Collector-Emitter Leakage Current	V_{CE} = 35V, R = 1K			1	mA
I_{CBO}	Collector-Base Leakage Current	V_{CB} = 40V			0.5	mA
V_{BE} (on)	Base-Emitter Voltage	I_C = 15 mA, V_{CE} = 10V	520	600	680	mV
V_{BE} (sat)	Base-Emitter Saturation Voltage	I_C = 2A, I_B = 80 mA			1.3	V
V_{BE} (sat)	Base-Emitter Saturation Voltage	I_C = 3A, I_B = 160 mA			1.6	V
V_{CE} (sat)	Collector-Emitter Saturation Voltage	I_C = 2A, I_B = 80 mA			1.5	V
V_{CE} (sat)	Collector-Emitter Saturation Voltage	I_C = 3A, I_B = 160 mA			5	V
HFE_1	DC Current Gain	I_C = 500 mA, V_{CE} = 10V	30	100		ratio
Cob	Collector Output Capacitance NPN types PNP types	V_{CB} = 10V, f = 1 MHz		 35 65		 pF pF

5 physical dimensions



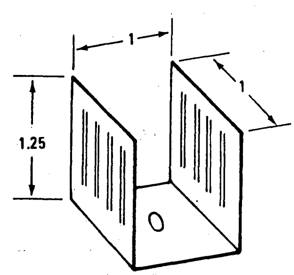
TO-126



TO-220

6 heatsink information

The TO-126 and TO-220 packages used with heatsink shown below permits about 9.2 Watts power dissipation and θ_{CA} = 9.4°C/W.

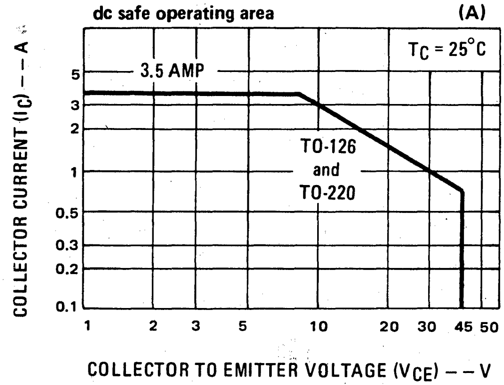


0.05 inch aluminium sheet

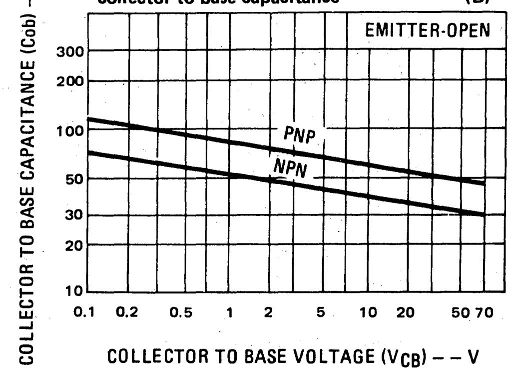
Mount transistor under heatsink and apply thermally conductive compound between contact surfaces.

7 typical performance characteristics

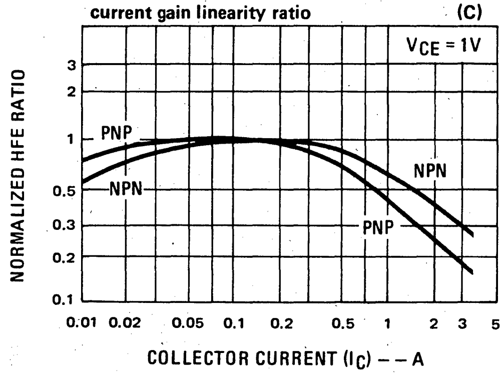
SOA
dc safe operating area (A)



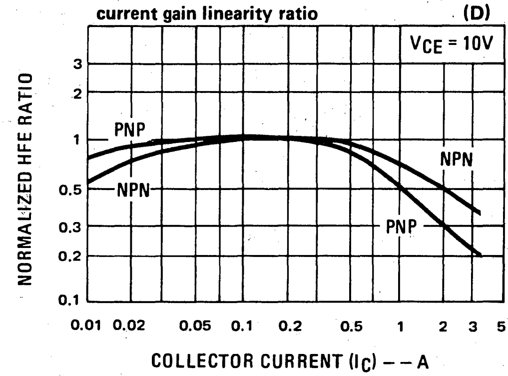
Cob
collector to base capacitance (B)



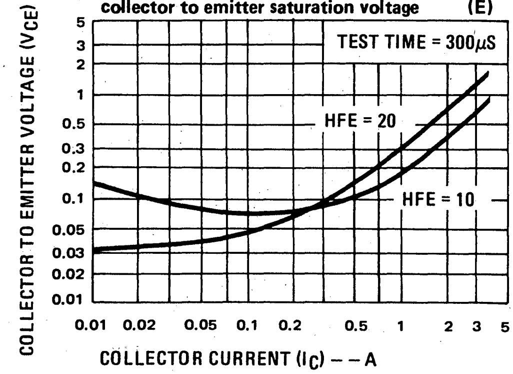
HFE1/HFE2
current gain linearity ratio (C)



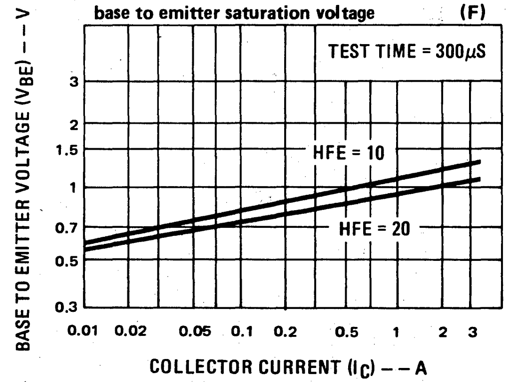
HFE1/HFE2
current gain linearity ratio (D)



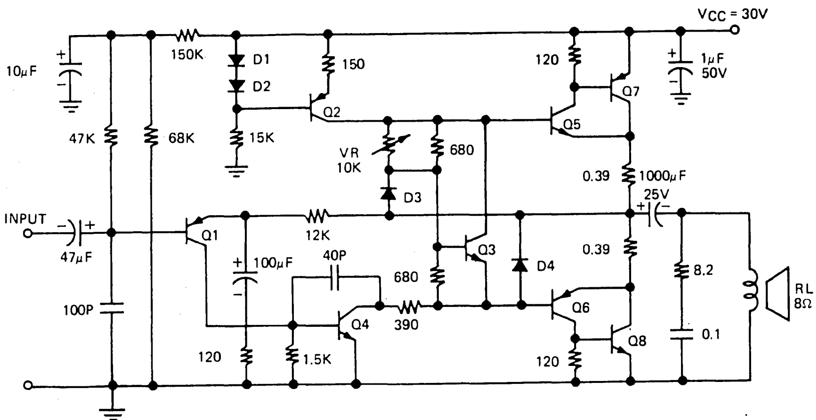
VCE(sat)
collector to emitter saturation voltage (E)



VBE(sat)
base to emitter saturation voltage (F)

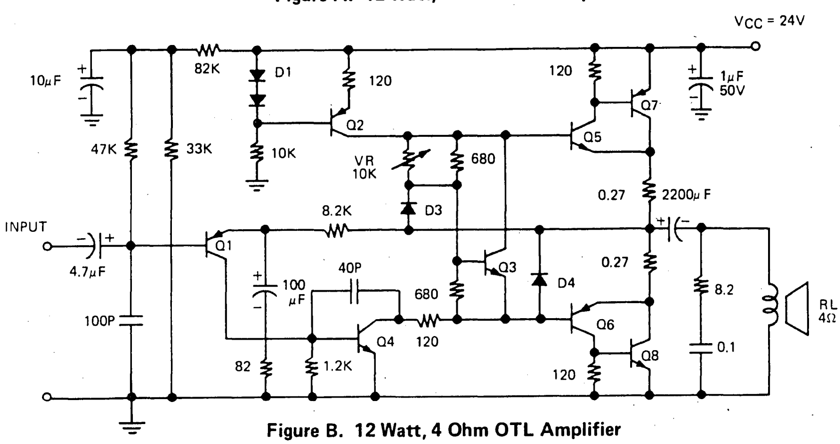


8 typical applications



Q1	NB021EY
Q2	NB122EY
Q3	NR001E
Q4	NB112EY
Q5	NB312E
Q6	NB322E
Q7	NA52W
Q8	NA51W

Figure A. 12 Watt, 8 Ohm OTL Amplifier



Q1	NB021EY
Q2	NB122EY
Q3	NR001E
Q4	NB112EY
Q5	NB312E
Q6	NB322E
Q7	NA52W
Q8	NA51W

Figure B. 12 Watt, 4 Ohm OTL Amplifier

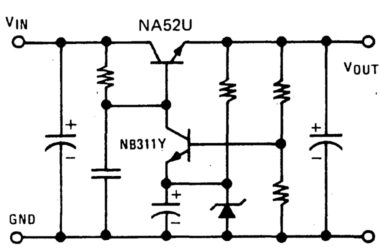


Figure C. Linear Regulator Circuit

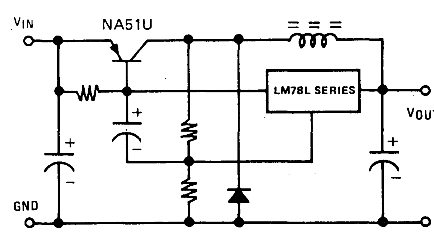


Figure D. Switching Regulator Circuit

National Semiconductor

NA61 (NPN) NA62 (PNP) 4.5 Amp complementary power transistors

features

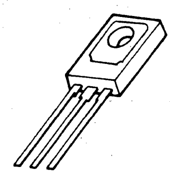
- 45 Volt/4.5 Amp rating
- Available in TO-126 and TO-220 packages
- Low V_{CE} (sat) and V_{BE} (sat) characteristics at I_C = 3A, I_B = 150 mA
- Guaranteed V_{CE} (sat) and V_{BE} (sat) at I_C = 4.5A, I_B = 300 mA for improved short-circuit protection design in audio amplifiers
- "Epoxy B" packaging concept for excellent reliability

applications

- 10 to 25 Watt, 4 Ohm audio power amplifiers
- High current switching circuits
- Converter/Inverter circuits
- TV receivers

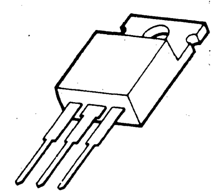
[1] packages and lead coding

TO-126



B C E

TO-220



B C E

PACKAGE CODE	
TO 126	TO 220
U	W

[2] maximum ratings

PARAMETER	SYMBOL	RATING	UNIT
Collector-Emitter Voltage	V_{CE}	45	V_{DC}
Collector-Base Voltage	V_{CB}	50	V_{DC}
Emitter-Base Voltage	V_{EB}	4	V_{DC}
Collector Current (continuous)	I_C (max)	4.5	A
Power Dissipation (T_A = 25°C)	P_D		
TO-126		1.8	W
TO-220		2.0	W
Power Dissipation (T_C = 25°C)	P_D		
TO-126		40	W
TO-220		40	W
Thermal Resistance			
TO-126	θ_{JA}/θ_{JC}	69.4/3.125	°C/W
TO-220	θ_{JA}/θ_{JC}	62.5/3.125	°C/W
Temperature, Junction and Storage	Tj, Tstg	–55 to + 150	°C

[3] ordering information

N A 6 X X

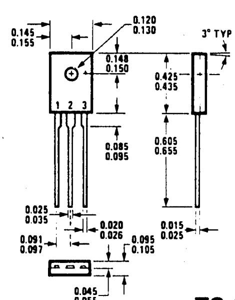
POLARITY: "1" for NPN, "2" for PNP

PACKAGE/LEAD CODE refer to [1]

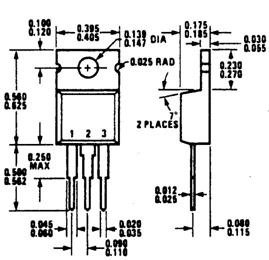
4 electrical characteristics $T_C = 25°C$

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
BV_{CER}	Collector-Emitter Sustaining Voltage	I_C = 10 mA, R = 1K	45			V
BV_{CBO}	Collector-Base Breakdown Voltage	$I_C = 100\mu A$	50			V
BV_{EBO}	Emitter-Base Breakdown Voltage	$I_E = 100\mu A$	4			V
I_{CER}	Collector-Emitter Leakage Current	V_{CE} = 35V, R = 1K			2	mA
I_{CBO}	Collector-Base Leakage Current	V_{CB} = 40V			1	mA
V_{BE} (on)	Base-Emitter Voltage	I_C = 20 mA, V_{CE} = 10V	520	600	680	mV
V_{BE} (sat)	Base-Emitter Saturation Voltage	I_C = 3A, I_B = 150 mA			1.5	V
V_{BE} (sat)	Base-Emitter Saturation Voltage	I_C = 4.5A, I_B = 300 mA			2	V
V_{CE} (sat)	Collector-Emitter Saturation Voltage	I_C = 3A, I_B = 150 mA			2	V
V_{CE} (sat)	Collector-Emitter Saturation Voltage	I_C = 4.5A, I_B = 300 mA			5	V
HFE_1	DC Current Gain	I_C = 500 mA, V_{CE} = 10V	30	100		ratio
Cob	Collector Output Capacitance NPN types PNP types	V_{CB} = 10V, f = 1 MHz		 40 70		 pF pF

5 physical dimensions



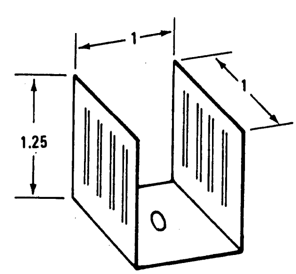
TO-126



TO-220

6 heatsink information

The TO-126 and TO-220 packages used with heatsink shown below permits about 10 Watts power dissipation and θ_{CA} = 9.4°C/W.



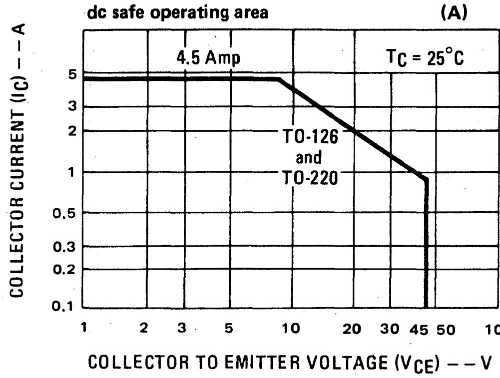
0.05 inch aluminium sheet

Mount transistor under heatsink and apply thermally conductive compound between contact surfaces.

7 typical performance characteristics

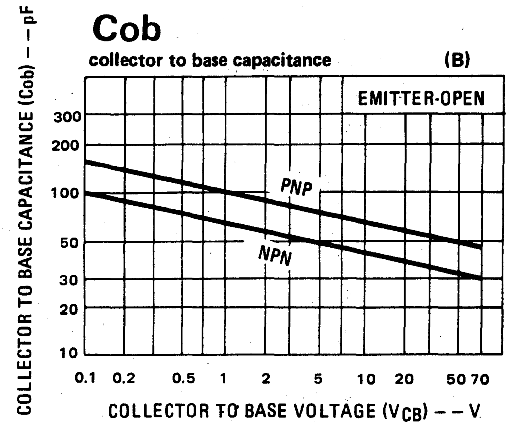
SOA

dc safe operating area (A)



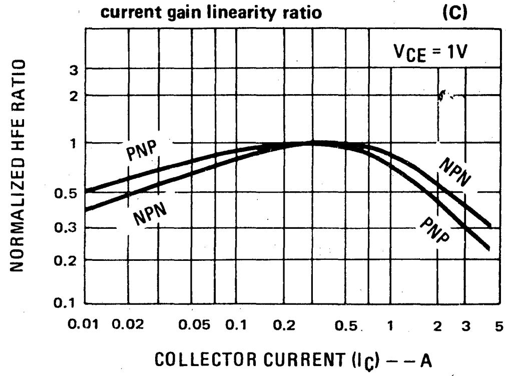
Cob

collector to base capacitance (B)



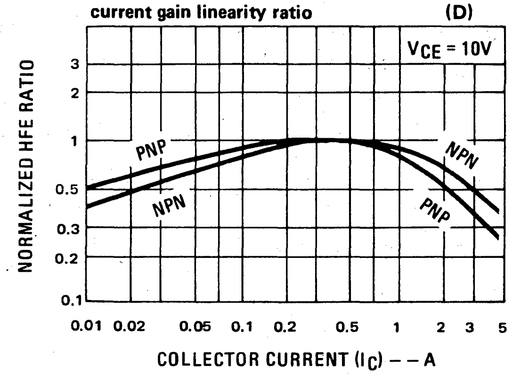
HFE1/HFE2

current gain linearity ratio (C)



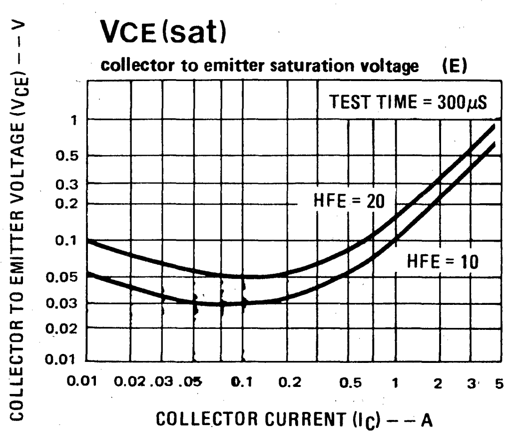
HFE1/HFE2

current gain linearity ratio (D)



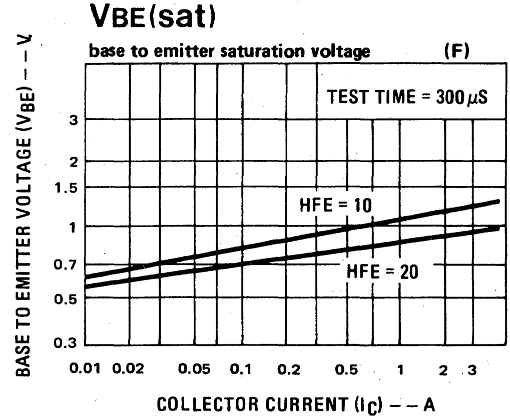
VCE(sat)

collector to emitter saturation voltage (E)



VBE(sat)

base to emitter saturation voltage (F)



8 typical applications

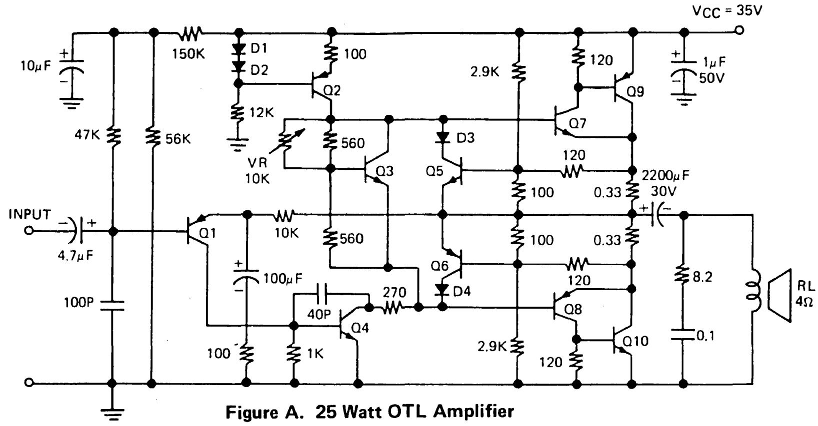


Figure A. 25 Watt OTL Amplifier

Q1	NB022EY
Q2	NB123EY
Q3	NR001E
Q4	NB113EY
Q5	NB111EY
Q6	NB121EY
Q7	NB313Y
Q8	NB323Y
Q9	NA62W
Q10	NA61W

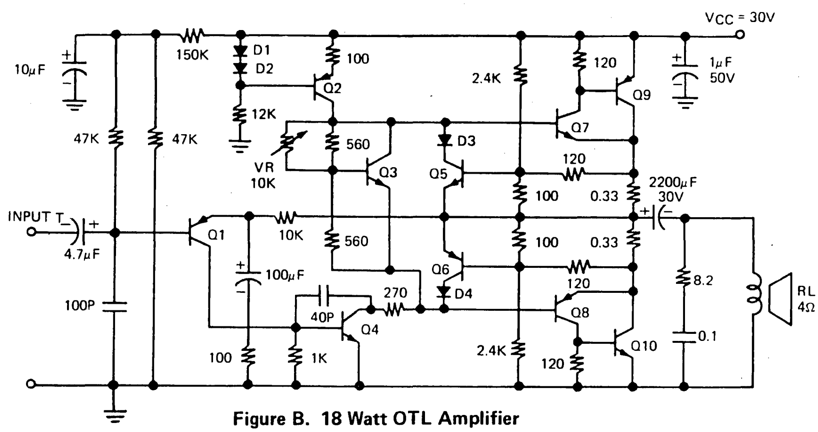


Figure B. 18 Watt OTL Amplifier

Q1	NB022EY
Q2	NB122EY
Q3	NR001E
Q4	NB112EY
Q5	NB111EY
Q6	NB121EY
Q7	NB313Y
Q8	NB323Y
Q9	NA62W
Q10	NA61W

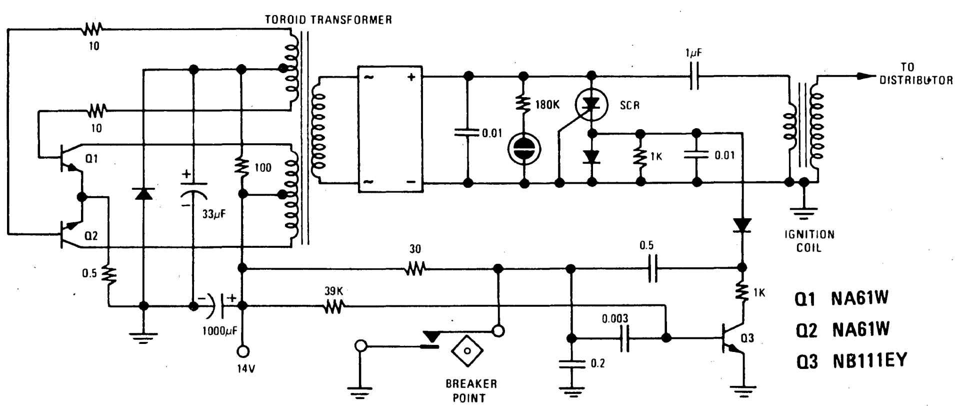


Figure C. Capacitor Discharge Ignition System

Q1	NA61W
Q2	NA61W
Q3	NB111EY

National Semiconductor

NA71 (NPN) NA72 (PNP) 3.5 Amp complementary power transistors

features

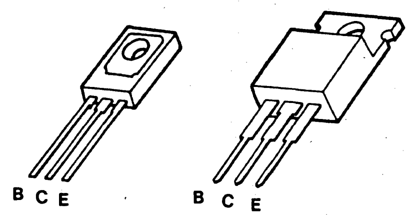
- 60 Volt/3.5 Amp rating
- Available in TO-126 and TO-220 packages
- Low V_{CE} (sat) and V_{BE} (sat) characteristics at $I_C = 2$ A, $I_B = 100mA$
- Guaranteed V_{CE} (sat) and V_{BE} (sat) at $I_C = 3A$, $I_B = 200mA$ for improved short circuited protection design in audio amplifiers
- "Epoxy B" packaging concept for excellent reliability

applications

- 10–25 Watt 8 Ohm audio power amplifiers
- High current switching circuits
- Converter/Inverter circuits
- TV receivers

1 packages and lead coding

TO-126 TO-220



PACKAGE CODE	
TO 126	TO 220
U	W

2 maximum ratings

PARAMETER	SYMBOL	RATING	UNIT
Collector-Emitter Voltage	V_{CE}	60	V_{DC}
Collector-Base Voltage	V_{CB}	65	V_{DC}
Emitter-Base Voltage	V_{EB}	4	V_{DC}
Collector Current (continuous)	I_C (max)	3.5	A
Power Dissipation ($T_A = 25°C$)	P_D		
TO-126		1.8	W
TO-220		2.0	W
Power Dissipation ($T_C = 25°C$)	P_D		
TO-126		40	W
TO-220		40	W
Thermal Resistance			
TO-126	θ_{JA}/θ_{JC}	69.4/3.125	°C/W
TO-220	θ_{JA}/θ_{JC}	62.5/3.125	°C/W
Temperature, Junction and Storage	Tj, Tstg	−55 to + 150	°C

3 ordering information

NA7XX

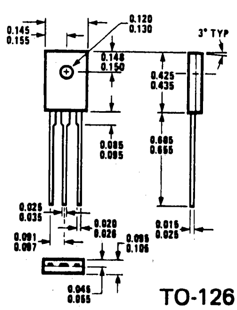
POLARITY "1" for NPN, "2" for PNP

PACKAGE/LEAD CODE refer to 1

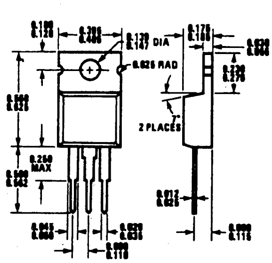
4 electrical characteristics $T_C = 25°C$

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
BV_{CER}	Collector-Emitter Sustaining Voltage	I_C = 10 mA, R = 1K	60			V
BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 100 μA	65			V
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 100 μA	4			V
I_{CER}	Collector-Emitter Leakage Current	V_{CE} = 50V, R = 1K			2	mA
I_{CBO}	Collector-Base Leakage Current	V_{CB} = 55V			1	mA
V_{BE} (on)	Base-Emitter Voltage	I_C = 20 mA, V_{CE} = 10V	520	600	680	mV
V_{BE} (sat)	Base -Emitter Saturation Voltage	I_C = 2A, I_B = 100 mA			1.5	V
V_{BE} (sat)	Base-Emitter Saturation Voltage	I_C = 3A, I_B = 200 mA			2	V
V_{CE} (sat)	Collector-Emitter Saturation Voltage	I_C = 2A, I_B = 100 mA			2	V
V_{CE} (sat)	Collector-Emitter Saturation Voltage	I_C = 3A, I_B = 200 mA			5	V
HFE_1	DC Current Gain	I_C = 500 mA, V_{CE} = 10V	30	100		ratio
C_{ob}	Collector Ouput Capacitance NPN types PNP types	V_{CB} = 10V, f = 1 MHz		 40 70		 pF pF

5 physical dimensions



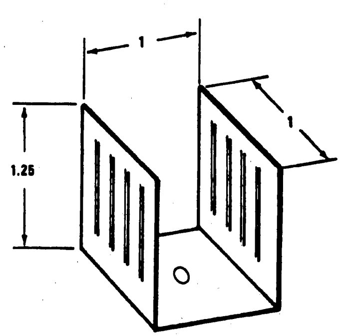
TO-126



TO-220

6 heatsink information

The TO-126 and TO-220 packages used with heatsink shown below permits about 10 Watts power dissipation and θ_{CA} = 9.4°C/W.



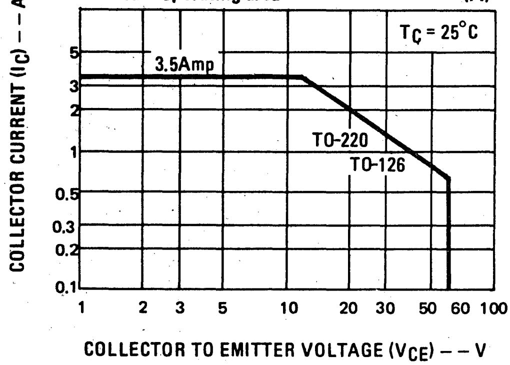
0.05 inch aluminium sheet

Mount transistor under heatsink and apply thermally conductive compound between contact surfaces.

7 typical performance characteristics

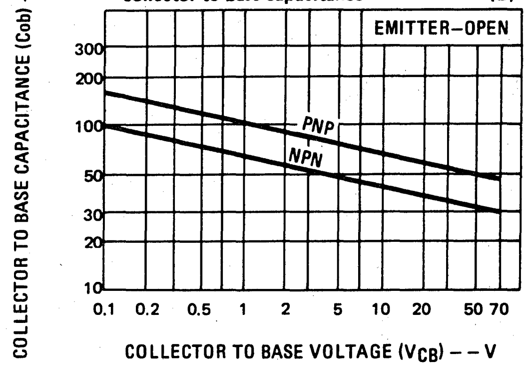
SOA

dc safe operating area (A)



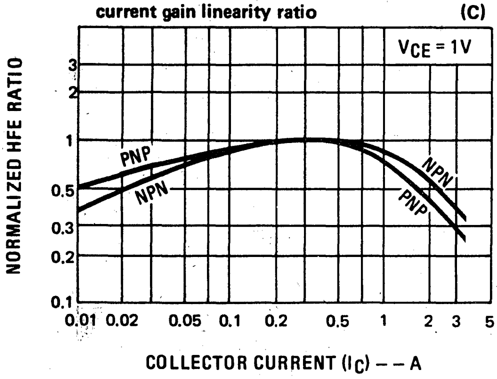
Cob

collector to base capacitance (B)



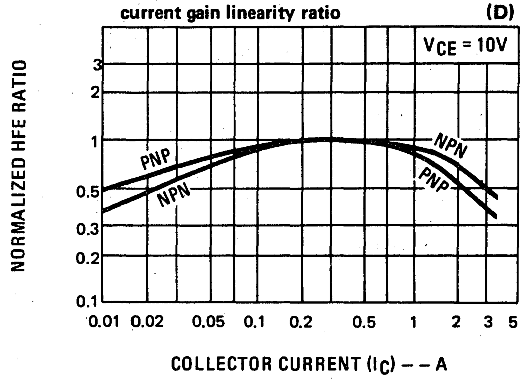
HFE1/HFE2

current gain linearity ratio (C)



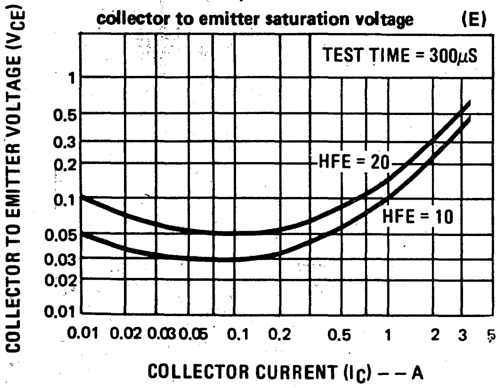
HFE1/HFE2

current gain linearity ratio (D)



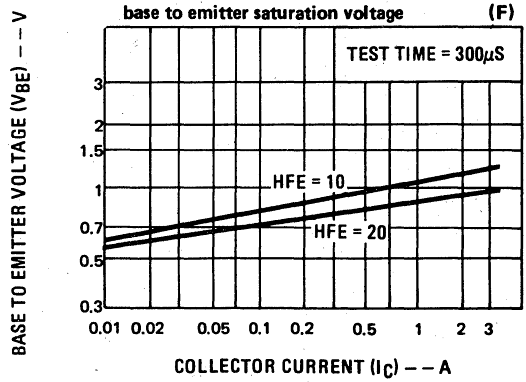
VCE (sat)

collector to emitter saturation voltage (E)

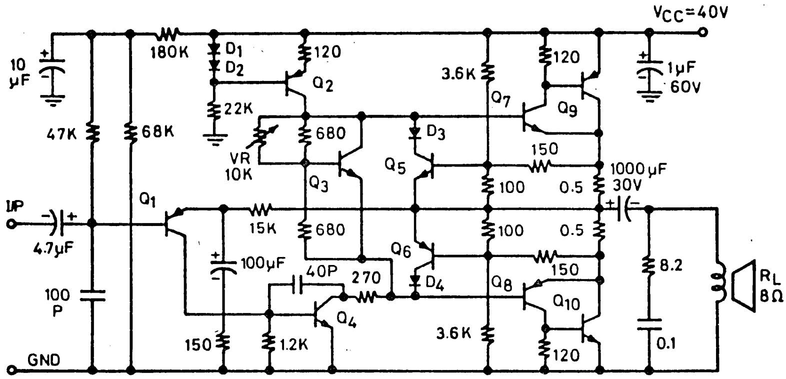


VBE (sat)

base to emitter saturation voltage (F)

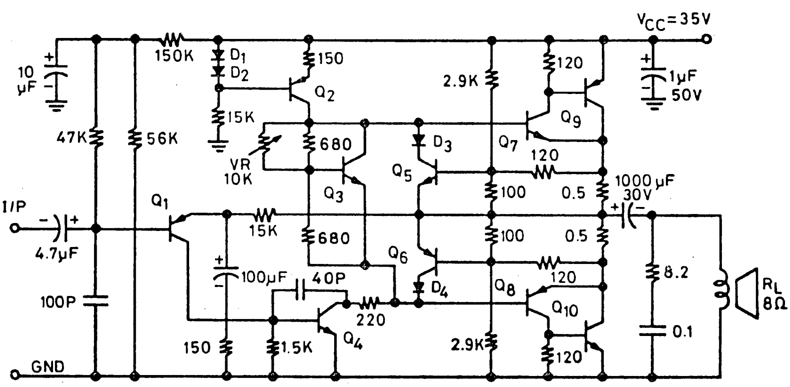


8 typical applications



Q1	NB022EY
Q2	NB123EY
Q3	NR001E
Q4	NB113EY
Q5	NB111EY
Q6	NB121EY
Q7	NB313Y
Q8	NB323Y
Q9	NA72W
Q10	NA71W

Figure A. 25 Watt OTL Amplifier



Q1	NB022EY
Q2	NB123EY
Q3	NR001E
Q4	NB113EY
Q5	NB111EY
Q6	NB121EY
Q7	NB313Y
Q8	NB323Y
Q9	NA72W
Q10	NA71W

Figure B. 18 Watt OTL Amplifier

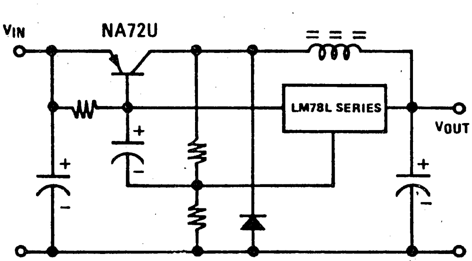


Figure C. Switching Regulator Circuit

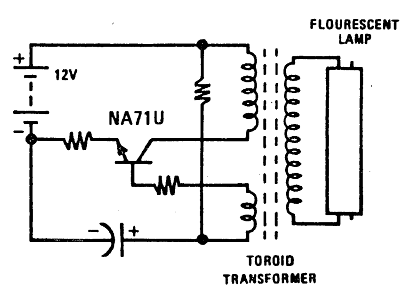


Figure D. Battery Lantern Circuit

National Semiconductor

NB011, 012 (NPN) NB021, 022 (PNP) 30mA general purpose transistors

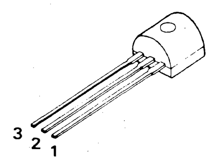
features

- 35 to 50 Volt at 30 mA collector ratings
- 300 mV guaranteed V_{CE} (sat) characteristics at I_C = 10 mA and I_B = 0.5 mA
- Matched HFE groupings for complementary applications
- "Epoxy B" packaging concept for excellent reliability

applications

- Small signal amplifier circuits
- Equalizer preamplifiers
- Low current switching circuits
- TV receivers

1 package and lead coding



PACKAGE CODE TO-92	LEAD 1	2	3
E	E	B	C
F	E	C	B
H	C	B	E

2 maximum ratings

PARAMETER	SYMBOL	NB011 NB021	NB012 NB022	UNIT
Collector-Emitter Voltage	V_{CEO}	35	50	V_{DC}
Collector-Base Voltage	V_{CB}	40	55	V_{DC}
Emitter-Base Voltage	V_{EB}	5	5	V_{DC}
Collector Current (continuous)	I_C (max)	30	30	mA_{DC}
Power Dissipation (T_A = 25°C)	P_D	0.6	0.6	W
Power Dissipation (T_C = 25°C)	P_D	1.0	1.0	W
Thermal Resistance	θ_{JA}	208	208	°C/W
	θ_{JC}	125	125	°C/W
Temperature, Junction and Storage	Tj, Tstg	–55 to + 150	–55 to + 150	°C

3 ordering information

NB0XXXX

- POLARITY: "1" for NPN, "2" for PNP
- VOLTAGE RATING: refer to 2
- PACKAGE/LEAD CODE: refer to 1
- HFE GROUPING: refer to 5

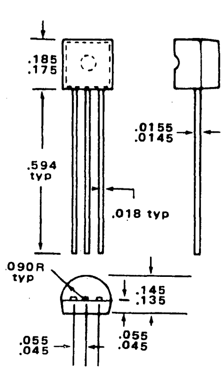
4 electrical characteristics $T_C = 25°C$

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
BV_{CEO}	Collector-Emitter Sustaining Voltage	I_C = 1 mA				
	NB011/021		35			V
	NB012/022		50			V
BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 100μA				
	NB011/021		40			V
	NB012/022		55			V
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 10μA	5			V
I_{CEO}	Collector-Emitter Leakage Current	V_{CE} = 30V NB011			1	μA
		45V NB012			1	μA
I_{CES}	Collector-Emitter Leakage Current	V_{CE} = 30V NB021			0.5	μA
		45V NB022			0.5	μA
I_{CBO}	Collector-Base Leakage Current	V_{CB} = 35V NB011/021			0.1	μA
		50V NB012/022			0.1	μA
I_{EBO}	Emitter-Base Leakage Current	V_{EB} = 4V			0.1	μA
V_{BE} (sat)	Base-Emitter Saturation Voltage	I_C = 10 mA, I_B = 0.5 mA		0.75	0.95	V
V_{CE} (sat)	Collector-Emitter Saturation Voltage	I_C = 10 mA, I_B = 0.5 mA		0.1	0.3	V
Cob	Collector Output Capacitance	V_{CB} = 10V, f = 1 MHz				
	NPN types			2		pF
	PNP types			3		pF
ft	Current Gain Bandwidth Product	I_C = 1 mA, V_{CE} = 5V	50	120		MHz

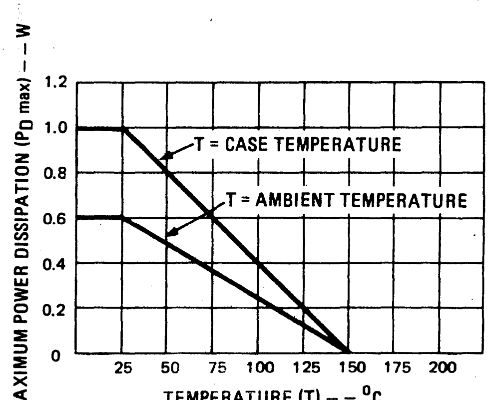
5 HFE groupings

GROUPING	PARAMETER	CONDITIONS	MIN	TYP	MAX	RATIO
I	DC Current Gain	I_C = 1 mA, V_{CE} = 5V	140	180	240	1:1.6
J	DC Current Gain	I_C = 1 mA, V_{CE} = 5V	200	260	350	1:1.6
K	DC Current Gain	I_C = 1 mA, V_{CE} = 5V	300	380	500	1:1.6
L	DC Current Gain	I_C = 1 mA, V_{CE} = 5V	450	580	750	1:1.6
T	DC Current Gain	I_C = 1 mA, V_{CE} = 5V	100	150	240	1:2.4
U	DC Current Gain	I_C = 1 mA, V_{CE} = 5V	200	320	500	1:2.4
V	DC Current Gain	I_C = 1 mA, V_{CE} = 5V	450	700	1100	1:2.4
Y	DC Current Gain	I_C = 1 mA, V_{CE} = 5V	100	190	350	1:3.5
Z	DC Current Gain	I_C = 1 mA, V_{CE} = 5V	300	580	1100	1:3.5

6 physical dimensions



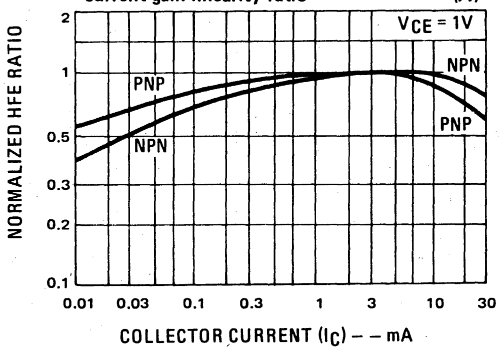
7 max power dissipation



8 typical performance characteristics

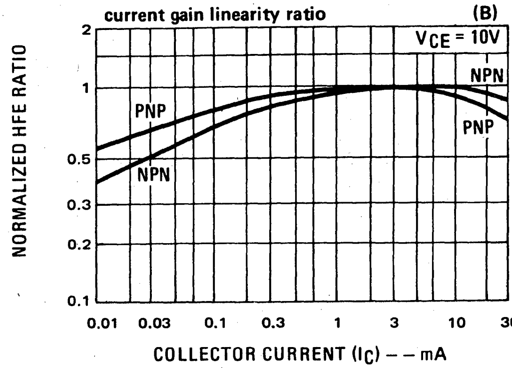
HFE1/HFE2

current gain linearity ratio (A)



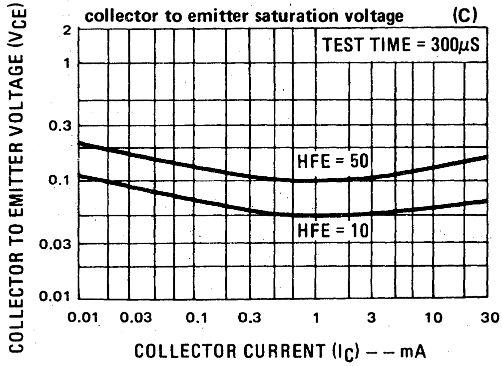
HFE1/HFE2

current gain linearity ratio (B)



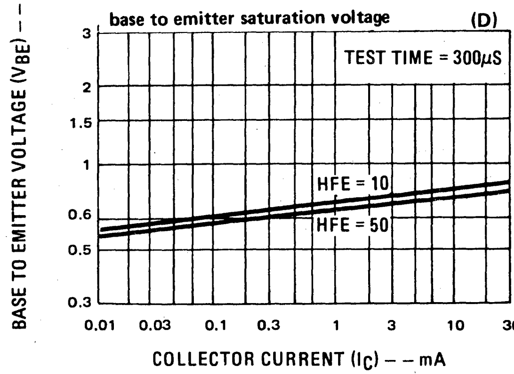
VCE (sat)

collector to emitter saturation voltage (C)



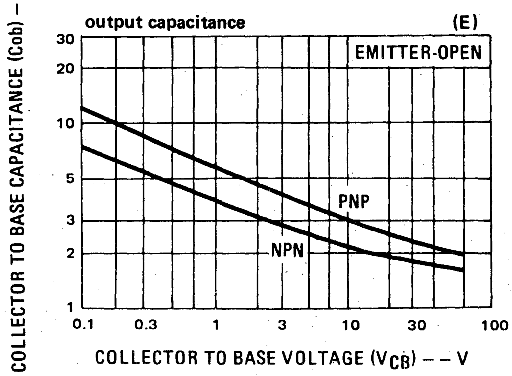
VBE (sat)

base to emitter saturation voltage (D)



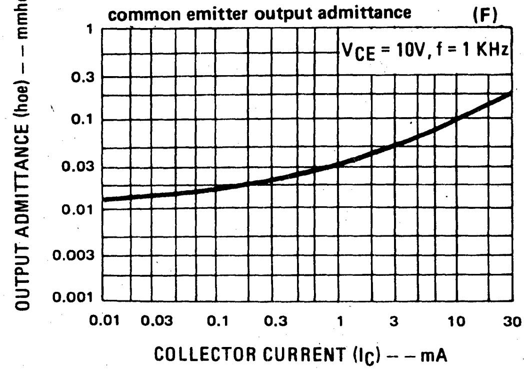
Cob

output capacitance (E)



hoe

common emitter output admittance (F)



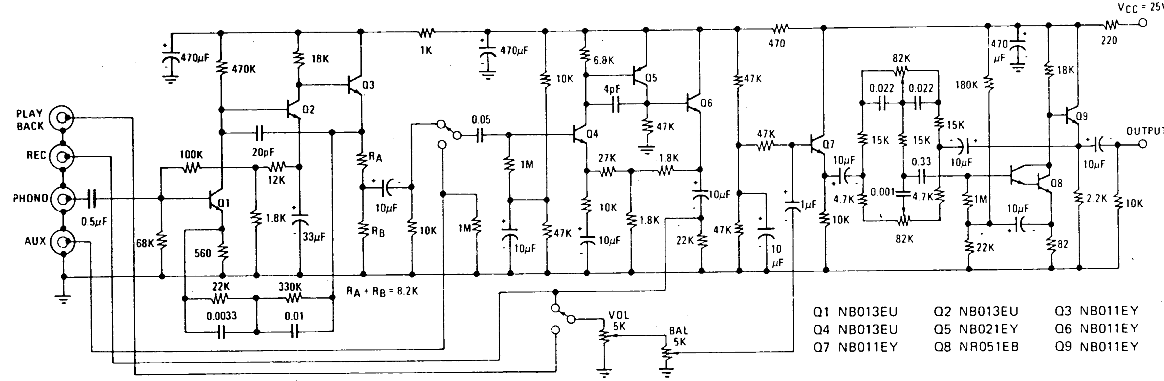
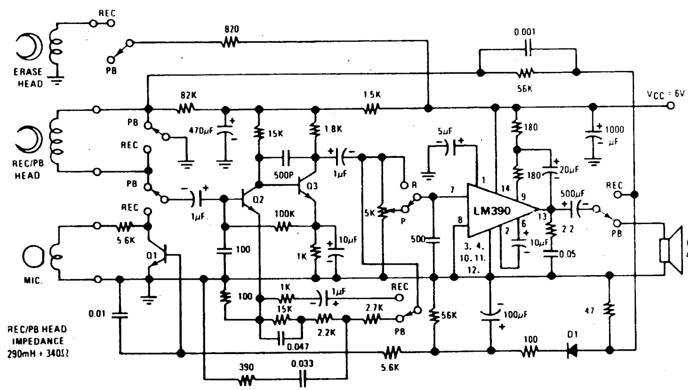
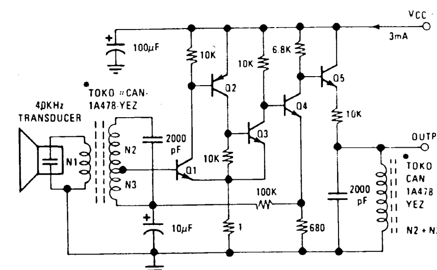


Figure A. High Quality Preamplifier with Tone Control Circuit



Q1 NR041E Q2 NB013EU Q3 NB011EY

Figure B. Battery Operated Recording/Playback Cassette Circuit



Q1 NB013EY	◆ Gain = 60K V/V	•L = 8mH
Q2 NB023EY	◆ Input impedance	Qμ = 50
Q3 NB011EY	= 1K Ohm	N1 = 40T
Q4 NB011EY	◆ Output noise	N2 = 360T
Q5 NB011EY	= 10mV rms	N3 = 40T

Figure C. High Gain Ultrasonic Amplifier

National Semiconductor

NB013, 014 (NPN) NB023, 024 (PNP) 30mA low noise transistors

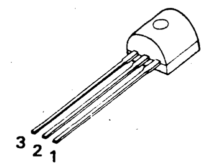
features

- 35 to 50 Volt at 30mA collector ratings
- 300mV guaranteed V_{CE} (sat) characteristics at I_C = 10mA and I_B = 0.5mA
- 1dB typical wide-band Noise Figure
- "Epoxy B" packaging concept for excellent reliability

applications

- Low noise amplifier circuits
- Equalizer, preamplifiers

[1] package and lead coding



PACKAGE CODE TO-92	LEAD 1	2	3
E	E	B	C
F	E	C	B
H	C	B	E

[2] maximum ratings

PARAMETER	SYMBOL	NB013 NB023	NB014 NB024	UNIT
Collector-Emitter Voltage	V_{CEO}	35	50	V_{DC}
Collector-Base Voltage	V_{CB}	40	55	V_{DC}
Emitter-Base Voltage	V_{EB}	5	5	V_{DC}
Collector Current (continuous)	I_C (max)	30	30	mA_{DC}
Power Dissipation (T_A = 25°C)	P_D	0.6	0.6	W
Power Dissipation (T_C = 25°C)	P_D	1.0	1.0	W
Thermal Resistance	θ_{JA}	208	208	°C/W
	θ_{JC}	125	125	°C/W
Temperature, Junction and Storage	Tj, Tstg	–55 to + 150	–55 to + 150	°C

[3] ordering information

NBOXXXX

- POLARITY: "1" for NPN, "2" for PNP
- VOLTAGE RATING: refer to [2]
- PACKAGE/LEAD CODE: refer to [1]
- HFE GROUPING: refer to [5]

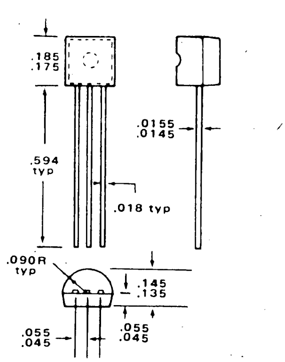
4 electrical characteristics $T_C = 25°C$

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
BV_{CEO}	Collector-Emitter Sustaining Voltage	I_C = 1 mA				
	NB013/023		35			V
	NB014/024		50			V
BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 100μA				
	NB013/023		40			V
	NB014/024		55			V
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 10μA	5			V
I_{CEO}	Collector-Emitter Leakage Current	V_{CE} = 30V NB013			1	μA
		45V NB014			1	μA
I_{CES}	Collector-Emitter Leakage Current	V_{CE} = 30V NB023			0.5	μA
		45V NB024			0.5	μA
I_{CBO}	Collector-Base Leakage Current	V_{CB} = 35V NB013/023			50	nA
		50V NB014/024			50	nA
I_{EBO}	Emitter-Base Leakage Current	V_{EB} = 4V			0.1	μA
V_{BE} (sat)	Base-Emitter Saturation Voltage	I_C = 10 mA, I_B = 0.5 mA		0.75	0.95	V
V_{CE} (sat)	Collector-Emitter Saturation Voltage	I_C = 10 mA, I_B = 0.5 mA		0.1	0.3	V
Cob	Collector Output Capacitance	V_{CB} = 10V, f = 1 MHz				
	NPN types			2		pF
	PNP types			3		pF
ft	Current Gain Bandwidth Product	I_C = 1 mA, V_{CE} = 5V	50	120		MHz
NF	Noise Figure	I_C = 10μA, V_{CE} = 5V, R_S = 10 K, BW = 15.7 KHz		1	4	dB

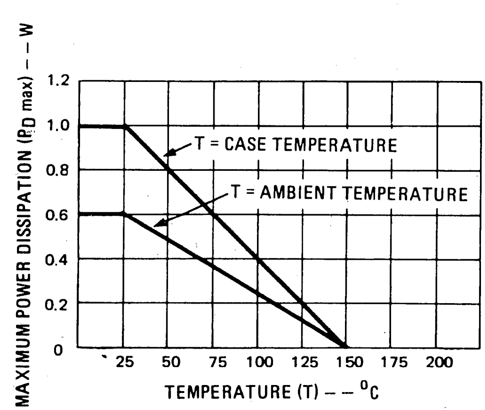
5 HFE groupings

GROUPING	PARAMETER	CONDITIONS	MIN	TYP	MAX	RATIO
I	DC Current Gain	I_C = 100μA, V_{CE} = 5V	140	180	240	1:1.6
J	DC Current Gain	I_C = 100μA, V_{CE} = 5V	200	260	350	1:1.6
K	DC Current Gain	I_C = 100μA, V_{CE} = 5V	300	380	500	1:1.6
L	DC Current Gain	I_C = 100μA, V_{CE} = 5V	450	580	750	1:1.6
T	DC Current Gain	I_C = 100μA, V_{CE} = 5V	100	150	240	1:2.4
U	DC Current Gain	I_C = 100μA, V_{CE} = 5V	200	320	500	1:2.4
V	DC Current Gain	I_C = 100μA, V_{CE} = 5V	450	700	1100	1:2.4
Y	DC Current Gain	I_C = 100μA, V_{CE} = 5V	100	190	350	1:3.5
Z	DC Current Gain	I_C = 100μA, V_{CE} = 5V	300	580	1100	1:3.5

6 physical dimensions

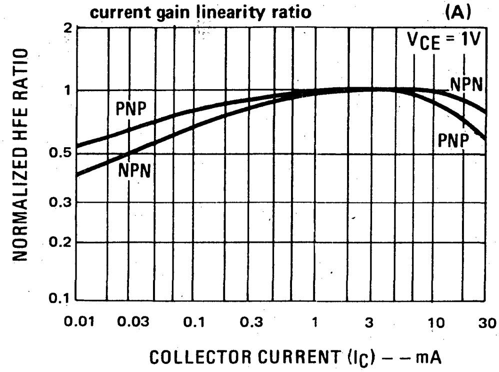


7 max power dissipation

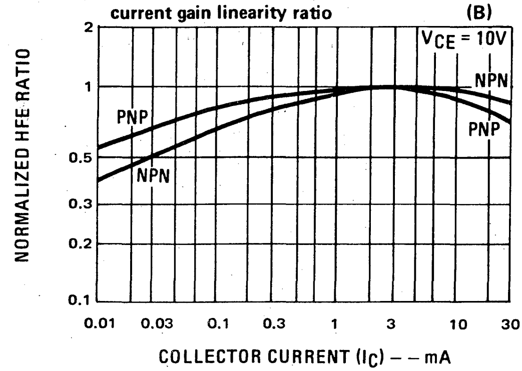


8 typical performance characteristics

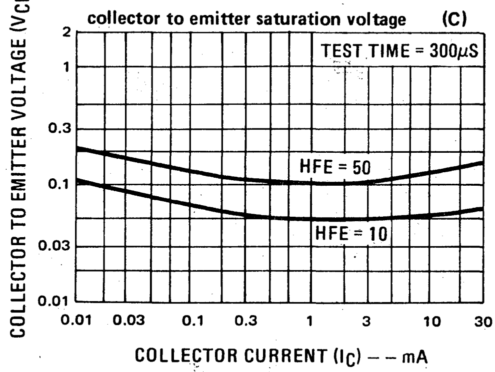
HFE1/HFE2
current gain linearity ratio (A)



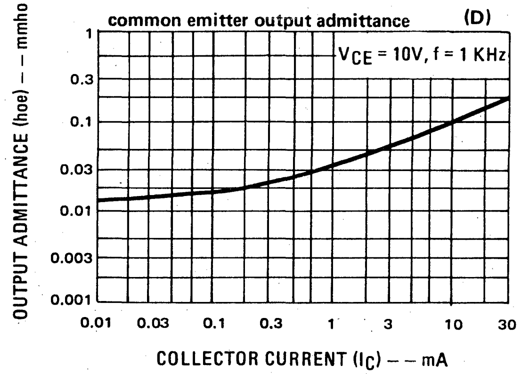
HFE1/HFE2
current gain linearity ratio (B)



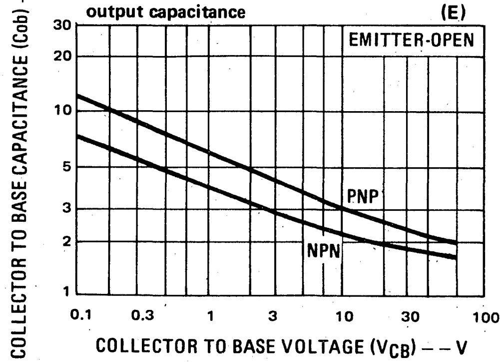
VCE(sat)
collector to emitter saturation voltage (C)



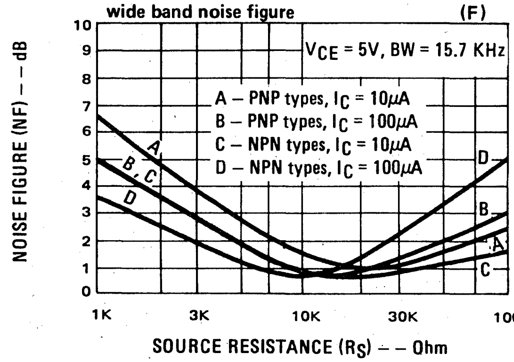
hoe
common emitter output admittance (D)

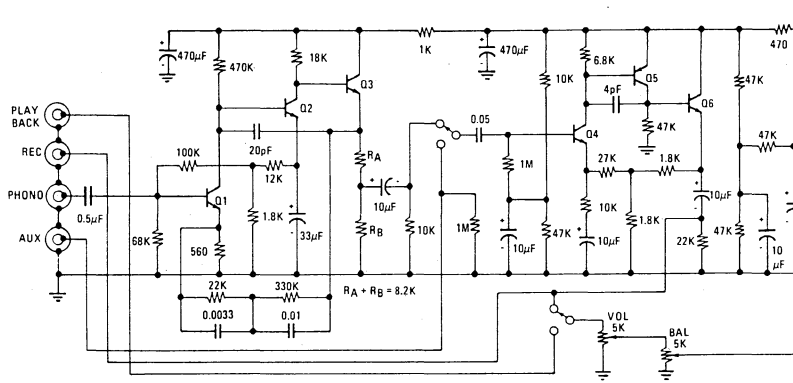


Cob
output capacitance (E)



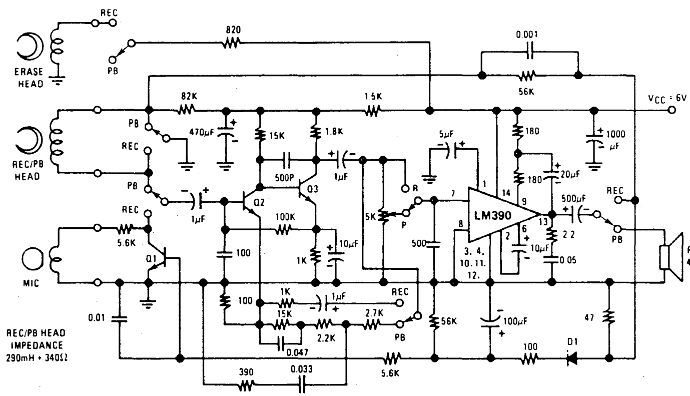
NF
wide band noise figure (F)





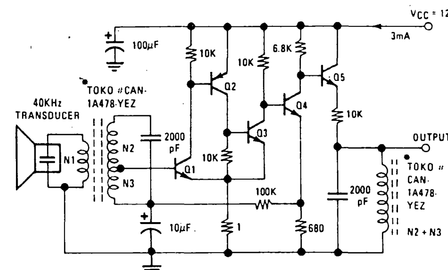
Q1 NB013EU	Q2 NB013EU	Q3 NB011EY
Q4 NB013EU	Q5 NB021EY	Q6 NB011EY
Q7 NB011EY	Q8 NR051EB	Q9 NB011EY

Figure A. High Quality Preamplifier with Tone Control Circuit



Q1 NR041E Q2 NB013EU Q3 NB011EY

Figure B. Battery Operated Recording/Playback Cassette Circuit



Q1 NB013EY	◆ Gain = 60K V/V	*L = 8mH
Q2 NB023EY	◆ Input impedance	Qμ = 50
Q3 NB011EY	= 1K Ohm	N1 = 40T
Q4 NB011EY	◆ Output noise	N2 = 360T
Q5 NB011EY	= 10mV rms	N3 = 40T

Figure C. High Gain Ultrasonic Amplifier

National Semiconductor

NB111,112,113(NPN) NB121,122,123(PNP) 100mA general purpose transistors

features

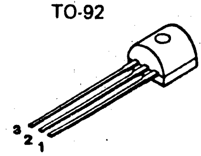
- 35 to 65 Volt at 100mA collector ratings
- 400mV guaranteed V_{CE} (sat) characteristics at I_C = 20mA and I_B = 0.4mA
- Matched HFE groupings for complementary applications
- "Epoxy B" packaging concept for excellent reliability

applications

- Small signal amplifier circuits
- Medium current level switching circuits
- LED drivers
- TV receivers

[1] package and lead coding

TO-92



PACKAGE CODE TO-92	LEAD 1	2	3
E	E	B	C
F	E	C	B
H	C	B	E

[2] maximum ratings

PARAMETER	SYMBOL	NB111 NB121	NB112 NB122	NB113 NB123	UNIT
Collector-Emitter Voltage	V_{CEO}	35	50	65	V_{DC}
Collector-Base Voltage	V_{CB}	40	55	70	V_{DC}
Emitter-Base Voltage	V_{EB}	6	6	6	V_{DC}
Collector Current (continuous)	I_C (max)	100	100	100	mA_{DC}
Power Dissipation (T_A = 25°C)	P_D	0.6	0.6	0.6	W
Power Dissipation (T_C = 25°C)	P_D	1.0	1.0	1.0	W
Thermal Resistance	θ_{JA}	208	208	208	°C/W
	θ_{JC}	125	125	125	°C/W
Temperature, Junction and Storage	T_j, T_{stg}	−55 to + 150	−55 to + 150	−55 to + 150	°C

[3] ordering information

NB1XXXX

- POLARITY: "1" for NPN, "2" for PNP
- VOLTAGE RATING: refer to [2]
- PACKAGE/LEAD CODE: refer to [1]
- HFE GROUPING: refer to [5]

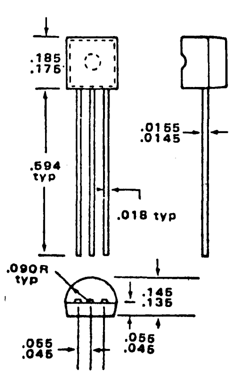
4 electrical characteristics $T_C = 25°C$

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
BV_{CEO}	Collector-Emitter Sustaining Voltage	$I_C = 1$ mA				
	NB111/121		35			V
	NB112/122		50			V
	NB113/123		65			V
BV_{CBO}	Collector-Base Breakdown Voltage	$I_C = 100\mu A$				
	NB111/121		40			V
	NB112/122		55			V
	NB113/123		70			V
BV_{EBO}	Emitter-Base Breakdown Voltage	$I_E = 10\mu A$	6			V
I_{CEO}	Collector-Emitter Leakage Current	$V_{CE} = 30V$ NB111/121			2	μA
		45V NB112/122			2	μA
		60V NB113/123			2	μA
I_{CBO}	Collector-Base Leakage Current	$V_{CB} = 35V$ NB111/121			0.1	μA
		50V NB112/122			0.1	μA
		65V NB113/123			0.1	μA
I_{EBO}	Emitter-Base Leakage Current	$V_{EB} = 5V$			0.1	μA
$V_{BE(sat)}$	Base-Emitter Saturation Voltage	$I_C = 20$ mA, $I_B = 0.4$ mA		0.8	0.95	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_C = 20$ mA, $I_B = 0.4$ mA		0.15	0.4	V
H_{FE1}	DC Current Gain	$I_C = 100\mu A$, $V_{CE} = 5V$	50			ratio
Cob	Collector Ouput Capacitance	$V_{CB} = 10V$, f = 1MHz				
	NPN types			2		pF
	PNP types			3		pF
ft	Current Gain Bandwidth Product	$I_C = 15$ mA, $V_{CE} = 5V$	100			MHz

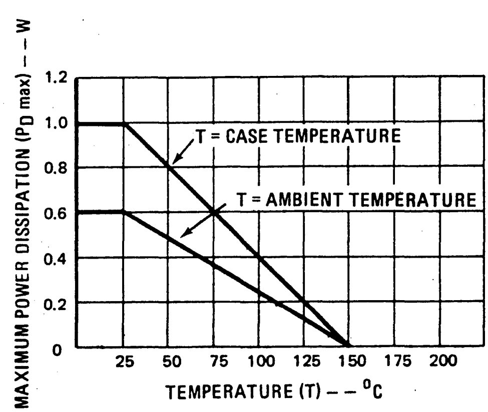
5 HFE groupings

GROUPING	PARAMETER	CONDITIONS	MIN	TYP	MAX	RATIO
H	DC Current Gain	$I_C = 15$ mA, $V_{CE} = 5V$	100	127	160	1:1.6
I	DC Current Gain	$I_C = 15$ mA, $V_{CE} = 5V$	140	180	240	1:1.6
J	DC Current Gain	$I_C = 15$ mA, $V_{CE} = 5V$	200	260	350	1:1.6
Y	DC Current Gain	$I_C = 15$ mA, $V_{CE} = 5V$	100	190	350	1:3.5

6 physical dimensions

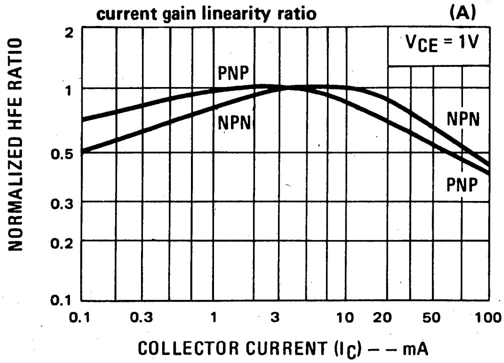


7 max power dissipation

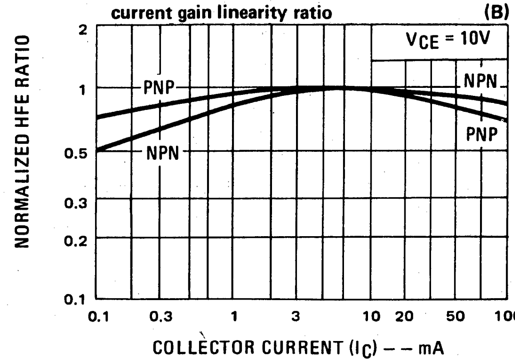


8 typical performance characteristics

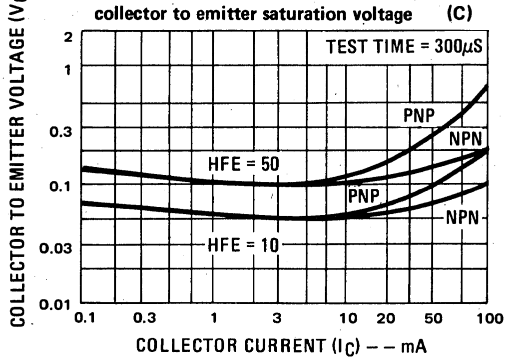
HFE1/HFE2
current gain linearity ratio (A)



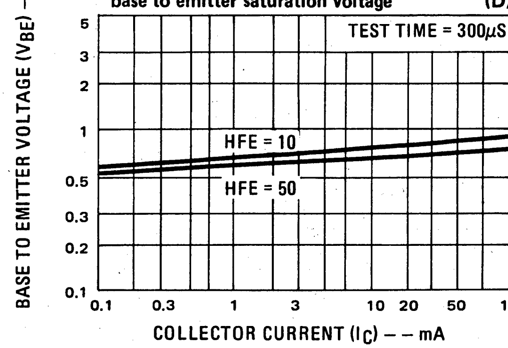
HFE1/HFE2
current gain linearity ratio (B)



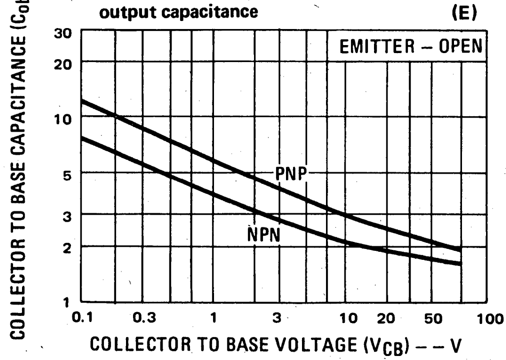
VCE(sat)
collector to emitter saturation voltage (C)



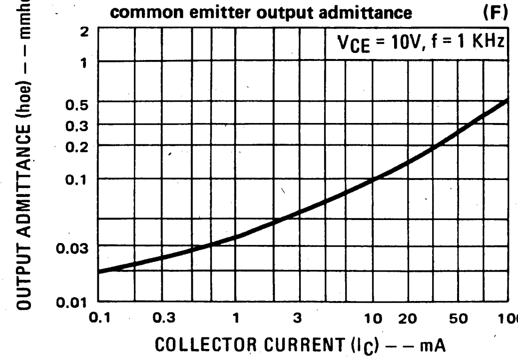
VBE(sat)
base to emitter saturation voltage (D)



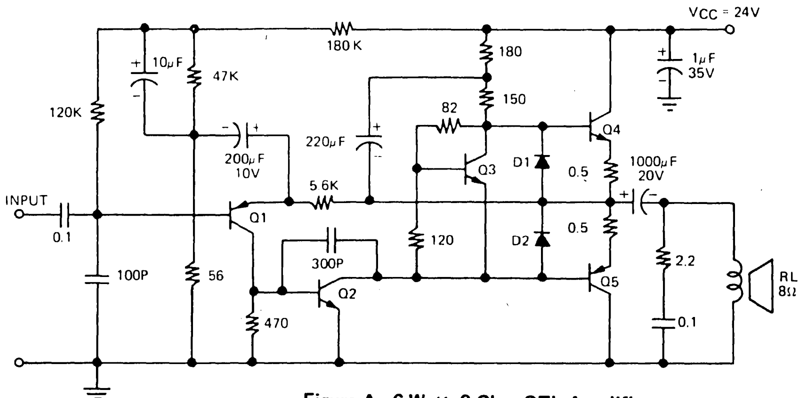
Cob
output capacitance (E)



hoe
common emitter output admittance (F)

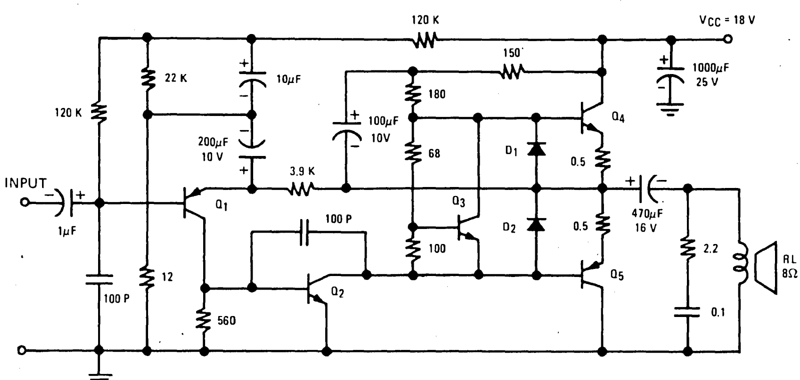


9 typical applications



Q1 NB021EY
Q2 NB211YY
Q3 NR001E
Q4 NA41U
Q5 NA42U

Figure A. 6 Watt, 8 Ohm OTL Amplifier



Q1 NB021EY
Q2 NB211EY
Q3 NR001E
Q4 NA31YG/I
Q5 NA32YG/I

Figure B. 4 Watt, 8 Ohm OTL Amplifier

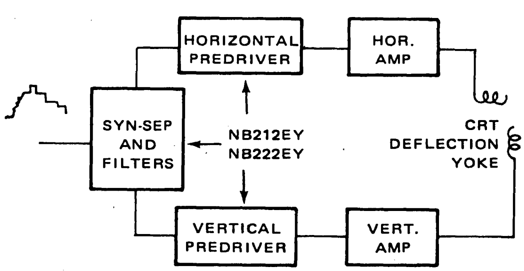


Figure C. TV processor/predriver applications

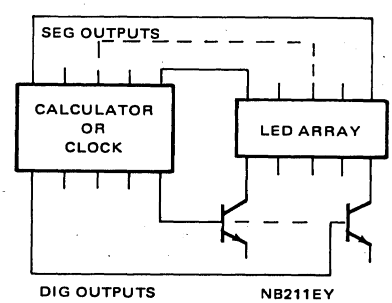


Figure D. Calculator/Clock driver application

National Semiconductor

NB211,212,213(NPN) NB221,222,223(PNP) 500mA medium current driver transistors

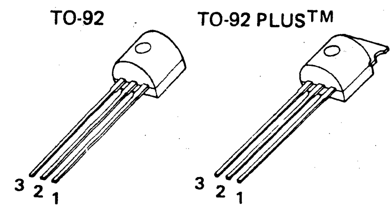
features

- 35 to 65 Volt at 500 mA collector ratings
- 1.2 Watts practical power dissipation (TO-92 PLUS™)
- 400 mV guaranteed V_{CE} (sat) characteristics at I_C = 100 mA and I_B = 2 mA
- Matched HFE groupings for complementary applications
- "Epoxy B" packaging concept for excellent reliability

applications

- 4 to 6 Watt amplifier class A drivers
- Medium current level switching circuits
- LED drivers
- TV receivers

1 package and lead coding



PACKAGE CODE TO-92	PACKAGE CODE TO-92 PLUS	LEAD 1	LEAD 2	LEAD 3
E	X	E	B	C
F	Y	E	C	B
	Z	B	C	E
H		C	B	E

2 maximum ratings

PARAMETER	SYMBOL	NB211 NB221	NB212 NB222	NB213 NB223	UNIT
Collector-Emitter Voltage	V_{CEO}	35	50	65	V_{DC}
Collector-Base Voltage	V_{CB}	40	55	70	V_{DC}
Emitter-Base Voltage	V_{EB}	6.0	6.0	6.0	V_{DC}
Collector Current (continuous)	I_C (max)	500	500	500	mA
Power Dissipation (T_A = 25°C)	P_D				
TO-92		0.6	0.6	0.6	W
TO-92 PLUS		0.75	0.75	0.75	W
Power Dissipation (T_C = 25°C)	P_D				
TO-92		1.0	1.0	1.0	W
TO-92 PLUS		2.5	2.5	2.5	W
Thermal Resistance					
TO-92	θ_{JA}/θ_{JC}	208/125	208/125	208/125	°C/W
TO-92 PLUS	θ_{JA}/θ_{JC}	167/50	167/50	167/50	°C/W
Temperature, Junction and Storage	Tj, Tstg	–55 to +150	–55 to +150	–55 to +150	°C

3 ordering information

NB2XXXX

- POLARITY: "1" for NPN, "2" for PNP
- VOLTAGE RATING: refer to 1
- PACKAGE/LEAD CODE: refer to 2
- HFE GROUPING: refer to 5

4 electrical characteristics $T_C = 25°C$

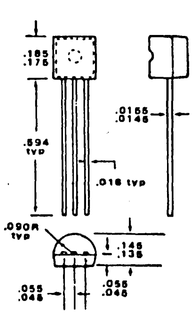
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
BV_{CEO}	Collector-Emitter Sustaining Voltage	I_C = 1 mA				
	NB211/221		35			V
	NB212/222		50			V
	NB213/223		65			V
BV_{CBO}	Collector-Base Breakdown Voltage	$I_C = 100\mu A$				
	NB211/221		40			V
	NB212/222		55			V
	NB213/223		70			V
BV_{EBO}	Emitter-Base Breakdown Voltage	$I_E = 10\mu A$	6			V
I_{CEO}	Collector-Emitter Leakage Current	V_{CE} = 30V NB211/221			10	μA
		45V NB212/222			10	μA
		60V NB213/223			10	μA
I_{CBO}	Collector-Base Leakage Current	V_{CB} = 35V NB211/221			0.5	μA
		50V NB212/222			0.5	μA
		65V NB213/223			0.5	μA
I_{EBO}	Emitter-Base Leakage Current	V_{EB} = 5V			0.1	μA
V_{BE} (sat)	Base-Emitter Saturation Voltage	I_C = 100 mA, I_B = 2 mA		0.8	0.95	V
V_{CE} (sat)	Collector-Emitter Saturation Voltage	I_C = 100 mA, I_B = 2 mA		0.2	0.4	V
H_{FE1}	DC Current Gain	I_C = 1 mA, V_{CE} = 5V	30			ratio
Cob	Collector Output Capacitance	V_{CB} = 10V, f = 1 MHz				
	NPN types			3.5		pF
	PNP types			4.5		pF
ft	Current Gain Bandwidth Product	I_C = 20 mA, V_{CE} = 5V	50			MHz

5 HFE groupings

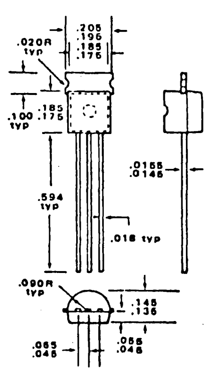
GROUPING	PARAMETER	CONDITIONS	MIN	TYP	MAX	RATIO
G	DC Current Gain	I_C = 30 mA, V_{CE} = 5V	68	85	110	1:1.6
H	DC Current Gain	I_C = 30 mA, V_{CE} = 5V	100	127	160	1:1.6
I	DC Current Gain	I_C = 30 mA, V_{CE} = 5V	140	180	240	1:1.6
J	DC Current Gain	I_C = 30 mA, V_{CE} = 5V	200	260	350	1:1.6
X	DC Current Gain	I_C = 30 mA, V_{CE} = 5V	30	58	110	1:3.5
Y	DC Current Gain	I_C = 30 mA, V_{CE} = 5V	100	190	250	1:3.5

6 physical dimensions

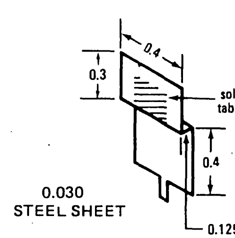
TO-92



TO-92 PLUS



7 heatsink information

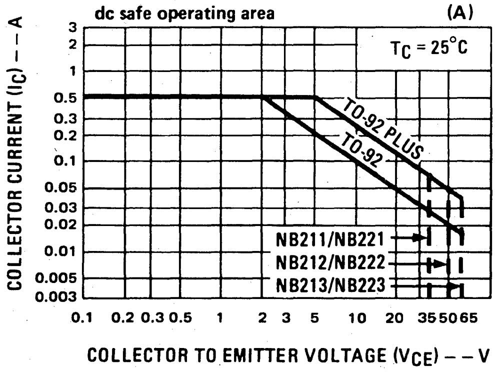


- TO-92 PLUS package with heatsink shown on right permits 1.6 Watts power dissipation and combined Thermal Resistance θ_{JA} = 78°C/W. If used without heatsink and PCB land area at collector lead > 1 sq. inch, P_D = 1.2W.

8 typical performance characteristics

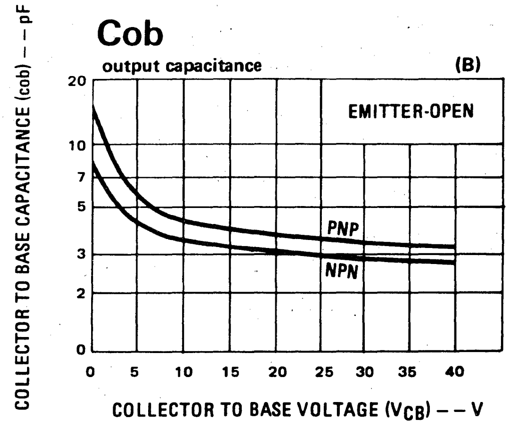
SOA

dc safe operating area (A)



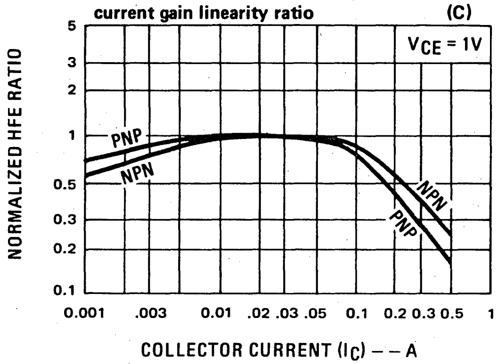
Cob

output capacitance (B)



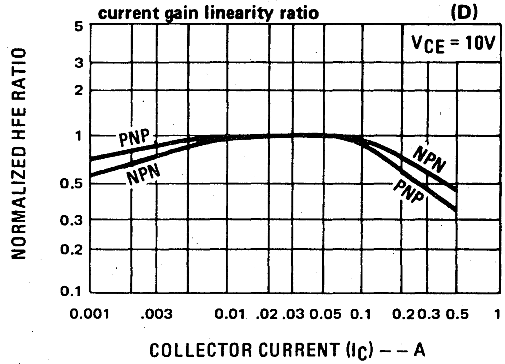
HFE1/HFE2

current gain linearity ratio (C)



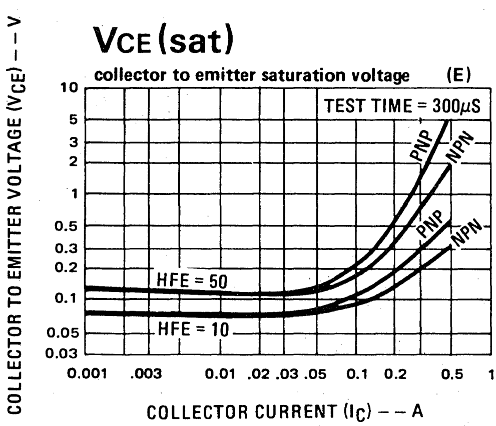
HFE1/HFE2

current gain linearity ratio (D)



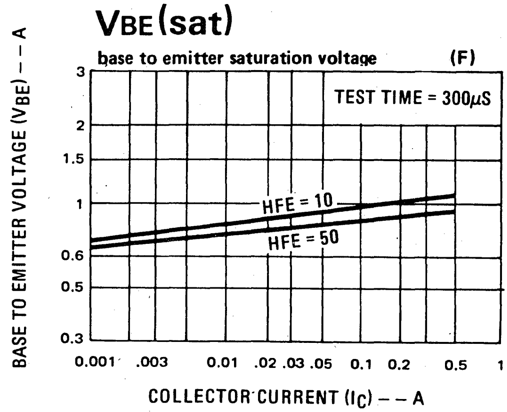
VCE (sat)

collector to emitter saturation voltage (E)

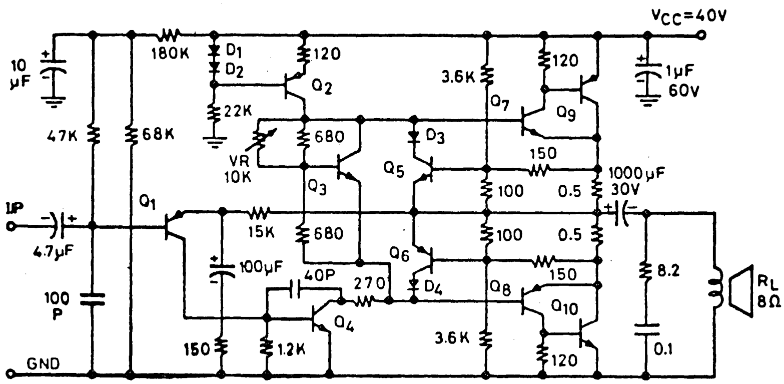


VBE (sat)

base to emitter saturation voltage (F)

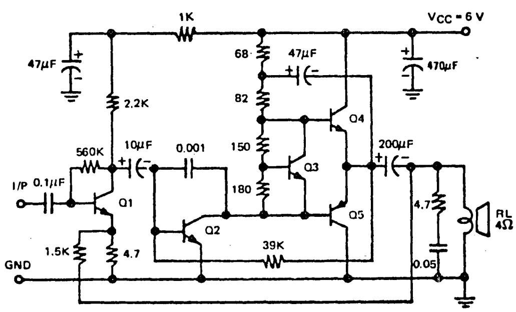


9 typical applications



Q1	NB022EY
Q2	NB123EY
Q3	NR001E
Q4	NB113EY
Q5	NB111EY
Q6	NB121EY
Q7	NB313Y
Q8	NB323Y
Q9	NA72W
Q10	NA71W

Figure A. 25 Watt OTL Amplifier



Q1	NB011EY
Q2	NB111EH/J
Q3	NR001
Q4	NA21EG/J
Q5	NA22EG/J

Figure B. 700mW 6V/4Ω OTL Amplifier

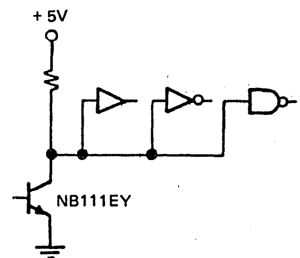


Figure C. High fan-out TTL driver

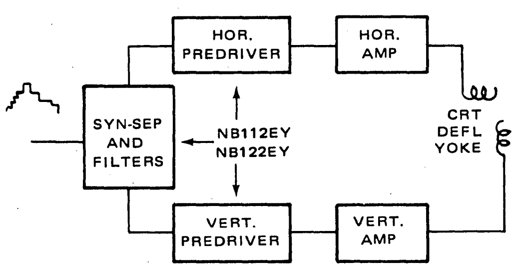


Figure D. TV processor/predriver applications

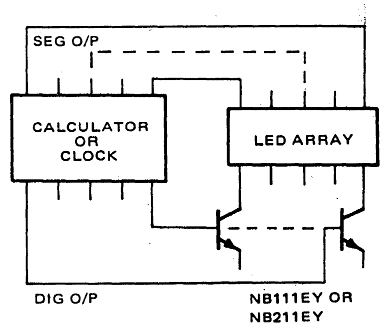


Figure E. Calculator/Clock driver application

National Semiconductor

NB311, 312, 313 (NPN) NB321, 322, 323 (PNP) 1.5Amp complementary power drivers

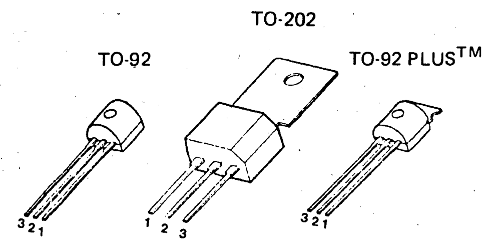
features

- 35 to 65 Volt at 1.5 Amp collector ratings
- Low V_{CE} (sat) and V_{BE} (sat) characteristics with I_C = 300 mA and I_B = 10 mA drive
- Available in TO-92, TO-92 PLUS™ and TO-202 packages
- "Epoxy B" packaging concept for excellent reliability

applications

- Driver stages in high-power audio amplifiers
- Medium-power switching circuits
- Converter/inverter circuits
- TV receivers

[1] packages and lead coding



PACKAGE CODE			LEAD		
TO-92	TO-92 PLUS	TO-202	1	2	3
E	X	K	E	B	C
F	Y	L	E	C	B
	Z	M	B	C	E
H			C	B	E

[2] maximum ratings

PARAMETER	SYMBOL	NB311 NB321	NB312 NB322	NB313 NB323	UNIT
Collector-Emitter Voltage	V_{CEO}	35	50	65	V_{DC}
Collector-Base Voltage	V_{CB}	40	55	70	V_{DC}
Emitter-Base Voltage	V_{EB}	6	6	6	V_{DC}
Collector Current (continuous)	I_C	1.5	1.5	1.5	A_{DC}
Power Dissipation (T_A = 25°C)	P_D				
TO-92		0.6	0.6	0.6	W
TO-92 PLUS		0.75	0.75	0.75	W
TO-202		1.75	1.75	1.75	W
Power Dissipation (T_C = 25°C)	P_D				
TO-92		1.0	1.0	1.0	W
TO-92 PLUS		2.5	2.5	2.5	W
TO-202		10	10	10	W
Temperature, Junction and Storage	T_j, T_{stg}	−55 to +150	−55 to +150	−55 to +150	°C

[3] ordering information

N B 3 X X X

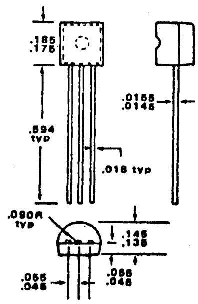
- POLARITY: "1" for NPN, "2" for PNP
- VOLTAGE RATING: refer to [2]
- PACKAGE/LEAD CODE: refer to [1]

4 electrical characteristics $T_c = 25^oC$

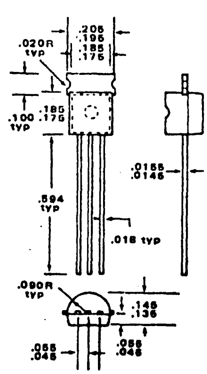
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
BV_{CEO}	Collector-Emitter Sustaining Voltage	I_C = 1 mA				
	NB311/321		35			V
	NB312/322		50			V
	NB313/323		65			V
BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 100 μA				
	NB311/321		40			V
	NB312/322		55			V
	NB313/323		70			V
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 10 μA	6			V
I_{CEO}	Collector-Emitter Leakage Current	V_{CE} = 30V NB311/321			50	μA
		45V NB312/322			50	μA
		60V NB313/323			50	μA
I_{CBO}	Collector-Base Leakage Current	V_{CB} = 35V NB311/321			0.5	μA
		50V NB312/322			0.5	μA
		65V NB313/323			0.5	μA
I_{EBO}	Emitter-Base Leakage Current	V_{EB} = 5V			0.5	μA
$V_{BE(sat)}$	Base-Emitter Saturation Voltage	I_C = 300 mA, I_B = 10 mA		0.9	1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_C = 300 mA, I_B = 10 mA		0.15	0.5	V
H_{FE1}	DC Current Gain	I_C = 1 mA, V_{CE} = 10V	30			
H_{FE2}	DC Current Gain	I_C = 100 mA, V_{CE} = 10V	50			
C_{ob}	Collector Output Capacitance	V_{CB} = 10V, f = 1 MHz				
	NPN types			10		pF
	PNP types			17		pF
f_t	Current Gain Bandwidth Product	I_C = 100 mA, V_{CE} = 10V	20			MHz

5 physical dimensions

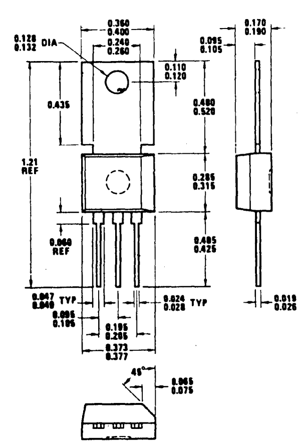
TO-92



TO-92 PLUS



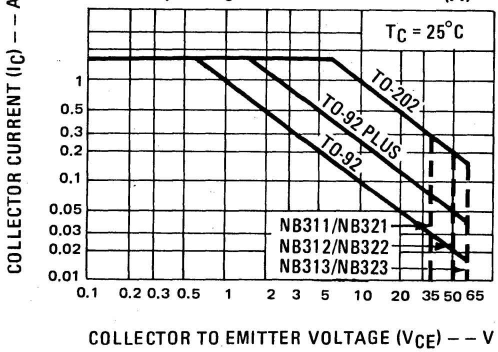
TO-202



6 typical performance characteristics

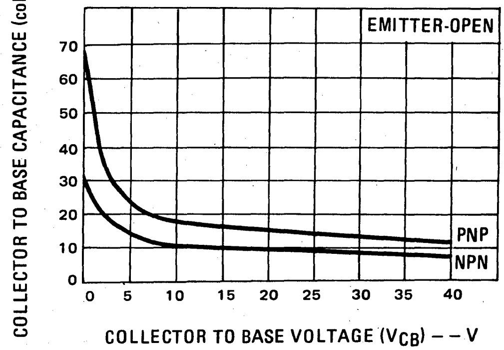
SOA

dc safe operating area (A)



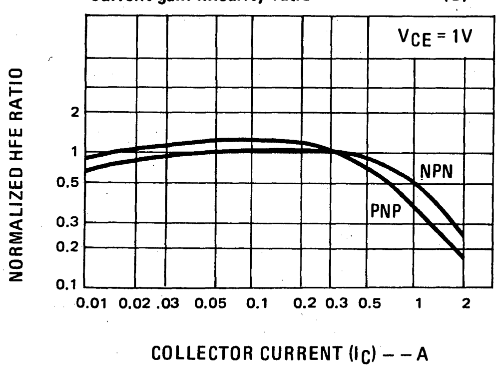
Cob

output capacitance (B)



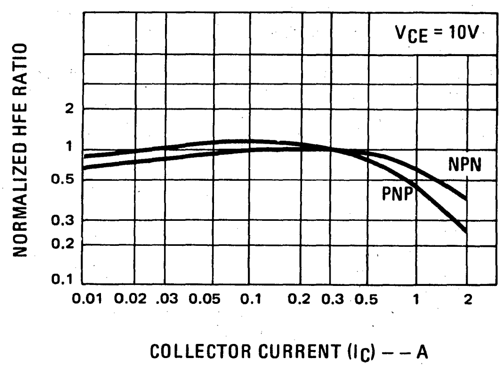
HFE1/HFE2

current gain linearity ratio (C)



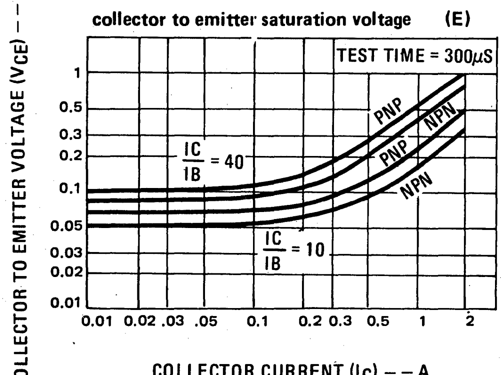
HFE1/HFE2

current gain linearity ratio (D)



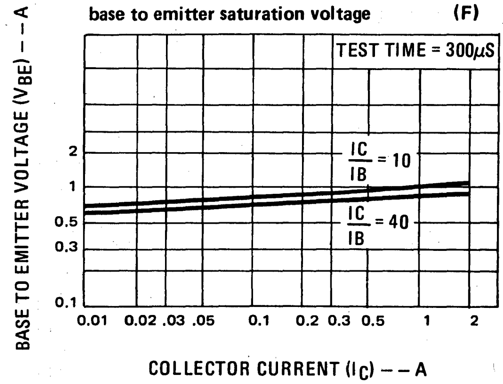
VCE(sat)

collector to emitter saturation voltage (E)



VBE(sat)

base to emitter saturation voltage (F)



7 typical applications

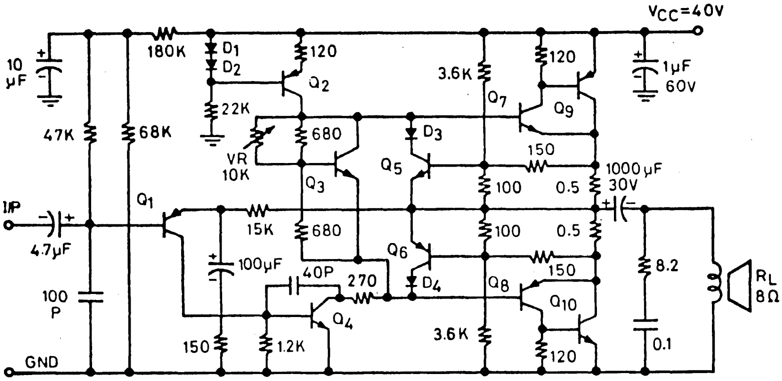


Figure A. 25 Watt OTL Amplifier

Q1	NB022EY
Q2	NB123EY
Q3	NR001E
Q4	NB113EY
Q5	NB111EY
Q6	NB121EY
Q7	NB313Y
Q8	NB323Y
Q9	NA72W
Q10	NA71W

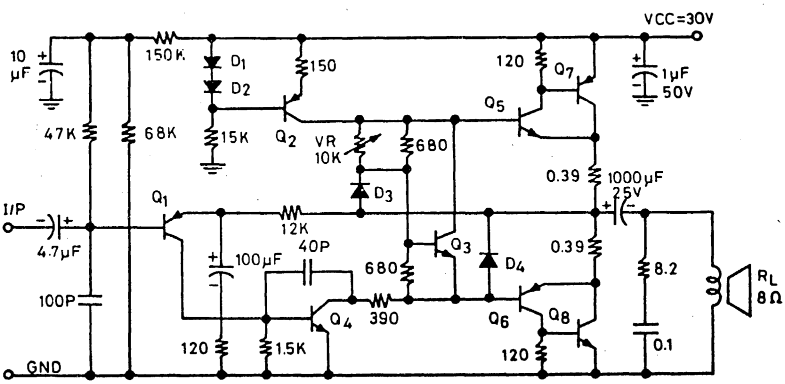


Figure B. 12 Watt OTL Amplifier

Q1	NB021EY
Q2	NB122EY
Q3	NR001E
Q4	NB112EY
Q5	NB312E
Q6	NB322E
Q7	NA52W
Q8	NA51W

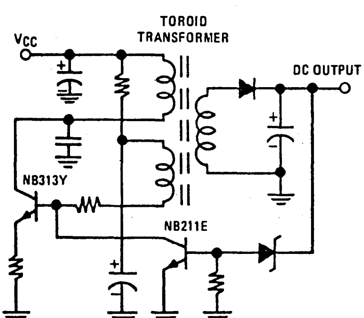


Figure C. Typical Converter Circuit

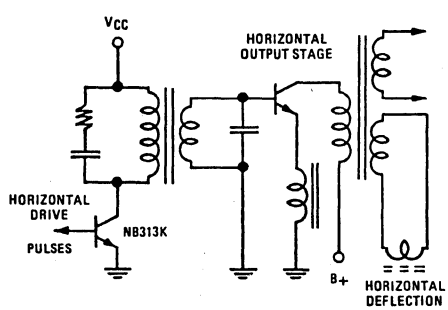


Figure D. Typical TV Horizontal Driver Application

National Semiconductor

NR041 (NPN) low-level signal switching transistor

features

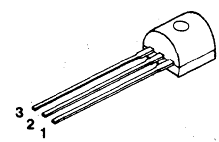
- 40mV guaranteed V_{CE} (sat) characteristics at I_C = 1mA and I_B = 0.1mA
- Linear collector characteristics
- 1dB typical wide-band Noise Figure
- "Epoxy B" packaging concept for excellent reliability

applications

- ALC device for CB microphone circuits
- Cassette circuits
- Audio signal switches
- Envelope modulators for musical equipment

1 package and lead coding

TO-92



PACKAGE CODE TO-92	LEAD 1	2	3
E	E	B	C
F	E	C	B
H	C	B	E

2 maximum ratings

PARAMETER	SYMBOL	RATING	UNIT
Collector-Emitter Voltage	V_{CEO}	20	V_{DC}
Collector-Base Voltage	V_{CB}	20	V_{DC}
Emitter-Base Voltage	V_{EB}	5	V_{DC}
Collector Current (continuous)	I_C (max)	30	mA_{DC}
Power Dissipation (T_A = 25°C)	P_D	0.6	W
Power Dissipation (T_C = 25°C)	P_D	1.0	W
Thermal Resistance	θ_{JA}	208	°C/W
	θ_{JC}	125	°C/W
Temperature, Junction and Storage	Tj, Tstg	– 55 to +150	°C

3 ordering information

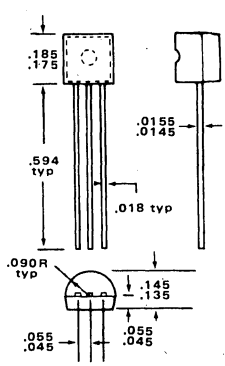
NR041X

X → PACKAGE/LEAD CODE
refer to [1]

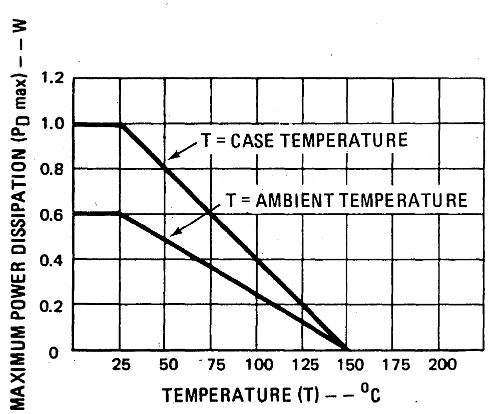
4 electrical characteristics $T_C = 25°C$

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
BV_{CEO}	Collector-Emitter Sustaining Voltage	I_C = 1 mA	20			V
BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 100μA	20			V
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 10μA	5			V
I_{CEO}	Collector-Emitter Leakage Current	V_{CE} = 15V			1	μA
I_{CBO}	Collector-Base Leakage Current	V_{CB} = 15V			50	nA
I_{EBO}	Emitter-Base Leakage Current	V_{EB} = 4V			0.1	μA
V_{BE} (sat)	Base-Emitter Saturation Voltage	I_C = 1 mA, I_B = 0.1 mA		0.65	0.8	V
V_{CE} (sat)	Collector-Emitter Saturation Voltage	I_C = 1 mA, I_B = 0.1 mA		25	40	mV
Cob	Collector Output Capacitance	V_{CB} = 10V, f = 1 MHz		2		pF
NF	Noise Figure	I_C = 10μA, V_{CE} = 5V R_S = 10K, BW = 15.7 KHz		1		dB

5 physical dimensions



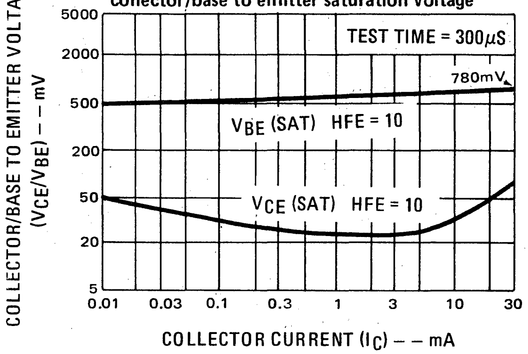
6 max power dissipation



7 typical performance characteristics

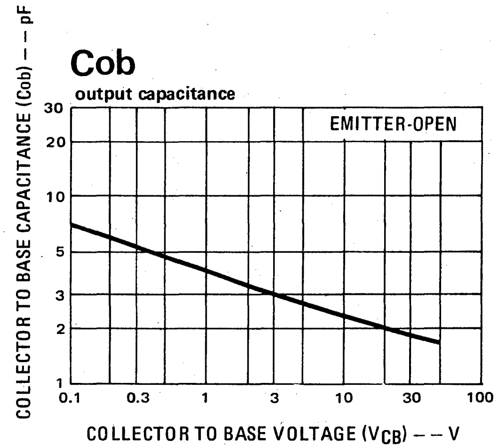
VCE(sat)/VBE(sat)

collector/base to emitter saturation voltage



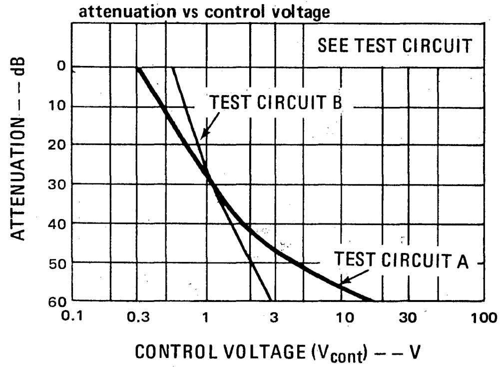
Cob

output capacitance



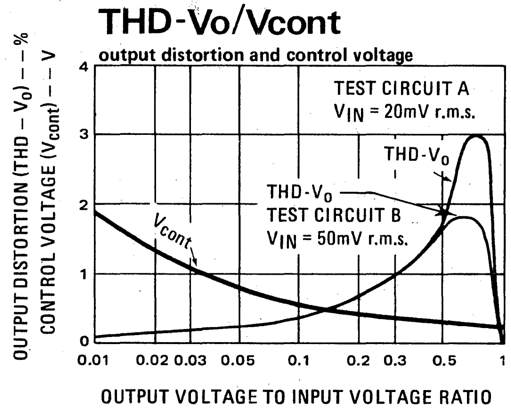
Attenuation

attenuation vs control voltage



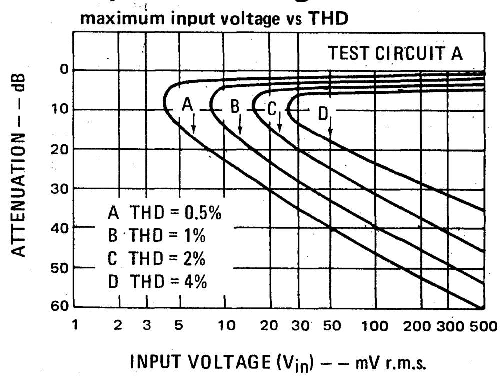
THD-Vo/Vcont

output distortion and control voltage

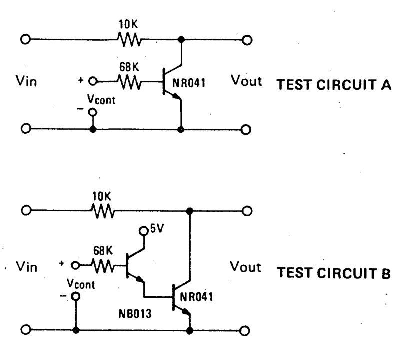


Dynamic range

maximum input voltage vs THD



Test circuits



NOTE: ATTENUATION = $20 \log_{10} \frac{Vout}{Vin}$

8 typical applications

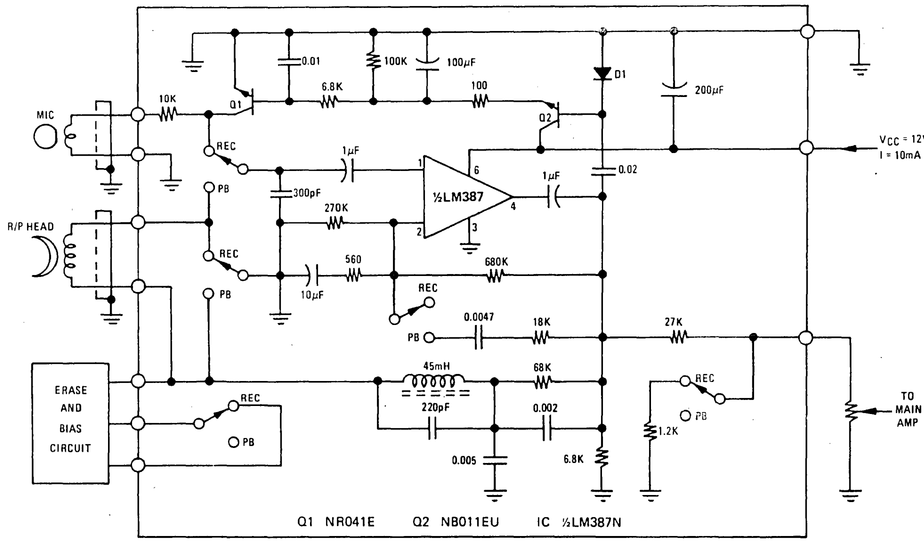


Figure A. 60dB ALC Range Record/Playback Preamplifier

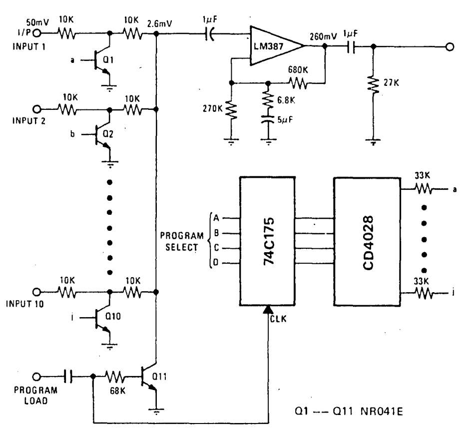


Figure B. 10 Channel Program Selector

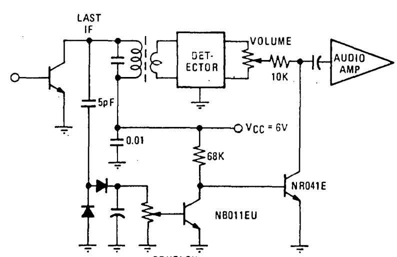


Figure C. Squelch Circuit

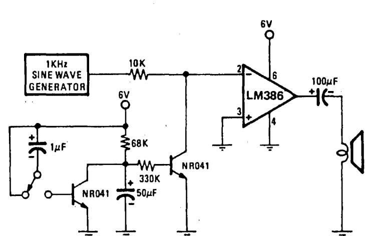


Figure D. Ringing Tone Generator

National Semiconductor

NR421(NPN) VHF amplifier/FM converter transistor

features

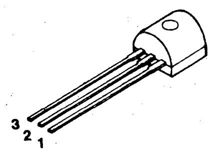
- 0.65pF typical feedback capacitance for excellent RF stability
- Guaranteed collector-base time constant and RF output resistance
- 150mV typical V_{CE} (sat) characteristics at I_C = 10 mA, and I_B = 0.5 mA
- 2 dB typical noise figure at 200 MHz
- "Epoxy B" packaging concept for excellent reliability

applications

- VHF RF amplifiers/converters
- CB radios
- Low-power RF oscillators

1 package and lead coding

TO-92



PACKAGE CODE TO-92	LEAD 1	2	3
D	B	E	C
F	E	C	B

2 maximum ratings

PARAMETER	SYMBOL	RATING	UNIT
Collector-Emitter Voltage	V_{CEO}	30	V_{DC}
Collector-Base Voltage	V_{CB}	35	V_{DC}
Emitter-Base Voltage	V_{EB}	3	V_{DC}
Collector Current (continuous)	I_C (max)	30	mA_{DC}
Power Dissipation (T_A = 25°C)	P_D	0.6	W
Power Dissipation (T_C = 25°C)	P_D	1.0	W
Thermal Resistance	θ_{JA}	208	°C/W
	θ_{JC}	125	°C/W
Temperature, Junction and Storage	Tj, Tstg	–55 to + 150	°C

3 ordering information

NR421XX

- First X: PACKAGE/LEAD CODE — refer to 1
- Second X: HFE GROUPING — refer to 5

4 electrical characteristics $T_C = 25°C$

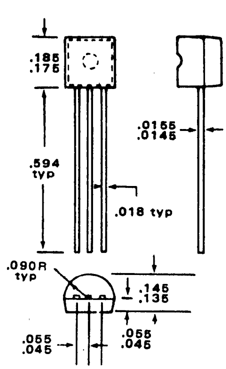
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
BV_{CEO}	Collector-Emitter Sustaining Voltage	I_C = 1 mA	30			V
BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 100μA	35			V
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 10μA	3	5.5		V
I_{CBO}	Collector-Base Leakage Current	V_{CB} = 30V			0.1	μA
V_{BE} (sat)	Base-Emitter Saturation Voltage	I_C = 10 mA, I_B = 0.5 mA		830	950	mV
V_{CE} (sat)	Collector-Emitter Saturation Voltage	I_C = 10 mA, I_B = 0.5 mA		150	300	mV
Ccb	Common Emitter Collector Feedback Capacitance	V_{CB} = 10V, f = 1 MHz		0.65	0.9	pF
Cob	Collector Output Capacitance	V_{CB} = 10V, f = 1 MHz		0.9	1.3	pF
rb'Cc	Collector Base Time Constant	I_C = 2 mA, V_{CE} = 5V		8	20	pS
Roep	Common Emitter Output Resistance	I_C = 2 mA, V_{CE} = 5V f = 200 MHz	5			KOhm
ft	Current Gain Bandwidth Product	I_C = 2 mA, V_{CE} = 5V	450	700		MHz

5 HFE groupings

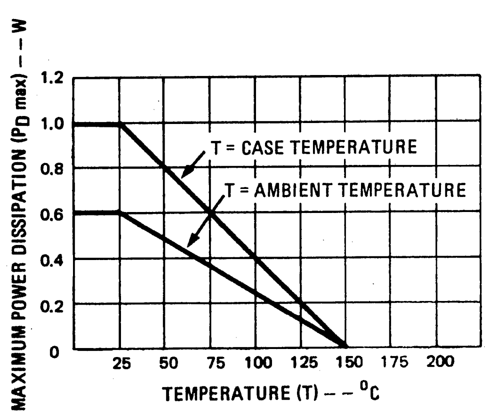
GROUPING	PARAMETER	CONDITIONS	MIN	TYP	MAX	RATIO
E	DC Current Gain	I_C = 2 mA, V_{CE} = 5V	30	38	50	1:1.6
F	DC Current Gain	I_C = 2 mA, V_{CE} = 5V	45	58	75	1:1.6
G	DC Current Gain	I_C = 2 mA, V_{CE} = 5V	68	85	110	1:1.6
H	DC Current Gain	I_C = 2 mA, V_{CE} = 5V	100	127	160	1:1.6
R	DC Current Gain	I_C = 2 mA, V_{CE} = 5V	20	32	50	1:2.4
S	DC Current Gain	I_C = 2 mA, V_{CE} = 5V	45	70	110	1:2.4
T	DC Current Gain	I_C = 2 mA, V_{CE} = 5V	100	150	240	1:2.4

6 physical dimensions

TO-92



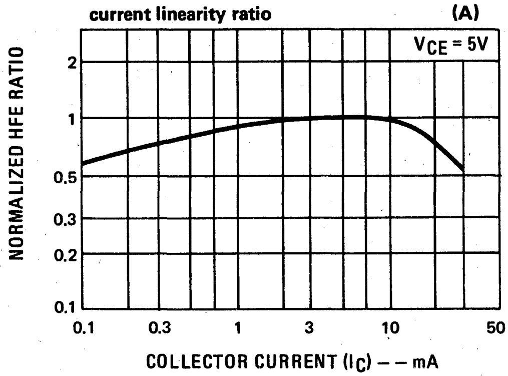
7 max power dissipation



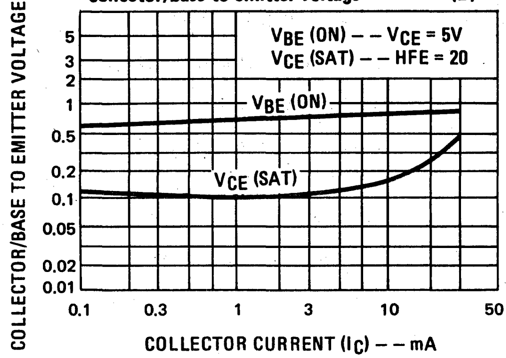
7

8 typical performance characteristics

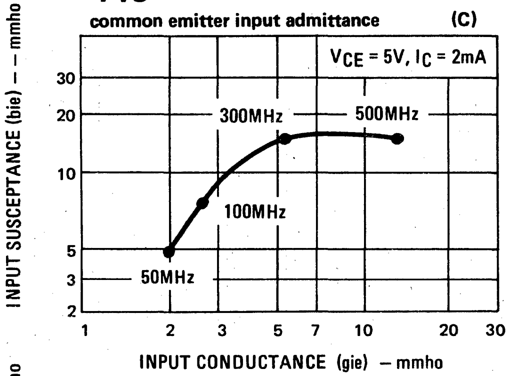
HFE1/HFE2
current linearity ratio (A)



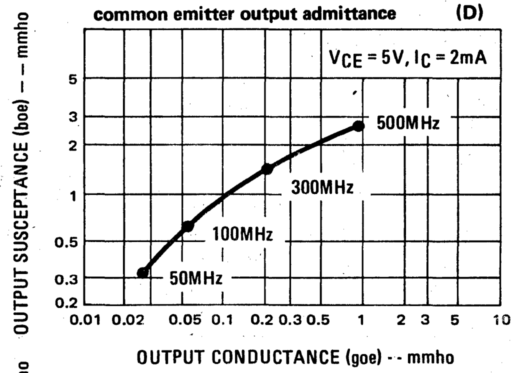
VCE(sat)/VBE(on)
collector/base to emitter voltage (B)



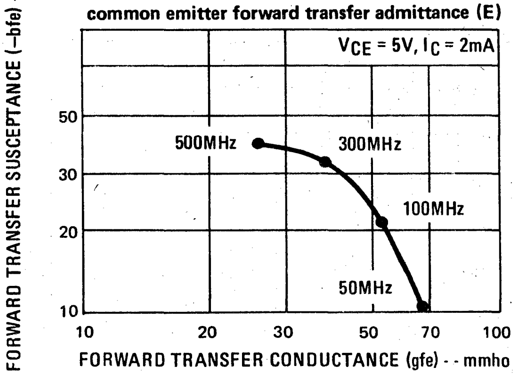
Yie
common emitter input admittance (C)



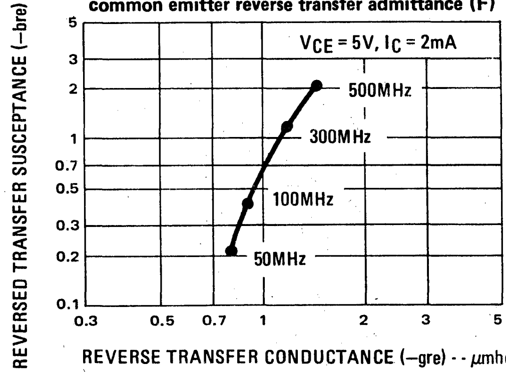
Yoe
common emitter output admittance (D)

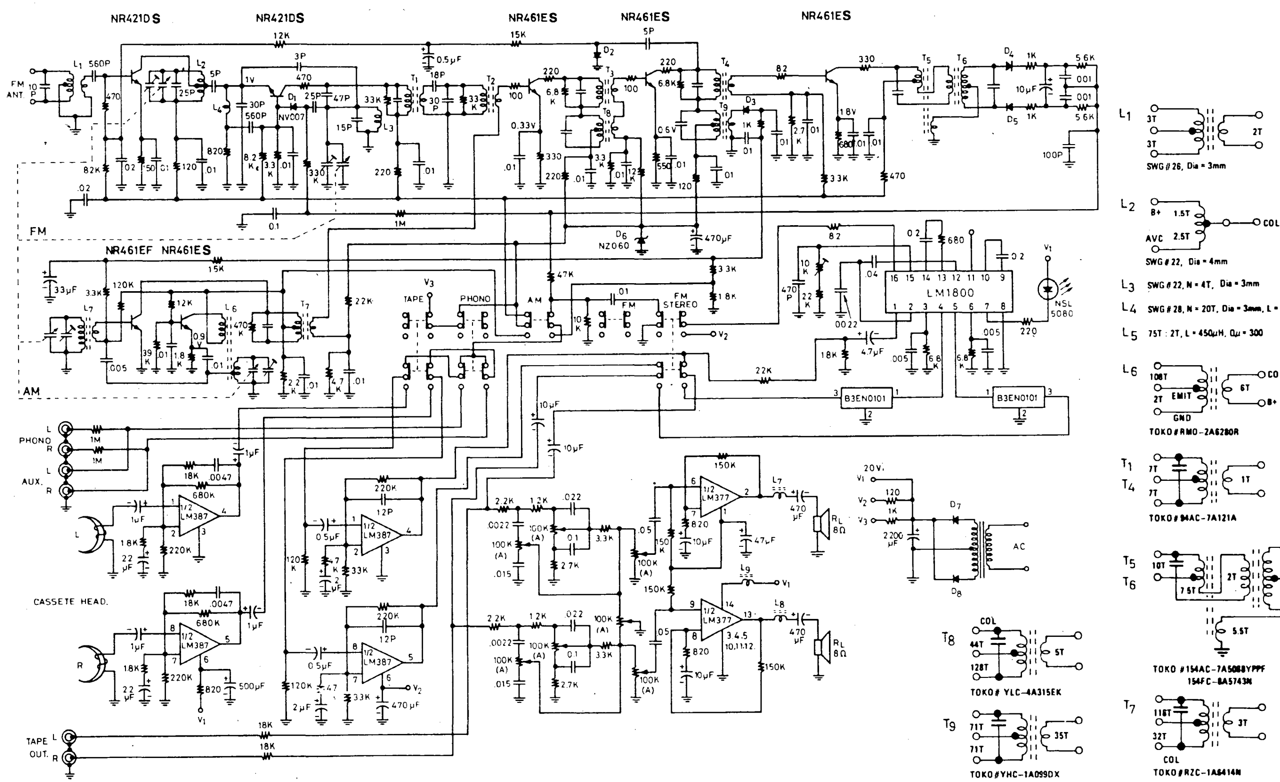


Yfe
common emitter forward transfer admittance (E)



Yre
common emitter reverse transfer admittance (F)





FM performance (88–108 MHz)

- 30dB quieting sensitivity: 2μV
- limiting sensitivity: 7μV
- AM rejection: 40dB
- AFC holding range: 800KHz
- stereo separation: 40dB

AM performance (525–1650 KHz)

- maximum sensitivity: 100μV/M
- 20dB quieting sensitivity: 280μV/M
- selectivity ±10KHz: –28dB
- AGC figure of merit: 52dB
- overload distortion: 3%

AUDIO performance

- 10% THD output power: 3W + 3W
- frequency response: 50Hz – 15KHz
- channel separation: 45dB
- tone control range: ±10dB
- typical system dist: 0.5%

Figure A. AM/FM/Cassette Home Stereo Circuit

National Semiconductor

NR431(NPN) HF amplifier/FM converter transistor

features

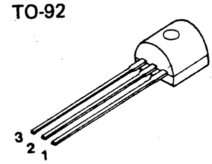
- 1.1pF typical collector feedback capacitance
- 5K Ohm minimum RF output resistance at 100 MHz
- 150mV typical V_{CE} (sat) charactersistics at I_C = 10 mA, and I_B = 0.5 mA
- "Epoxy B" packaging concept for excellent reliability

applications

- High frequency amplifiers/converters
- CB radios
- Low power RF oscillators

1 package and lead coding

TO-92



PACKAGE CODE TO-92	LEAD 1	2	3
E	E	B	C
F	E	C	B
H	C	B	E

2 maximum ratings

PARAMETER	SYMBOL	RATING	UNIT
Collector-Emitter Voltage	V_{CEO}	15	V_{DC}
Collector-Base Voltage	V_{CB}	18	V_{DC}
Emitter-Base Voltage	V_{EB}	3	V_{DC}
Collector Current (continuous)	I_C (max)	30	mA_{DC}
Power Dissipation (T_A = 25°C)	P_D	0.6	W
Power Dissipation (T_C = 25°C)	P_D	1.0	W
Thermal Resistance	θ_{JA}	208	°C/W
	θ_{JC}	125	°C/W
Temperature, Junction and Storage	Tj, T_{stg}	–55 to + 150	°C

3 ordering information

NR431XX

- First X: PACKAGE/LEAD CODE, refer to 1
- Second X: HFE GROUPING, refer to 5

4 electrical characteristics $T_C = 25°C$

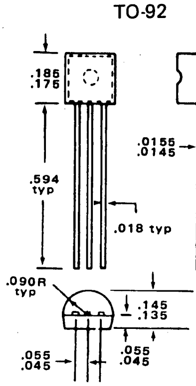
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
BV_{CEO}	Collector-Emitter Sustaining Voltage	I_C = 1 mA	15			V
BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 100μA	18			V
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 10μA	3	5.6		V
I_{CBO}	Collector-Base Leakage Current	V_{CB} = 15V			0.1	μA
V_{BE} (sat)	Base-Emitter Saturation Voltage	I_C = 10 mA, I_B = 0.5 mA		830	950	mV
V_{CE} (sat)	Collector-Emitter Saturation Voltage	I_C = 10 mA, I_B = 0.5 mA		150	300	mV
Ccb	Common Emitter Collector Feedback Capacitance	V_{CB} = 10V, f = 1 MHz		1.1	1.4	pF
Cob	Collector Output Capacitance	V_{CB} = 10V, f = 1 MHz		1.4	1.7	pF
Roep	Common Emitter Output Resistance	I_C = 1mA, V_{CE} = 5V f = 100 MHz	5			KOhm
ft	Current Gain Bandwidth Product	I_C = 1mA, V_{CE} = 5V	350	600		MHz

5 HFE groupings

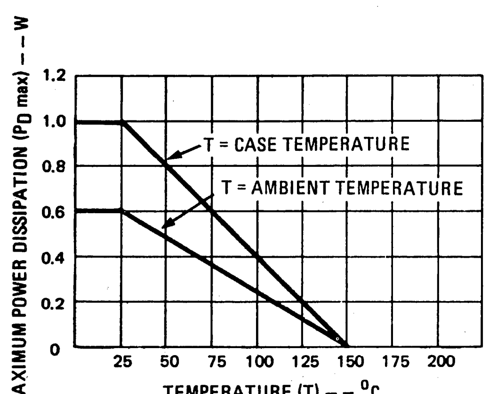
GROUPING	PARAMETER	CONDITIONS	MIN	TYP	MAX	RATIO
E	DC Current Gain	I_C = 1 mA, V_{CE} = 5V	30	38	50	1:1.6
F	DC Current Gain	I_C = 1 mA, V_{CE} = 5V	45	58	75	1:1.6
G	DC Current Gain	I_C = 1 mA, V_{CE} = 5V	68	85	110	1:1.6
R	DC Current Gain	I_C = 1 mA, V_{CE} = 5V	20	32	50	1:2.4
S	DC Current Gain	I_C = 1 mA, V_{CE} = 5V	45	70	110	1:2.4

6 physical dimensions

TO-92

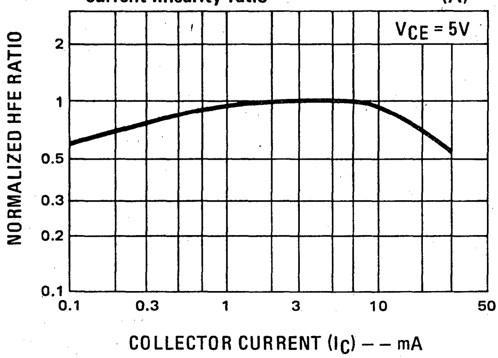


7 max power dissipation

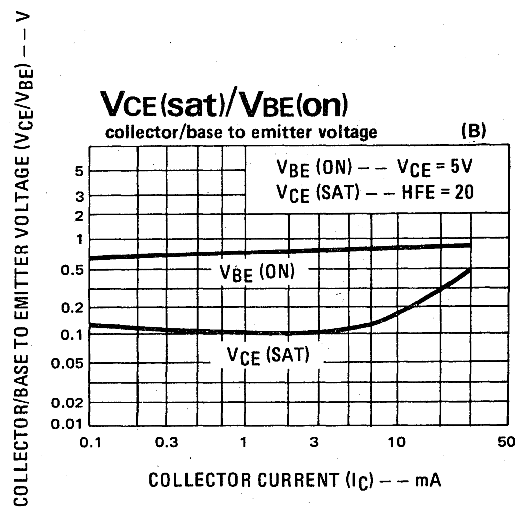


8 typical performance characteristics

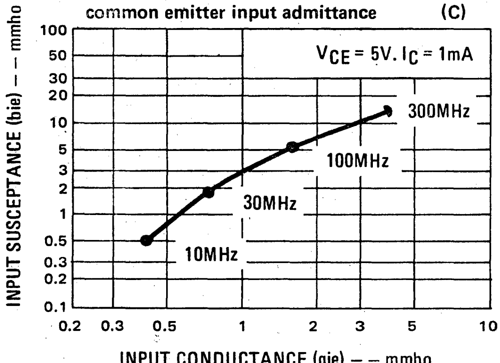
HFE1/HFE2
current linearity ratio (A)



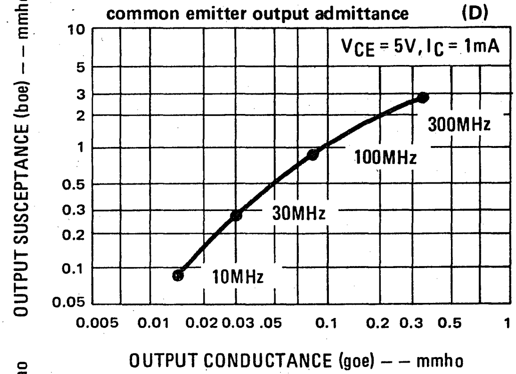
VCE(sat)/VBE(on)
collector/base to emitter voltage (B)



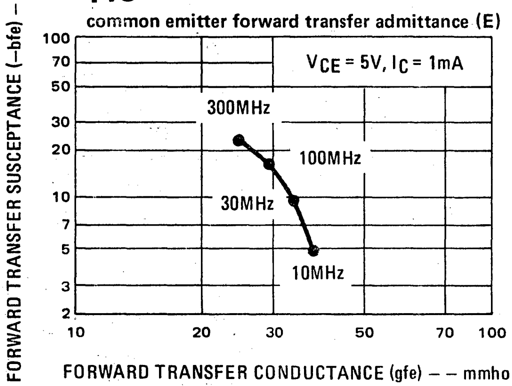
Yie
common emitter input admittance (C)



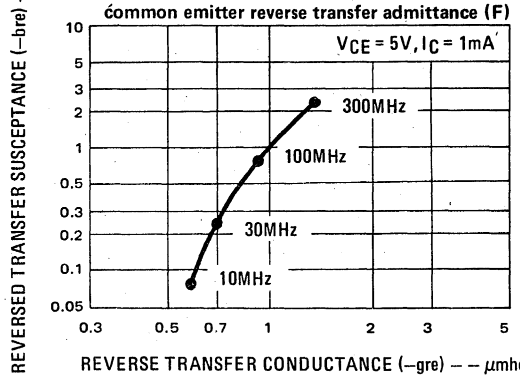
Yoe
common emitter output admittance (D)

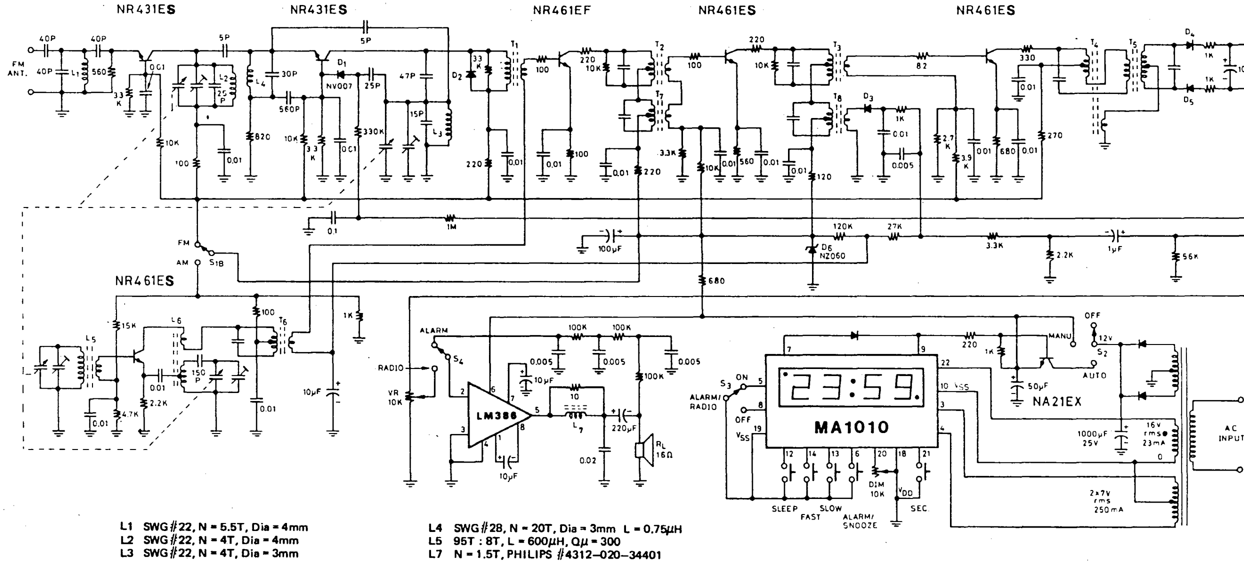


Yfe
common emitter forward transfer admittance (E)



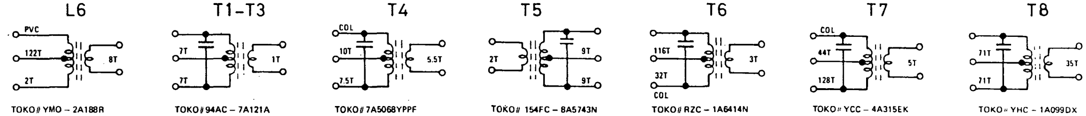
Yre
common emitter reverse transfer admittance (F)





L1 SWG#22, N = 5.5T, Dia = 4mm
L2 SWG#22, N = 4T, Dia = 4mm
L3 SWG#22, N = 4T, Dia = 3mm

L4 SWG#28, N = 20T, Dia = 3mm L = 0.75μH
L5 95T : 8T, L = 600μH, Qμ = 300
L7 N = 1.5T, PHILIPS #4312-020-34401



FM performance (88–108 MHz)

- 30dB quieting sensitivity: 5μV
- limiting sensitivity: 20μV
- AM rejection: 40dB
- AFC holding range: 800KHz
- Bandwidth: 180KHz

AM performance (525–1650 KHz)

- maximum sensitivity: 100μV/M
- 20dB quieting sensitivity: 280μV/M
- selectivity ± 10KHz: –28dB
- AGC figure of merit: 40dB
- overload distortion: 6%

AUDIO performance

- gain at 1 KHz: 200
- 10% THD output power: 900mW
- frequency response: 70Hz – 12KHz
- typical system dist: 0.8%
- alarm tone frequency: 600Hz

Figure A. AM/FM clock radio

National Semiconductor

NR461(NPN) low-noise RF/IF transistor

features

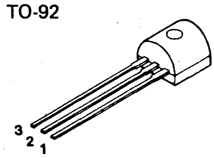
- Low C_{cb} for excellent RF stability
- High R_{oep} for simplified RF coupling designs
- 70mV typical V_{CE} (sat) characteristics at I_C = 10 mA, and I_B = 0.5 mA
- 1.1 dB typical noise figure at 1 MHz
- "Epoxy B" packaging concept for excellent reliability

applications

- MW/SW/CB radios
- 0.1 to 50 MHz frequency converters
- 455KHz to 10.7 MHz IF stages
- Low-power RF oscillators

1 package and lead coding

TO-92



PACKAGE CODE TO-92	LEAD 1	2	3
E	E	B	C
F	E	C	B
H	C	B	E

2 maximum ratings

PARAMETER	SYMBOL	RATING	UNIT
Collector-Emitter Voltage	V_{CEO}	30	V_{DC}
Collector-Base Voltage	V_{CB}	35	V_{DC}
Emitter-Base Voltage	V_{EB}	4	V_{DC}
Collector Current (continuous)	I_C (max)	30	mA_{DC}
Power Dissipation (T_A = 25°C)	P_D	0.6	W
Power Dissipation (T_C = 25°C)	P_D	1.0	W
Thermal Resistance	θ_{JA}	208	°C/W
	θ_{JC}	125	°C/W
Temperature, Junction and Storage	Tj, Tstg	−55 to + 150	°C

3 ordering information

PACKAGE/LEAD CODE refer to 1

NR461XX

HFE GROUPING refer to 5

4 electrical characteristics $T_C = 25°C$

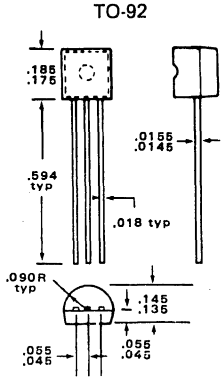
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
BV_{CEO}	Collector-Emitter Sustaining Voltage	$I_C = 1$ mA	30			V
BV_{CBO}	Collector-Base Breakdown Voltage	$I_C = 100\mu A$	35			V
BV_{EBO}	Emitter-Base Breakdown Voltage	$I_E = 10\mu A$	4	5.5		V
I_{CBO}	Collector-Base Leakage Current	$V_{CB} = 30V$			0.1	μA
V_{BE} (sat)	Base-Emitter Saturation Voltage	$I_C = 10$ mA, $I_B = 0.5$ mA		760	950	mV
V_{CE} (sat)	Collector-Emitter Saturation Voltage	$I_C = 10$ mA, $I_B = 0.5$ mA		70	300	mV
Ccb	Common Emitter Collector Feedback Capacitance	$V_{CB} = 10V$, f = 1 MHz		0.9	1.1	pF
Roep	Common Emitter Output Resistance	$I_C = 1$ mA, $V_{CE} = 5V$				
		f = 455 KHz	100			KOhm
		f = 10.7 MHz	20			KOhm
ft	Current Gain Bandwidth Product	$I_C = 1$ mA, $V_{CE} = 5V$	180	300		MHz

5 HFE groupings

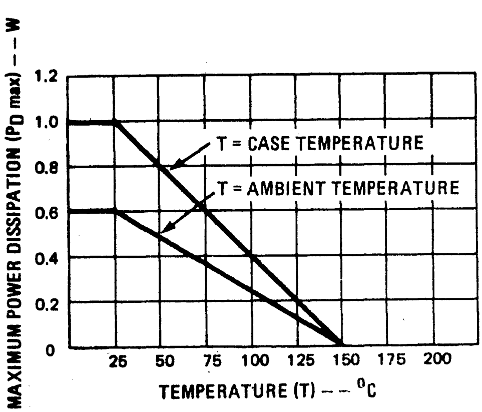
GROUPING	PARAMETER	CONDITIONS	MIN	TYP	MAX	RATIO
E	DC Current Gain	$I_C = 1$ mA, $V_{CE} = 5V$	30	38	50	1:1.6
F	DC Current Gain	$I_C = 1$ mA, $V_{CE} = 5V$	45	58	75	1:1.6
G	DC Current Gain	$I_C = 1$ mA, $V_{CE} = 5V$	68	85	110	1:1.6
H	DC Current Gain	$I_C = 1$ mA, $V_{CE} = 5V$	100	127	160	1:1.6
R	DC Current Gain	$I_C = 1$ mA, $V_{CE} = 5V$	20	32	50	1:2.4
S	DC Current Gain	$I_C = 1$ mA, $V_{CE} = 5V$	45	70	110	1:2.4
T	DC Current Gain	$I_C = 1$ mA, $V_{CE} = 5V$	100	150	240	1:2.4

6 physical dimensions

TO-92



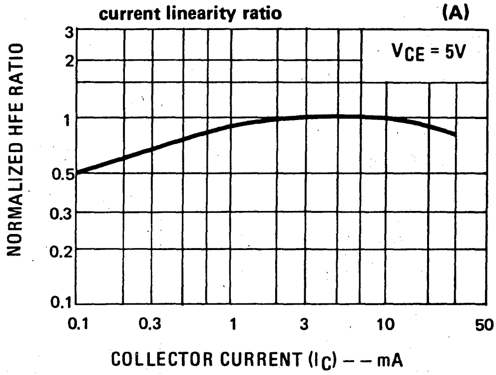
7 max power dissipation



8 typical performance characteristics

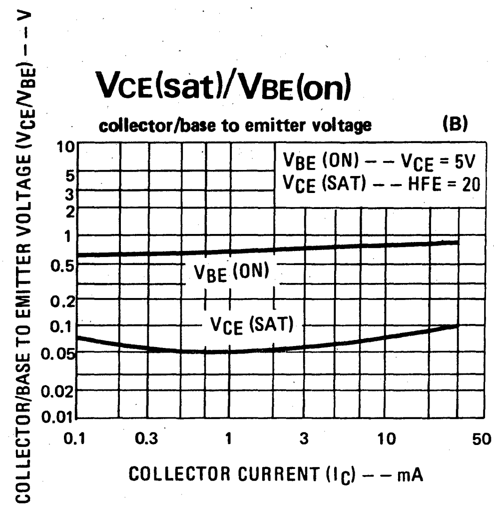
HFE1/HFE2

current linearity ratio (A)



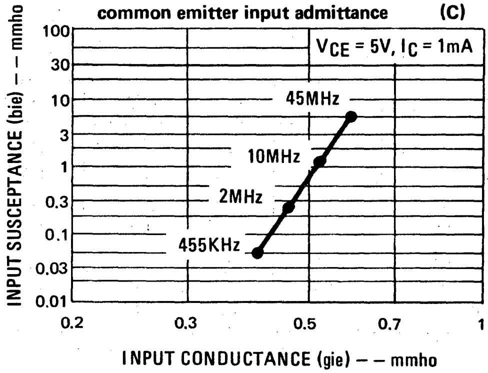
VCE(sat)/VBE(on)

collector/base to emitter voltage (B)



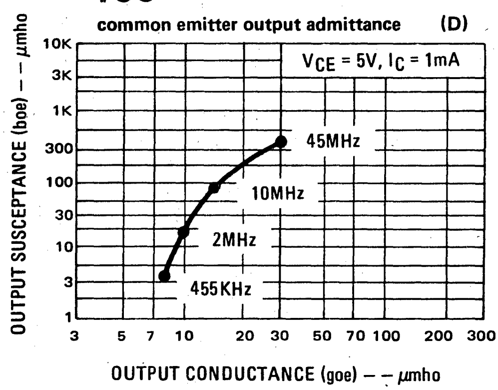
Yie

common emitter input admittance (C)



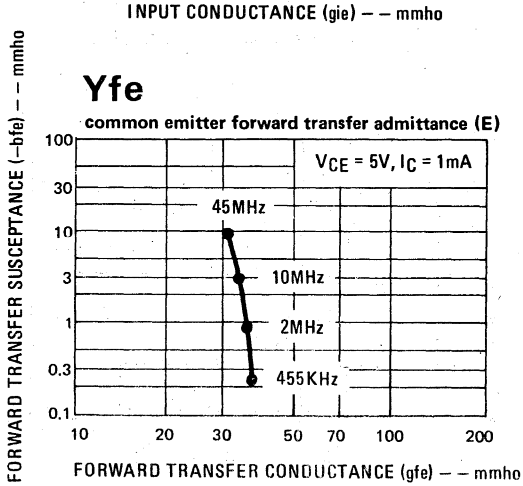
Yoe

common emitter output admittance (D)



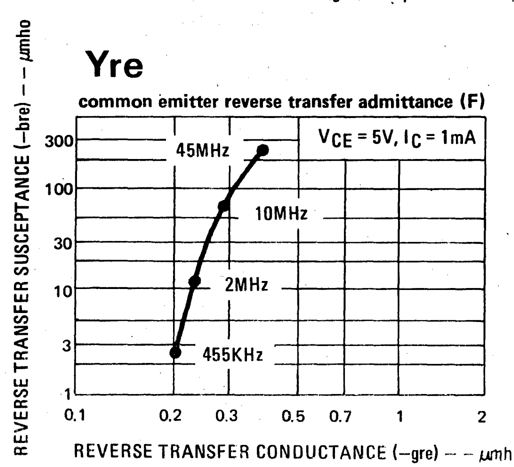
Yfe

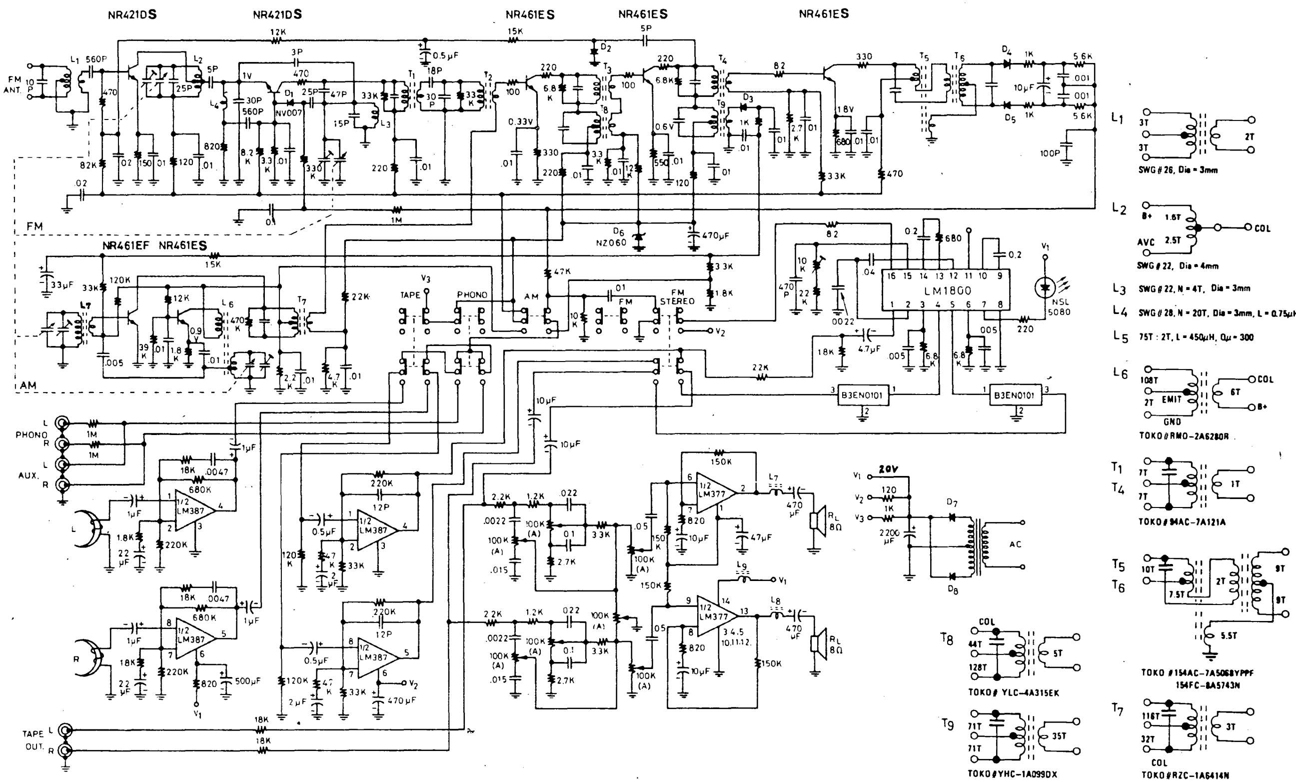
common emitter forward transfer admittance (E)



Yre

common emitter reverse transfer admittance (F)





FM performance (88–108 MHz)	
30dB quieting sensitivity	2μV
limiting sensitivity:	7μV
AM rejection:	40dB
AFC holding range:	800KHz
stereo separation:	40dB

AM performance (525–1650 KHz)	
maximum sensitivity:	100μV/M
20dB quieting sensitivity:	280μV/M
selectivity ±10KHz:	–28dB
AGC figure of merit:	52dB
overload distortion:	3%

AUDIO performance	
10% THD output power:	3W + 3W
frequency response:	50Hz – 15KHz
channel separation:	45dB
tone control range:	±10dB
typical system dist:	0.5%

Figure A. AM/FM/Cassette Home Stereo Circuit

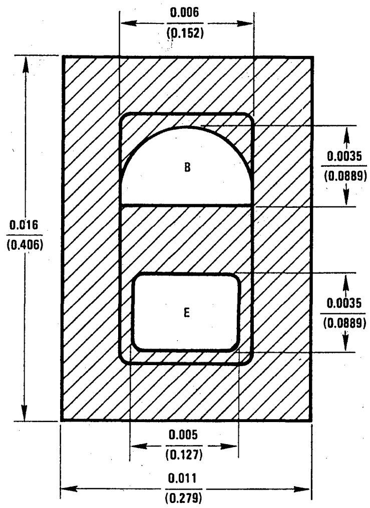
Section 8

Process Characteristics Double-Diffused Epitaxial Transistors

8

National Semiconductor

Process 02 NPN Small Signal



DESCRIPTION

Process 02 is a non-overlay, double-diffused, silicon epitaxial device.

APPLICATION

An economical device, good for all-around applications from DC to low radio frequencies. Ideal for use in general amplifier and control functions in consumer, industrial and automotive environments up to 100 mA.

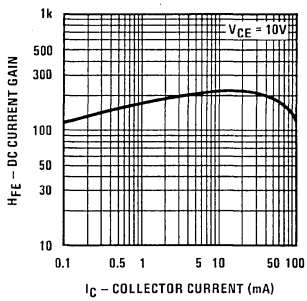
PRINCIPAL DEVICE TYPE

TO-92, EBC: MPS-A20

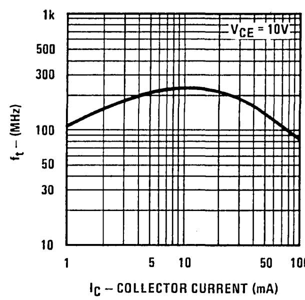
Parameter	Conditions	Min	Typ	Max	Units	Notes
BV_{CEO}	$I_C = 10$ mA	40			V	
BV_{CBO}	$I_C = 10\ \mu A$	45			V	
BV_{EBO}	$I_E = 10\ \mu A$	6.0			V	
I_{CBO}	$V_{CB} = 40V$			100	nA	
I_{EBO}	$V_{EB} = 5V$			100	nA	
h_{FE}	$I_C = 100\ \mu A$, $V_{CE} = 10V$	35				
h_{FE}	$I_C = 5$ mA, $V_{CE} = 10V$	60	180	480		
h_{FE}	$I_C = 100$ mA, $V_{CE} = 10V$	25				
$V_{BE(ON)}$	$I_C = 5$ mA, $V_{CE} = 10V$			0.85	V	
$V_{CE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA			0.25	V	
f_T	$I_C = 5$ mA, $V_{CE} = 10V$, f = 100 MHz	125	225		MHz	
C_{ib}	$V_{EB} = 0.5V$, f = 1 MHz			10	pF	
C_{ob}	$V_{CB} = 10V$, $I_E = 0$, f = 1 MHz		2.0	4.0	pF	

Process 02

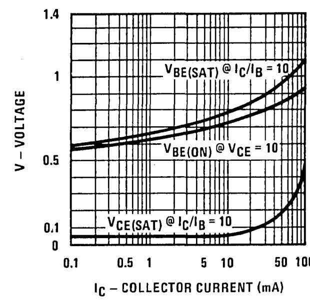
DC Current Gain vs Collector Current



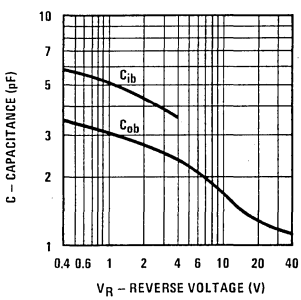
Bandwidth Product vs Collector Current



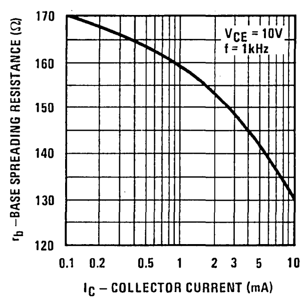
Saturation and ON Voltages vs Collector Current



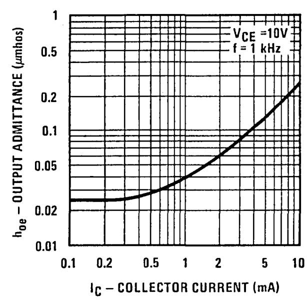
Capacitance vs Reverse Voltage



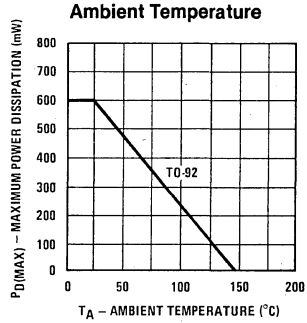
Output Admittance vs Collector Current



Base Spreading Resistance vs Collector Current

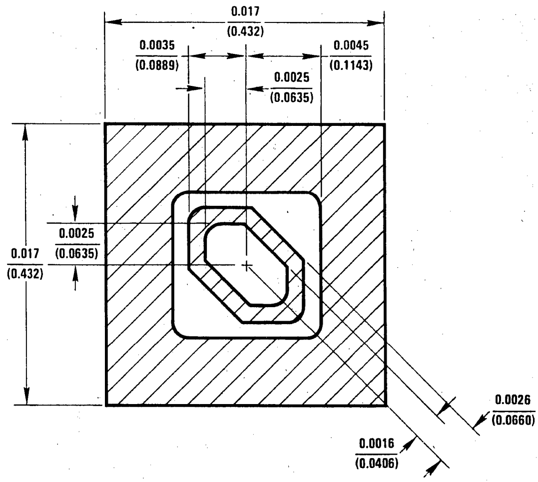


Maximum Power Dissipation vs Ambient Temperature



National Semiconductor

Process 04 NPN Small Signal



DESCRIPTION

Process 04 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 71.

APPLICATION

This device was designed for low noise, high gain, general purpose amplifier applications from 10 μA to 100 mA collector current.

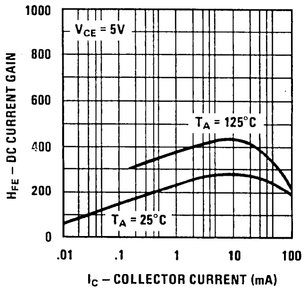
PRINCIPAL DEVICE TYPES

TO-18: BC107 Series
TO-92, ECB: 2N2923 Series
2N5172
TO-92, EBC: MPS2923 Series

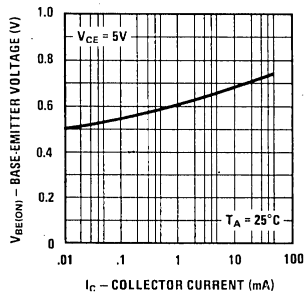
Parameter	Conditions	Min	Typ	Max	Units	Notes
NF (spot)	$I_C = 200\ \mu A$, $V_{CE} = 5V$, $f = 1$ kHz, $R_S = 2k$		2.0	4.0	dB	TO-18
C_{ob}	$V_{CB} = 10V$, $f = 1$ MHz		2.5	3.5	pF	
C_{ib}	$V_{EB} = 0.5V$, $f = 1$ MHz			10	pF	
f_T	$V_{CE} = 5V$, $I_C = 10$ mA	125	250		MHz	
h_{FE}	$V_{CE} = 5V$, $I_C = 100\ \mu A$	50				
h_{FE}	$V_{CE} = 5V$, $I_C = 2$ mA	75	250	600		
h_{FE}	$V_{CE} = 5V$, $I_C = 100$ mA	40				
h_{FE}	$V_{CE} = 1V$, $I_C = 100$ mA	25				
$V_{CE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA			0.2	V	
$V_{CE(SAT)}$	$I_C = 100$ mA, $I_B = 10$ mA			0.5	V	
$V_{BE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA			0.85	V	
$V_{BE(SAT)}$	$I_C = 100$ mA, $I_B = 10$ mA			0.95	V	
BV_{CBO}	$I_C = 10\ \mu A$	45			V	
BV_{CEO}	$I_C = 10$ mA	35			V	
BV_{EBO}	$I_E = 10\ \mu A$	7.0			V	
I_{CBO}	$V_{CB} = 40V$			100	nA	
I_{EBO}	$V_{EB} = 6V$			100	nA	

Process 04

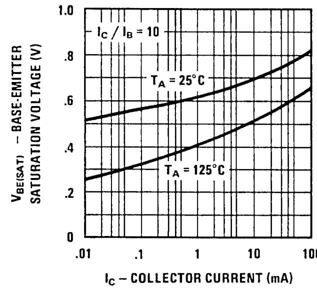
DC Current Gain vs Collector Current



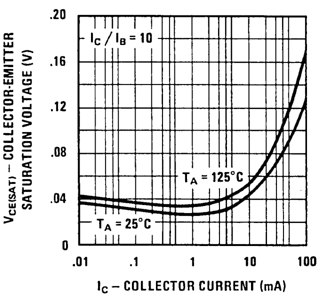
Base-Emitter ON Voltage vs Collector Current



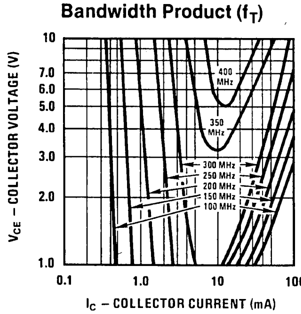
Base-Emitter Saturation Voltage vs Collector Current



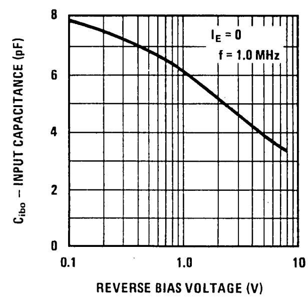
Collector-Emitter Saturation Voltage vs Collector Current



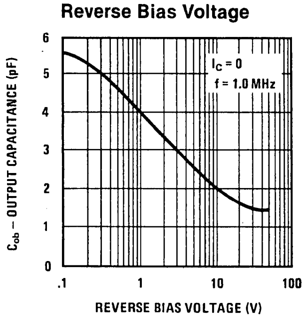
Contours of Constant Gain Bandwidth Product (f_T)



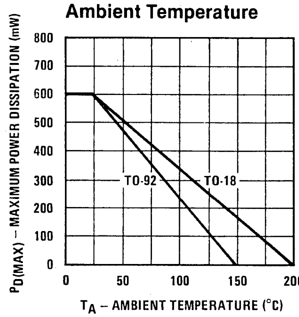
Input Capacitance vs Reverse Bias Voltage



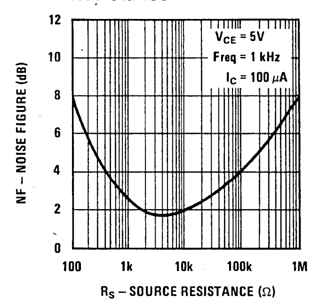
Output Capacitance vs Reverse Bias Voltage



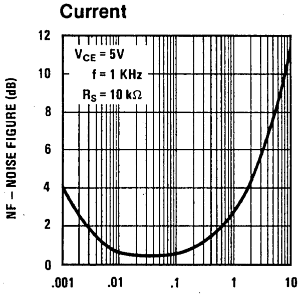
Maximum Power Dissipation vs Ambient Temperature



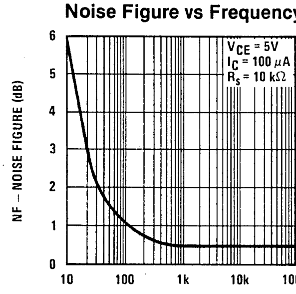
Noise Figure vs Source Resistance



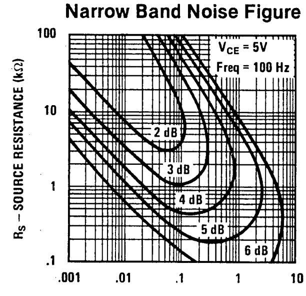
Noise Figure vs Collector Current



Noise Figure vs Frequency

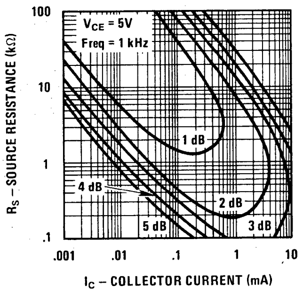


Contours of Constant Narrow Band Noise Figure

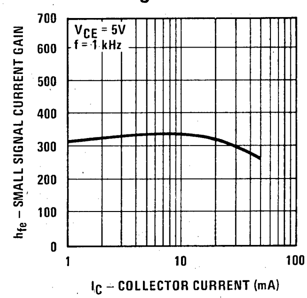


Process 04

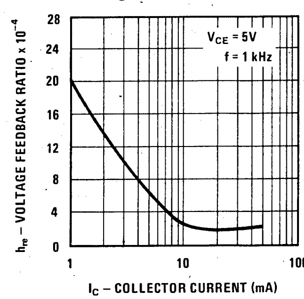
Contours of Constant Narrow Band Noise Figure



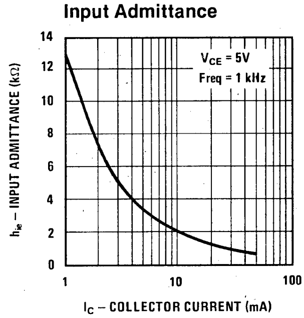
Small Signal Current Gain



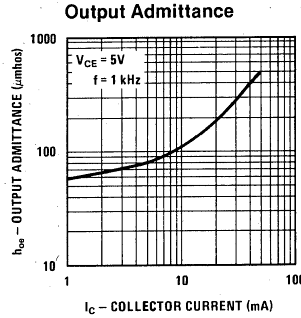
Voltage Feedback Ratio



Input Admittance

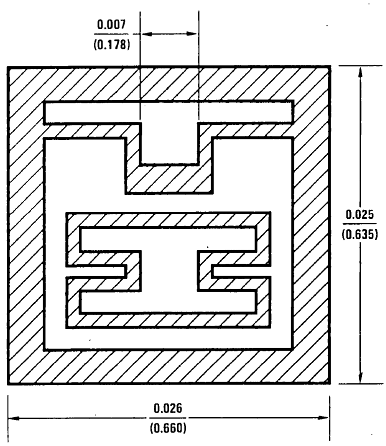


Output Admittance



National Semiconductor

Process 05 NPN Darlington



DESCRIPTION

Process 05 is a monolithic, double-diffused, silicon epitaxial Darlington. Complement to Process 61.

APPLICATION

This device is designed for applications requiring extremely high current gain at collector currents to 1.5A.

PRINCIPAL DEVICE TYPES

TO-202, EBC: D40C1-8, D40K1-4, NSD151-4, NSDU45, 45A

TO-237, EBC: 2N6724, 5 (92PU45, 45A)

TO-92, EBC: MPSA12-14

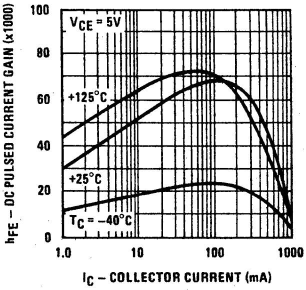
TO-92, ECB: 2N5305-08

Parameter	Conditions	Min	Typ	Max	Units	Notes
NF	$I_C = 1$ mA, $V_{CE} = 5V$, $R_S = 100k$, f = 1 kHz		2		dB	
C_{CB}	$V_{CB} = 10V$, $I_E = 0$, f = 1 MHz		4	6	pF	
h_{FE}	$I_C = 10$ mA, $V_{CE} = 5V$	4,000				
h_{FE}	$I_C = 100$ mA, $V_{CE} = 5V$	8,000	40,000	200,000		
h_{FE}	$I_C = 1A$, $V_{CE} = 5V$	3,000				
$V_{CE(SAT)}$	10 mA, 0.01 mA			1.0	V	
$V_{CE(SAT)}$	100 mA, 0.1 mA			1.5	V	
$V_{BE(ON)}$	10 mA, 5V		1.2	1.4	V	
$V_{BE(ON)}$	100 mA, 5V		1.25	1.8	V	
h_{fe}	$I_C = 10$ mA, $V_{CE} = 5.0V$, f = 1 kHz		60,000			
BV_{CES}	$I_C = 100\ \mu A$	40			V	
BV_{EBO}	$I_E = 10\ \mu A$	12			V	
I_{CES}	$V_{CE} = 15V$, $V_{BE} = 0$			100	nA	
I_{CBO}	$V_{CB} = 30V$, $I_E = 0$			100	nA	
I_{EBO}	$V_{EB} = 10V$, $I_C = 0$			100	nA	
$P_{D(max)}$						
TO-202	$T_C = 25°C$	10			W	
	$T_A = 25°C$	2				
TO-237	$T_{COLLECTOR\ LEAD} = 25°C$	2			W	
	$T_A = 25°C$	850			mW	
TO-92	$T_A = 25°C$	600			mW	
θ_{JC}						
TO-202	$T_C = 25°C$			12.5	°C/W	
TO-237	$T_{COLLECTOR\ LEAD} = 25°C$			62.5	°C/W	
θ_{JA}						
TO-202	$T_A = 25°C$			62.5	°C/W	
TO-237	$T_A = 25°C$			147	°C/W	
TO-92	$T_A = 25°C$			208	°C/W	
$T_{J(max)}$	All Plastic Parts	150			°C	

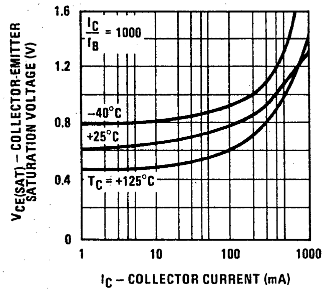
8

Process 05

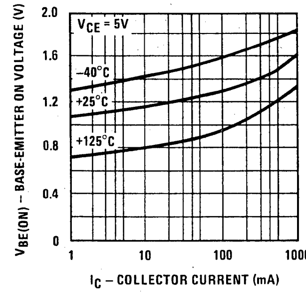
DC Pulsed Current Gain vs Collector Current



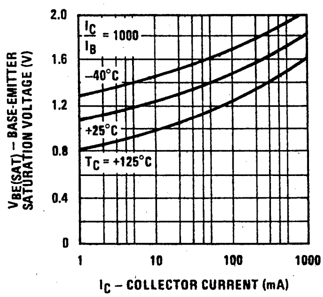
Collector-Emitter Saturation Voltage vs Collector Current



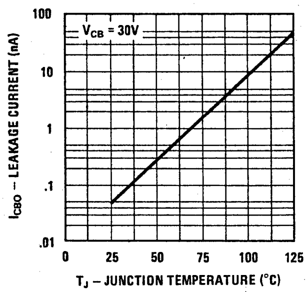
Base-Emitter ON Voltage vs Collector Current



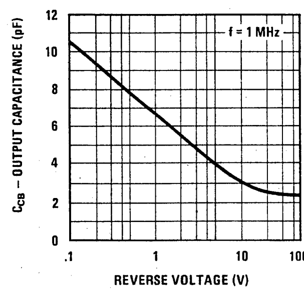
Base-Emitter Saturation Voltage vs Collector Current



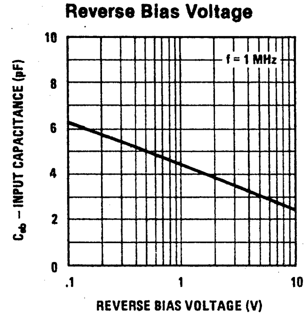
Collector-Base Diode Reverse Current vs Temperature



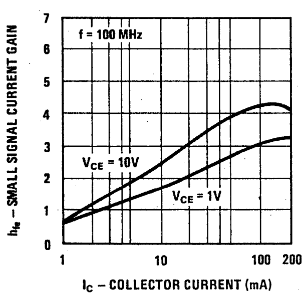
Output Capacitance vs Reverse Bias Voltage



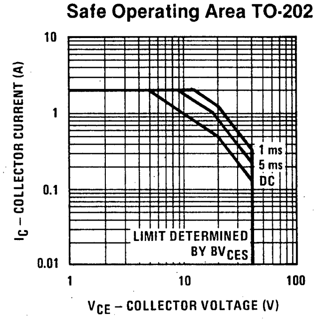
Input Capacitance vs Reverse Bias Voltage



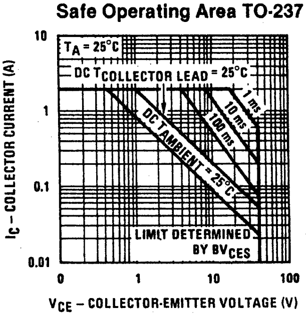
Small Signal Current Gain vs Collector Current



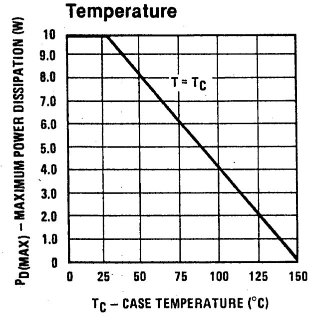
Safe Operating Area TO-202



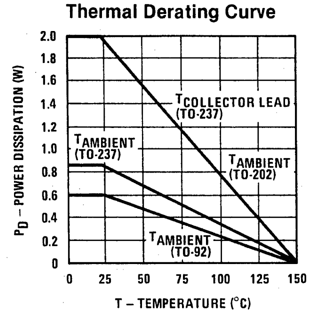
Safe Operating Area TO-237



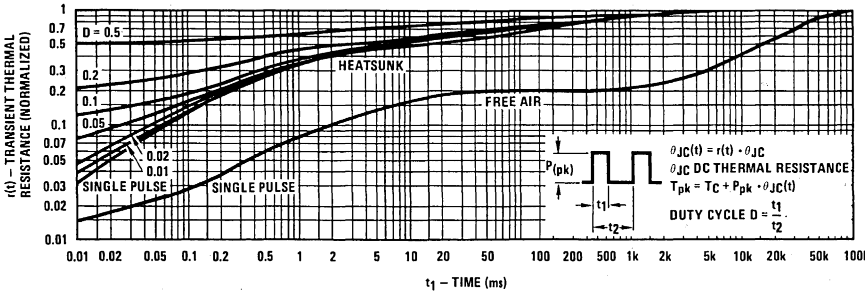
Maximum Power Dissipation TO-202 vs Case Temperature



Thermal Derating Curve

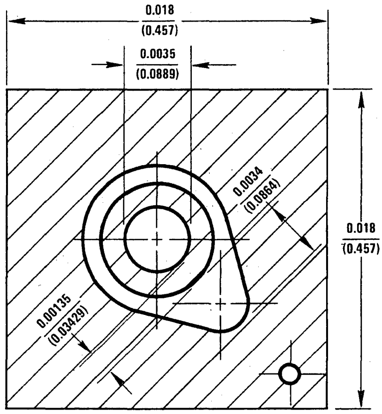


Thermal Response in TO-202 Package



National Semiconductor

Process 07 NPN Small Signal



DESCRIPTION

Process 07 a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 62.

APPLICATION

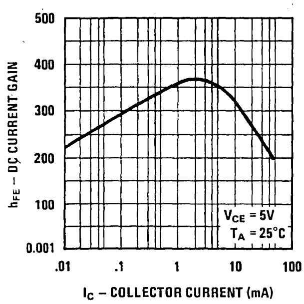
This device was designed for low noise, high gain, general purpose amplifier applications from 1 μA to 25 mA collector current.

PRINCIPAL DEVICE TYPES

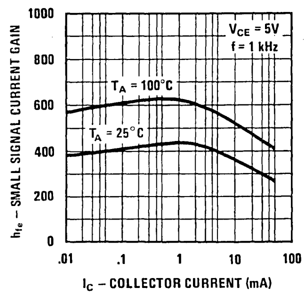
TO-18: 2N930
TO-92, EBC: 2N5088
TO-92, ECB: 2N3392

Parameter	Conditions	Min	Typ	Max	Units	Notes
NF (spot)	$I_C = 10\ \mu A$, $V_{CE} = 5V$, $R_S = 10k$, f = 100 kHz		3	10	dB	TO-18
NF (spot)	$I_C = 10\ \mu A$, $V_{CE} = 5V$, $R_S = 10k$, f = 1 kHz		1	3	dB	TO-18
NF (spot)	$I_C = 10\ \mu A$, $V_{CE} = 5V$, $R_S = 10k$, f = 10 kHz		1	3	dB	TO-18
NF (wideband)	$I_C = 10\ \mu A$, $V_{CE} = 5V$, $R_S = 10k$, $P_{BW} = 15.7$ kHz		1	3	dB	TO-18
h_{fe}	$I_C = 500\ \mu A$, $V_{CE} = 5V$, f = 20 MHz	3	6			
C_{ob}	$V_{CB} = 5V$, f = 1 MHz		1.7	3.0	pF	
C_{eb}	$V_{EB} = 0.50V$, f = 1 MHz			8.0	pF	
h_{FE}	$I_C = 1\ \mu A$, $V_{CE} = 5V$	35				
h_{FE}	$I_C = 10\ \mu A$, $V_{CE} = 5V$	50				
h_{FE}	$I_C = 100\ \mu A$, $V_{CE} = 5V$	70				
h_{FE}	$I_C = 500\ \mu A$, $V_{CE} = 5V$	80				
h_{FE}	$I_C = 1$ mA, $V_{CE} = 5V$	90	360	1,000		
h_{FE}	$I_C = 20$ mA, $V_{CE} = 5V$	50				
$V_{CE(SAT)}$	$I_C = 1$ mA, $I_B = 0.10$ mA			0.10	V	
$V_{CE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA			0.15	V	
$V_{BE(SAT)}$	$I_C = 1$ mA, $I_B = 0.1$ mA			0.75	V	
$V_{BE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA			0.85	V	
BV_{CEO}	$I_C = 1$ mA	60			V	
BV_{CBO}	$I_C = 10\ \mu A$	60			V	
BV_{EBO}	$I_E = 10\ \mu A$	8			V	
I_{CBO}	$V_{CB} = 45V$			100	nA	
I_{EBO}	$V_{EB} = 6V$			100	nA	

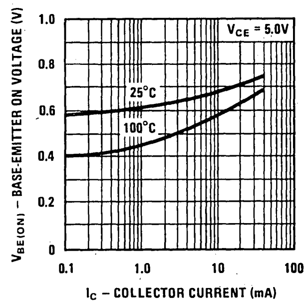
DC Current Gain vs Collector Current



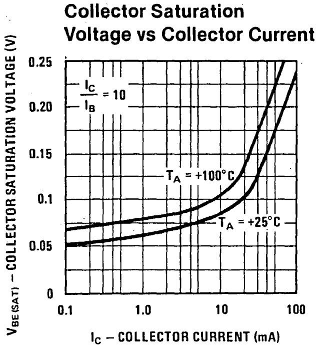
Small Signal Current Gain vs Collector Current



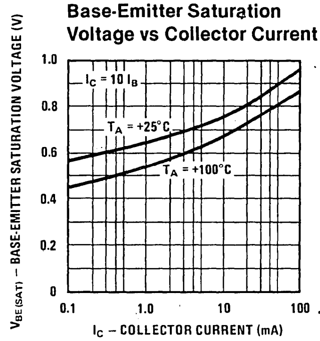
Base-Emitter ON Voltage vs Collector Current



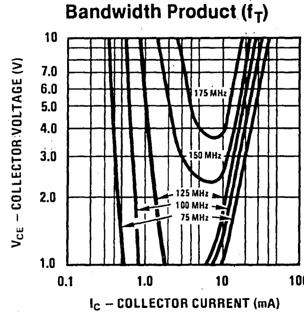
Collector Saturation Voltage vs Collector Current



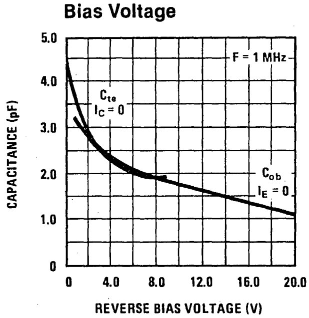
Base-Emitter Saturation Voltage vs Collector Current



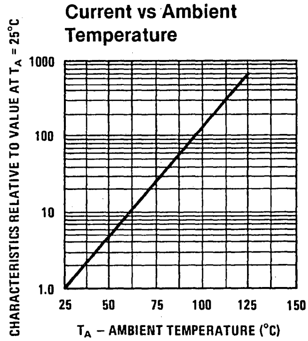
Contours of Constant Gain Bandwidth Product (f_T)



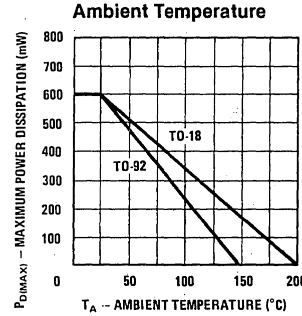
Input and Output Capacitance vs Reverse Bias Voltage



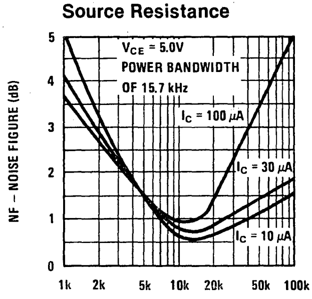
Normalized Collector Cutoff Current vs Ambient Temperature



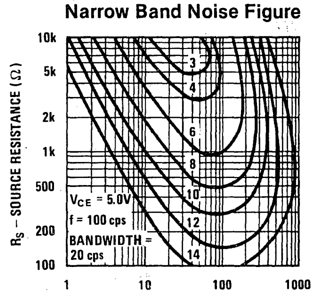
Maximum Power Dissipation vs Ambient Temperature



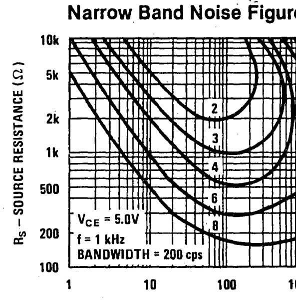
Wideband Noise Figure vs Source Resistance



Contours of Constant Narrow Band Noise Figure

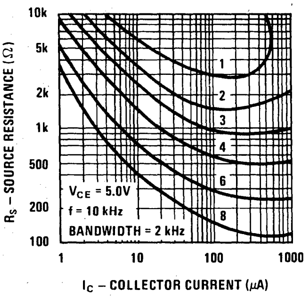


Contours of Constant Narrow Band Noise Figure

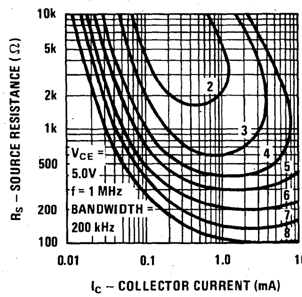


Process 07

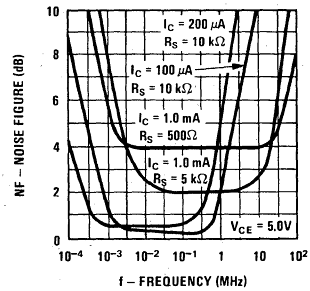
Contours of Constant Narrow Band Noise Figure



Contours of Constant Narrow Band Noise Figure



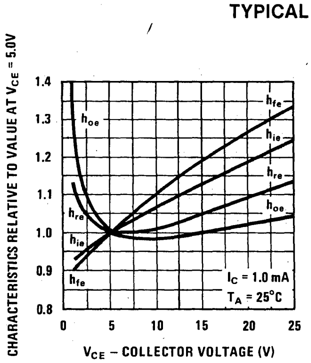
Noise Figure vs Frequency

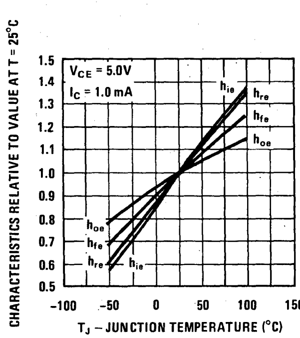


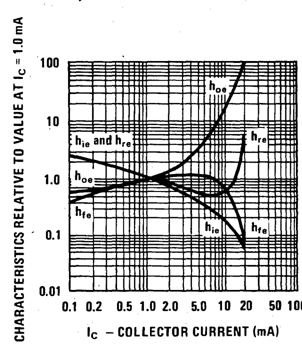
SMALL SIGNAL CHARACTERISTICS (f = 1.0 kHz)

Symbol	Characteristic	Typ	Units	Conditions
h_{ie}	Input Resistance	15	kΩ	$I_C = 1.0$ mA, $V_{CE} = 5.0$V
h_{oe}	Output Conductance	15	μmho	$I_C = 1.0$ mA, $V_{CE} = 5.0$V
h_{re}	Voltage Feedback Ratio	425	$\times 10^{-6}$	$I_C = 1.0$ mA, $V_{CE} = 5.0$V
h_{fe}	Small Signal Current Gain	400		$I_C = 1.0$ mA, $V_{CE} = 5.0$V
h_{ib}	Input Resistance	27	Ω	$I_C = 1.0$ mA, $V_{CE} = 5.0$V

TYPICAL COMMON EMITTER CHARACTERISTICS (f = 1.0 kHz)

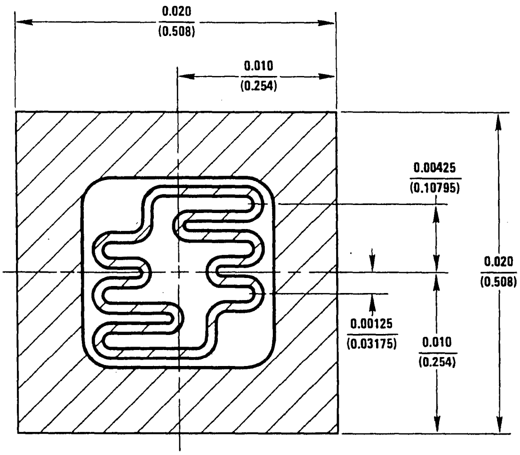






National Semiconductor

Process 09 NPN Medium Power



DESCRIPTION

Process 09 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 68.

APPLICATION

This device was designed for general purpose audio amplifier applications at collector currents to 1A.

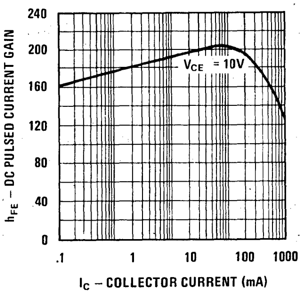
PRINCIPAL DEVICE TYPES

TO-92, EBC: CS9013

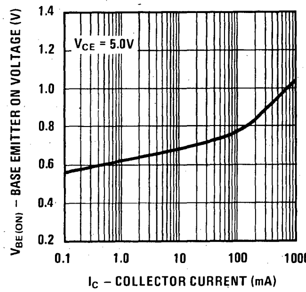
Parameter	Conditions	Min	Typ	Max	Units	Notes
C_{ob}	$V_{CB} = 10V$, $f = 1$ MHz		6	8	pF	
C_{ib}	$V_{EB} = 0.5V$, $f = 1$ MHz			35	pF	
NF	$V_{CE} = 10V$, $I_C = 1$ mA, $R_S = 100\Omega$, $f = 1$ kHz		2.0		dB	
f_T	$V_{CE} = 10V$, $I_C = 50$ mA	200			MHz	
h_{FE}	$V_{CE} = 1.0V$, $I_C = 1$ mA	40				
h_{FE}	$V_{CE} = 1.0V$, $I_C = 100$ mA	60	180	360		
h_{FE}	$V_{CE} = 1.0V$, $I_C = 500$ mA	35				
$V_{CE(SAT)}$	$I_C = 150$ mA, $I_B = 15$ mA			0.2	V	
$V_{CE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA		0.25	0.4	V	
$V_{BE(SAT)}$	$I_C = 150$ mA, $I_B = 15$ mA			1.0	V	
$V_{BE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA			1.2	V	
BV_{CBO}	$I_C = 100\ \mu A$	45				
BV_{CEO}	$I_C = 10$ mA	25				
BV_{EBO}	$I_E = 10\ \mu A$	6.0				
I_{CBO}	$V_{CB} = 40V$			100	nA	
I_{EBO}	$V_{EB} = 4.0V$			100	nA	

Process 09

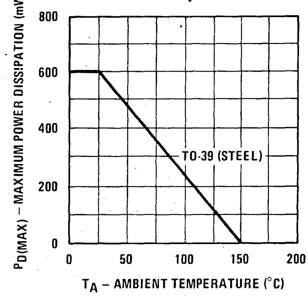
DC Pulsed Current Gain vs Collector Current



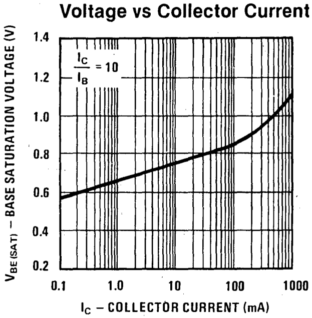
Base-Emitter ON Voltage vs Collector Current



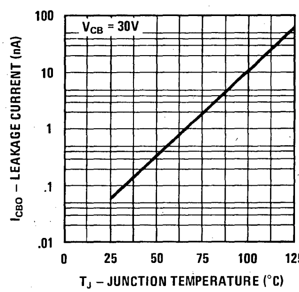
Maximum Power Dissipation vs Ambient Temperature



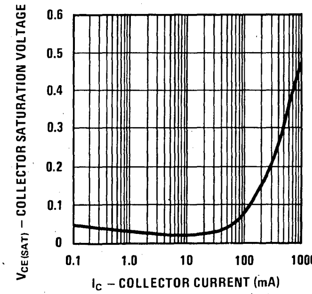
Base-Emitter Saturation Voltage vs Collector Current



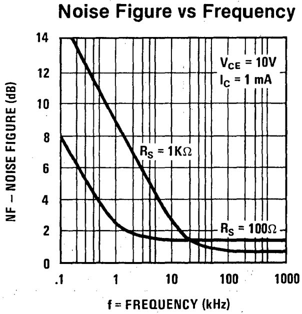
Collector-Base Diode Reverse Current vs Temperature



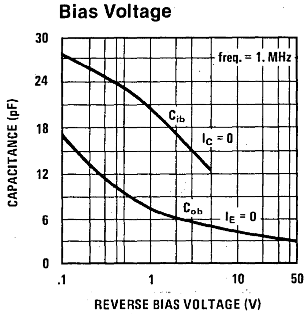
Collector-Emitter Saturation Voltage vs Collector Current



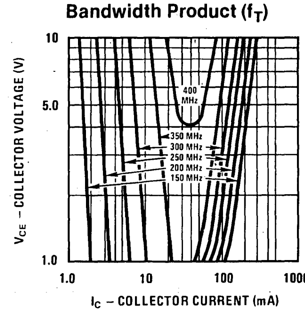
Noise Figure vs Frequency



Capacitance vs Reverse Bias Voltage

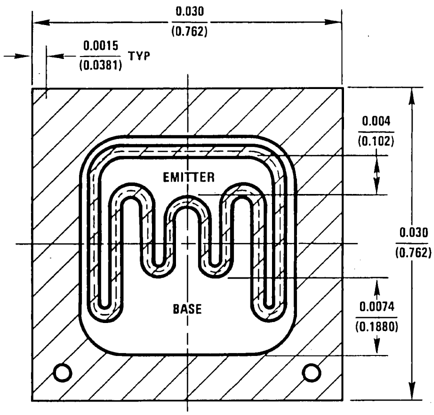


Contours of Constant Gain Bandwidth Product (f_T)



National Semiconductor

Process 12 NPN Medium Power



DESCRIPTION

Process 12 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 67.

APPLICATION

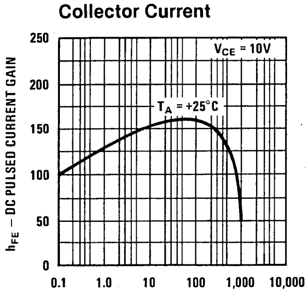
This device was designed for general purpose medium power amplifiers and switches requiring collector currents up to 1A and collector voltages up to 80V.

PRINCIPAL DEVICE TYPES

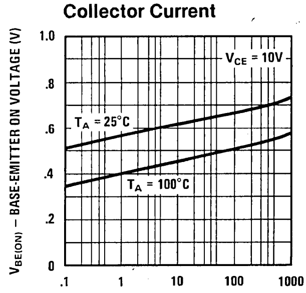
TO-92, EBC: MPSA05
TO-39: 2N3019
TO-202: NSD106
TO-237: TN3019
TN3020

Parameter	Conditions	Min	Typ	Max	Units	Notes
t_{ON}	$I_C = 150$ mA, $I_{B1} = 15$ mA		50		ns	*Figure 1*
t_{OFF}	$I_C = 150$ mA, $I_{B2} = 15$ mA		400		ns	*Figure 1*
h_{fe}	$I_C = 50$ mA, $V_{CE} = 10V$, f = 20 MHz	4.0	6.5			
C_{ob}	$V_{CB} = 10V$, f = 1 MHz		6.5	10	pF	
C_{eb}	$V_{EB} = 0.5V$, f = 1 MHz			60	pF	
h_{FE}	$I_C = 1$ mA, $V_{CE} = 10V$	30				
h_{FE}	$I_C = 10$ mA, $V_{CE} = 10V$	35				
h_{FE}	$I_C = 150$ mA, $V_{CE} = 10V$	40	160	320		
h_{FE}	$I_C = 500$ mA, $V_{CE} = 10V$	30				
$V_{CE(SAT)}$	$I_C = 100$ mA, $I_B = 10$ mA			0.2	V	
$V_{CE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA			0.5	V	
$V_{BE(SAT)}$	$I_C = 100$ mA, $I_B = 10$ mA			0.90	V	
$V_{BE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA			1.20	V	
BV_{CEO}	$I_C = 10$ mA	65			V	
BV_{CBO}	$I_C = 100$ μA	100			V	
BV_{EBO}	$I_C = 10$ μA	7			V	
I_{CBO}	$V_{CB} = 80V$			100	nA	
I_{EBO}	$V_{EB} = 6V$			100	nA	

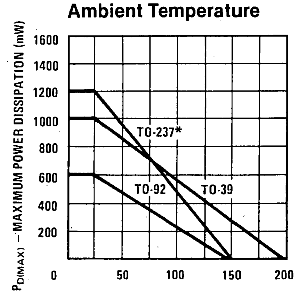
Pulsed DC Current Gain vs Collector Current



Base-Emitter ON Voltage vs Collector Current

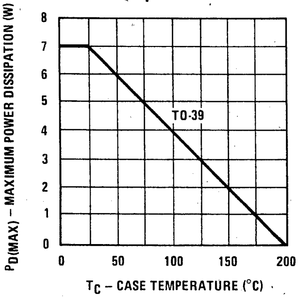


Maximum Power Dissipation vs Ambient Temperature

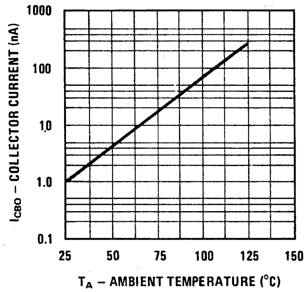


* One square inch of copper run

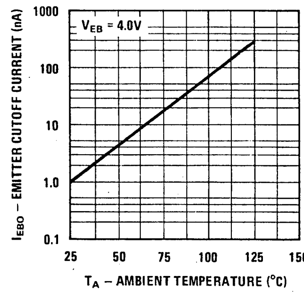
Maximum Power Dissipation vs Case Temperature



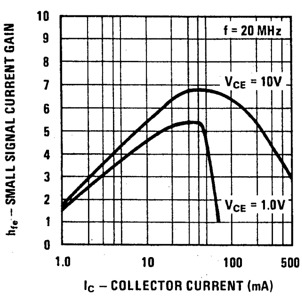
Collector Reverse Current vs Ambient Temperature



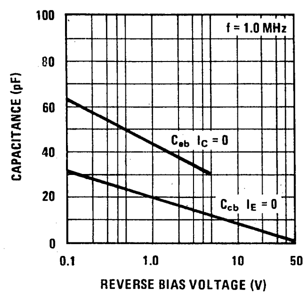
Emitter Cutoff Current vs Ambient Temperature



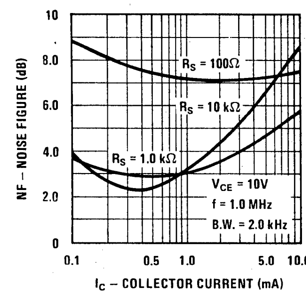
Small Signal Current Gain at 20 MHz



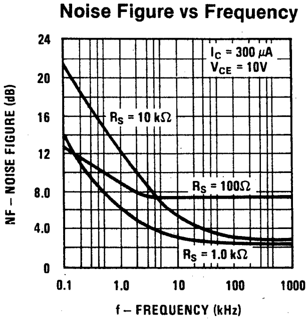
Collector-Base and Emitter-Base Capacitance vs Reverse Bias Voltage



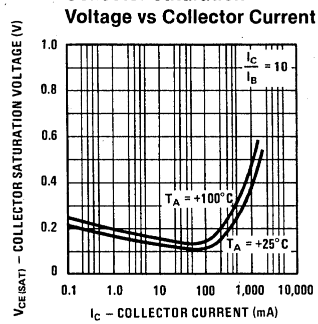
Noise Figure vs Collector Current



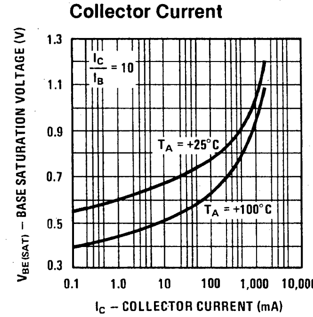
Noise Figure vs Frequency



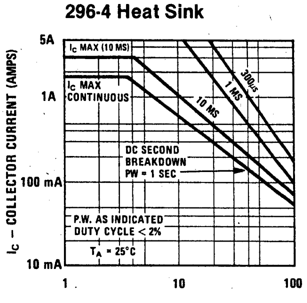
Collector Saturation Voltage vs Collector Current



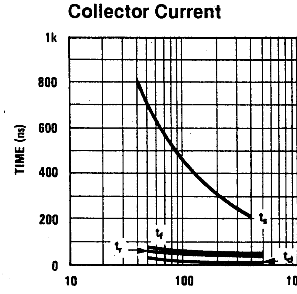
Base Saturation Voltage vs Collector Current



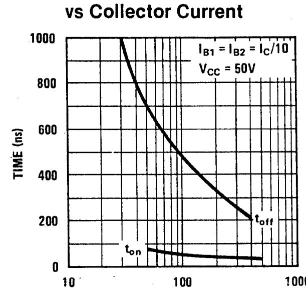
Safe Operating Area TO-39 with "Wake Field" Type 296-4 Heat Sink



Switching Times vs Collector Current

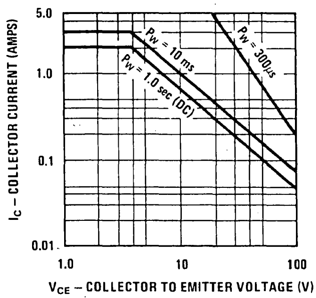


Turn On and Turn Off Times vs Collector Current

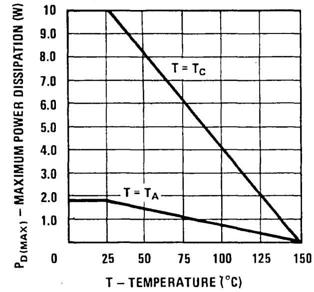


Process 12

Safe Operating Area TO-202



Maximum Power Dissipation TO-202 vs Case and Ambient Temperature



I_C	R_b	R_L
150 mA	314Ω	330Ω
300 mA	157Ω	167Ω
500 mA	94Ω	100Ω

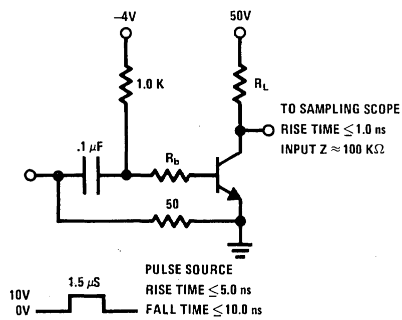
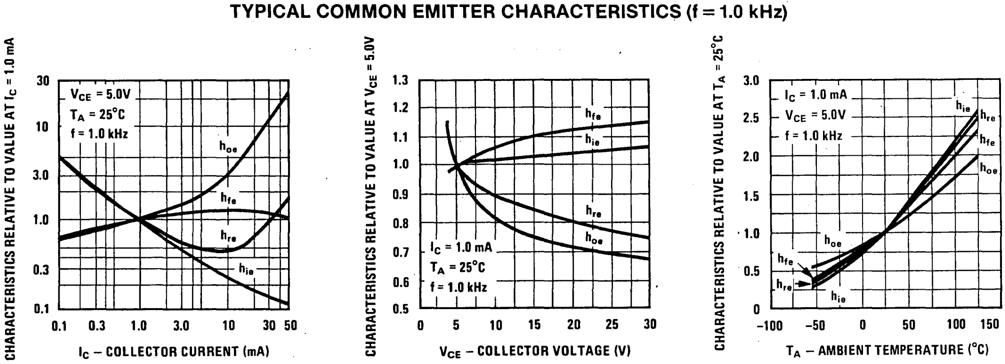


FIGURE 1. t_{ON}, t_{OFF} Test Circuit

SMALL SIGNAL CHARACTERISTICS (f = 1.0 kHz)

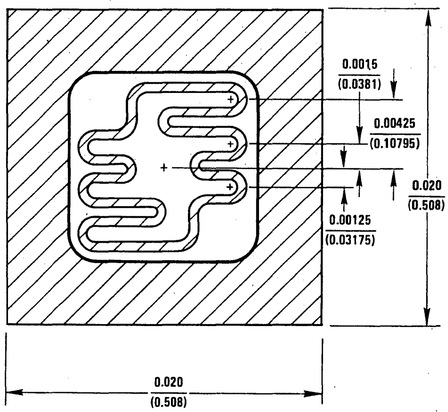
Symbol	Characteristic	Typ	Units	Conditions
h_{ie}	Input Resistance	3000	Ω	$I_C = 1.0$ mA, $V_{CE} = 5.0$V
h_{oe}	Output Conductance	8.0	µmhos	$I_C = 1.0$ mA, $V_{CE} = 5.0$V
h_{re}	Voltage Feedback Ratio	2.1	$\times 10^{-4}$	$I_C = 1.0$ mA, $V_{CE} = 5.0$V
h_{fe}	Small Signal Current Gain	100		$I_C = 1.0$ mA, $V_{CE} = 5.0$V

TYPICAL COMMON EMITTER CHARACTERISTICS (f = 1.0 kHz)



National Semiconductor

Process 13 NPN Medium Power



DESCRIPTION

Process 13 is a non-overlay, double-diffused, silicon epitaxial device.

APPLICATION

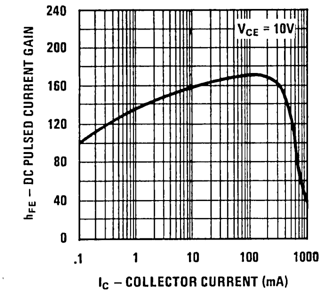
This device was designed for use as medium power amplifiers and switches requiring collector currents of 100 μA to 500 mA.

PRINCIPAL DEVICE TYPES

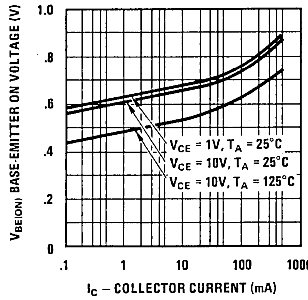
TO-92, EBC: 2N440T
TO-92, ECB: 2N3704

Parameter	Conditions	Min	Typ	Max	Units	Notes
t_{ON}	$I_C = 150$ mA, $I_{B1} = 15$ mA		35		ns	
t_{OFF}	$I_C = 150$ mA, $I_{B2} = 15$ mA		250		ns	
h_{fe}	$I_C = 20$ mA, $V_{CE} = 20V$, f = 100 MHz	2.0	3.0			
NF (spot)	$I_C = 100$ μA, $V_{CE} = 10V$, $R_S = 1$ kΩ, f = 1 kHz		1.2		dB	
C_{ob}	$V_{CB} = 10V$, f = 1 MHz		4.5	8.0	pF	
C_{ib}	$V_{EB} = 0.5V$, f = 1 MHz			35	pF	
h_{FE}	$V_{CE} = 1.0V$, $I_C = 1.0$ mA	30				
h_{FE}	$V_{CE} = 1.0V$, $I_C = 10$ mA	40				
h_{FE}	$V_{CE} = 1.0V$, $I_C = 100$ mA	50	150	300		
h_{FE}	$V_{CE} = 1.0V$, $I_C = 500$ mA	25				
$V_{CE(SAT)}$	$I_C = 150$ mA, $I_B = 15$ mA			0.2	V	
$V_{CE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA			0.5	V	
$V_{BE(SAT)}$	$I_C = 150$ mA, $I_B = 15$ mA			1.0	V	
$V_{BE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA			1.2	V	
BV_{CBO}	$I_C = 100$ μA	60			V	
BV_{CEO}	$I_C = 10$ mA	35			V	
BV_{EBO}	$I_C = 10$ μA	6.0			V	
I_{CBO}	$V_{CB} = 40V$			100	nA	
I_{EBO}	$V_{EB} = 4V$			100	nA	

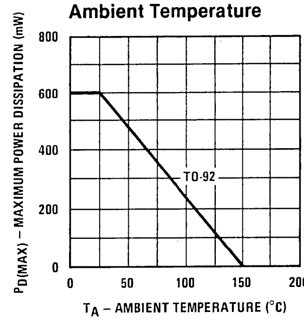
DC Pulsed Current Gain vs Collector Current



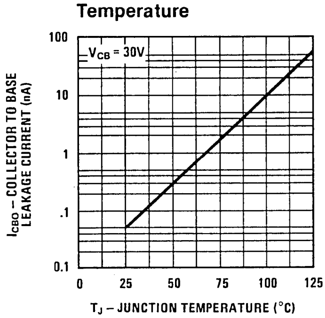
Base-Emitter ON Voltage vs Collector Current



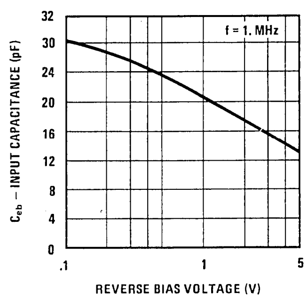
Maximum Power Dissipation vs Ambient Temperature



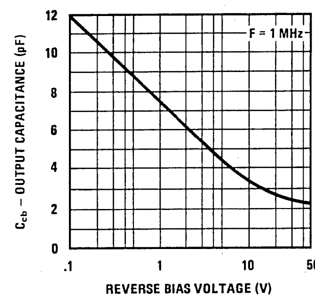
Collector-Base Diode Reverse Current vs Temperature



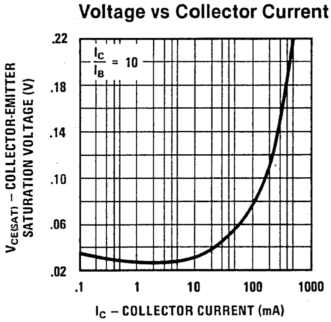
Input Capacitance vs Reverse Bias Voltage



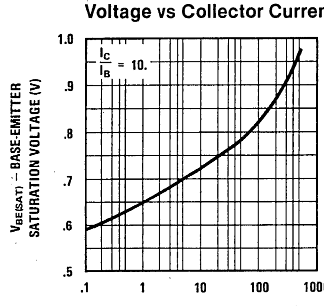
Output Capacitance vs Reverse Bias Voltage



Collector-Emitter Saturation Voltage vs Collector Current

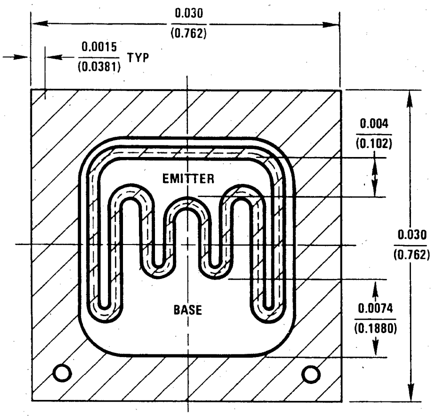


Base-Emitter Saturation Voltage vs Collector Current



National Semiconductor

Process 14 NPN Medium Power



DESCRIPTION

Process 14 is a non-overlay, double-diffused, silicon epitaxial device.

APPLICATION

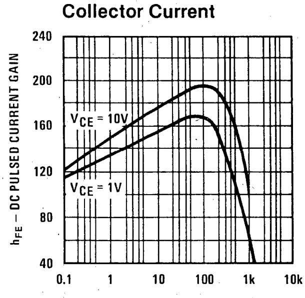
This device was designed for general purpose amplifier applications at collector currents to 1A.

PRINCIPAL DEVICE TYPES

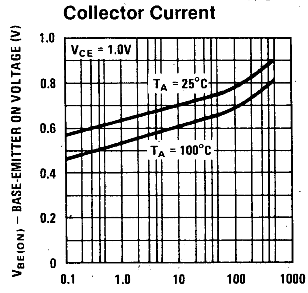
TO-39: BFY50
TO-92, EBC: MPS6560

Parameter	Conditions	Min	Typ	Max	Units	Notes
C_{ob}	$V_{CB}=10V$, f = 1 MHz		8	12	pF	
C_{ib}	$V_{EB}=0.5V$, f = 1 MHz			65	pF	
h_{fe}	$I_C=50$ mA, $V_{CE}=10V$, f = 20 MHz	5	10			
NF	$I_C=100\ \mu A$, $V_{CE}=5V$, $R_S=1\ k\Omega$, f = 1 kHz		1.2		dB	
h_{FE}	$I_C=1$ mA, $V_{CE}=1V$	40				
h_{FE}	$I_C=10$ mA, $V_{CE}=1V$	50				
h_{FE}	$I_C=150$ mA, $V_{CE}=1V$	60	180	360		
h_{FE}	$I_C=500$ mA, $V_{CE}=1V$	30				
$V_{CE(SAT)}$	$I_C=10$ mA, $I_B=1$ mA			0.10	V	
$V_{CE(SAT)}$	$I_C=150$ mA, $I_B=10$ mA			0.15	V	
$V_{BE(SAT)}$	$I_C=10$ mA, $I_B=1$ mA			0.85	V	
$V_{BE(SAT)}$	$I_C=150$ mA, $I_B=10$ mA			1.0	V	
BV_{CEO}	$I_C=10$ mA	35			V	
BV_{CBO}	$I_C=100\ \mu A$	60			V	
BV_{EBO}	$I_E=10\ \mu A$	7			V	
I_{CBO}	$V_{CB}=40V$			100	nA	
I_{EBO}	$V_{EB}=5V$			100	nA	

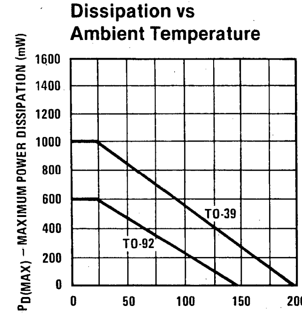
DC Pulsed Current Gain vs Collector Current



Base-Emitter ON Voltage vs Collector Current

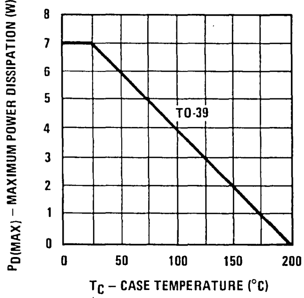


Maximum Power Dissipation vs Ambient Temperature

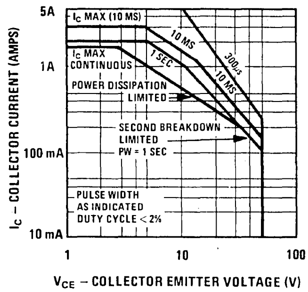


Process 14

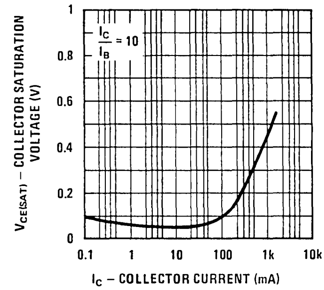
Maximum Power Dissipation vs Case Temperature



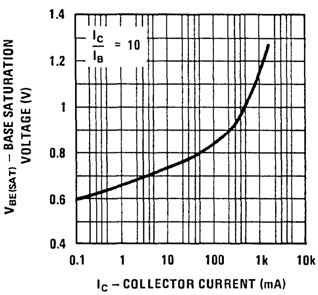
Safe Operating Area TO-39 with "Wake Field" Type 296-4 Heat Sink



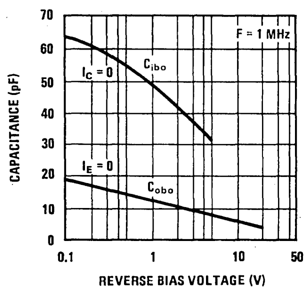
Collector-Emitter Saturation Voltage vs Collector Current



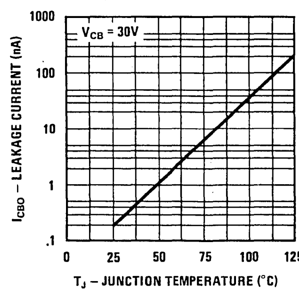
Base-Emitter Saturation Voltage vs Collector Current



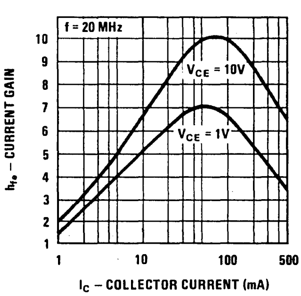
Capacitance vs Reverse Bias Voltage



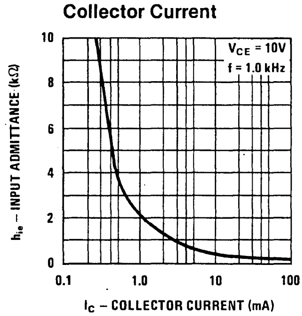
Collector-Base Diode Reverse Current vs Temperature



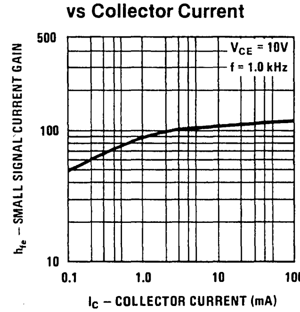
Small Signal Current Gain at 20 MHz vs Collector Current



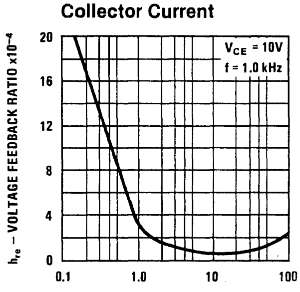
Input Admittance vs Collector Current



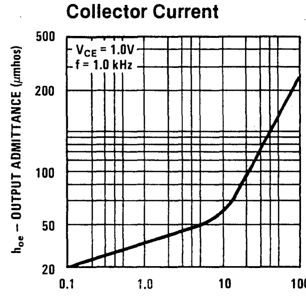
Small Signal Current Gain vs Collector Current



Voltage Feedback Ratio vs Collector Current

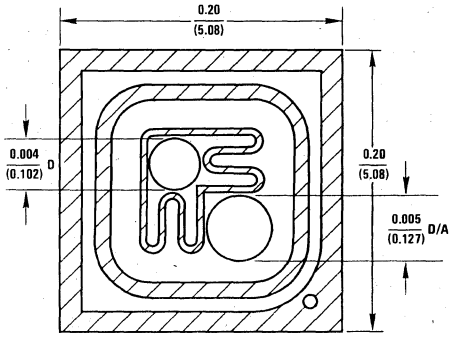


Output Admittance vs Collector Current



National Semiconductor

Process 16 NPN High Voltage



DESCRIPTION

Process 16 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 74.

APPLICATION

This device was designed for general purpose high voltage amplifiers and gas discharge display driving.

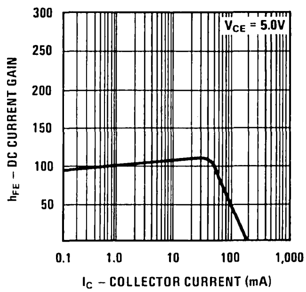
PRINCIPAL DEVICE TYPES

TO-92, EBC: 2N5551

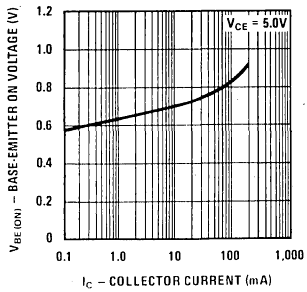
Parameter	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 1.0$ mA	120			V
BV_{CBO}	$I_C = 10\ \mu A$	140			V
BV_{EBO}	$I_E = 10\ \mu A$	6			V
I_{CBO}	$V_{CB} = 100V$			100	nA
I_{EBO}	$V_{EB} = 4.0V$			100	nA
h_{FE}	$I_C = 1.0$ mA, $V_{CE} = 5.0V$	40			
h_{FE}	$I_C = 10$ mA, $V_{CE} = 5.0V$	50	120	300	
h_{FE}	$I_C = 50$ mA, $V_{CE} = 5.0V$	20			
$V_{CE(SAT)}$	$I_C = 10$ mA, $I_B = 1.0$ mA			0.15	V
$V_{CE(SAT)}$	$I_C = 50$ mA, $I_B = 5.0$ mA			0.30	V
$V_{BE(SAT)}$	$I_C = 10$ mA, $I_B = 1.0$ mA			0.90	V
$V_{BE(SAT)}$	$I_C = 50$ mA, $I_B = 5$ mA			1.2	V
f_T	$I_C = 10$ mA, $V_{CE} = 10V$, f = 100 MHz	100	220		MHz
C_{ob}	$V_{CB} = 10V$, f = 1 MHz		3.0	5.0	pF
C_{ib}	$V_{EB} = 0.5V$, f = 1 MHz			30	pF

Process 16

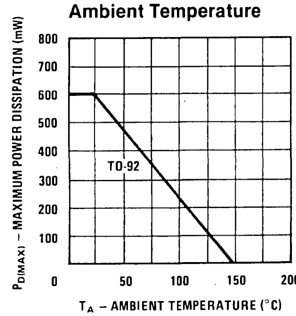
DC Current Gain vs Collector Current



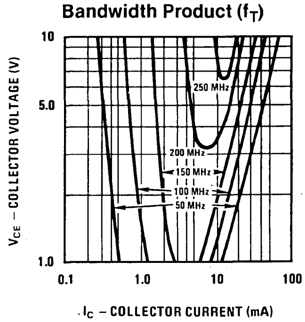
Base-Emitter ON Voltage vs Collector Current



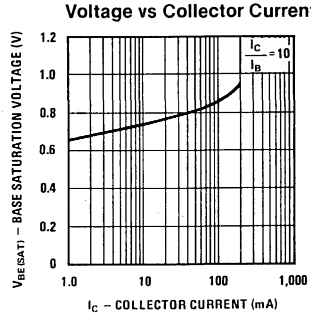
Maximum Power Dissipation vs Ambient Temperature



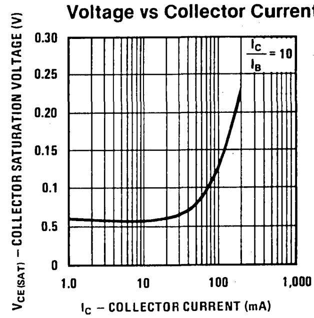
Contours of Constant Gain Bandwidth Product (f_T)



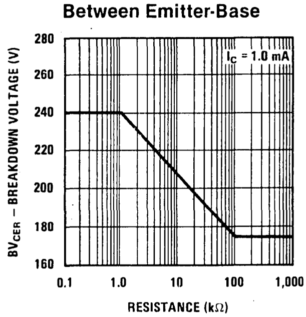
Base-Emitter Saturation Voltage vs Collector Current



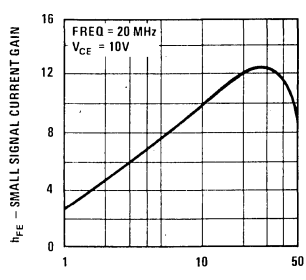
Collector-Emitter Saturation Voltage vs Collector Current



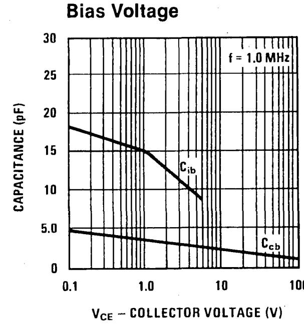
Collector-Emitter Breakdown Voltage with Resistance Between Emitter-Base



Small Signal Current Gain vs Collector Current

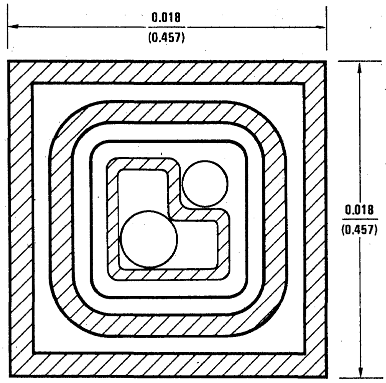


Input and Output Capacitance vs Reverse Bias Voltage



National Semiconductor

Process 17
NPN High Voltage Video Output



DESCRIPTION

Process 17 is a non-overlay, planar epitaxial silicon transistor with a field plate.

APPLICATION

This device was designed as video output to drive color CRT, mainly in complementary configurations. Complement to Process 76.

PRINCIPAL DEVICE TYPES

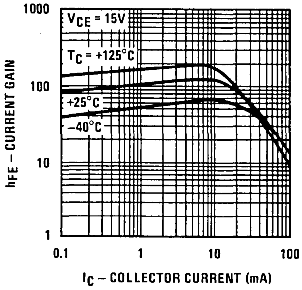
TO-202, ECB: NSE869
NSE871

TO-237, ECB: 92PE869
92PE871

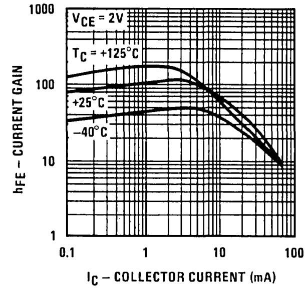
Parameter	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 1$ mA (Note 1)	220	280		V
BV_{CES}	$I_C = 100\ \mu A$		400		V
BV_{EBO}	$I_E = 10\ \mu A$	6			V
I_{CES}	$V_{CE} = 150V$			200	nA
I_{EBO}	$V_{EB} = 5V$			100	nA
h_{FE1}	$V_{CE} = 15V$, $I_C = 0.1$ mA		60		
h_{FE2}	$V_{CE} = 15V$, $I_C = 25$ mA	40	80	200	
h_{FE3}	$V_{CE} = 15V$, $I_C = 50$ mA		25		
$V_{CE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA		0.1	1.0	V
$V_{BE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA		0.7		V
f_T	$V_{CE} = 15V$, $I_C = 10$ mA, f = 20 MHz		90		MHz
C_{cb}	$V_{CB} = 10V$, f = 1 MHz		1.6		pF
C_{ib}	$V_{EB} = 1V$, f = 1 MHz		2.7		pF
$P_{D(max)}$					
TO-202	$T_C = 25°C$ $T_A = 25°C$	8 1.8			W
TO-237	$T_{COLLECTOR\ LEAD} = 25°C$ $T_A = 25°C$	2 0.85			W
θ_{JC}					
TO-202				15.6	°C/W
TO-237				69.4	°C/W
θ_{JA}					
TO-202				62.5	°C/W
TO-237				147	°C/W
$T_{J(max)}$	All Plastic Parts			150	°C

Note 1: Pulsed measurement, 300 μs pulse width

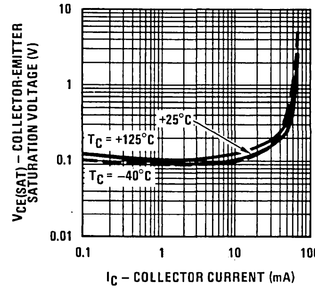
DC Current Gain vs Collector Current



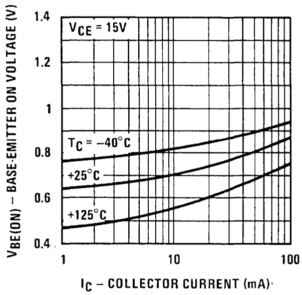
DC Current Gain vs Collector Current



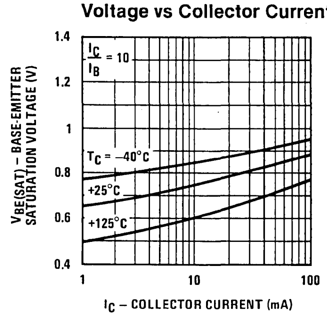
Collector-Emitter Saturation Voltage vs Collector Current



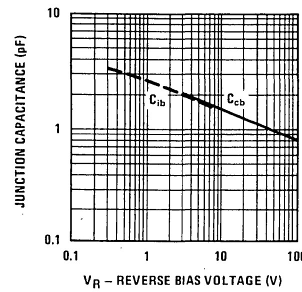
Base-Emitter ON Voltage vs Collector Current



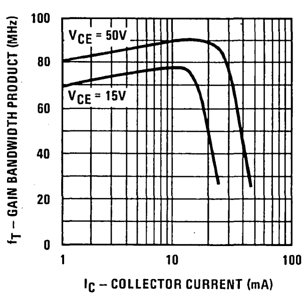
Base-Emitter Saturation Voltage vs Collector Current



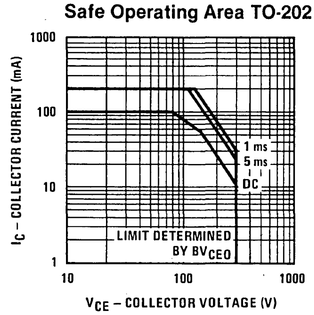
Junction Capacitance vs Reverse Bias Voltage



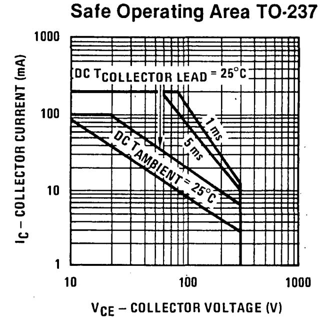
Gain Bandwidth Product vs Collector Current



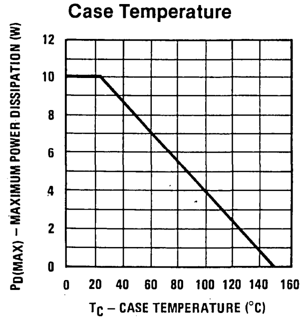
Safe Operating Area TO-202



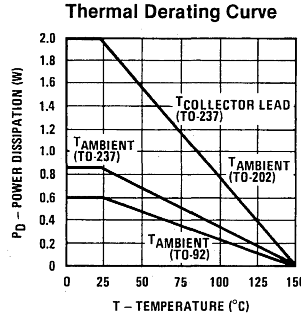
Safe Operating Area TO-237



Maximum Power Dissipation vs Case Temperature

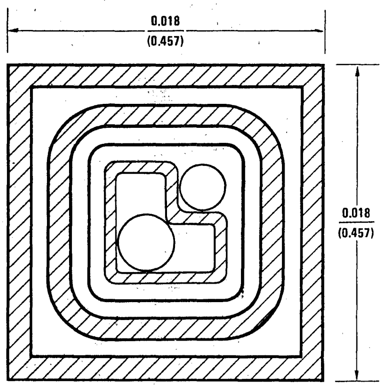


Thermal Derating Curve



National Semiconductor

Process 18 NPN Medium Power



DESCRIPTION

Process 18 is a non-overlay, double-diffused, silicon epitaxial device.

APPLICATION

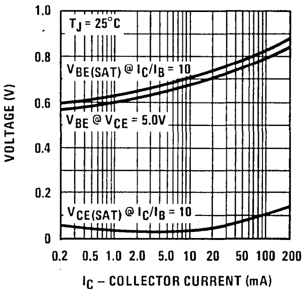
This device was designed for use in general purpose amplifier and switching applications operating in the range of 100 μA to 100 mA.

PRINCIPAL DEVICE TYPES

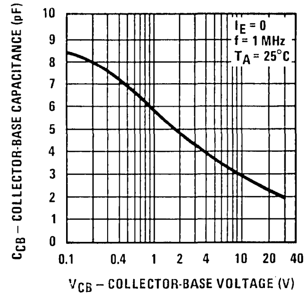
TO-92, CBE: TIS98
TO-92, EBC: MPS8098

Parameter	Conditions	Min	Typ	Max	Units
f_T	$I_C = 10$ mA, $V_{CE} = 5V$, f = 100 MHz	150			MHz
C_{CB}	$V_{CB} = 5V$, f = 1 MHz			5.0	pF
C_{EB}	$V_{EB} = 0.5V$, f = 1 MHz			20	pF
NF	$I_C = 100$ μA, $V_{CE} = 5V$, $R_S = 10$ kΩ, $P_{BW} = 15.7$ kHz		2		dB
h_{FE}	$I_C = 100$ μA, $V_{CE} = 5V$	40			
h_{FE}	$I_C = 1$ mA, $V_{CE} = 5V$	50			
h_{FE}	$I_C = 10$ mA, $V_{CE} = 5V$	60	180	360	
h_{FE}	$I_C = 100$ mA, $V_{CE} = 5V$	40			
$V_{BE(ON)}$	$I_C = 10$ mA, $V_{CE} = 5V$			0.85	V
$V_{CE(SAT)}$	$I_C = 100$ mA, $I_B = 10$ mA			0.50	V
BV_{CBO}	$I_C = 10$ μA	60			V
BV_{CEO}	$I_C = 10$ mA	50			V
BV_{EBO}	$I_E = 10$ μA	5			V
I_{CBO}	$V_{CB} = 40V$			100	nA
I_{EBO}	$V_{EB} = 4V$			100	nA

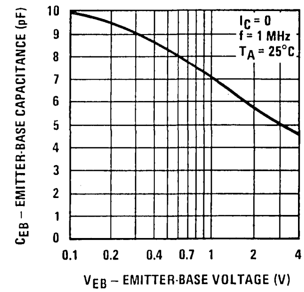
Collector-Emitter and Base-Emitter Voltage vs Collector Current



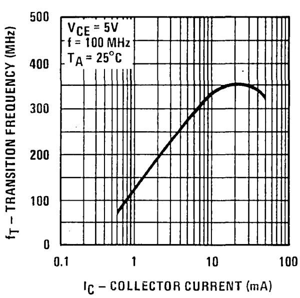
Collector-Base Capacitance vs Reverse Voltage



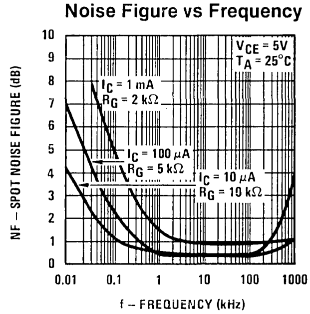
Emitter-Base Capacitance vs Reverse Voltage



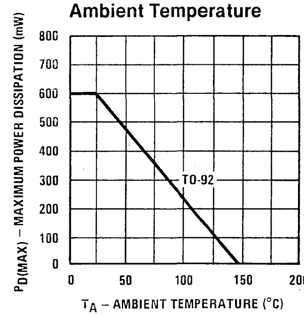
Transition Frequency vs Collector Current



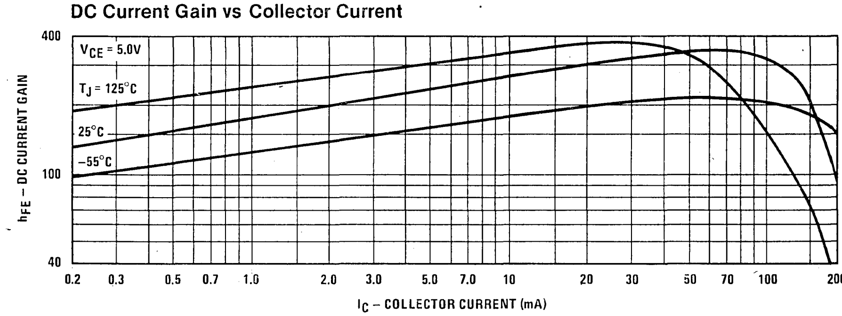
Noise Figure vs Frequency



Maximum Power Dissipation vs Ambient Temperature

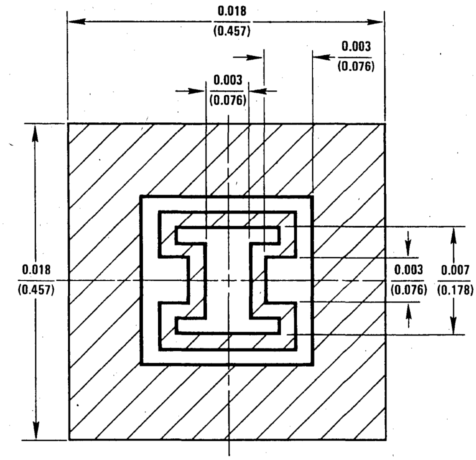


DC Current Gain vs Collector Current



National Semiconductor

Process 19 NPN Medium Power



DESCRIPTION

Process 19 is a non-overlay, double-diffused, gold doped, silicon epitaxial device. Complement to Process 63.

APPLICATION

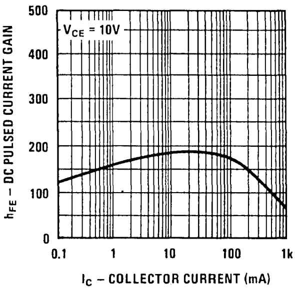
This device was designed for use as a medium power amplifier and switch requiring collector currents of 0.1 mA to 500 mA.

PRINCIPAL DEVICE TYPES

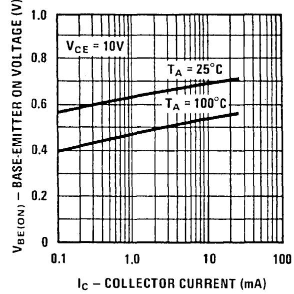
TO-5: 2N2219
TO-18: 2N2222
TO-92, EBC: MPS3642
PN2222
TO-237: TN2219

Parameter	Conditions	Min	Typ	Max	Units	Notes
t_{ON}	$I_C = 150$ mA, $I_{B1} = 15$ mA		25	35	ns	
t_{OFF}	$I_C = 150$ mA, $I_{B2} = 15$ mA		200	285	ns	
h_{fe}	$I_C = 20$ mA, $V_{CE} = 20V$, f = 100 MHz	2.0	3.5			
C_{ob}	$V_{CB} = 10V$, f = 1 MHz		4.0	6.0	pF	
C_{ib}	$V_{EB} = 0.5V$, f = 1 MHz			25	pF	
NF (spot)	$I_C = 100\ \mu A$, $V_{CE} = 10V$, $R_S = 1\ k\Omega$, f = 1 kHz		1.2		dB	
h_{FE}	$I_C = 100\ \mu A$, $V_{CE} = 10V$	30				
h_{FE}	$I_C = 1$ mA, $V_{CE} = 10V$	40				
h_{FE}	$I_C = 10$ mA, $V_{CE} = 10V$	50				
h_{FE}	$I_C = 150$ mA, $V_{CE} = 10V$	60	180	420		
h_{FE}	$I_C = 500$ mA, $V_{CE} = 10V$	30				
$V_{CE(SAT)}$	$I_C = 100$ mA, $I_B = 10$ mA			0.50	V	
$V_{CE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA			1.0	V	
$V_{BE(SAT)}$	$I_C = 100$ mA, $I_B = 10$ mA			1.2	V	
$V_{BE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA			1.5	V	
BV_{CEO}	$I_C = 10$ mA	35			V	
BV_{CBO}	$I_C = 100\ \mu A$	60			V	
BV_{EBO}	$I_E = 10\ \mu A$	6			V	
I_{CBO}	$V_{CB} = 40V$			100	nA	
I_{EBO}	$V_{EB} = 4V$			100	nA	

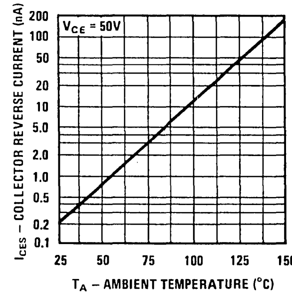
DC Pulsed Current Gain vs Collector Current



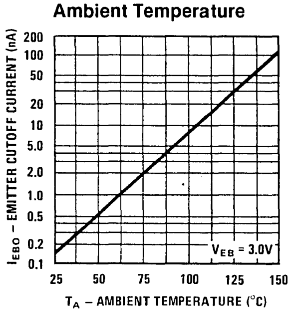
Base-Emitter ON Voltage vs Collector Current



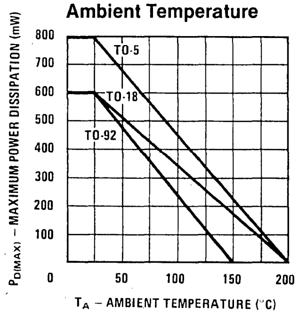
Collector Reverse Current vs Ambient Temperature



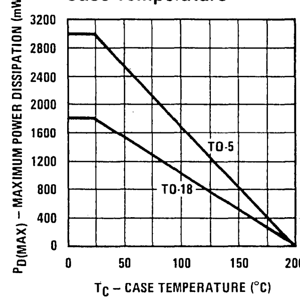
Emitter Cutoff Current vs Ambient Temperature



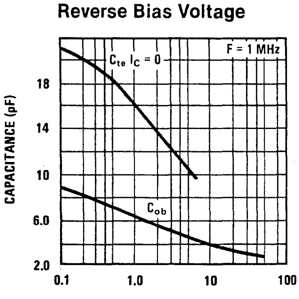
Maximum Power Dissipation vs Ambient Temperature



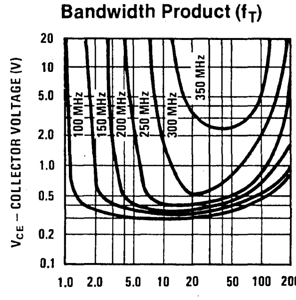
Maximum Power Dissipation vs Case Temperature



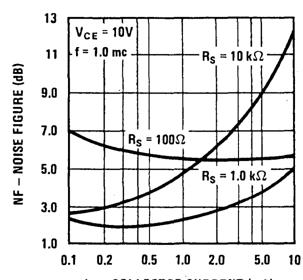
Emitter Transition and Output Capacitance vs Reverse Bias Voltage



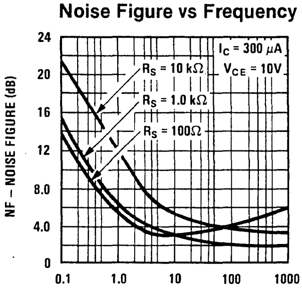
Contours of Constant Gain Bandwidth Product (f_T)



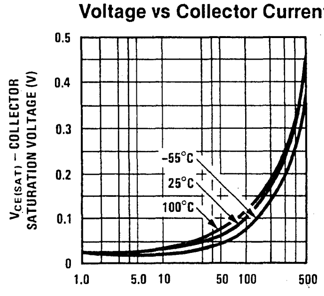
Noise Figure vs Collector Current



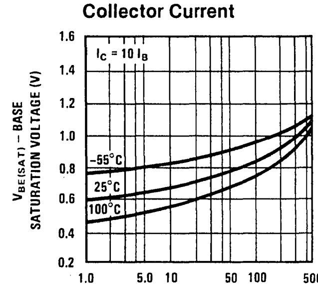
Noise Figure vs Frequency



Collector Saturation Voltage vs Collector Current

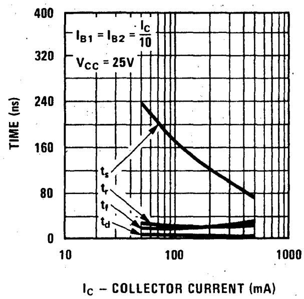


Base Saturation Voltage vs Collector Current

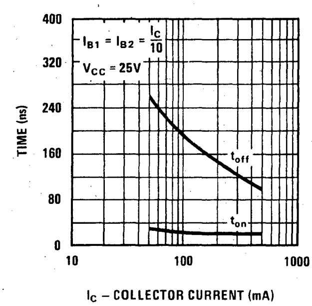


Process 19

Switching Times vs Collector Current



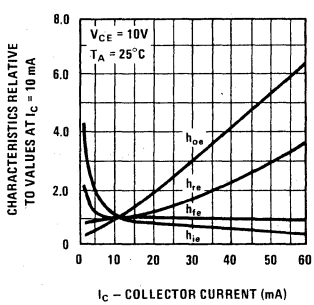
Turn On and Turn Off Times vs Collector Current

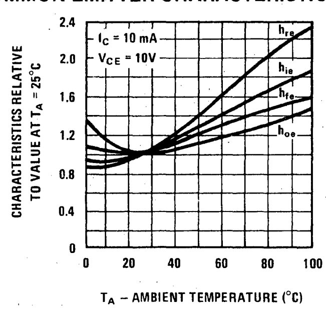


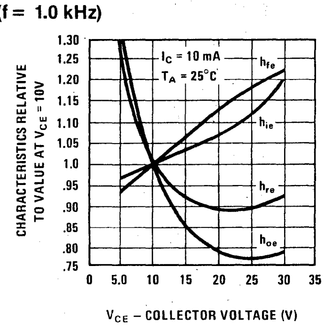
SMALL SIGNAL CHARACTERISTICS (f = 1.0 kHz)

Symbol	Characteristic	Typ	Units	Conditions
h_{ie}	Input Resistance	700	Ω	$I_C = 10$ mA, $V_{CE} = 10V$
h_{oe}	Output Conductance	120	µmhos	$I_C = 10$ mA, $V_{CE} = 10V$
h_{fe}	Small Signal Current Gain	240		$I_C = 10$ mA, $V_{CE} = 10V$
h_{re}	Voltage Feedback Ratio	460	$\times 10^{-6}$	$I_C = 10$ mA, $V_{CE} = 10V$

TYPICAL COMMON EMITTER CHARACTERISTICS (f = 1.0 kHz)

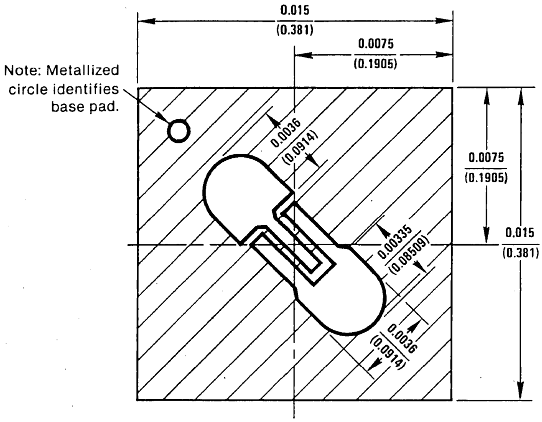






National Semiconductor

Process 21
NPN High Speed Switch



DESCRIPTION

Process 21 is an overlay, double-diffused, gold doped, silicon epitaxial device. Complement to Process 65.

APPLICATION

This device was designed for high speed saturated switching at collector currents of 10 mA to 100 mA.

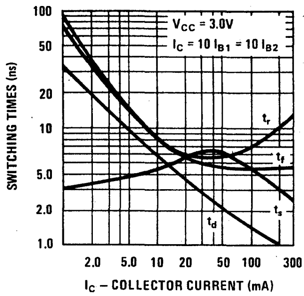
PRINCIPAL DEVICE TYPES

TO-18: 2N2369
TO-92, EBC: PN2369

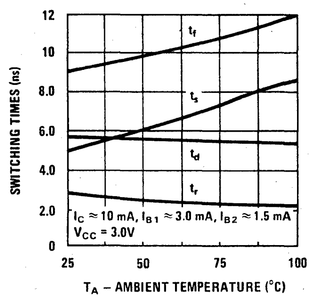
Parameter	Conditions	Min	Typ	Max	Units	Notes
t_S	$I_{B1} = I_{B2} = I_C = 10$ mA		7	13	ns	*Figure 1*
t_{ON}	$I_C = 10$ mA, $I_{B1} = 3$ mA		9	12	ns	*Figure 2*
t_{OFF}	$I_C = 10$ mA, $I_{B2} = 1.50$ mA		12	20	ns	*Figure 2*
h_{fe}	$I_C = 10$ mA, $V_{CE} = 10V$, f = 100 MHz	4.5	6.5			
C_{ob}	$V_{CB} = 5V$, f = 1 MHz		2.0	4.0	pF	
C_{ib}	$V_{EB} = 0.5V$, f = 1 MHz			5.0	pF	
h_{FE}	$I_C = 1$ mA, $V_{CE} = 1V$	30				
h_{FE}	$I_C = 10$ mA, $V_{CE} = 1V$	35	70	150		
h_{FE}	$I_C = 50$ mA, $V_{CE} = 1V$	30	55	150		
h_{FE}	$I_C = 100$ mA, $V_{CE} = 1V$	20				
h_{FE}	$I_C = 10$ mA, $V_{CE} = 0.35V$	30				
h_{FE}	$I_C = 30$ mA, $V_{CE} = 0.4V$	30				
$V_{CE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA			0.2	V	
$V_{CE(SAT)}$	$I_C = 100$ mA, $I_B = 10$ mA			0.5	V	
$V_{BE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA			0.85	V	
$V_{BE(SAT)}$	$I_C = 100$ mA, $I_B = 10$ mA			1.5	V	
BV_{CEO}	$I_C = 10$ mA	12			V	
BV_{CBO}	$I_C = 10\ \mu A$	30			V	
BV_{EBO}	$I_E = 10\ \mu A$	4.5			V	
I_{CBO}	$V_{CB} = 20V$			100	nA	
I_{EBO}	$V_{EB} = 3V$			100	nA	

Process 21

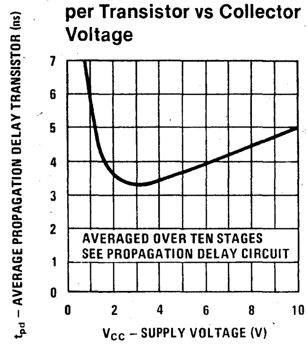
Switching Times vs Collector Current



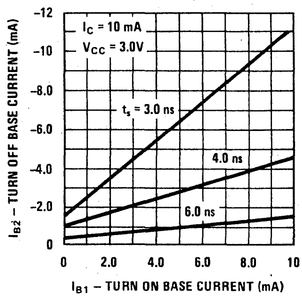
Switching Times vs Ambient Temperature



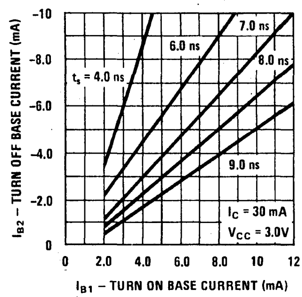
Average Propagation Delay per Transistor vs Collector Voltage



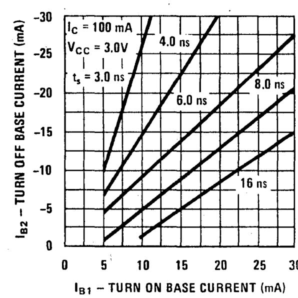
Storage Time vs Turn On and Turn Off Base Currents



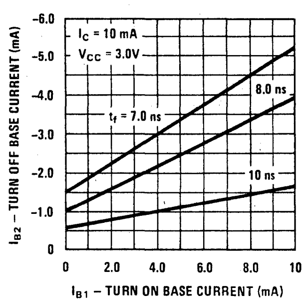
Storage Time vs Turn On and Turn Off Base Currents



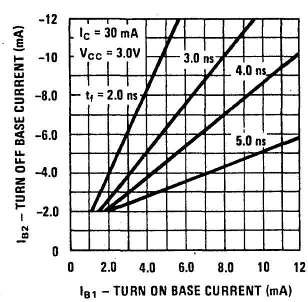
Storage Time vs Turn On and Turn Off Base Currents



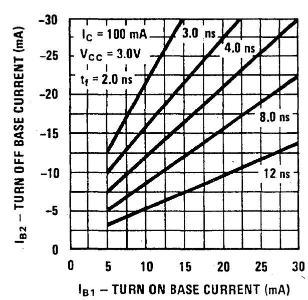
Fall Time vs Turn On and Turn OFF Base Current



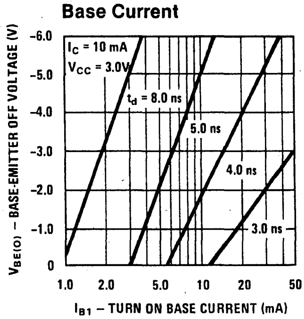
Fall Time vs Turn On and Turn Off Base Current



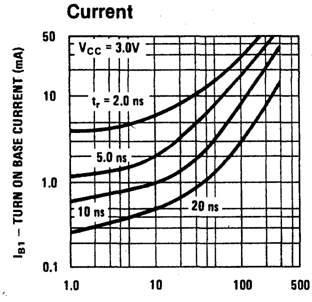
Fall Time vs Turn On and Turn Off Base Current



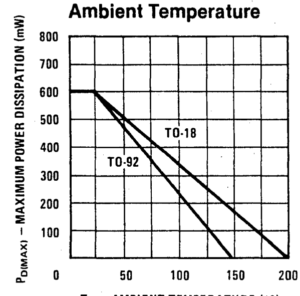
Delay Time vs Base-Emitter Off Voltage and Turn On Base Current



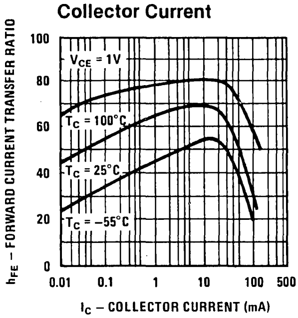
Rise Time vs Turn On Base Current and Collector Current



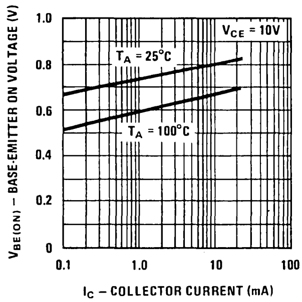
Maximum Power Dissipation vs Ambient Temperature



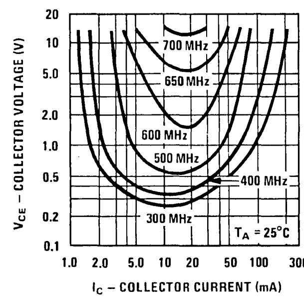
DC Current Gain vs Collector Current



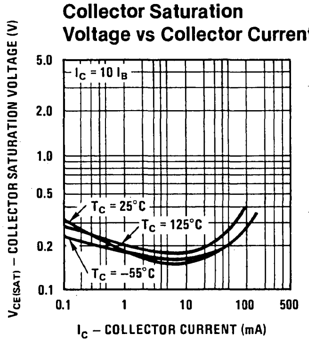
Base-Emitter On Voltage vs Collector Current



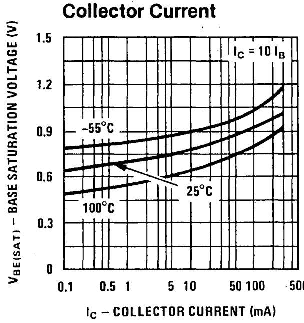
Contours of Constant Gain Bandwidth Product (f_T)



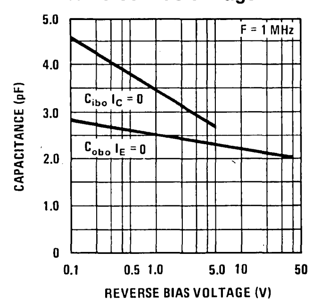
Collector Saturation Voltage vs Collector Current



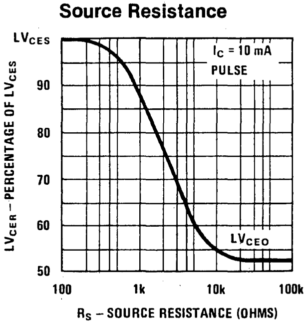
Base Saturation Voltage vs Collector Current



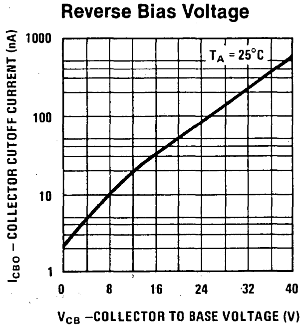
Emitter Transition and Output Capacitances vs Reverse Bias Voltage



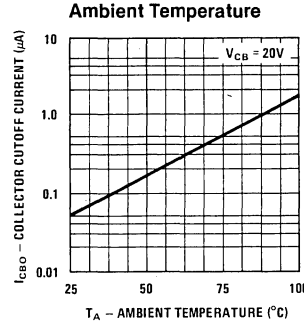
Lower Limiting Voltage vs Source Resistance



Collector Cutoff Current vs Reverse Bias Voltage



Collector Cutoff Current vs Ambient Temperature



Process 21

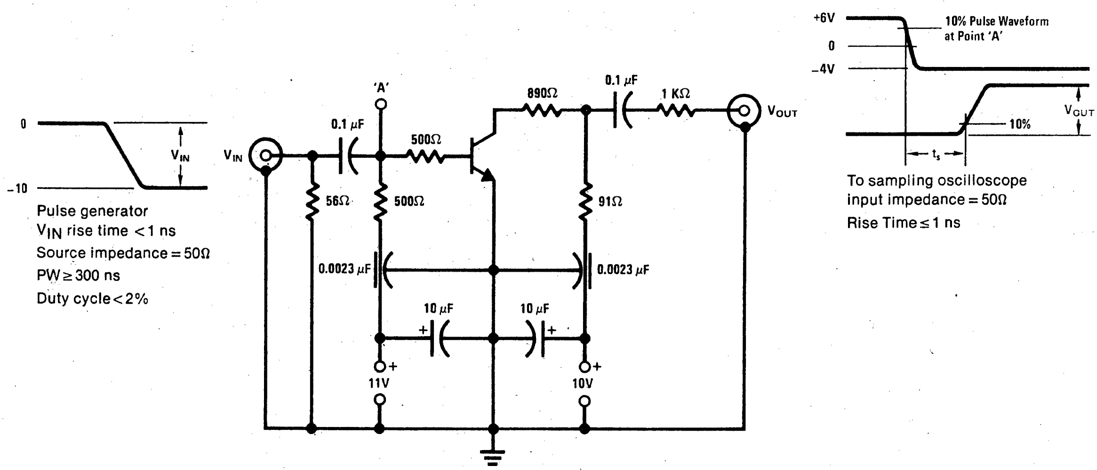


FIGURE 1. Charge Storage Time Measurement Circuit

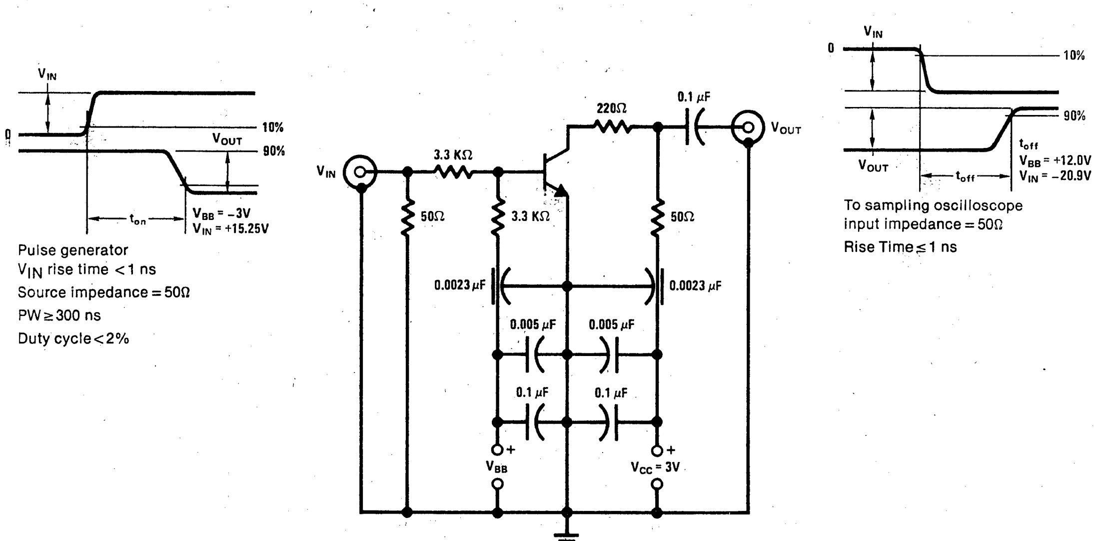
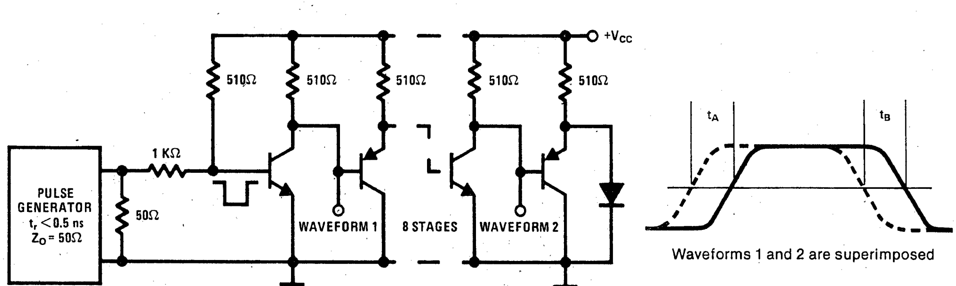


FIGURE 2. t_{ON}, t_{OFF} Measurement Circuit



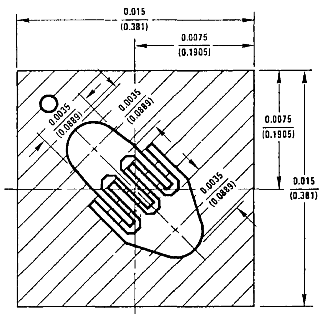
$$t_{pd} = \frac{t_A + t_B}{20}$$

t_{pd} = Average propagation per transistor

FIGURE 3. Circuit for Measurement of Propagation Delay

National Semiconductor

Process 22 NPN Small Signal



DESCRIPTION

Process 22 is an overlay, double-diffused, gold doped, silicon epitaxial device. Complement to Process 64.

APPLICATION

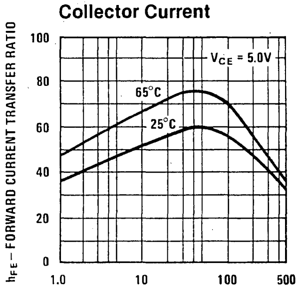
This device was designed for high speed logic and core driver applications to 300 mA.

PRINCIPAL DEVICE TYPES

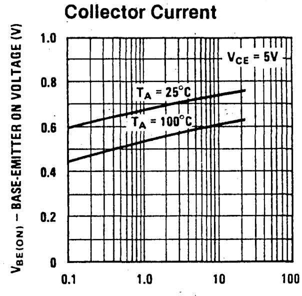
TO-52: 2N3013
TO-92, EBC: 2N5772

Parameter	Conditions	Min	Typ	Max	Units	Notes
t_s	$I_C = 10$ mA, $I_{B1} = I_{B2} = 10$ mA		12	18	ns	*Figure 1*
t_{ON}	$I_C = 300$ mA, $I_{B1} = I_{B2} = 30$ mA		10	18	ns	*Figure 2*
t_{OFF}	$I_C = 300$ mA, $I_{B1} = I_{B2} = 30$ mA		18	30	ns	
C_{ob}	$V_{CB} = 5V$, f = 1 MHz		3.0	5.0	pF	
C_{ib}	$V_{EB} = 0.5V$, f = 1 MHz			8.0	pF	
h_{fe}	$I_C = 30$ mA, $V_{CE} = 10V$, f = 100 MHz	3.5	7.0			
h_{FE}	$V_{CE} = 1V$, 10 mA	20				
h_{FE}	$V_{CE} = 1V$, $I_C = 30$ mA	25	60	150		
h_{FE}	$V_{CE} = 1V$, $I_C = 100$ mA	20	45	150		
h_{FE}	$V_{CE} = 1V$, $I_C = 300$ mA	15				
h_{FE}	$V_{CE} = 0.4V$, $I_C = 30$ mA	20				
h_{FE}	$V_{CE} = 0.5V$, $I_C = 100$ mA	20				
$V_{CE(SAT)}$	$I_C = 30$ mA, $I_B = 3$ mA			0.20	V	
$V_{CE(SAT)}$	$I_C = 100$ mA, $I_B = 10$ mA			0.30	V	
$V_{CE(SAT)}$	$I_C = 300$ mA, $I_B = 30$ mA			0.50	V	
$V_{BE(SAT)}$	$I_C = 30$ mA, $I_B = 3$ mA			0.95	V	
$V_{BE(SAT)}$	$I_C = 100$ mA, $I_B = 10$ mA			1.2	V	
$V_{BE(SAT)}$	$I_C = 300$ mA, $I_B = 30$ mA			1.7	V	
BV_{CBO}	$I_C = 10\ \mu A$	35			V	
BV_{CEO}	$I_C = 10$ mA	15			V	
BV_{EBO}	$I_E = 10\ \mu A$	5.0			V	
I_{CBO}	$V_{CB} = 25V$			100	nA	
I_{EBO}	$V_{EB} = 3V$			100	nA	

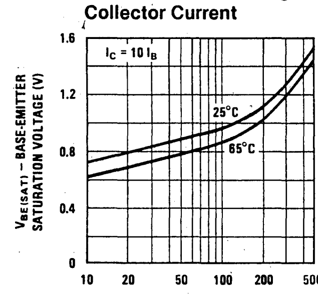
DC Current Gain vs Collector Current



Base-Emitter On Voltage vs Collector Current

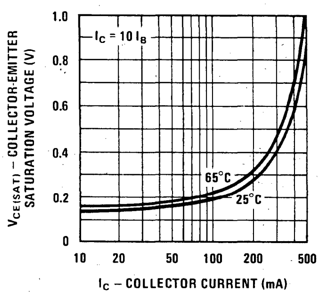


Base Saturation Voltage vs Collector Current

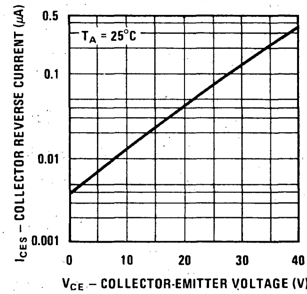


Process 22

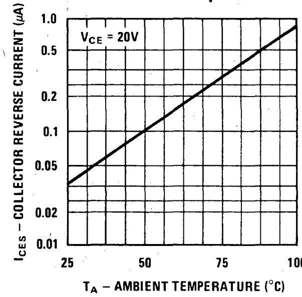
Collector Saturation Voltage vs Collector Current



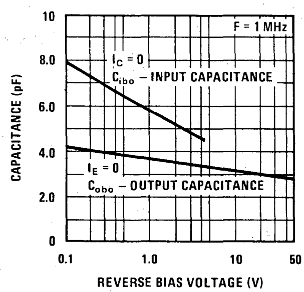
Collector Reverse Current vs Reverse Bias Voltage



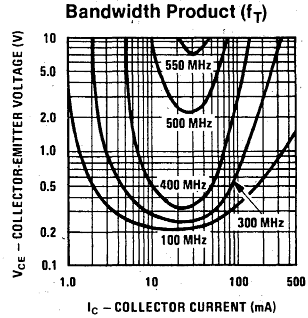
Collector Reverse Current vs Ambient Temperature



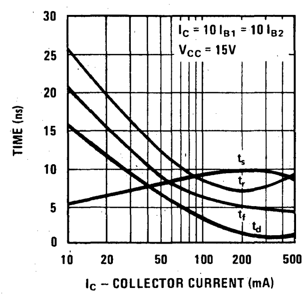
Input and Output Capacitance vs Reverse Bias Voltage



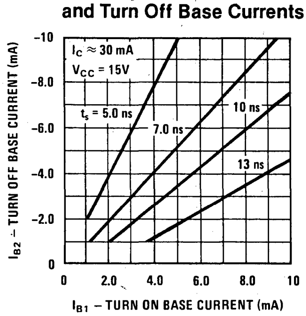
Contours of Constant Gain Bandwidth Product (f_T)



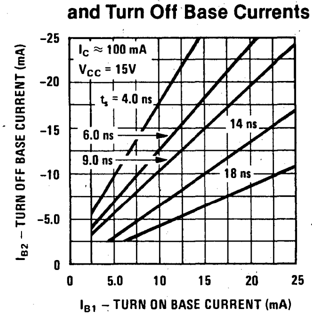
Switching Times vs Collector Current



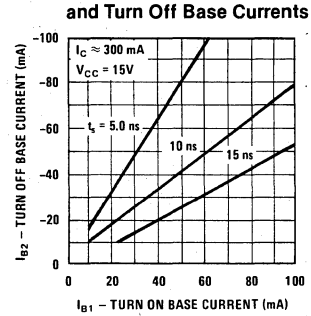
Storage Time vs Turn On and Turn Off Base Currents



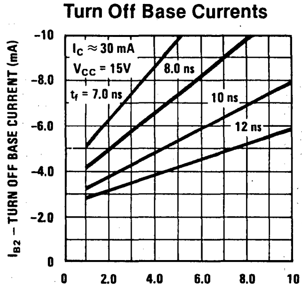
Storage Time vs Turn On and Turn Off Base Currents



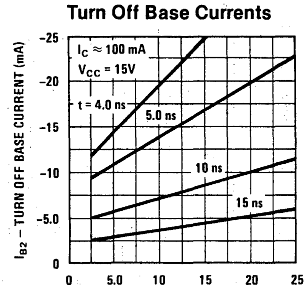
Storage Time vs Turn On and Turn Off Base Currents



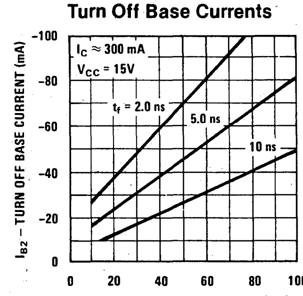
Fall Time vs Turn On and Turn Off Base Currents



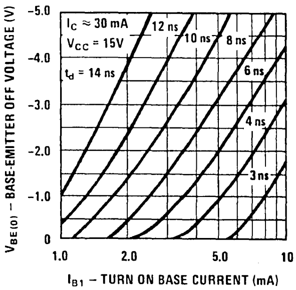
Fall Time vs Turn On and Turn Off Base Currents



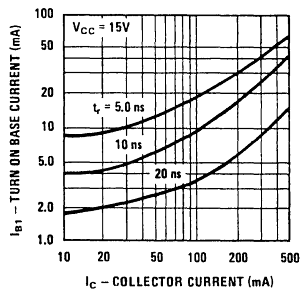
Fall Time vs Turn On and Turn Off Base Currents



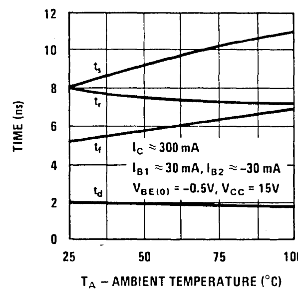
Delay Time vs Base-Emitter Off Voltage and Turn On Base Current



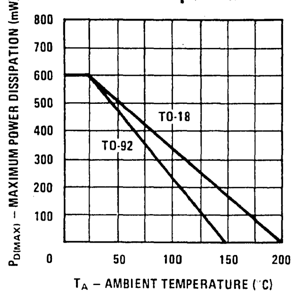
Rise Time vs Collector and Turn On Base Currents



Switching Times vs Ambient Temperature



Maximum Power Dissipation vs Ambient Temperature



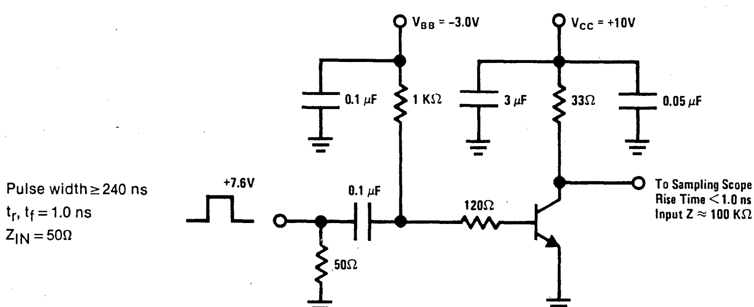


FIGURE 1. t_{ON}, t_{OFF} Test Circuit

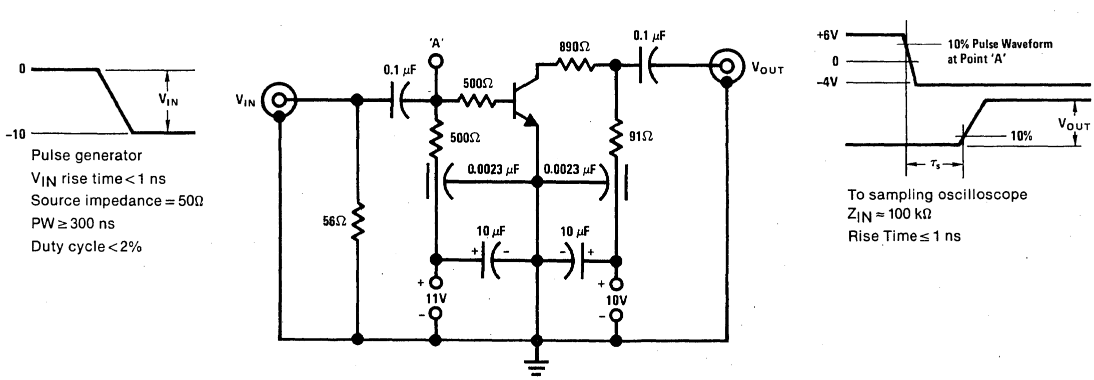
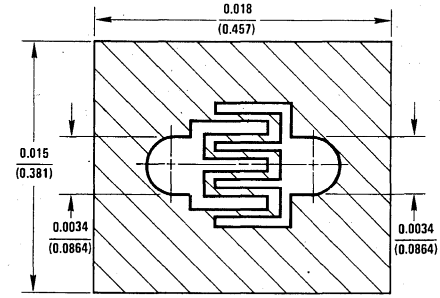


FIGURE 2. Charge Storage Time Measurement Circuit

National Semiconductor

Process 23 NPN Small Signal



DESCRIPTION

Process 23 is an overlay, double-diffused, gold doped, silicon epitaxial device. Complement to Process 66.

APPLICATION

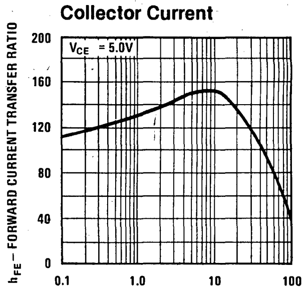
This device is designed as a general purpose amplifier and switch. The useful dynamic range extends to 100 mA as a switch and to 100 MHz as an amplifier.

PRINCIPAL DEVICE TYPES

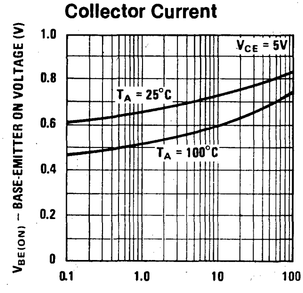
TO-18: NS3904
TO-92, EBC: 2N3904

Parameter	Conditions	Min	Typ	Max	Units	Notes
t_{ON}	$I_C = 10$ mA, $I_{B1} = 1$ mA		30	70	ns	*Figure 1*
t_{OFF}	$I_C = 10$ mA, $I_{B2} = 1$ mA		150	250	ns	*Figure 2*
C_{ob}	$V_{CB} = 5V$, f = 1 MHz		2.7	4.0	pF	
C_{ib}	$V_{EB} = 0.5V$, f = 1 MHz			8.0	pF	
NF	$V_{CE} = 5V$, $I_C = 100\ \mu A$, $R_S = 1\ k\Omega$, $P_{BW} = 15.7$ kHz		2.0		dB	
h_{fe}	$I_C = 10$ mA, $V_{CE} = 20V$, f = 100 MHz	2.5	4.5			
h_{FE}	$I_C = 100\ \mu A$, $V_{CE} = 5V$	40				
h_{FE}	$I_C = 1$ mA, $V_{CE} = 5V$	90				
h_{FE}	$I_C = 10$ mA, $V_{CE} = 5V$	60	150	360		
h_{FE}	$I_C = 50$ mA, $V_{CE} = 5V$	40				
h_{FE}	$I_C = 100$ mA, $V_{CE} = 5V$	20				
$V_{CE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA			0.15	V	
$V_{BE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA			0.80	V	
$V_{CE(SAT)}$	$I_C = 50$ mA, $I_B = 5$ mA			0.25	V	
$V_{BE(SAT)}$	$I_C = 50$ mA, $I_B = 5$ mA			0.85	V	
BV_{CBO}	$I_C = 10\ \mu A$	60			V	
BV_{CEO}	$I_C = 1$ mA	30			V	
BV_{EBO}	$I_E = 10\ \mu A$	6.0			V	
I_{CBO}	$V_{CB} = 30V$			100	nA	
I_{EBO}	$V_{EB} = 4V$			100	nA	

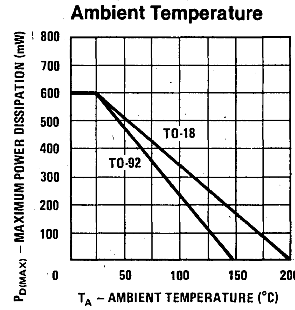
DC Current Gain vs Collector Current



Base-Emitter ON Voltage vs Collector Current

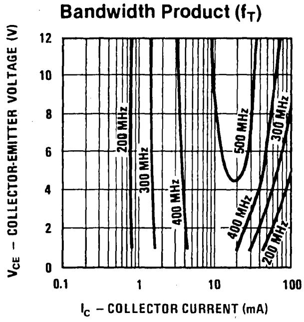


Maximum Power Dissipation vs Ambient Temperature

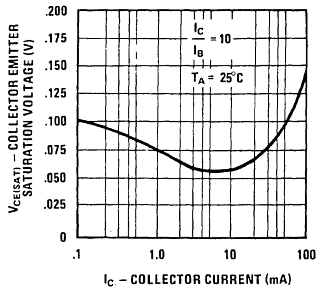


Process 23

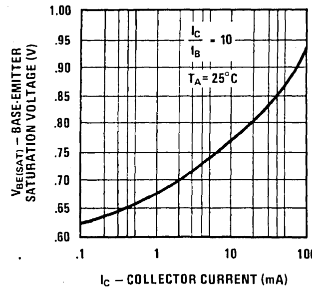
Contours of Constant Gain Bandwidth Product (f_T)



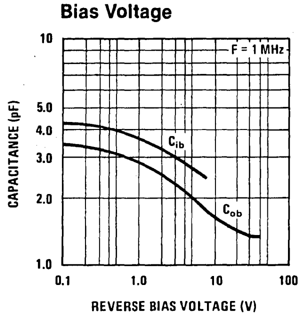
Collector Saturation Voltage vs Collector Current



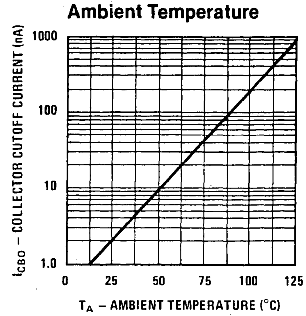
Base Saturation Voltage vs Collector Current



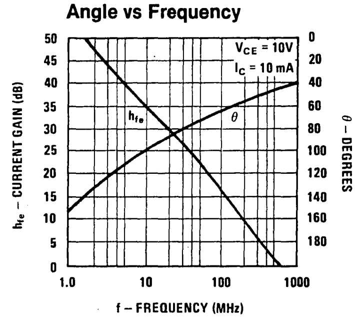
Capacitance vs Reverse Bias Voltage



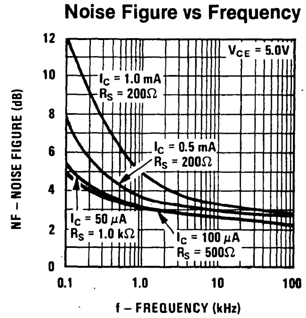
Collector Cutoff Current vs Ambient Temperature



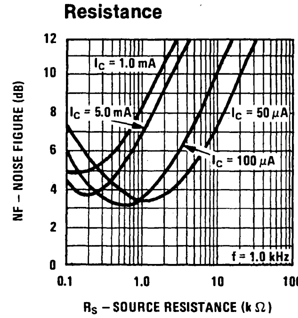
Current Gain and Phase Angle vs Frequency



Noise Figure vs Frequency

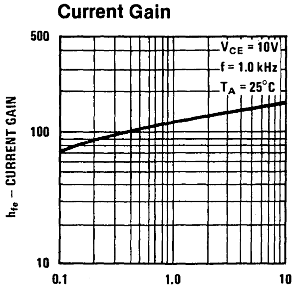


Noise Figure vs Source Resistance

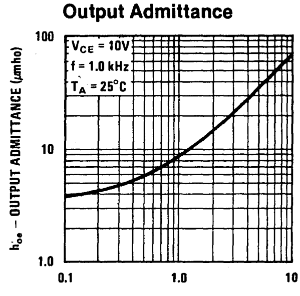


H PARAMETERS ($V_{CE} = 10\ V_{DC}$, $f = 1.0$ kHz, $T_A = 25°C$)

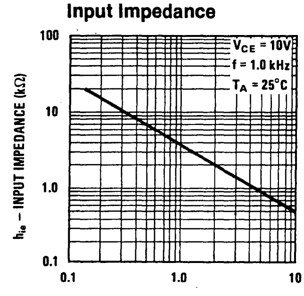
Current Gain



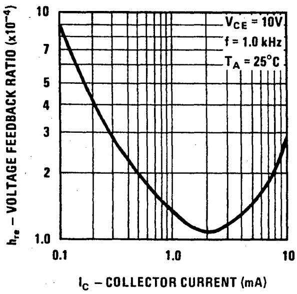
Output Admittance



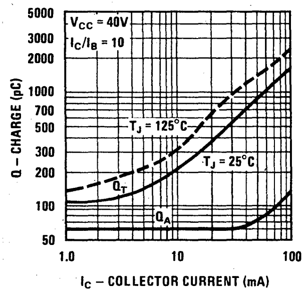
Input Impedance



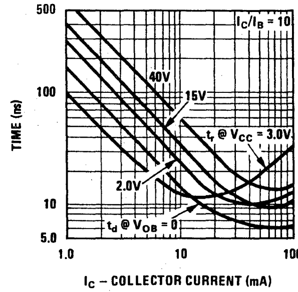
Voltage Feedback Ratio



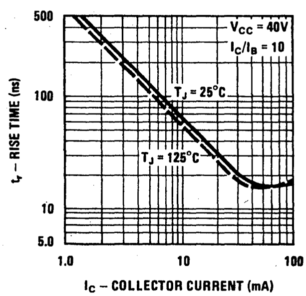
Charge Data



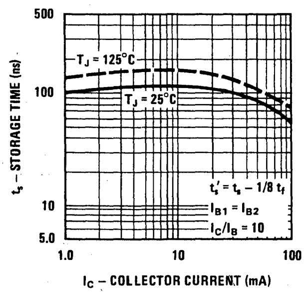
Turn On Time



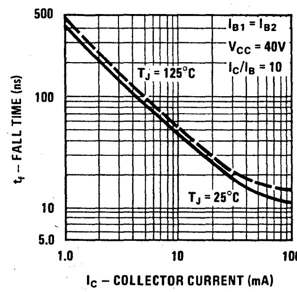
Rise Time



Storage Time



Fall Time



TRANSIENT CHARACTERISTICS (—T_J = 25°C — — T_J = 125°C)

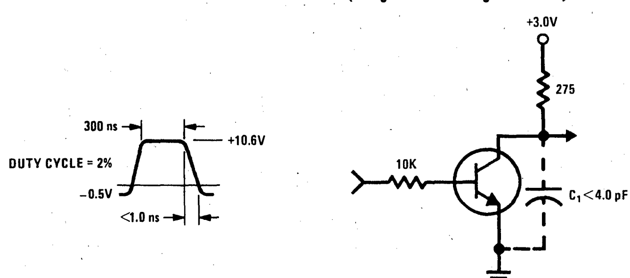


FIGURE 1. Delay and Rise Time Equivalent Test Circuit

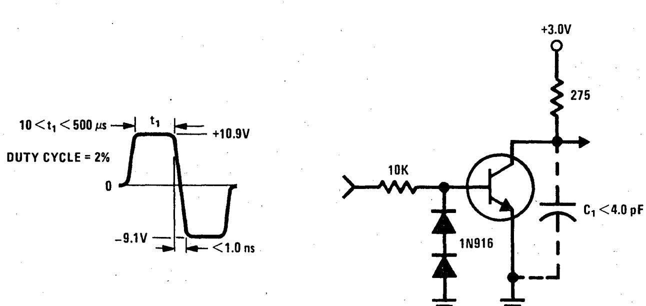
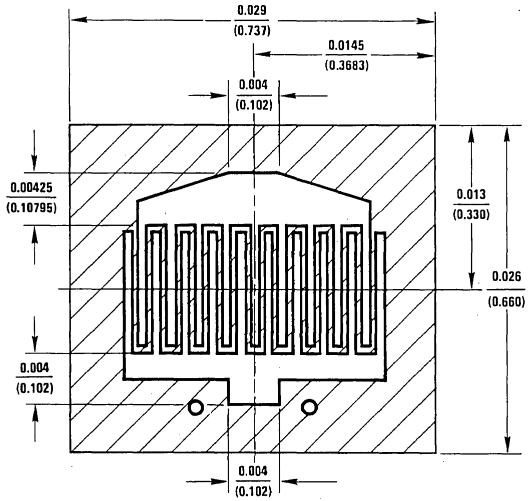


FIGURE 2. Storage and Fall Time Equivalent Test Circuit

National Semiconductor

Process 25 NPN Memory Driver



DESCRIPTION

Process 25 is an overlay, double-diffused, gold doped, silicon epitaxial device. Complement to Process 70.

APPLICATION

This device was designed for high speed core driver applications.

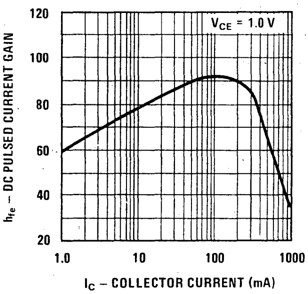
PRINCIPAL DEVICE TYPES

TO-18: 2N4014
TO-39: 2N3725
TO-237: TN3725

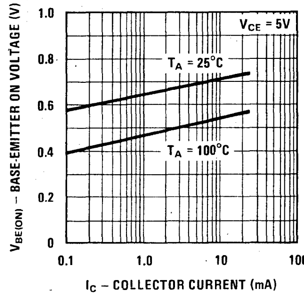
Parameter	Conditions	Min	Typ	Max	Units	Notes
t_{ON}	$I_C = 500$ mA, $I_{B1} = 50$ mA		12	35	ns	*Figure 1*
t_{OFF}	$I_C = 500$ mA, $I_{B2} = 50$ mA		50	60	ns	*Figure 1*
h_{fe}	$I_C = 50$ mA, $V_{CE} = 10V$, f = 100 MHz	2.5	4.25			
C_{ob}	$V_{CB} = 10V$, f = 1 MHz		6	8	pF	
C_{ib}	$V_{EB} = 0.5V$, f = 1 MHz			55	pF	
h_{FE}	$I_C = 10$ mA, $V_{CE} = 1V$	40				
h_{FE}	$I_C = 100$ mA, $V_{CE} = 1V$	45	90	150		
h_{FE}	$I_C = 300$ mA, $V_{CE} = 1V$	35				
h_{FE}	$I_C = 500$ mA, $V_{CE} = 1V$	25				
h_{FE}	$I_C = 800$ mA, $V_{CE} = 1V$	20				
h_{FE}	$I_C = 1A$, $V_{CE} = 1V$	15				
h_{FE}	$I_C = 800$ mA, $V_{CE} = 2V$	25				
h_{FE}	$I_C = 1A$, $V_{CE} = 5V$	25				
$V_{CE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA			0.20	V	
$V_{CE(SAT)}$	$I_C = 100$ mA, $I_B = 10$ mA			0.20	V	
$V_{CE(SAT)}$	$I_C = 300$ mA, $I_B = 30$ mA			0.40	V	
$V_{CE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA			0.50	V	
$V_{CE(SAT)}$	$I_C = 800$ mA, 80 mA			0.80	V	
$V_{CE(SAT)}$	$I_C = 1A$, $I_B = 100$ mA			1.20	V	
$V_{BE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA			0.70	V	
$V_{BE(SAT)}$	$I_C = 100$ mA, $I_B = 10$ mA			0.85	V	
$V_{BE(SAT)}$	$I_C = 300$ mA, $I_B = 30$ mA			1.20	V	
$V_{BE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA			1.20	V	
$V_{BE(SAT)}$	$I_C = 800$ mA, $I_B = 80$ mA			1.50	V	
$V_{BE(SAT)}$	$I_C = 1A$, $I_B = 100$ mA			1.70	V	
BV_{CEO}	$I_C = 10$ mA	40			V	
BV_{CBO}	$I_C = 100\ \mu A$	80			V	
BV_{EBO}	$I_C = 10\ \mu A$	6			V	
I_{CBO}	$V_{CB} = 40V$			100	nA	
I_{EBO}	$V_{EB} = 4V$			100	nA	

Process 25

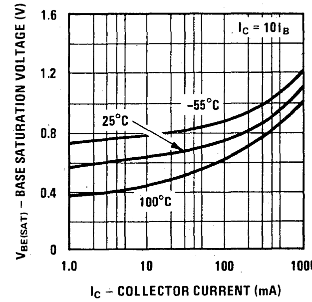
DC Pulsed Current Gain vs Collector Current



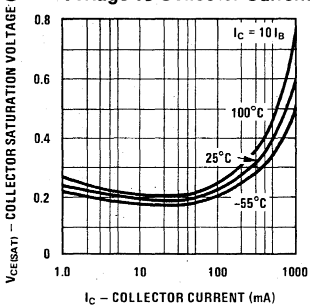
Base-Emitter ON Voltage vs Collector Current



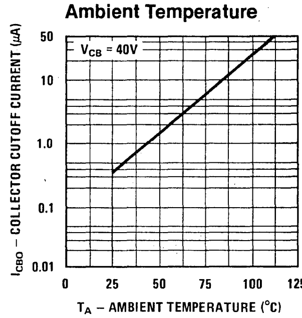
Base Saturation Voltage vs Collector Current



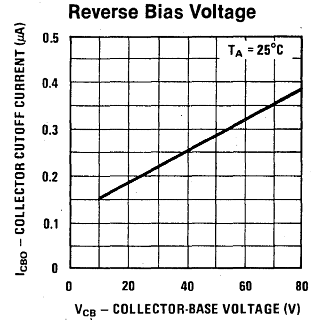
Collector Saturation Voltage vs Collector Current



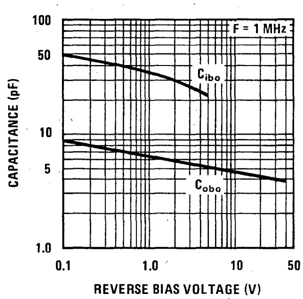
Collector Cutoff Current vs Ambient Temperature



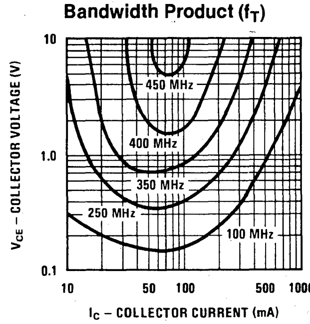
Collector Cutoff Current vs Reverse Bias Voltage



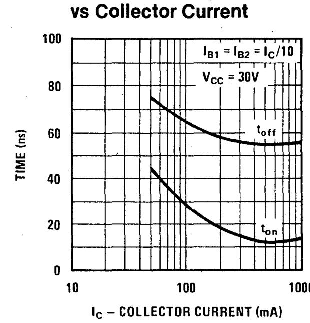
Input and Output Capacitance vs Reverse Bias



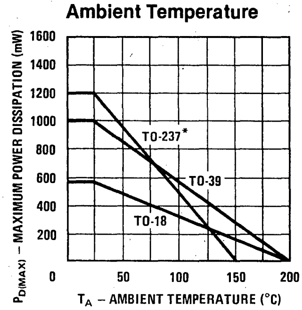
Contours of Constant Bandwidth Product (f_T)



Turn On and Turn Off Times vs Collector Current

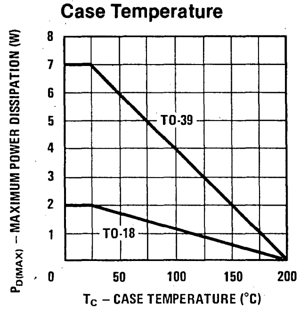


Maximum Power Dissipation vs Ambient Temperature

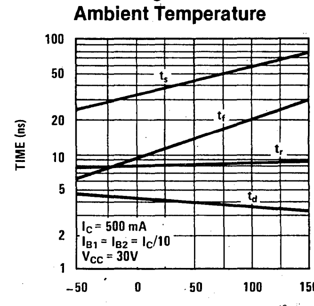


* One square inch of copper run

Maximum Power Dissipation vs Case Temperature

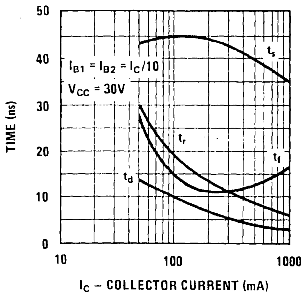


Switching Times vs Ambient Temperature

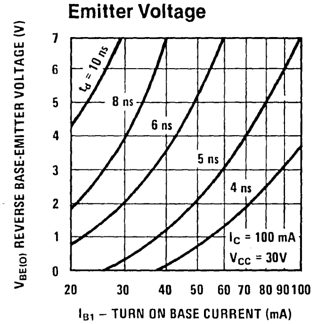


Process 25

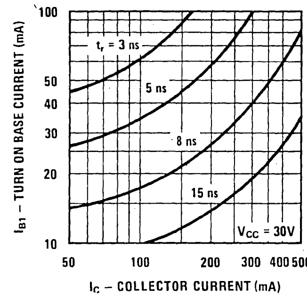
Switching Times vs Collector Current



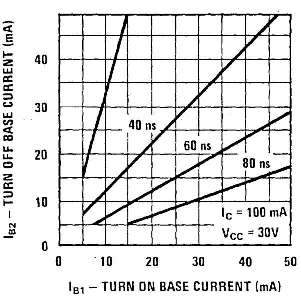
Delay Time vs Turn On Base Current and Reverse Base-Emitter Voltage



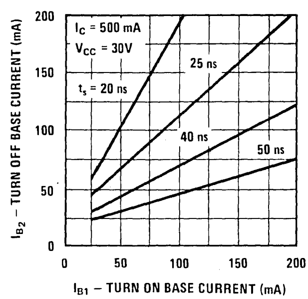
Rise Time vs Collector and Turn On Base Currents



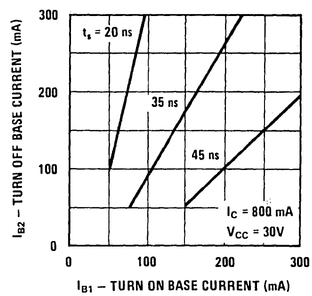
Storage Time vs Turn On and Turn Off Base Currents



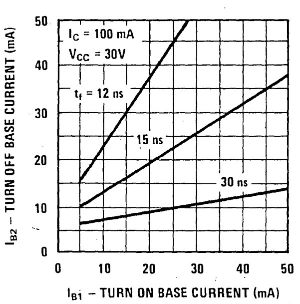
Storage Time vs Turn On and Turn Off Base Currents



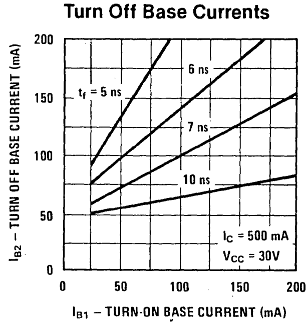
Storage Time vs Turn On and Turn Off Base Currents



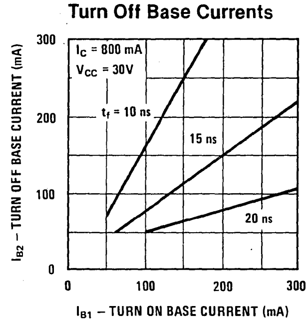
Fall Time vs Turn On and Turn Off Base Currents



Fall Time vs Turn On and Turn Off Base Currents



Fall Time vs Turn On and Turn Off Base Currents



SWITCHING TIME TEST CIRCUIT

$V_{IN} = +9.7$
t_r and $t_f \leq 1$ ns
PW ≈ 1 μs
$Z_{IN} = 50\Omega$
Duty cycle < 2%

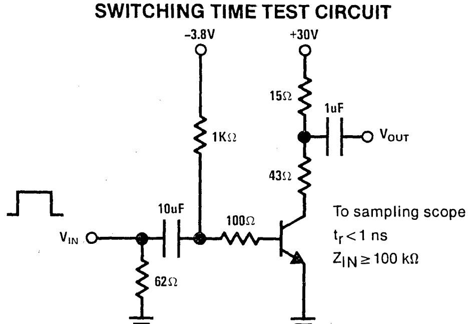


FIGURE 1. $I_C \approx 500$ mA, $I_{B1} \approx 50$ mA, $I_{B2} \approx -50$ mA

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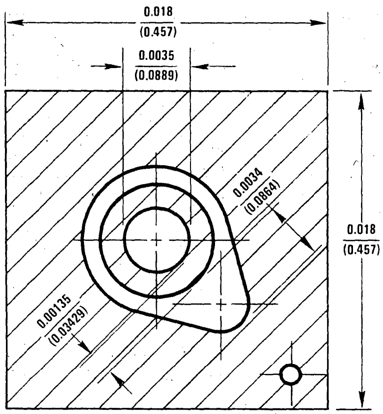
National Semiconductor

Process 27 NPN Small Signal



DESCRIPTION

Process 27 is a non-overlay, double-diffused, silicon epitaxial device.

APPLICATION

This device is designed for general purpose amplifier and switch applications, useful from audio to RF frequencies.

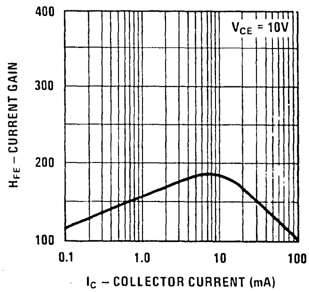
PRINCIPAL DEVICE TYPES

TO-18: 2N915
TO-92, EBC: PN3694
TO-92, ECB: 2N3394

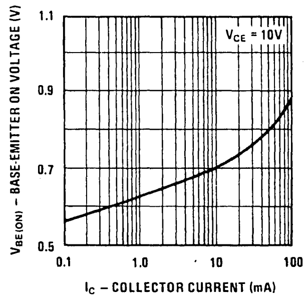
Parameter	Conditions	Min	Typ	Max	Units	Notes
NF (wideband)	$V_{CE}=5V$, $I_C=100\ \mu A$, $P_{BW}=15.7$ kHz		1.5		dB	
NF (spot)	$V_{CE}=5V$, $I_C=100\ \mu A$, f = 1 kHz, $R_S=1k$		1.5		dB	
C_{ob}	$V_{CB}=10V$, f = 1 MHz		2.5	3.5	pF	
C_{ib}	$V_{EB}=0.50V$, f = 1 MHz			7.0	pF	
f_T	$V_{CE}=10V$, $I_C=10$ mA	250	450		MHz	
h_{FE}	$V_{CE}=10V$, $I_C=100\ \mu A$	40				
h_{FE}	$V_{CE}=10V$, $I_C=1$ mA	50				
h_{FE}	$V_{CE}=10V$, $I_C=10$ mA	60	180	360		
h_{FE}	$V_{CE}=10V$, $I_C=50$ mA	45				
$V_{CE(SAT)}$	$I_C=10$ mA, $I_B=1$ mA			0.20	V	
$V_{BE(SAT)}$	$I_C=1$ mA, $I_B=1$ mA			0.85	V	
BV_{CBO}	$I_C=100\ \mu A$	50			V	
BV_{CEO}	$I_C=10$ mA	35			V	
BV_{EBO}	$I_E=10\ \mu A$	5.0			V	
I_{CBO}	$V_{CB}=40V$			100	nA	
I_{EBO}	$V_{EB}=4.0V$			100	nA	

Process 27

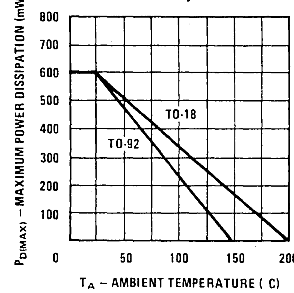
DC Current Gain vs Collector Current



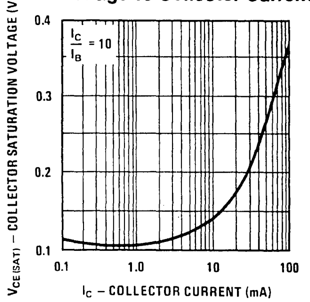
Base-Emitter ON Voltage vs Collector Current



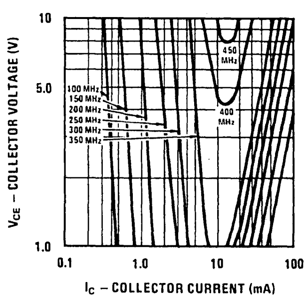
Maximum Power Dissipation vs Ambient Temperature



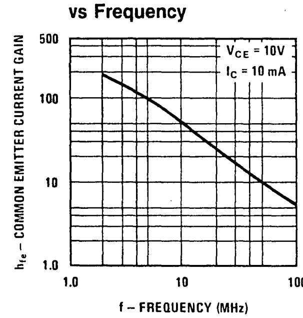
Collector-Emitter Saturation Voltage vs Collector Current



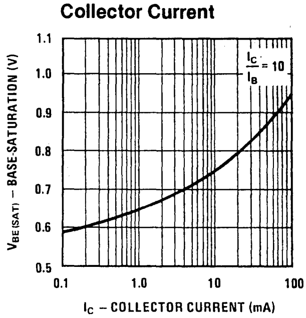
Small Signal Current Gain vs Collector Current



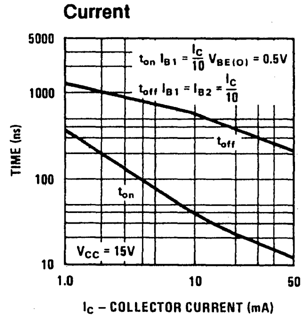
Small Signal Current Gain vs Frequency



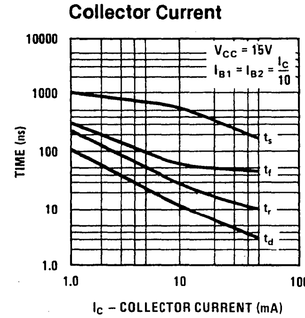
Base Saturation Voltage vs Collector Current



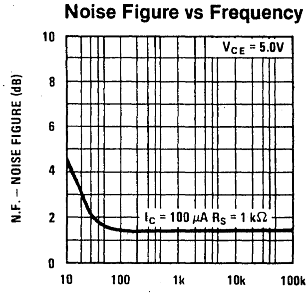
t_{ON} and t_{OFF} vs Collector Current



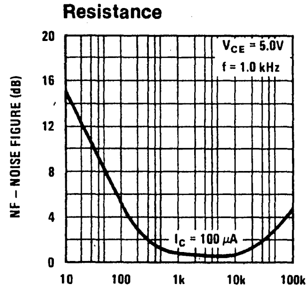
Switching Times vs Collector Current



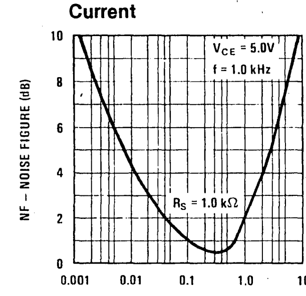
Noise Figure vs Frequency



Noise Figure vs Source Resistance

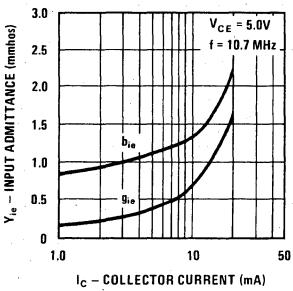


Noise Figure vs Collector Current

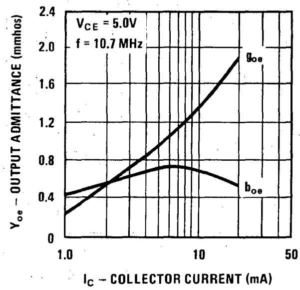


COMMON EMITTER Y PARAMETERS

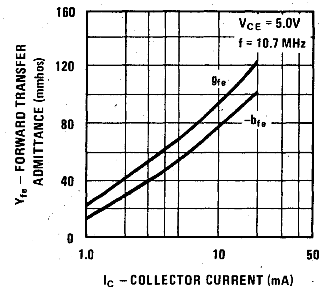
Input Admittance vs Collector Current



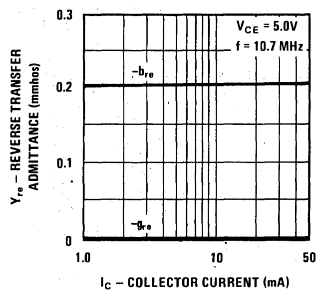
Output Admittance vs Collector Current



Forward Transfer Admittance vs Collector Current

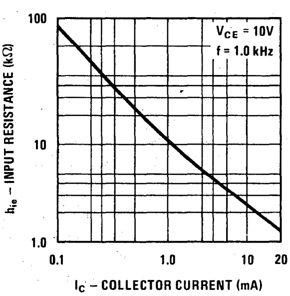


Reverse Transfer Admittance vs Collector Current

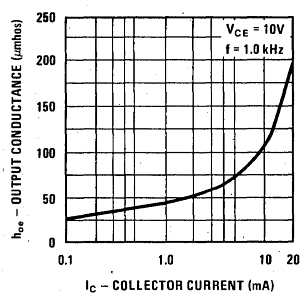


COMMON EMITTER H PARAMETERS

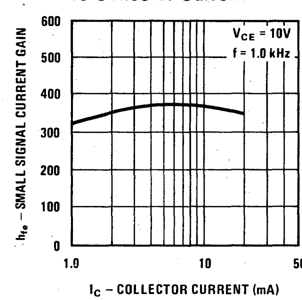
Small Signal Input Resistance vs Collector Current



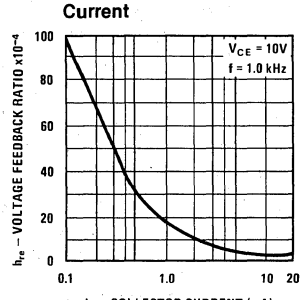
Small Signal Output Conductance vs Collector Current



Small Signal Current Gain vs Collector Current



Small Signal Voltage Feedback Ratio vs Collector Current



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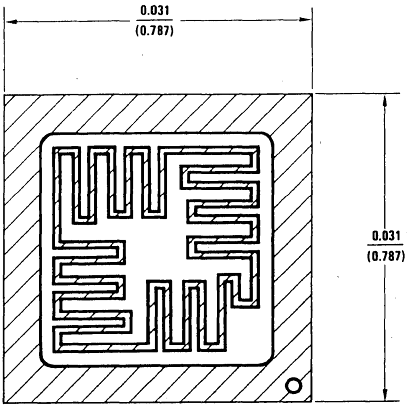
Process 37 NPN Medium Power



DESCRIPTION

Process 37 is a double-diffused, silicon epitaxial planar device. Complement to Process 77.

APPLICATION

This device was designed for general purpose medium power amplifiers and switching circuits that require collector currents to 2A.

PRINCIPAL DEVICE TYPES

TO-202, EBC: NSD102, 103
NSDU01, 01A
NSDU02

TO-202, BCE: NSE180

TO-237, EBC: 2N6714, 15
(92PU01, 01A)

TO-237, ECB: NA21/31 Series

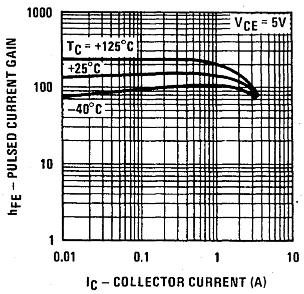
TO-126, ECB: MJE180
MJE720

TO-92, EBC: ED1702

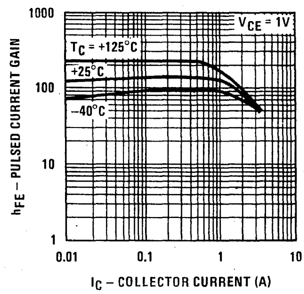
Parameter	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 10$ mA	25			V
BV_{CBO}	$I_C = 100\ \mu A$	40			V
BV_{EBO}	$I_E = 10\ \mu A$	5			V
I_{CBO}	$V_{CB} = 20V$			100	nA
I_{EBO}	$V_{EB} = 4V$			100	nA
h_{FE}	$I_C = 100$ mA, $V_{CE} = 1V$	60	160	360	
h_{FE}	$I_C = 1A$, $V_{CE} = 1V$	40			
$V_{CE(SAT)}$	$I_C = 1A$, $I_B = 0.1A$			0.5	V
$V_{BE(SAT)}$	$I_C = 1A$, $I_B = 0.1A$			1.25	V
f_T	$I_C = 100$ mA, $V_{CE} = 10V$	150	300		MHz
C_{ob}	$V_{CB} = 10V$, f = 1 MHz		17	20	pF
$P_{D(max)}$					
TO-126	$T_C = 25°C$ $T_A = 25°C$	15 1.5			W
TO-202	$T_C = 25°C$ $T_A = 25°C$	10 2			W
TO-237	$T_{COLLECTOR\ LEAD} = 25°C$ $T_A = 25°C$	2 850			W mW
TO-92	$T_A = 25°C$	600			mW
θ_{JC}					
TO-220	$T_C = 25°C$				°C/W
TO-126	$T_C = 25°C$			8.33	°C/W
TO-202	$T_C = 25°C$			12.5	°C/W
TO-237	$T_{COLLECTOR\ LEAD} = 25°C$			62.5	°C/W
θ_{JA}					
TO-126	$T_A = 25°C$			83.3	°C/W
TO-202	$T_A = 25°C$			62.5	°C/W
TO-237	$T_A = 25°C$			147	°C/W
TO-92	$T_A = 25°C$			208	°C/W
$T_{J(max)}$	All Plastic Parts	150			°C

Process 37

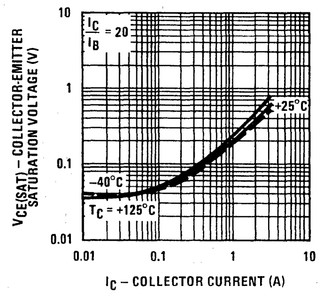
Typical Pulsed Current Gain vs Collector Current



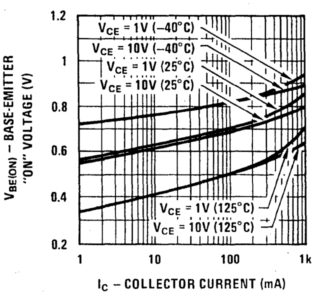
Typical Pulsed Current Gain vs Collector Current



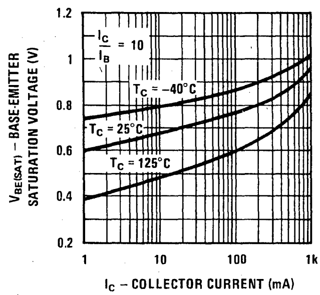
Collector-Emitter Saturation Voltage vs Collector Current



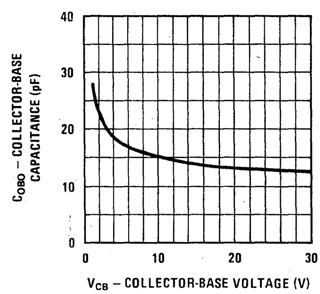
Base-Emitter ON Voltage vs Collector Current



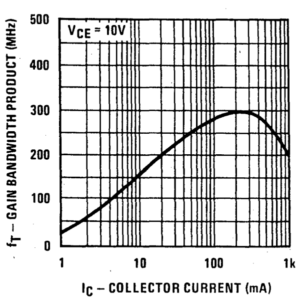
Base-Emitter Saturation Voltage vs Collector Current



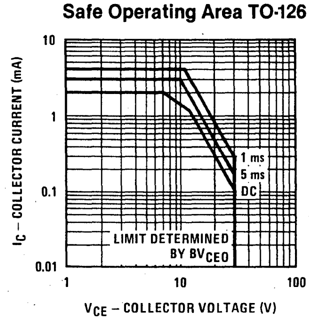
Collector-Base Capacitance vs Collector-Base Voltage



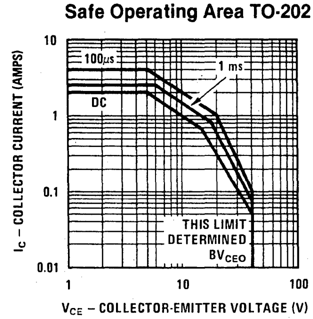
Gain Bandwidth Product vs Collector Current



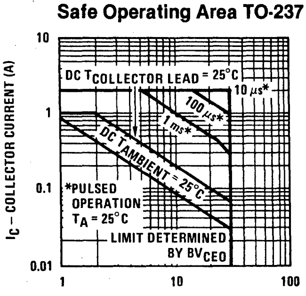
Safe Operating Area TO-126



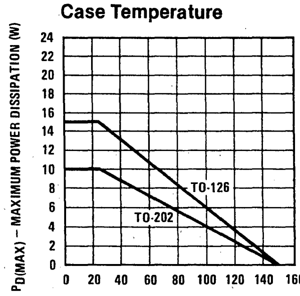
Safe Operating Area TO-202



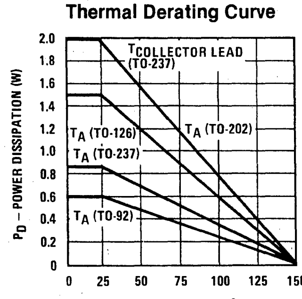
Safe Operating Area TO-237



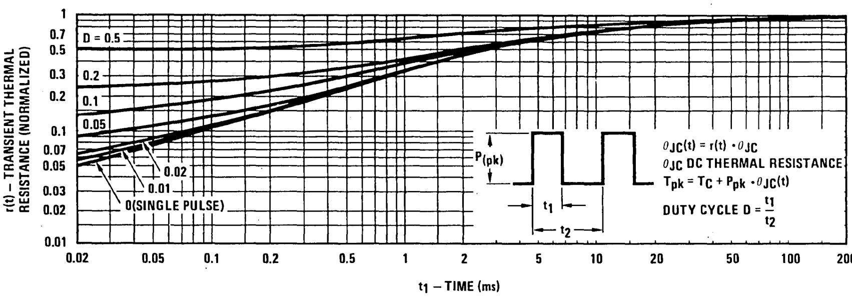
Maximum Power Dissipation vs Case Temperature



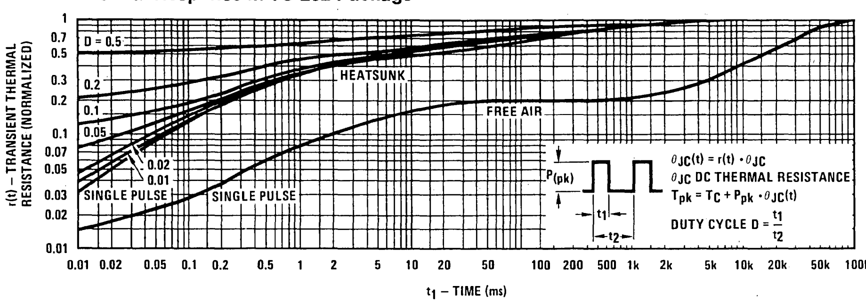
Thermal Derating Curve



Thermal Response in TO-126 Package

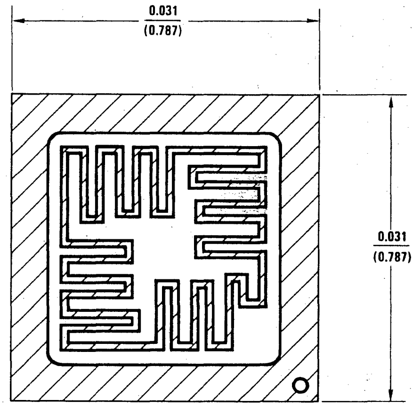


Thermal Response in TO-202 Package



National Semiconductor

Process 38 NPN Medium Power



DESCRIPTION

Process 38 is a double-diffused, silicon epitaxial planar device. Complement to Process 78.

APPLICATION

This device was designed for general purpose medium power amplifier and switching circuits that require collector currents to 1.5A.

PRINCIPAL DEVICE TYPES

TO-202, EBC: 2N6551, D40D1-14, D40E5, 7, NSD102, 103, NSDU05

TO-202, BCE: NSE180, 181

TO-237, EBC: 2N6716 (92PU05)

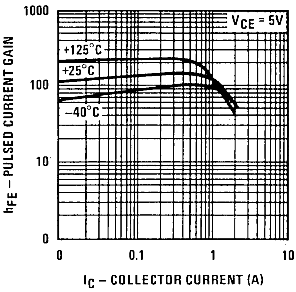
TO-237, ECB: 2N6705, 6 (92PE37A, B)

TO-126, ECB: BDE345, MJE181, MJE721

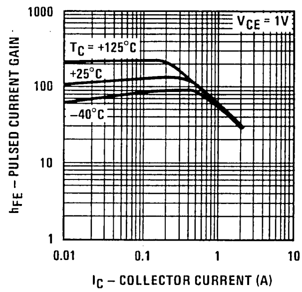
Parameter	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 10$ mA	40			V
BV_{CBO}	$I_C = 100\ \mu A$	65			V
BV_{EBO}	$I_E = 10\ \mu A$	5			V
I_{CBO}	$V_{CB} = 40V$			100	nA
I_{EBO}	$V_{EB} = 4V$			100	nA
h_{FE}	$I_C = 100$ mA, $V_{CE} = 1V$	60	160	360	
h_{FE}	$I_C = 1A$, $V_{CE} = 1V$	20			
$V_{CE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA			0.5	V
$V_{BE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA			1.25	V
f_T	$I_C = 100$ mA, $V_{CE} = 10V$	125	250		MHz
C_{ob}	$V_{CB} = 10V$, f = 1 MHz		14	18	pF
$P_{D(max)}$					
TO-126	$T_C = 25°C$	15			W
	$T_A = 25°C$	1.5			
TO-202	$T_C = 25°C$	10			W
	$T_A = 25°C$	2			
TO-237	$T_{COLLECTOR\ LEAD} = 25°C$	2			W
	$T_A = 25°C$	850			mW
TO-92	$T_C = 25°C$	600			mW
θ_{JC}					
TO-220	$T_C = 25°C$				°C/W
TO-126	$T_C = 25°C$			8.33	°C/W
TO-202	$T_C = 25°C$			12.5	°C/W
TO-237	$T_{COLLECTOR\ LEAD} = 25°C$			62.5	°C/W
θ_{JA}					
TO-126	$T_A = 25°C$			83.3	°C/W
TO-202	$T_A = 25°C$			62.5	°C/W
TO-237	$T_A = 25°C$			147	°C/W
TO-92	$T_A = 25°C$			208	°C/W
$T_{J(max)}$	All Plastic Parts	150			°C

Process 38

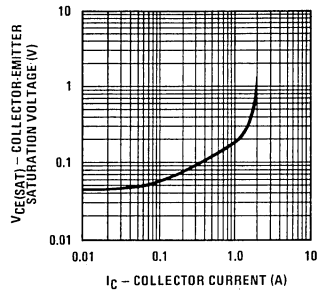
Typical Pulsed Current Gain vs Collector Current



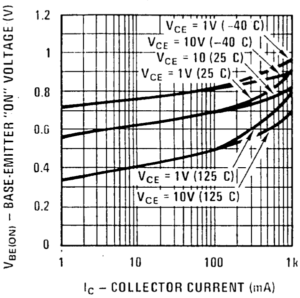
Typical Pulsed Current Gain vs Collector Current



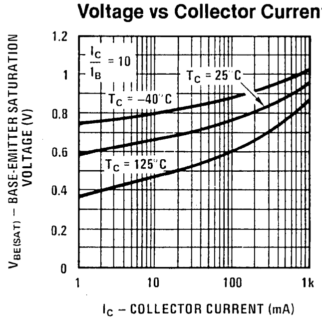
Collector-Emitter Saturation Voltage vs Collector Current



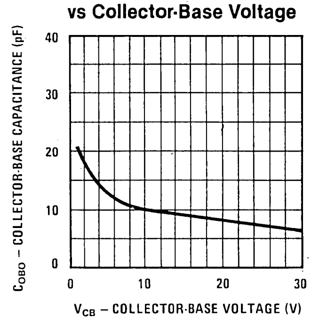
Base-Emitter ON Voltage vs Collector Current



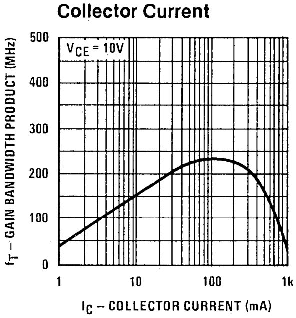
Base-Emitter Saturation Voltage vs Collector Current



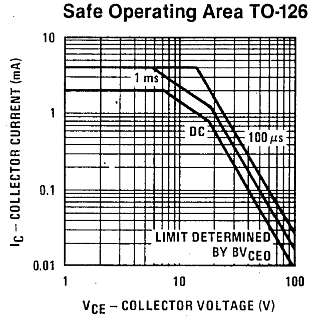
Collector-Base Capacitance vs Collector-Base Voltage



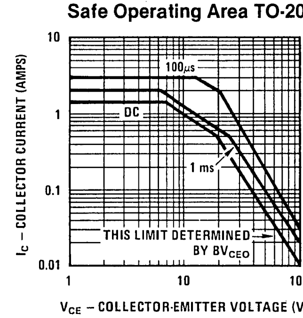
Gain Bandwidth Product vs Collector Current



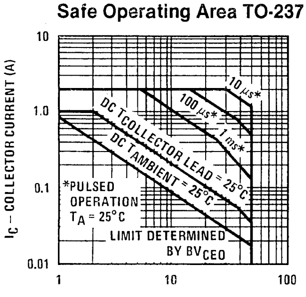
Safe Operating Area TO-126



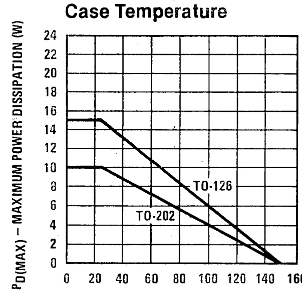
Safe Operating Area TO-202



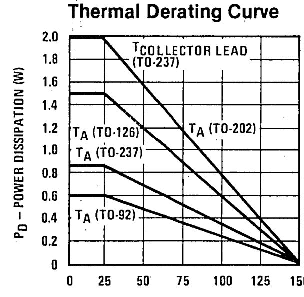
Safe Operating Area TO-237



Maximum Power Dissipation vs Case Temperature

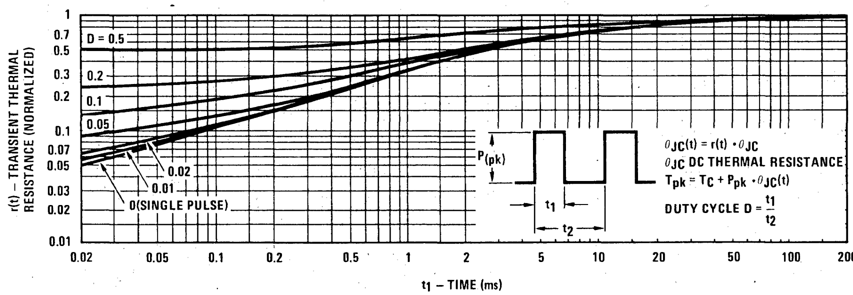


Thermal Derating Curve

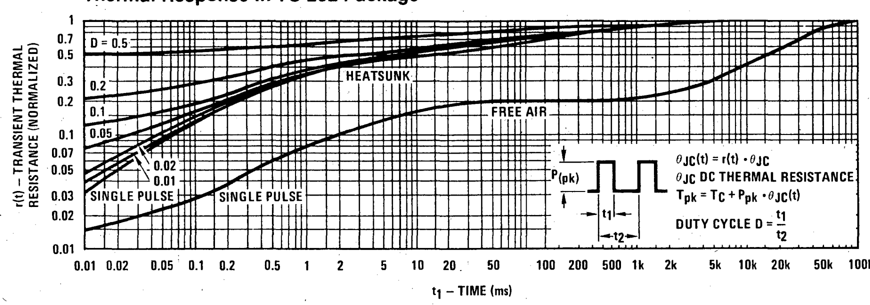


Process 38

Thermal Response in TO-126 Package

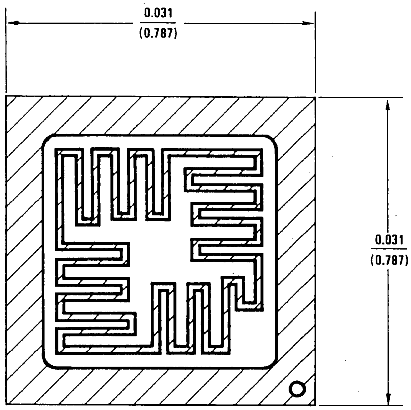


Thermal Response in TO-202 Package



National Semiconductor

Process 39 NPN Medium Power



DESCRIPTION

Process 39 is a double-diffused, silicon epitaxial planar device. Complement to Process 79.

APPLICATION

This device was designed for general purpose medium power amplifier and switching circuits that require collector currents to 1A.

PRINCIPAL DEVICE TYPES

TO-202, EBC: 2N6552, 3
NSD104-106
NSDU07

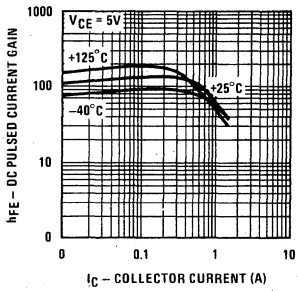
TO-237, EBC: 2N6717, 18
(92PU06, 07)

TO-237, ECB: 2N6707
(92PE37C)

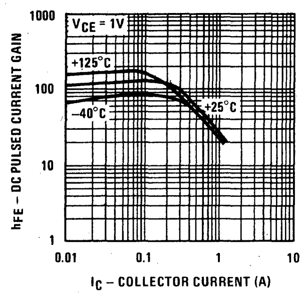
Parameter	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 10$ mA	80			V
BV_{CBO}	$I_C = 100\ \mu A$	100			V
BV_{EBO}	$I_E = 10\ \mu A$	5			V
I_{CBO}	$V_{CB} = 80V$			100	nA
I_{EBO}	$V_{EB} = 4V$			100	nA
h_{FE}	$I_C = 100$ mA, $V_{CE} = 1V$	50		300	
h_{FE}	$I_C = 500$ mA, $V_{CE} = 1V$	20			
$V_{CE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA			0.8	V
$V_{BE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA			1.3	V
f_T	$I_C = 100$ mA, $V_{CE} = 10V$	80	150		MHz
C_{ob}	$V_{CB} = 10V$, f = 1 MHz		10	15	pF
$P_{D(max)}$					
TO-126	$T_C = 25°C$ $T_A = 25°C$	15 1.5			W
TO-202	$T_C = 25°C$ $T_A = 25°C$	10 2			W
TO-237	$T_{COLLECTOR\ LEAD} = 25°C$ $T_A = 25°C$	2 850			W mW
TO-92	$T_A = 25°C$	600			mW
θ_{JC}					
TO-220	$T_C = 25°C$				°C/W
TO-126	$T_C = 25°C$			8.33	°C/W
TO-202	$T_C = 25°C$			12.5	°C/W
TO-237	$T_{COLLECTOR\ LEAD} = 25°C$			62.5	°C/W
θ_{JA}					
TO-126	$T_A = 25°C$			83.3	°C/W
TO-202	$T_A = 25°C$			62.5	°C/W
TO-237	$T_A = 25°C$			147	°C/W
TO-92	$T_A = 25°C$			208	°C/W
$T_{J(max)}$	All Plastic Parts	150			°C

Process 39

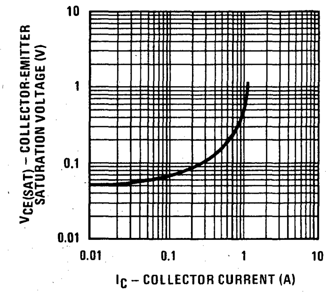
Typical Pulsed Current Gain vs Collector Current



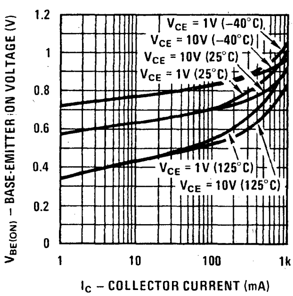
Typical Pulsed Current Gain vs Collector Current



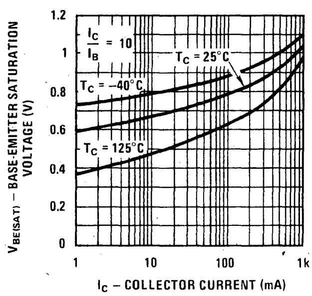
Collector-Emitter Saturation Voltage vs Collector Current



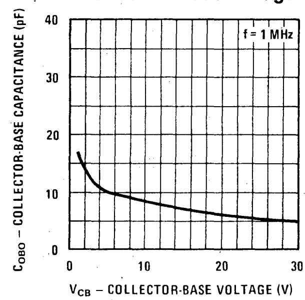
Base-Emitter ON Voltage vs Collector Current



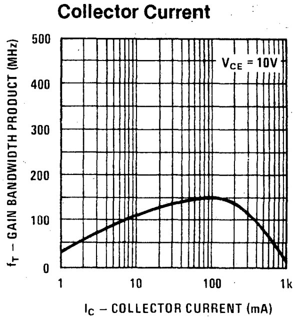
Base-Emitter Saturation Voltage vs Collector Current



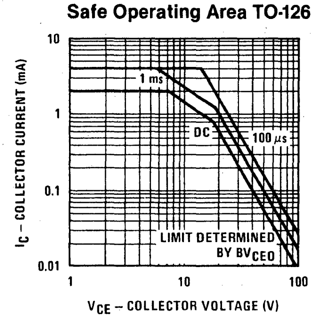
Collector-Base Capacitance vs Collector-Base Voltage



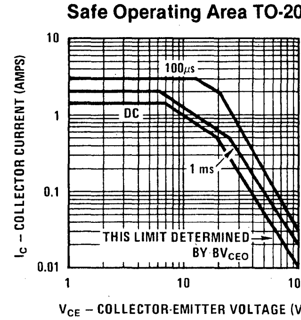
Gain Bandwidth Product vs Collector Current



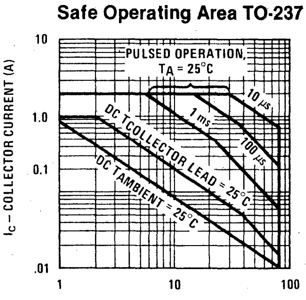
Safe Operating Area TO-126



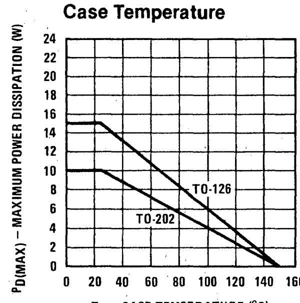
Safe Operating Area TO-202



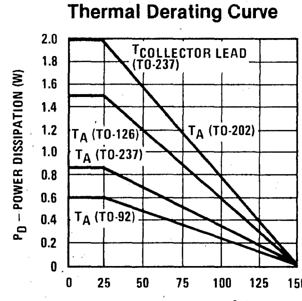
Safe Operating Area TO-237



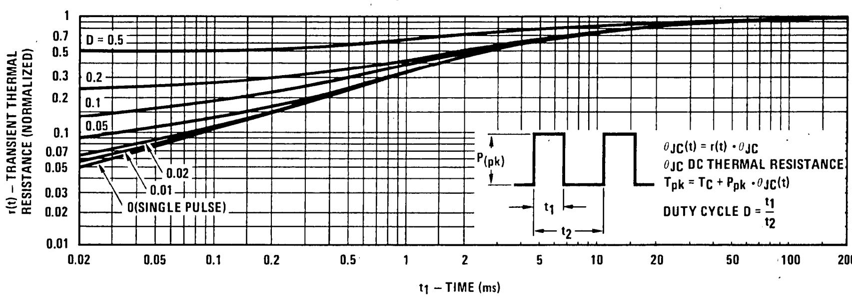
Maximum Power Dissipation vs Case Temperature



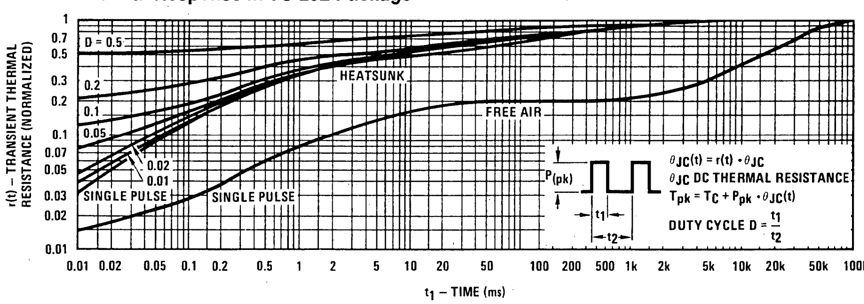
Thermal Derating Curve



Thermal Response in TO-126 Package

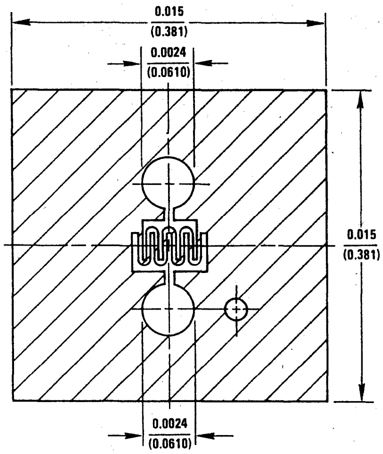


Thermal Response in TO-202 Package



National Semiconductor

Process 40 NPN RF Amp



DESCRIPTION

Process 40 is an overlay, double-diffused, silicon epitaxial device.

APPLICATION

This device was designed for use in low noise UHF/VHF amplifiers with collector current in the 100 μA to 20 mA range in common emitter or common base mode of operation, and in low frequency drift, high output UHF oscillators.

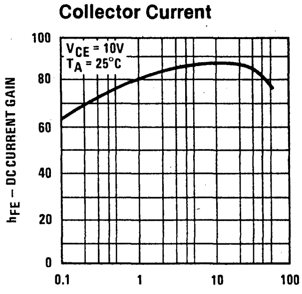
PRINCIPAL DEVICE TYPES

TO-72

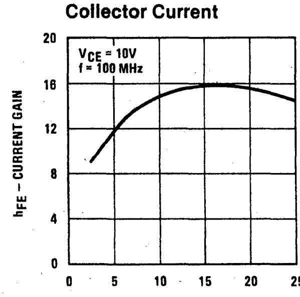
TO-92

Parameter	Conditions	Min	Typ	Max	Units	Notes
P_G	f = 450 MHz, V_{CE} = 10V, I_C = 2 mA	12	16		dB	*Figure 1*
NF	f = 450 MHz, V_{CE} = 10V, I_C = 2 mA, R_G = 50Ω		3.0	5.0	dB	*Figure 1*
P_{OUT}	f = 500 MHz, V_{CB} = 15V, I_E = 10 mA	40	65		mW	TO-92 *Figure 2*
h_{fe}	f = 100 MHz, V_{CE} = 10V, I_C = 10 mA	10	15			
rb'Cc	f = 79.8 MHz, V_{CE} = 10V, I_C = 5 mA			10	ps	
C_{CB}	f = 1.0 MHz, V_{CB} = 10V, I_E = 0		0.5	0.6	pF	TO-72
C_{CE}	f = 1.0 MHz, V_{CE} = 10V, I_B = 0		0.2	0.3	pF	TO-72
C_{EB}	f = 1.0 MHz, V_{EB} = 0.5V, I_C = 0		0.8	1.5	pF	TO-72
h_{FE}	V_{CE} = 10V, I_C = 5 mA	40	90	200		
h_{FE}	V_{CE} = 6V, I_C = 1 mA	30				
$V_{CE(SAT)}$	I_C = 10 mA, I_B = 5 mA			0.2	V	
BV_{CEO}	I_C = 1 mA	20			V	
BV_{CBO}	I_C = 10 μA	30			V	
BV_{EBO}	I_E = 10 μA	4.0			V	
I_{CBO}	V_{CB} = 20V			100	nA	
I_{EBO}	V_{EB} = 3V			100	nA	

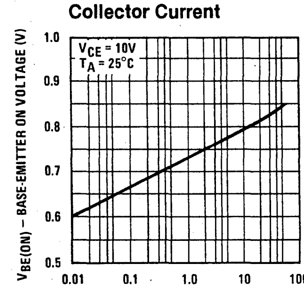
DC Current Gain vs Collector Current



Current Gain at 100 MHz vs Collector Current

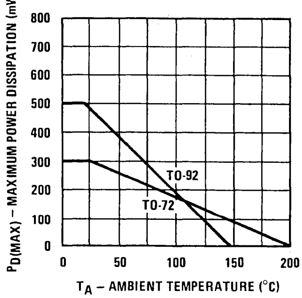


Base-Emitter ON Voltage vs Collector Current

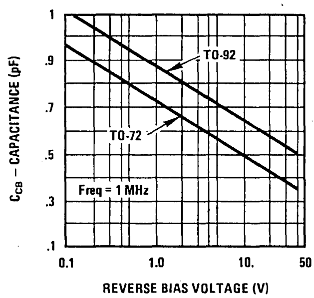


Process 40

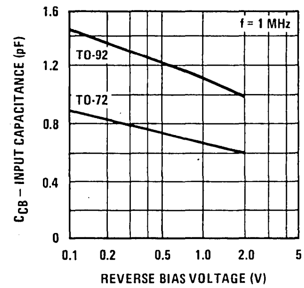
Maximum Power Dissipation vs Ambient Temperature



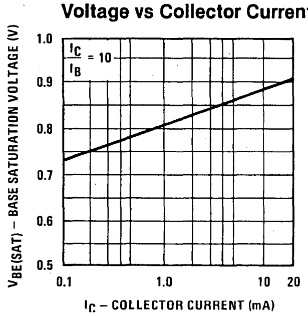
Reverse Transfer Capacitance vs Reverse Bias Voltage



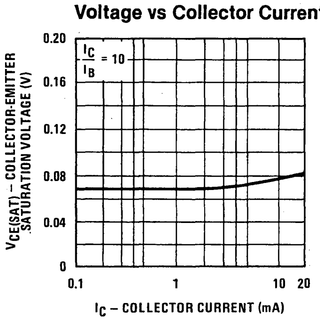
Input Capacitance vs Reverse Bias Voltage

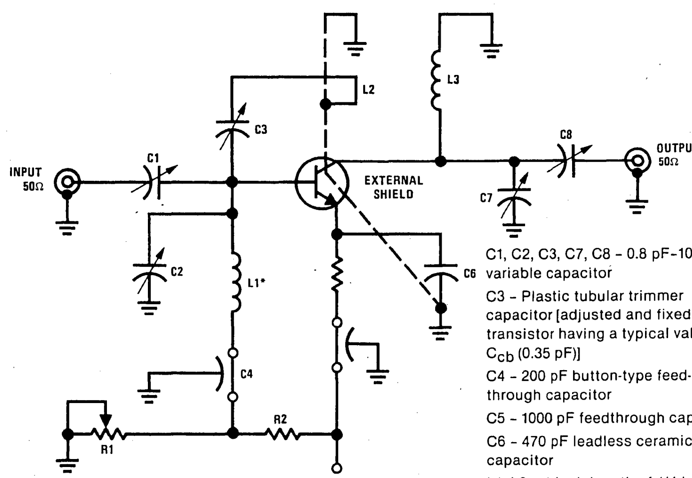


Base-Emitter Saturation Voltage vs Collector Current



Collector-Emitter Saturation Voltage vs Collector Current





C1, C2, C3, C7, C8 - 0.8 pF–10 pF variable capacitor

C3 - Plastic tubular trimmer capacitor [adjusted and fixed for a transistor having a typical value of C_{cb} (0.35 pF)]

C4 - 200 pF button-type feed-through capacitor

C5 - 1000 pF feedthrough capacitor

C6 - 470 pF leadless ceramic disc capacitor

L1, L3 - 1 inch length of 1/4 inch diameter copper bar stock

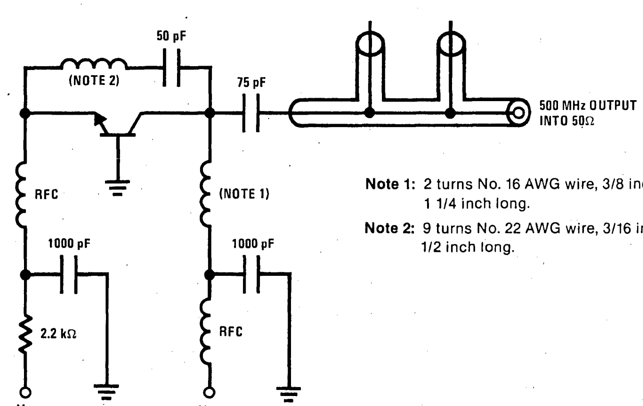
L2 - 1/2 loop No. 14 AWG enameled wire parallel to and approximately 1/4 inch from L3

R1 - 5 kΩ potentiometer

R2 - 1.2 kΩ

R3 - 2 kΩ

FIGURE 1. Neutralized 450 MHz Gain and Noise Figure Circuit



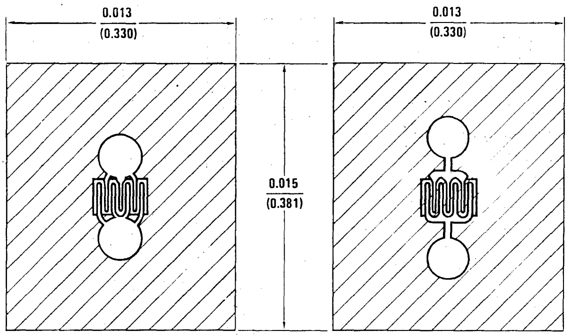
Note 1: 2 turns No. 16 AWG wire, 3/8 inch OD, 1 1/4 inch long.

Note 2: 9 turns No. 22 AWG wire, 3/16 inch OD, 1/2 inch long.

FIGURE 2. 500 MHz Oscillator Circuit

National Semiconductor

Process 41
NPN UHF Amp/Mixer



DESCRIPTION

Process 41 is an overlay, double-diffused, silicon epitaxial device.

APPLICATION

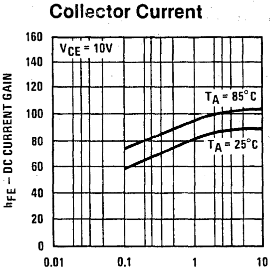
This device was designed for use in extremely low noise UHF/VHF preamplifiers operated common emitter or common base, and in UHF mixers.

PRINCIPAL DEVICE TYPES

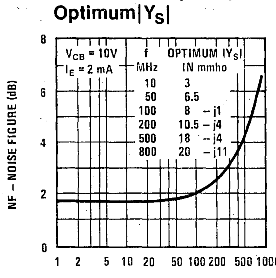
TO-72
TO-92

Parameter	Conditions	Min	Typ	Max	Units	Notes
NF	f = 800 MHz, V_{CB} = 10V, I_C = 2 mA, Common Base, $\|Y_S\|$ = Optimum		5.5		dB	TO-72
NF	f = 800 MHz, V_{CB} = 10V, I_C = 2 mA, Common Base, $\|Y_S\|$ = 10 ± i0 mmhos		7.0	9.5	dB	TO-72
P_G	f = 800 MHz, V_{CB} = 10V, I_C = 2 mA, Common Base, R_L = 500Ω	7.5	9.0		dB	TO-72
NF	f = 450 MHz, V_{CE} = 10V, I_C = 2 mA, Common Emitter, R_S = 75Ω		2.0		dB	TO-72
NF	f = 200 MHz, V_{CB} = 10V, I_C = 3 mA, Common Base, R_S = 100Ω		2.5	3.0	dB	*Figure 1*
P_G	f = 200 MHz, V_{CB} = 10V, I_C = 3 mA, Common Base, R_L = 1 kΩ	13	16		dB	*Figure 1*
rb'Cc	f = 79.8 MHz, V_{CB} = 10V, I_C = 3 mA		2.5	5.0	ps	TO-72
h_{fe}	f = 100 MHz, V_{CE} = 10V, I_C = 3 mA	7.0	8.5			
C_{CB}	f = 1.0 MHz, V_{CB} = 10V, I_E = 0		0.28	0.35	pF	TO-72
C_{CE}	f = 1.0 MHz, V_{CE} = 10V, I_B = 0		0.12 0.19	0.20 0.30	pF pF	TO-72 TO-92
h_{FE}	V_{CE} = 10V, I_C = 3 mA	30	75	200		
BV_{CEO}	I_C = 1 mA	20			V	
BV_{CBO}	I_C = 10 μA	30			V	
BV_{EBO}	I_E = 1 μA	3.0			V	
I_{CBO}	V_{CB} = 20V			100	nA	
I_{EBO}	V_{EB} = 2V			100	nA	

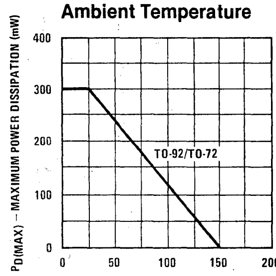
DC Current Gain vs Collector Current



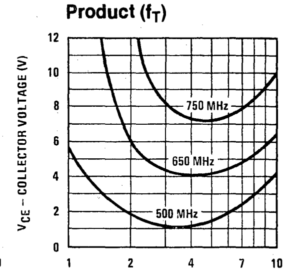
Common Base Noise Figure vs Frequency at Optimum $|Y_S|$



Maximum Power Dissipation vs Ambient Temperature

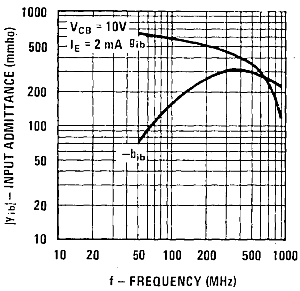


Contours of Constant Gain Bandwidth Product (f_T)

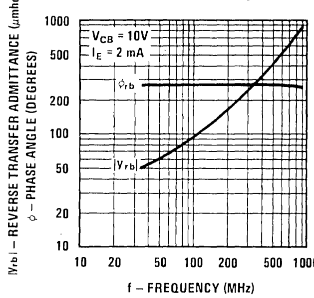


Process 41

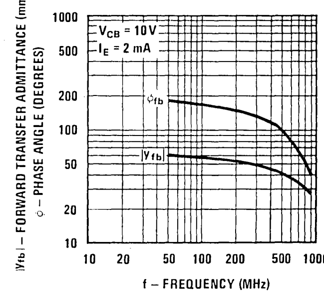
Input Admittance vs Frequency



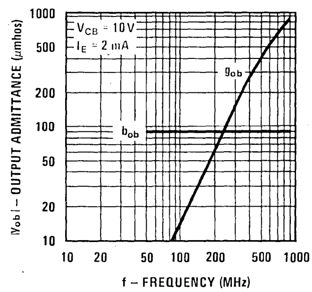
Reverse Transfer Admittance vs Frequency



Forward Transfer Admittance vs Frequency

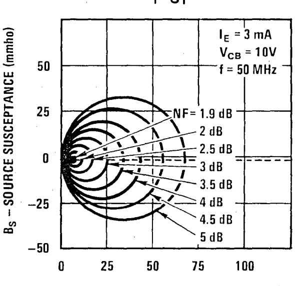


Output Admittance vs Frequency

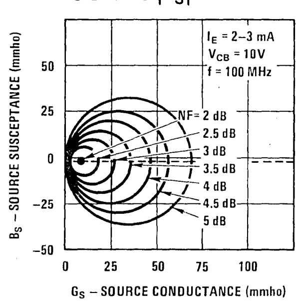


CONTOURS OF CONSTANT NOISE FIGURES

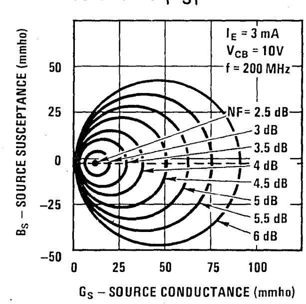
Common Base Noise Figure vs Source |Y_S|

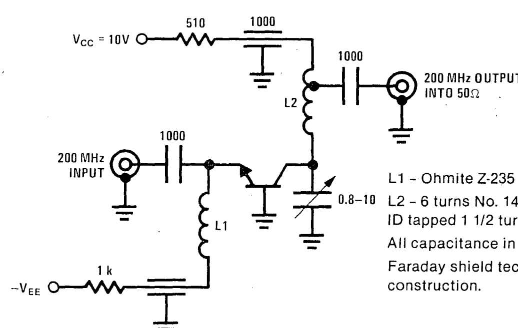


Common Base Noise Figure vs Source |Y_S|



Common Base Noise Figure vs Source |Y_S|





L1 - Ohmite Z-235 RF choke

L2 - 6 turns No. 14 wire, 1 inch L × 1/4 inch ID tapped 1 1/2 turns from cold side.

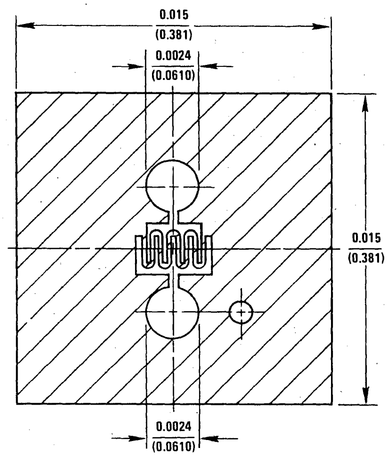
All capacitance in pF, all resistance in ohms.

Faraday shield techniques used in jig construction.

FIGURE 1. Common Base 200 MHz PG and NF Circuit

National Semiconductor

Process 42 NPN RF Amp



DESCRIPTION

Process 42 is an overlay, double-diffused, silicon epitaxial device.

APPLICATION

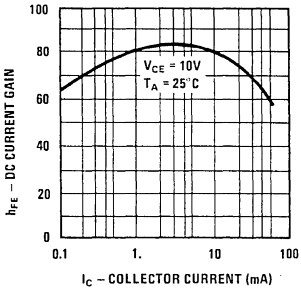
This device was designed for use in low noise UHF/VHF amplifiers with collector current in the 100 μA to 10 mA range in common emitter or common base mode of operation, and in low frequency drift, high output UHF oscillators.

PRINCIPAL DEVICE TYPES

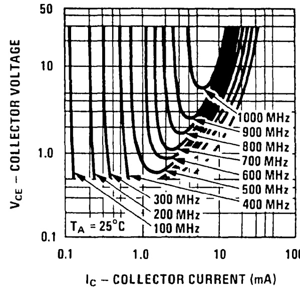
TO-72: 2N5179
TO-92, ECB: 2SC535
TO-92, BEC: MPS-H10

Parameter	Conditions	Min	Typ	Max	Units	Notes
P_G	f = 450 MHz, V_{CE} = 10V, I_C = 2 mA	10	13		dB	*Figure 1*
NF	f = 450 MHz, V_{CE} = 10V, I_C = 2 mA, R_G = 50Ω		3.0	5.0	dB	*Figure 1*
P_{OUT}	f = 500 MHz, V_{CB} = 15V, I_E = 8 mA	30	50		mW	TO-92 *Figure 3*
P_G	f = 200 MHz, V_{CE} = 10V, I_C = 2 mA	22	27		dB	*Figure 2*
NF	f = 200 MHz, V_{CE} = 10V, I_C = 2 mA, R_S = 120Ω		2.0	3.5	dB	*Figure 2*
h_{fe}	f = 100 MHz, V_{CE} = 10V, I_C = 5 mA	6	10			
rb′Cc	f = 79.8 MHz, V_{CE} = 10V, I_C = 5 mA			10	ps	
C_{CB}	f = 1.0 MHz, V_{CB} = 10V, I_E = 0		0.4	0.5	pF	TO-72
C_{CE}	f = 1.0 MHz, V_{CE} = 10V, I_B = 0		0.2	0.3	pF	TO-72
C_{EB}	f = 1.0 MHz, V_{EB} = 0.5V, I_C = 0		0.8	1.5	pF	TO-72
h_{FE}	V_{CE} = 10V, I_C = 5 mA	40	90	200		
h_{FE}	V_{CE} = 6V, I_C = 1 mA	30				
$V_{CE(SAT)}$	I_C = 10 mA, I_B = 5 mA			0.2	V	
BV_{CEO}	I_C = 1 mA	30			V	
BV_{CBO}	I_C = 10 μA	35			V	
BV_{EBO}	I_E = 10 μA	4			V	
I_{CBO}	V_{CB} = 30V			100	nA	
I_{EBO}	V_{EB} = 3V			100	nA	

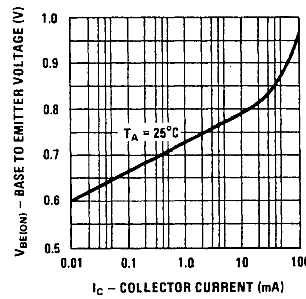
DC Current Gain vs Collector Current



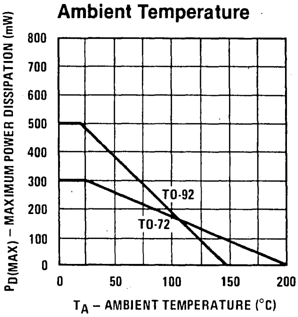
Contours of Constant Gain Bandwidth Product (f_T)



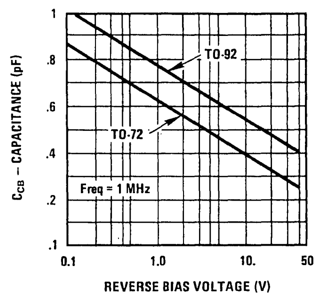
Base-Emitter ON Voltage vs Collector Current



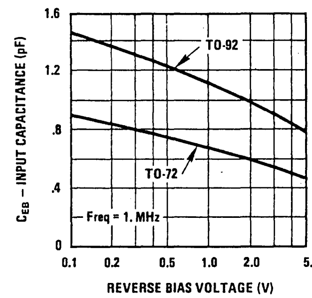
Maximum Power Dissipation vs Ambient Temperature



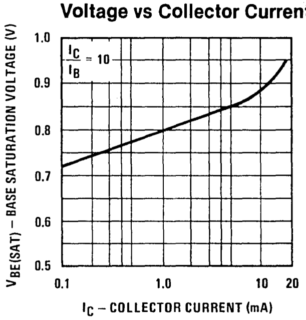
Reverse Transfer Capacitance vs Reverse Bias Voltage



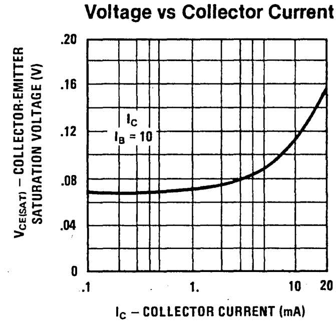
Input Capacitance vs Reverse Bias Voltage



Base-Emitter Saturation Voltage vs Collector Current



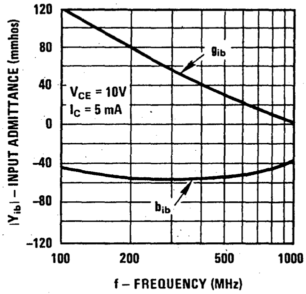
Collector-Emitter Saturation Voltage vs Collector Current



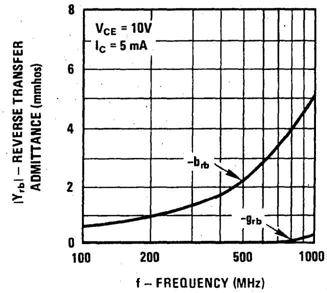
Process 42

COMMON BASE Y PARAMETERS VS FREQUENCY

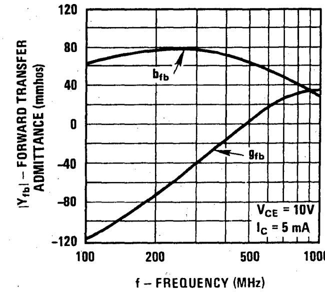
Input Admittance vs Frequency



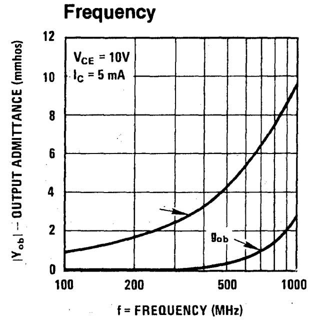
Reverse Transfer Admittance vs Frequency



Forward Transfer Admittance vs Frequency

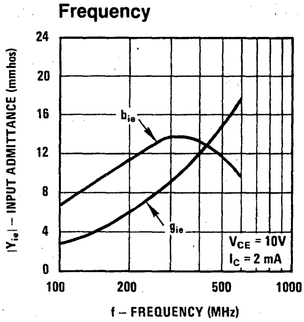


Output Admittance vs Frequency

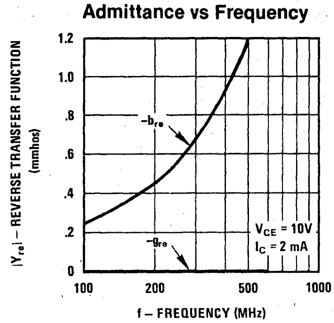


COMMON EMITTER Y PARAMETERS VS FREQUENCY

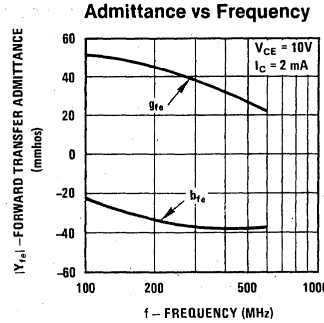
Input Admittance vs Frequency



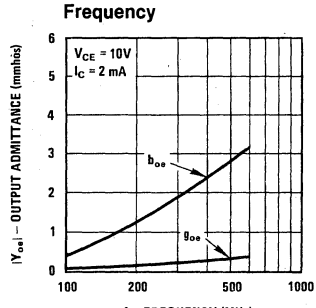
Reverse Transfer Admittance vs Frequency

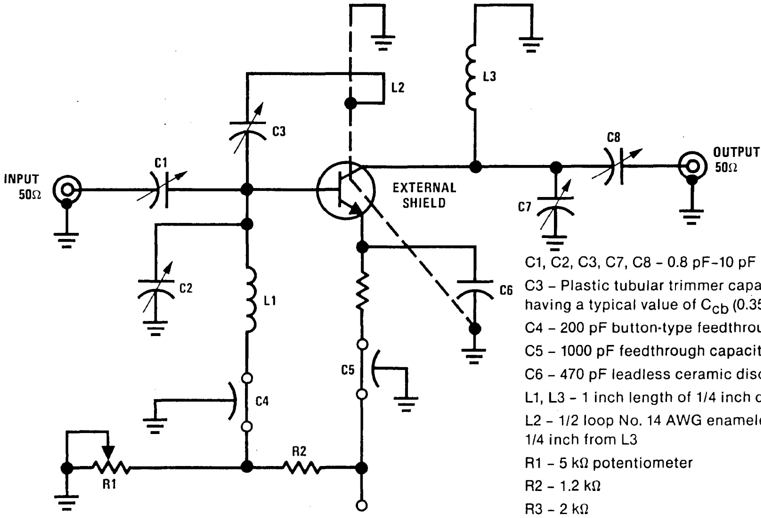


Forward Transfer Admittance vs Frequency



Output Admittance vs Frequency





C1, C2, C3, C7, C8 - 0.8 pF-10 pF variable capacitor

C3 - Plastic tubular trimmer capacitor [adjusted and fixed for a transistor having a typical value of C_{cb} (0.35 pF)]

C4 - 200 pF button-type feedthrough capacitor

C5 - 1000 pF feedthrough capacitor

C6 - 470 pF leadless ceramic disc capacitor

L1, L3 - 1 inch length of 1/4 inch diameter copper bar stock

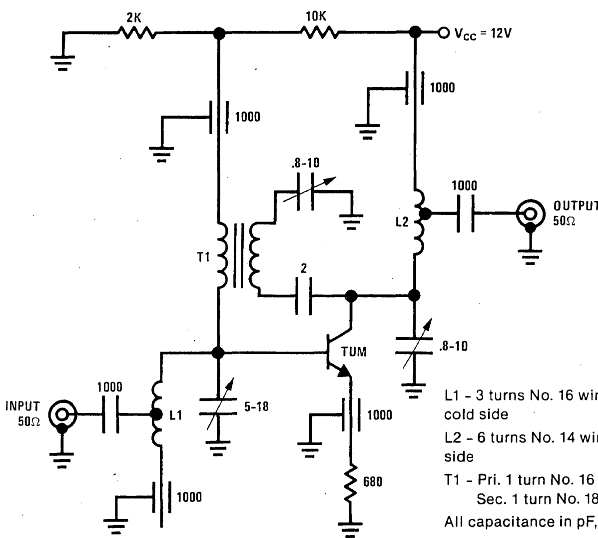
L2 - 1/2 loop No. 14 AWG enameled wire parallel to and approximately 1/4 inch from L3

R1 - 5 kΩ potentiometer

R2 - 1.2 kΩ

R3 - 2 kΩ

FIGURE 1. Neutralized 450 MHz Gain and Noise Figure Circuit



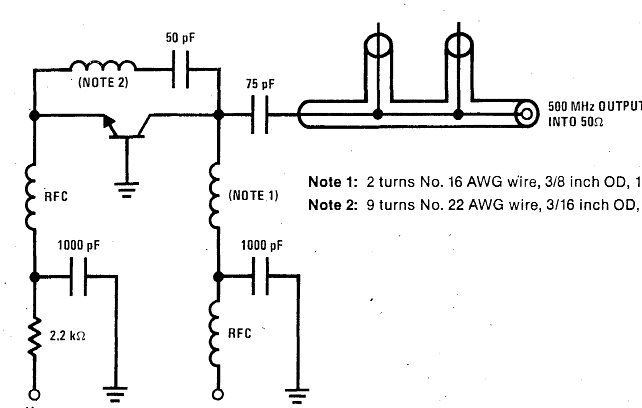
L1 - 3 turns No. 16 wire, 1/2 inch L × 1/4 inch ID tapped 1 1/2 turns from cold side

L2 - 6 turns No. 14 wire, 1 inch L × 1/4 inch ID tapped 1 1/2 turns from cold side

T1 - Pri. 1 turn No. 16 wire; Sec. 1 turn No. 18 wire — Core is Indiana General P/N F-684-Q3

All capacitance in pF, all resistance in ohms.

FIGURE 2. Neutralized 200 MHz PF and NF Circuit



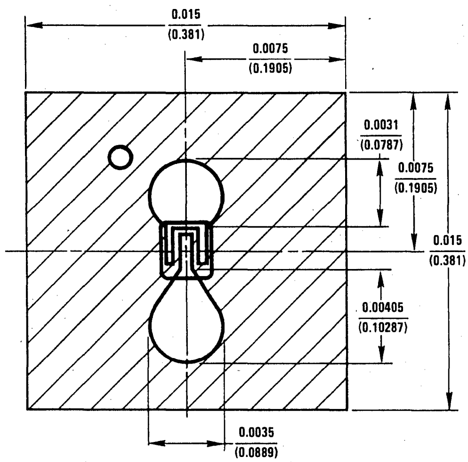
Note 1: 2 turns No. 16 AWG wire, 3/8 inch OD, 1 1/4 inch long.

Note 2: 9 turns No. 22 AWG wire, 3/16 inch OD, 1/2 inch long.

FIGURE 3. 500 MHz Oscillator Circuit

National Semiconductor

Process 43
NPN VHF/UHF Oscillator



DESCRIPTION

Process 43 is an overlay, double-diffused, silicon epitaxial device.

APPLICATION

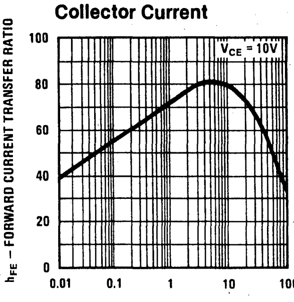
This device was designed for use as RF amplifiers, oscillators and multipliers with collector current in the 1 mA to 2 mA range.

PRINCIPAL DEVICE TYPES

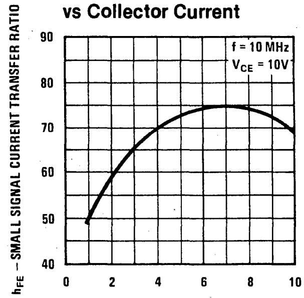
TO-72: 2N918
TO-92, EBC: PN3563
PN5130
TO-92, ECB: 2N3663

Parameter	Conditions	Min	Typ	Max	Units	Notes
G_{PE}	f = 200 MHz, I_C = 5 mA, V_{CE} = 10V	14	18		dB	Neutralized
NF	f = 60 MHz, I_C = 1 mA, V_{CE} = 10V, R_S = 200Ω		3.5	6.0	dB	
PO	f = 500 MHz, I_C = 8 mA, V_{CE} = 15V	20	35		mW	*Figure 1*
PO	f = 900 MHz, I_C = 8 mA, V_{CE} = 15V	3.0	8.0		mW	
h_{fe}	I_C = 5 mA, V_{CE} = 10V, f = 100 MHz	6.0	9.0			
rb'Cc	f = 79.8 MHz, V_{CE} = 10V, I_E = 8 mA		10	25	ps	
C_{CB}	V_{CB} = 10V, I_E = 0		1.2	1.7	pF	
C_{EB}	V_{EB} = 0.5V, I_C = 0		1.4	2.0	pF	
h_{FE}	I_C = 1 mA, V_{CE} = 1V	25				
h_{FE}	I_C = 5 mA, V_{CE} = 10V	40	80	200		
h_{FE}	I_C = 30 mA, V_{CE} = 10V	30				
$V_{CE(SAT)}$	I_C = 10 mA, I_B = 1 mA		0.25		V	
$V_{BE(SAT)}$	I_C = 10 mA, I_B = 1 mA		0.9		V	
BV_{CEO}	I_C = 3 mA	15			V	
BV_{CBO}	I_C = 10 μA	30			V	
BV_{EBO}	I_E = 10 μA	4			V	
I_{CBO}	V_{CB} = 20V			100	nA	
I_{EBO}	V_{CB} = 3V			100	nA	

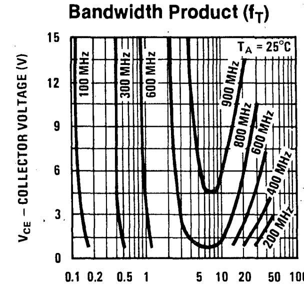
DC Current Gain vs Collector Current



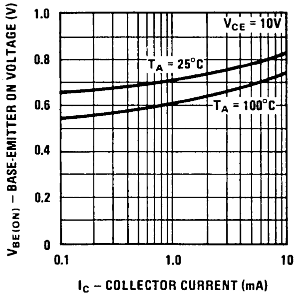
Small Signal Current Gain vs Collector Current



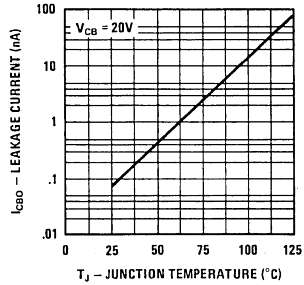
Contours of Constant Gain Bandwidth Product (f_T)



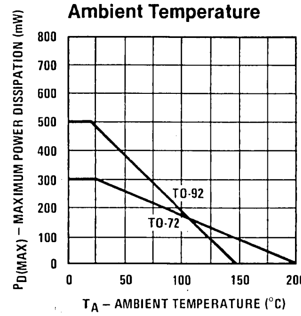
Base-Emitter ON Voltage vs Collector Current



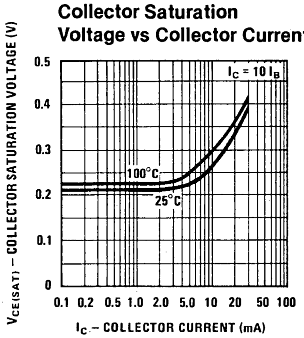
Collector-Base Diode Reverse Current vs Temperature



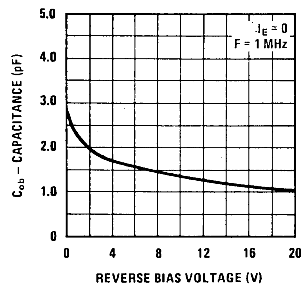
Maximum Power Dissipation vs Ambient Temperature



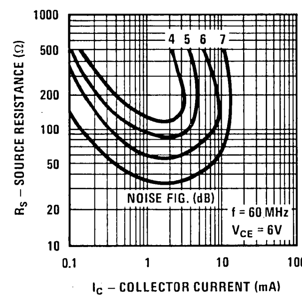
Collector Saturation Voltage vs Collector Current

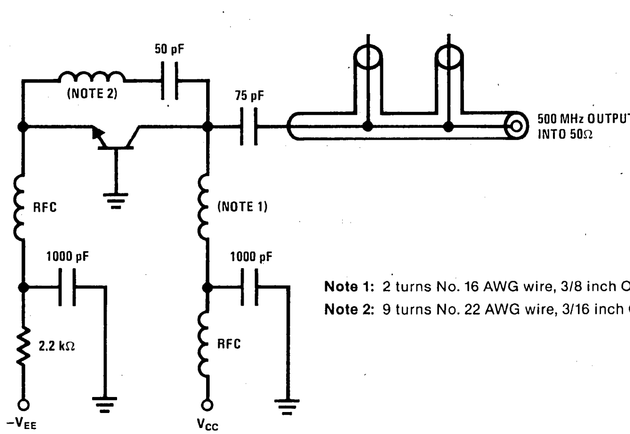


Output Capacitance vs Reverse Bias Voltage



Contours of Constant Noise Figure





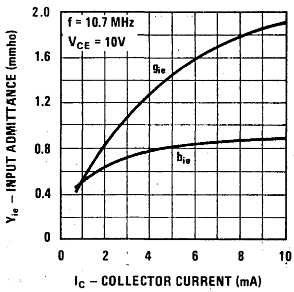
Note 1: 2 turns No. 16 AWG wire, 3/8 inch OD, 1 1/4 inch long.

Note 2: 9 turns No. 22 AWG wire, 3/16 inch OD, 1/2 inch long.

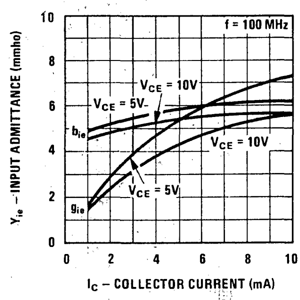
FIGURE 1. 500 MHz Oscillator Circuit

COMMON EMITTER Y PARAMETERS VS FREQUENCY

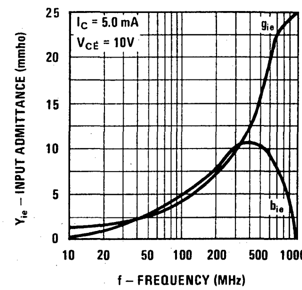
Input Admittance vs Collector Current-Output Short Circuit



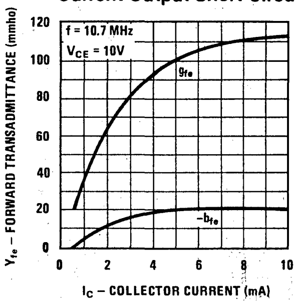
Input Admittance vs Collector Current-Output Short Circuit



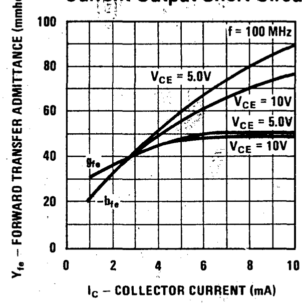
Input Admittance vs Frequency-Output Short Circuit



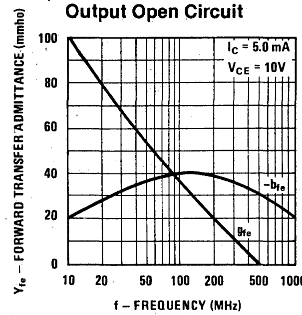
Forward Transfer Admittance vs Collector Current-Output Short Circuit



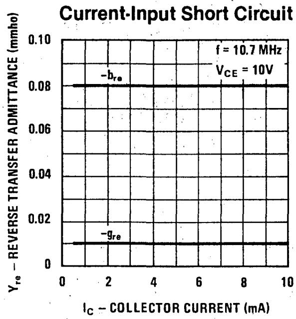
Forward Transfer Admittance vs Collector Current-Output Short Circuit



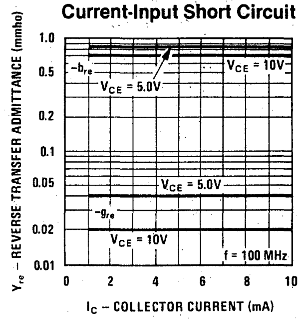
Forward Transfer Admittance vs Frequency-Output Open Circuit



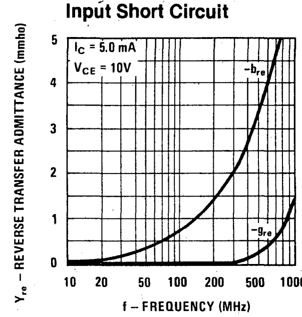
Reverse Transfer Admittance vs Collector Current-Input Short Circuit



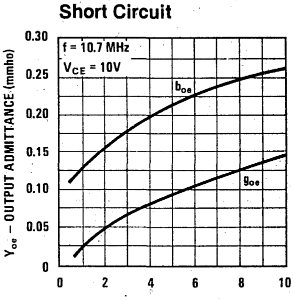
Reverse Transfer Admittance vs Collector Current-Input Short Circuit



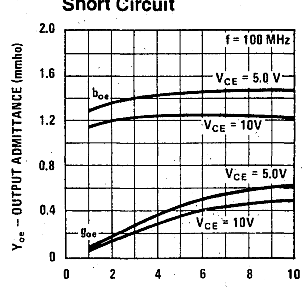
Reverse Transfer Admittance vs Frequency-Input Short Circuit



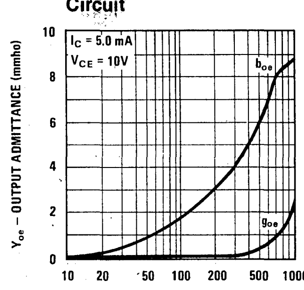
Output Admittance vs Collector Current-Input Short Circuit



Output Admittance vs Collector Current-Input Short Circuit

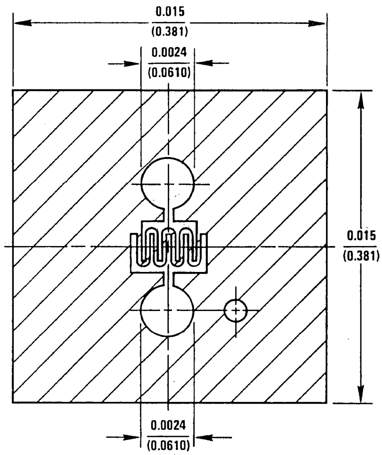


Output Admittance vs Frequency-Input Short Circuit



National Semiconductor

Process 44 NPN AGC-RF Amp



DESCRIPTION

Process 44 is an overlay, double-diffused, silicon device.

APPLICATION

This device was designed for use as a low noise VHF amplifier with forward AGC capability.

PRINCIPAL DEVICE TYPES

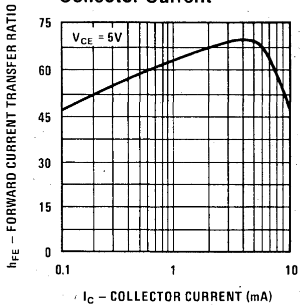
TO-72: SE5020

TO-92, BEC: MPS6568
MPS-H30

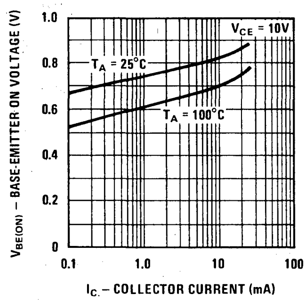
Parameter	Conditions	Min	Typ	Max	Units	Notes
NF	f = 200 MHz, I_C = 2 mA, V_{CE} = 10V, R_S = 50Ω		2.0	3.0	dB	*Figure 1*
P_G	f = 200 MHz, I_C = 2 mA, V_{CE} = 10V, R_S = 50Ω	20	24		dB	*Figure 1*
NF	f = 45 MHz, I_C = 4 mA, V_{CE} = 10V, R_S = 50Ω		3.0	5.0	dB	*Figure 2*
P_G	f = 45 MHz, I_C = 4 mA, V_{CE} = 10V, R_S = 50Ω	23	26		dB	*Figure 2*
AGC	f = 200 MHz, V_{AGC} at 30 dB Down	3.9	4.5	5.2	V	*Figure 1*
AGC	f = 45 MHz, V_{AGC} at 30 dB Down	4.0	5.0	6.0	V	*Figure 2*
C_{cb}	V_{CB} = 10V, I_E = 0		0.35	0.50	pF	TO-72
			0.45	0.55	pF	TO-92
h_{fe}	V_{CE} = 10V, I_C = 4 mA, f = 100 MHz	4.0	5.5			
h_{FE}	I_C = 4 mA, V_{CE} = 5V	30	70	200		
$V_{CE(SAT)}$	I_C = 10 mA, I_B = 5 mA		0.5	2.0	V	
$V_{BE(SAT)}$	I_C = 10 mA, I_B = 5 mA		0.85	0.95	V	
BV_{CEO}	I_C = 1 mA	30			V	
BV_{CBO}	I_C = 10 μA	30			V	
BV_{EBO}	I_E = 10 μA	4.0			V	
I_{CBO}	V_{CB} = 20V			100	nA	
I_{EBO}	V_{EB} = 3V			100	nA	

Process 44

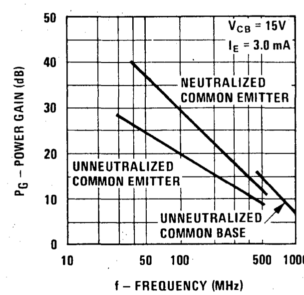
Pulsed DC Current Gain vs Collector Current



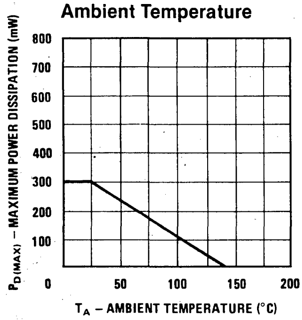
Base-Emitter ON Voltage vs Collector Current



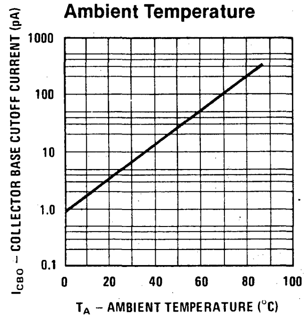
Power Gain vs Frequency



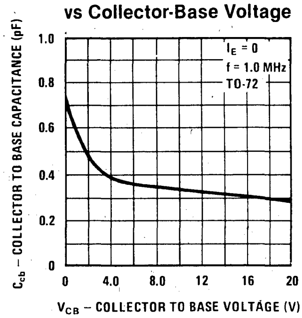
Maximum Power Dissipation vs Ambient Temperature



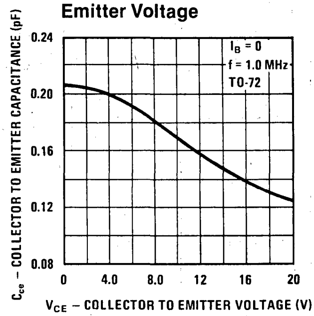
Collector Cutoff Current vs Ambient Temperature



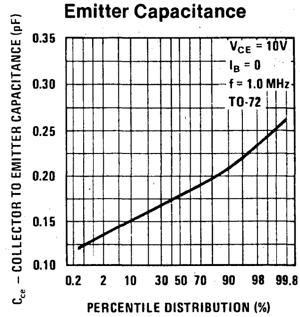
Collector-Base Capacitance vs Collector-Base Voltage



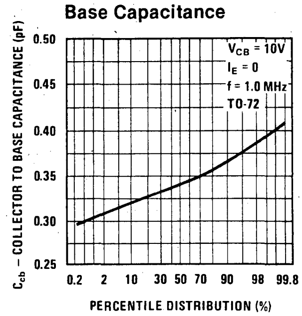
Collector-Emitter Capacitance vs Collector-Emitter Voltage



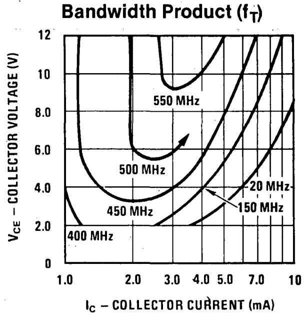
Distribution of Collector-Emitter Capacitance



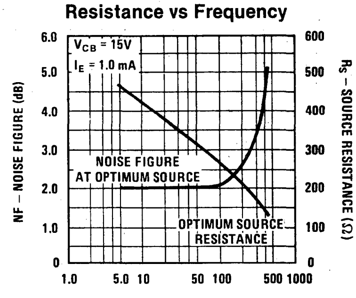
Distribution of Collector-Base Capacitance



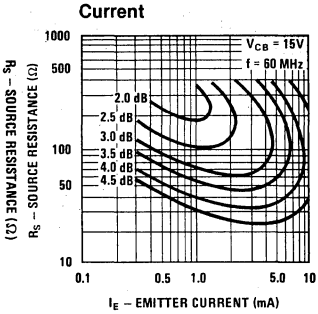
Contours of Constant Gain Bandwidth Product (f_T)



Noise Figure and Source Resistance vs Frequency



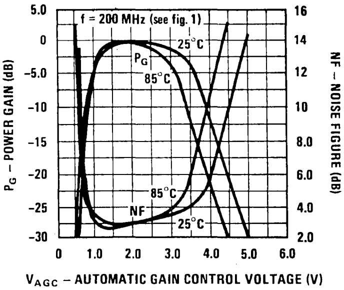
Noise Figure vs Source Resistance and Collector Current



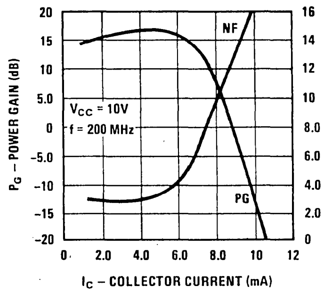
COMMON EMITTER PERFORMANCE

Process 44

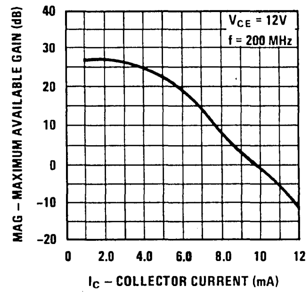
Power Gain and Noise Figure vs Automatic Gain Control Voltage



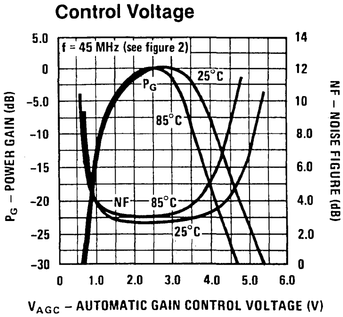
Power Gain and Noise Figure vs Collector Current



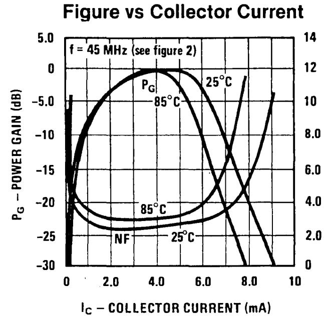
Maximum Available Gain vs Collector Current



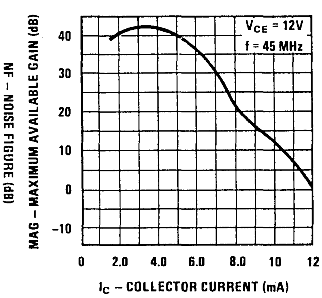
Power Gain and Noise Figure vs Automatic Gain Control Voltage

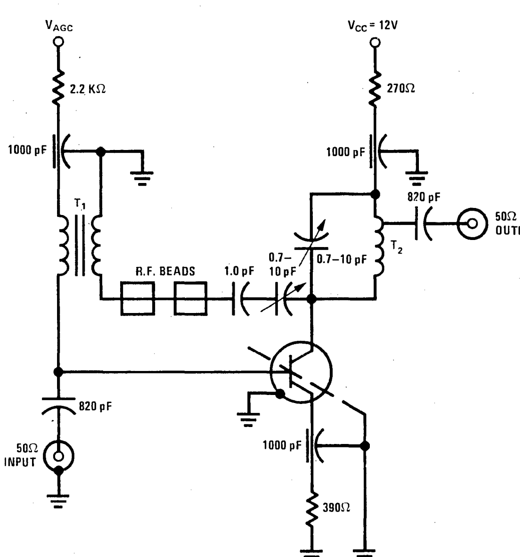


Power Gain and Noise Figure vs Collector Current



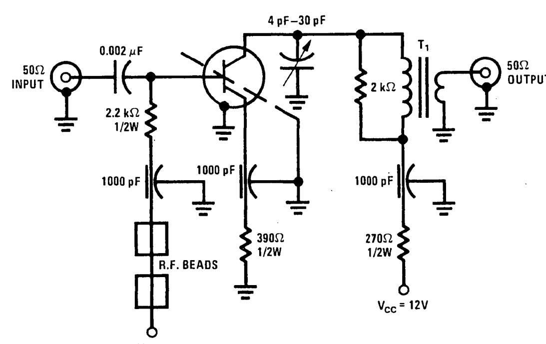
Maximum Available Gain vs Collector Current





T_1-Ferrite Core Indiana Gen. Corp. F-684-Q_3
T_2-6 turns No. 16 buss wire ID = 1/4 inch L = 3/4 inch

FIGURE 1. 200 MHz, AGC, Power Gain and Noise Figure Test Jig



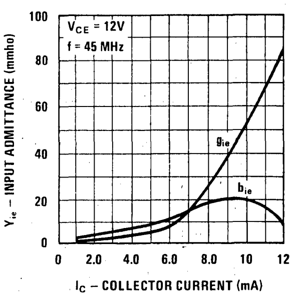
T_1-Q_3 Toroid 4:1 ratio, 8 turns-Pri. 2 turns-Sec. } No. 22 wire

FIGURE 2. 45 MHz, AGC, Power Gain and Noise Figure Test Jig

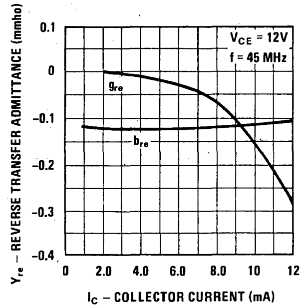
Process 44

COMMON EMITTER Y PARAMETERS VS FREQUENCY

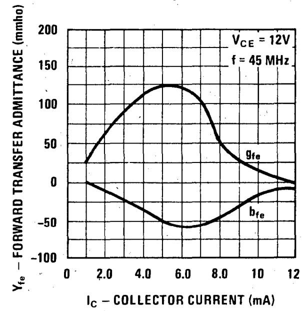
Input Admittance vs Collector Current-Output Short Circuit



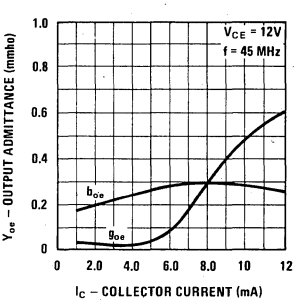
Reverse Transfer Admittance vs Collector Current-Input Short Circuit



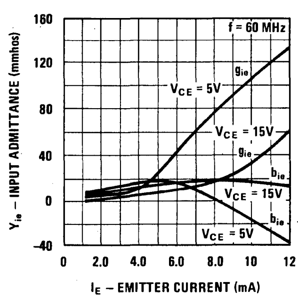
Forward Transfer Admittance vs Collector Current-Output Short Circuit



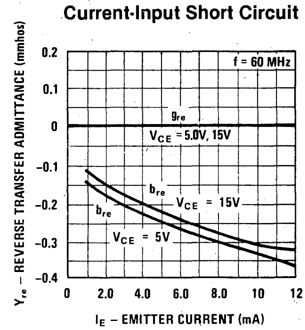
Output Admittance vs Collector Current-Input Short Circuit



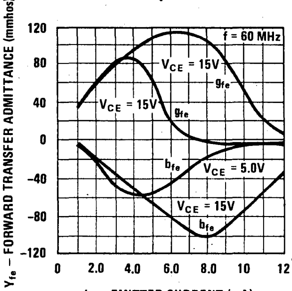
Input Admittance vs Emitter Current-Output Short Circuit



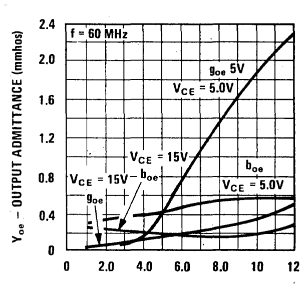
Reverse Transfer Admittance vs Emitter Current-Input Short Circuit



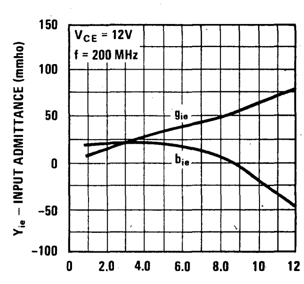
Forward Transfer Admittance vs Emitter Current-Output Short Circuit



Output Admittance vs Emitter Current-Input Short Circuit

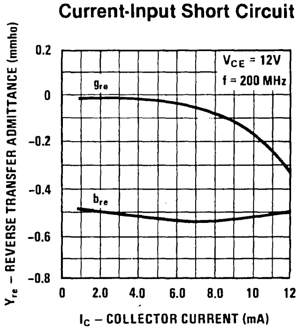


Input Admittance vs Collector Current-Output Short Circuit

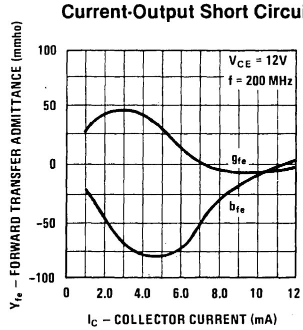


COMMON EMITTER Y PARAMETER VS FREQUENCY (Continued)

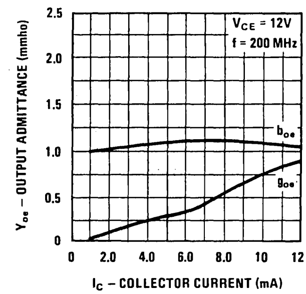
Reverse Transfer Admittance vs Collector Current-Input Short Circuit



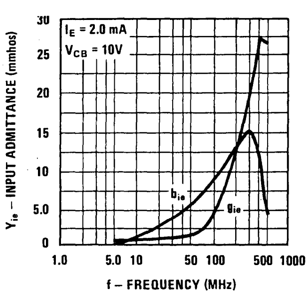
Forward Transfer Admittance vs Collector Current-Output Short Circuit



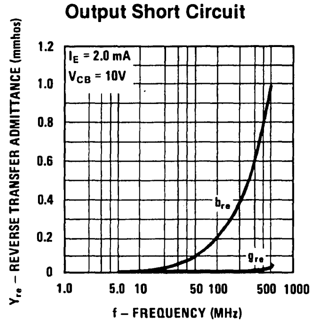
Output Admittance vs Collector Current-Input Short Circuit



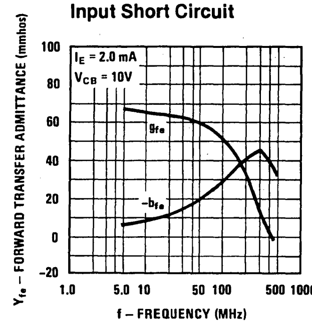
Input Admittance vs Frequency-Output Short Circuit



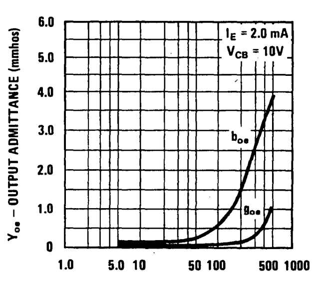
Reverse Transfer Admittance vs Frequency-Output Short Circuit



Forward Transfer Admittance vs Frequency-Input Short Circuit



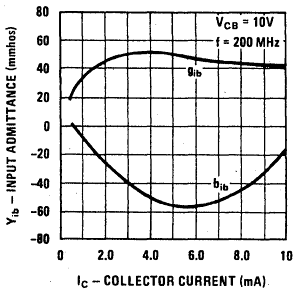
Output Admittance vs Frequency-Input Short Circuit



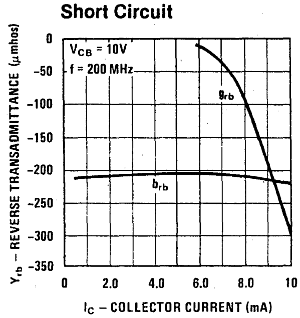
Process 44

COMMON BASE Y PARAMETERS VS FREQUENCY

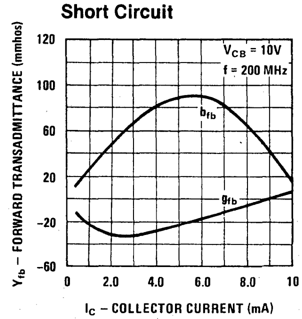
Input Admittance vs Collector Current-Output Short Circuit



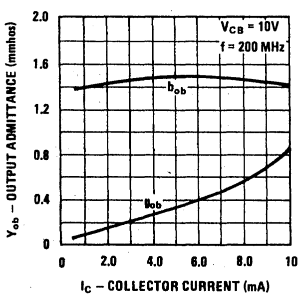
Reverse Transadmittance vs Collector Current-Input Short Circuit



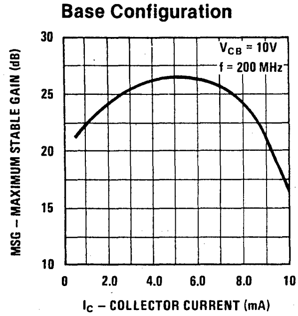
Forward Transadmittance vs Collector Current-Output Short Circuit



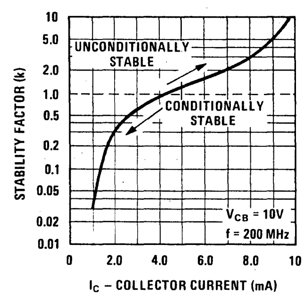
Output Admittance vs Collector Current-Input Short Circuit



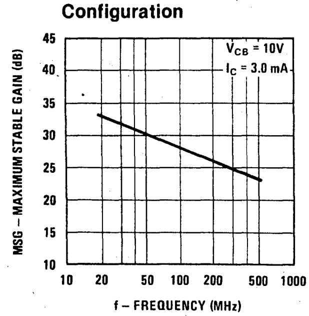
Maximum Stable Gain vs Collector Current Common Base Configuration

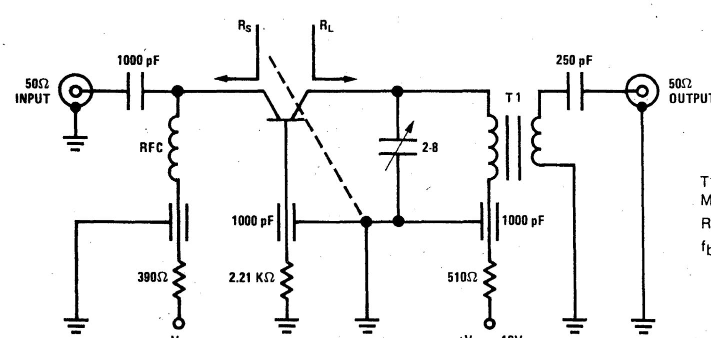


Common Base Configuration Stability Factor-k vs Collector Current



Maximum Stable Gain vs Frequency Common Base Configuration





T1 - 3:1 ratio No. 22 Bifilar on Micrometals Toroid, P/N T30-12

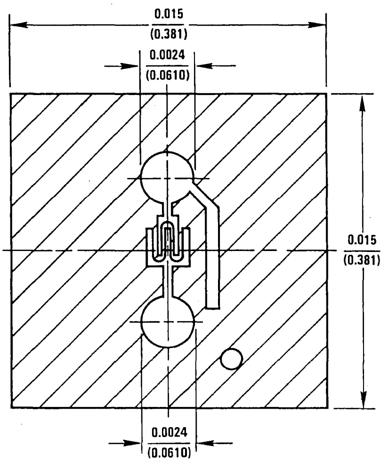
$R_S = 50Ω$, $R_L = 2.5$ kΩ

$f_{bw} = 8.0$ MHz

FIGURE 3. 200 MHz Common Base Power Gain, Noise Figure, Automatic Gain Control Test Circuit

National Semiconductor

Process 45 NPN AGC-IF Amp



DESCRIPTION

Process 45 is an overlay, double-diffused, silicon device, with a Faraday shield diffusion.

APPLICATION

This device was designed for use as a forward AGC amplifier in IF amplifiers without neutralization.

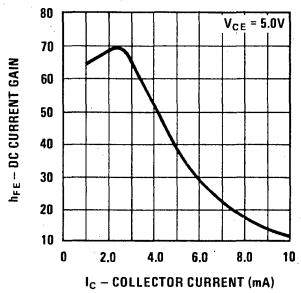
PRINCIPAL DEVICE TYPES

TO-72: SE5055 (pkg 28)
TO-92, BEC: MPS-H32

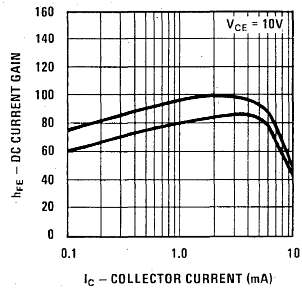
Parameter	Conditions	Min	Typ	Max	Units	Notes
P_G	f = 45 MHz, V_{CE} = 10V, I_C = 3 mA, R_G = 50Ω	27.0	30		dB	*Figure 1*
NF	f = 45 MHz, V_{CE} = 10V, I_C = 3 mA, R_G = 50Ω		2.8	5.0	dB	*Figure 1*
C_{re}	V_{CB} = 10V, I_E = 0		0.13	0.22	pF	TO-72
C_{re}	V_{CB} = 10V, I_E = 0		0.20	0.30	pF	TO-92
V_{AGC}	f = 45 MHz, V_{CC} = 12V, 30 dB Gain Reduction	3.8	4.4	5.1	V	*Figure 1*
V_{AGC}	f = 45 MHz, V_{CC} = 12V, 50 dB Gain Reduction		6.8	8.5	V	*Figure 1*
h_{fe}	V_{CE} = 10V, I_C = 2 mA, f = 100 MHz	3.0	5.5			
h_{FE}	V_{CE} = 10V, I_C = 2 mA	30	80	200		
h_{FE}	V_{CE} = 10V, I_C = 10 mA	18	35			
$V_{CE(SAT)}$	I_C = 10 mA, I_B = 5 mA		0.5	2.0	V	
$V_{BE(SAT)}$	I_C = 10 mA, I_B = 5 mA		0.92	1.0	V	
BV_{CEO}	I_C = 1 mA	30			V	
BV_{CBO}	I_C = 10 μA	30			V	
BV_{EBO}	I_E = 10 μA	4.0			V	
I_{CBO}	V_{CB} = 20V			100	nA	
I_{EBO}	V_{EB} = 3V			100	nA	

Process 45

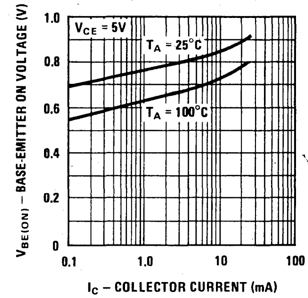
DC Current Gain vs Collector Current



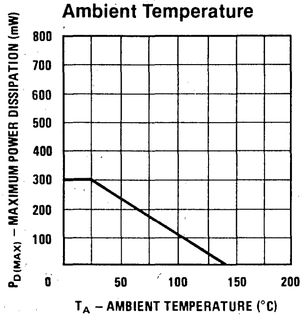
DC Current Gain vs Collector Current



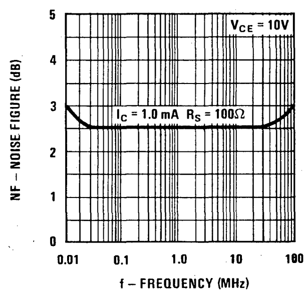
Base-Emitter ON Voltage vs Collector Current



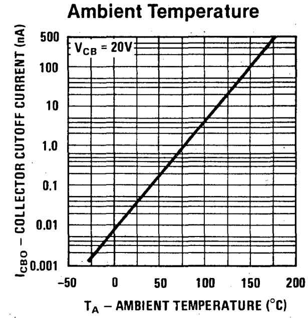
Maximum Power Dissipation vs Ambient Temperature



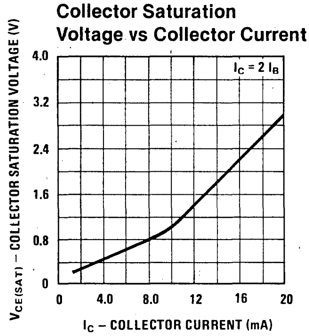
Noise Figure vs Frequency



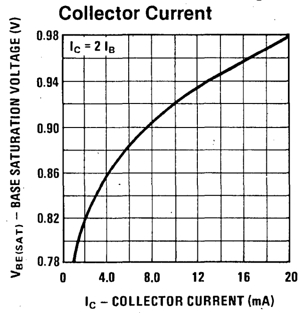
Collector Cutoff Current vs Ambient Temperature



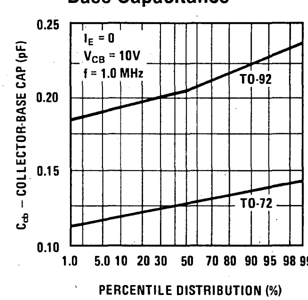
Collector Saturation Voltage vs Collector Current



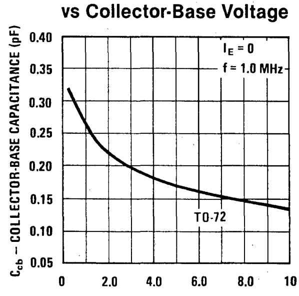
Base Saturation Voltage vs Collector Current



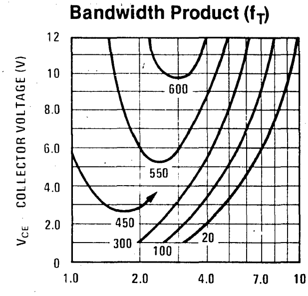
Distribution of Collector-Base Capacitance



Collector-Base Capacitance vs Collector-Base Voltage



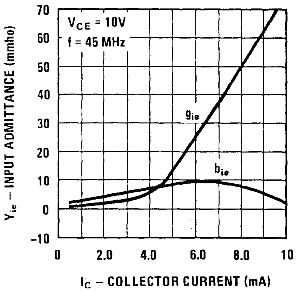
Contours of Constant Gain Bandwidth Product (f_T)



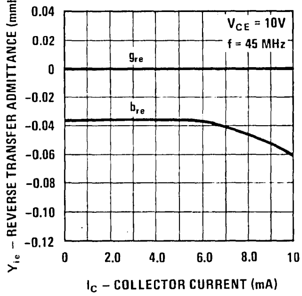
Process 45

COMMON EMITTER Y PARAMETERS VS FREQUENCY

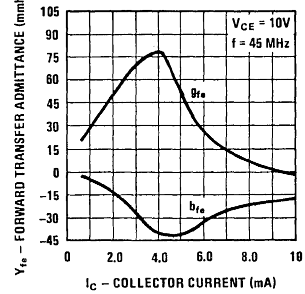
Input Admittance vs Collector Current-Output Short Circuit



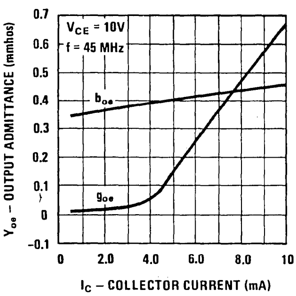
Reverse Transfer Admittance vs Collector Current-Input Short Circuit



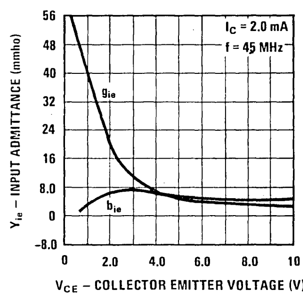
Forward Transfer Admittance vs Collector Current-Output Short Circuit



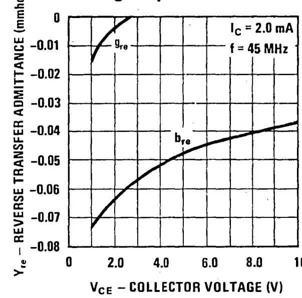
Output Admittance vs Collector Current-Input Short Circuit



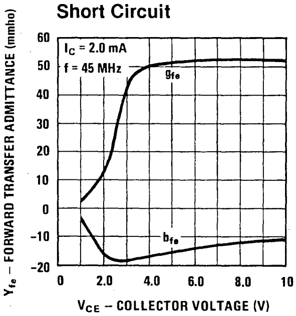
Input Admittance vs Collector Voltage-Output Short Circuit



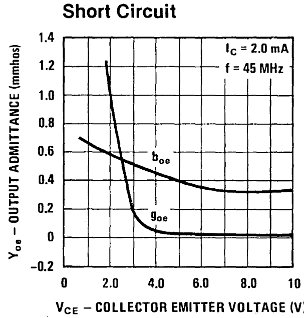
Reverse Transfer Admittance vs Collector Voltage-Input Short Circuit



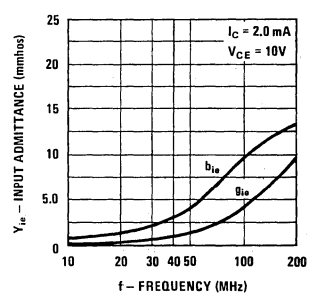
Forward Transfer Admittance vs Collector Voltage-Output Short Circuit



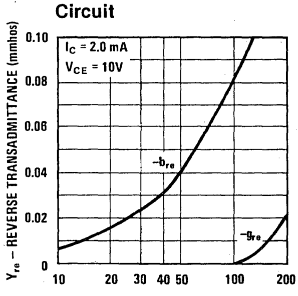
Output Admittance vs Collector Voltage-Input Short Circuit



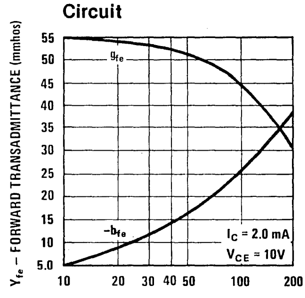
Input Admittance vs Frequency-Output Short Circuit



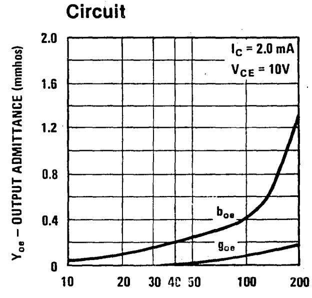
Reverse Transadmittance vs Frequency-Input Short Circuit



Forward Transadmittance vs Frequency-Output Short Circuit



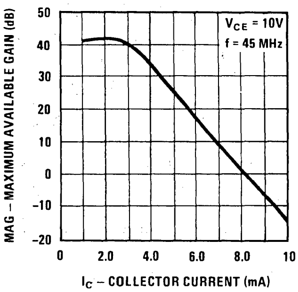
Output Admittance vs Frequency-Input Short Circuit



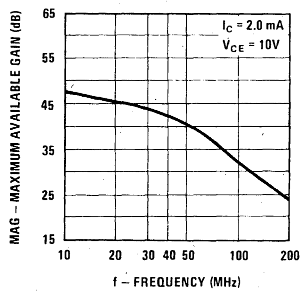
Process 45

COMMON EMITTER PERFORMANCE

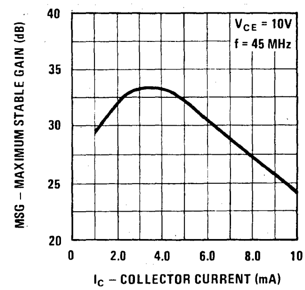
Maximum Available Gain vs Collector Current



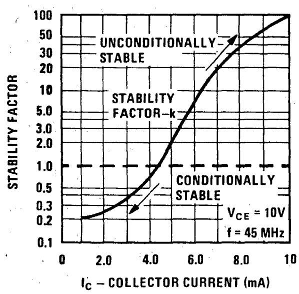
Maximum Available Gain vs Frequency



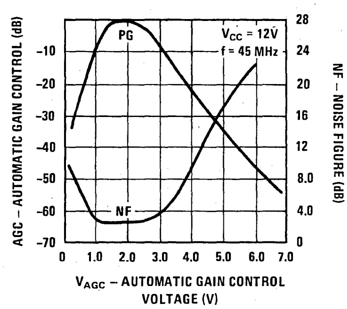
Maximum Stable Gain vs Collector Current



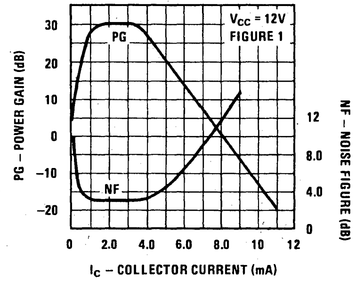
Stability Factor* vs Collector Current



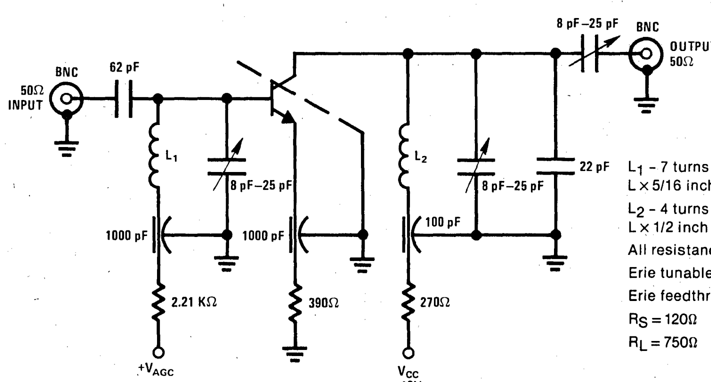
Automatic Gain Control and Noise Figure vs Automatic Gain Control Voltage



Power Gain and Noise Figure vs Collector Current



* Rollet stability factor "k" is defined as $R = \dfrac{2g_ig_o - R_e(Y_fY_r)}{|Y_fY_r|}$



L_1 - 7 turns No. 16 buss wire 5/8 inch L × 5/16 inch ID

L_2 - 4 turns No. 16 buss wire 1/2 inch L × 1/2 inch ID

All resistance 1/2W, 1% tol.

Erie tunables P/N N300

Erie feedthrough P/N 370CB102J

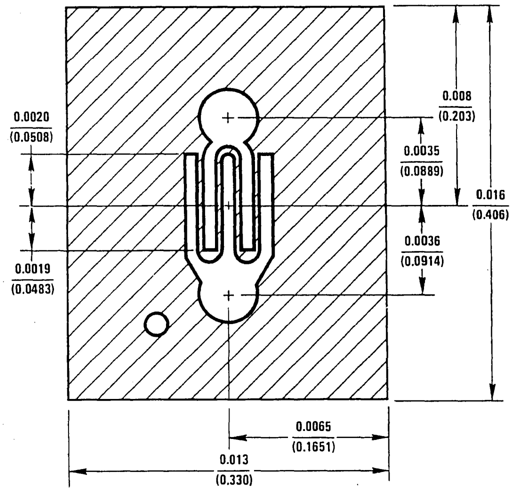
R_S = 120Ω

R_L = 750Ω

FIGURE 1. SE5055 45 MHz Gain, Noise Figure, AGC Circuit

National Semiconductor

Process 46 NPN RF-IF Amp



DESCRIPTION

Process 46 is an overlay, double-diffused, silicon epitaxial device.

APPLICATION

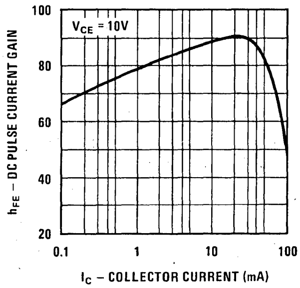
This device was designed for linear RF amplifier applications up to 100 MHz with collector current in the 1 mA to 30 mA range.

PRINCIPAL DEVICE TYPES

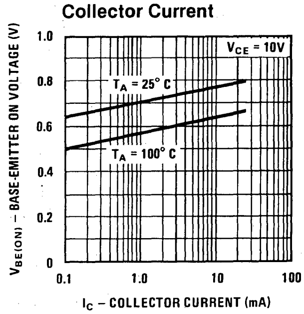
TO-92, EBC: CS9016
PE5025

Parameter	Conditions	Min	Typ	Max	Units	Notes
G_{pe}	f = 45 MHz, V_{CE} = 10V, I_C = 10 mA	25	28		dB	
C_{CB}	V_{CB} = 10V		0.8	1.1	pF	
g_{oe}	f = 45 MHz, V_{CE} = 10V, I_C = 10 mA			200	μmho	
h_{fe}	I_C = 10 mA, V_{CE} = 10V, f = 100 MHz	3.0	4.5			
h_{FE}	I_C = 10 mA, V_{CE} = 10V	30	100	250		
$V_{CE(SAT)}$	I_C = 20 mA, I_B = 1 mA		0.2	0.5	V	
BV_{CEO}	I_C = 1 mA	35			V	
BV_{CBO}	I_C = 10 μA	45			V	
BV_{EBO}	I_C = 10 μA	4.0			V	
I_{CBO}	V_{CB} = 30V			100	nA	
I_{EBO}	V_{EB} = 3V			100	nA	

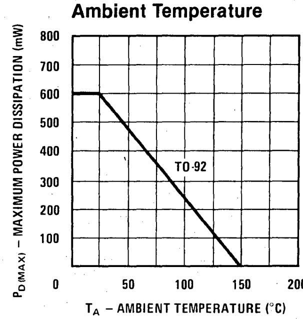
DC Current Gain vs Collector Current



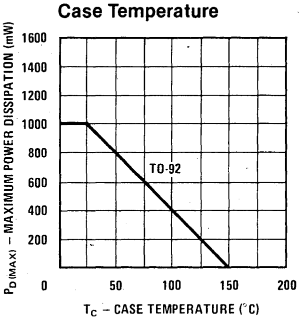
Base-Emitter ON Voltage vs Collector Current



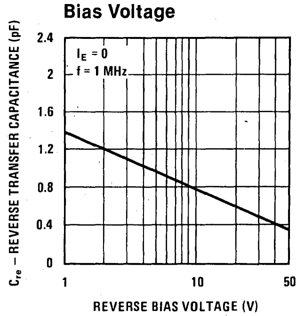
Maximum Power Dissipation vs Ambient Temperature



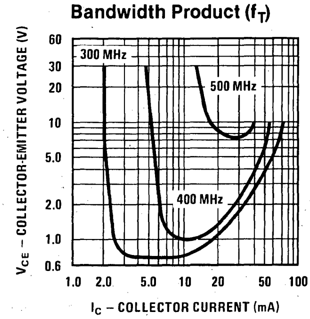
Maximum Power Dissipation vs Case Temperature



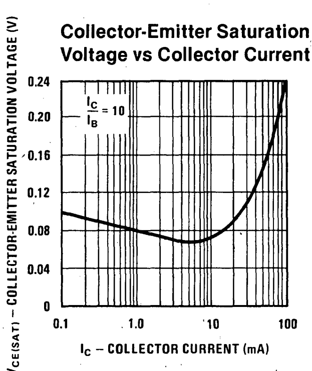
Reverse Transfer Capacitance vs Reverse Bias Voltage



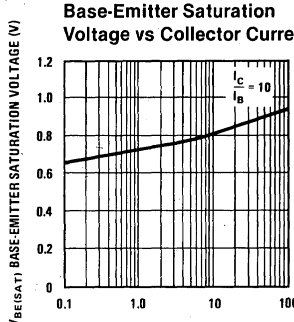
Contours of Constant Gain Bandwidth Product (f_T)



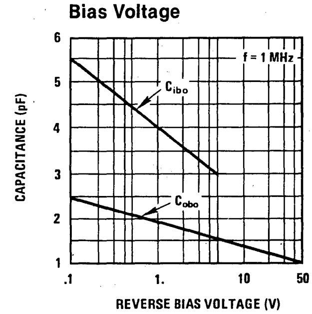
Collector-Emitter Saturation Voltage vs Collector Current



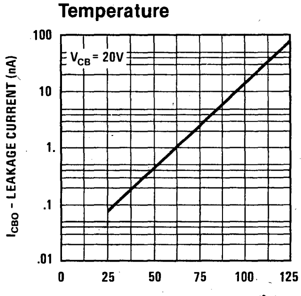
Base-Emitter Saturation Voltage vs Collector Current



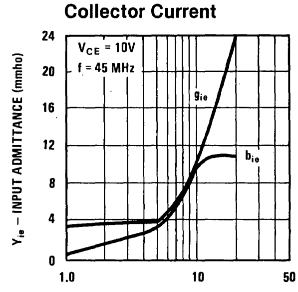
Capacitance vs Reverse Bias Voltage



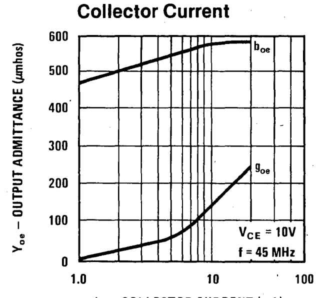
Collector-Base Diode Reverse Current vs Temperature



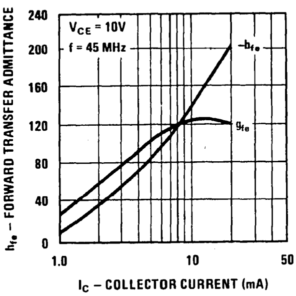
Input Admittance vs Collector Current



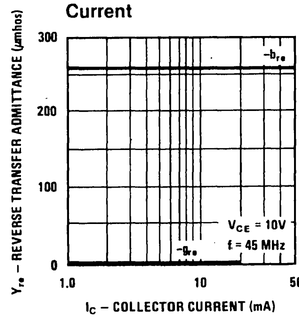
Output Admittance vs Collector Current



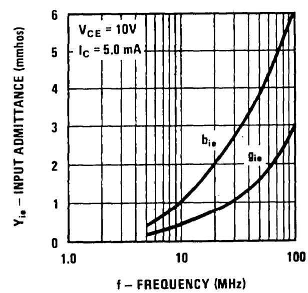
Forward Transfer Admittance vs Collector Current



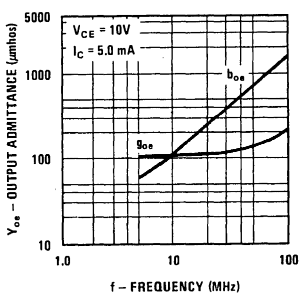
Reverse Transfer Admittance vs Collector Current



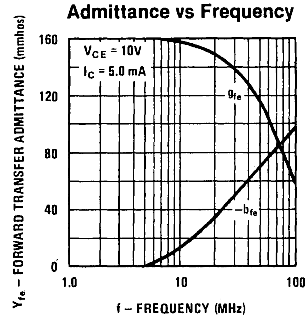
Input Admittance vs Frequency



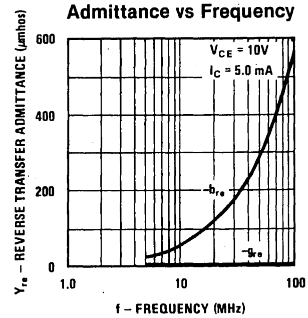
Output Admittance vs Frequency



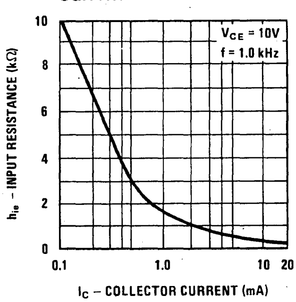
Forward Transfer Admittance vs Frequency



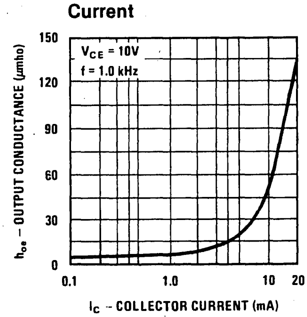
Reverse Transfer Admittance vs Frequency



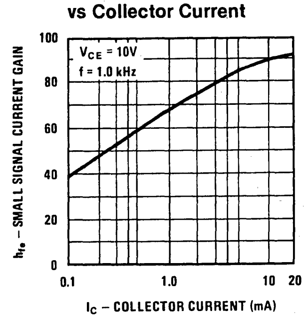
Small Signal Input Resistance vs Collector Current



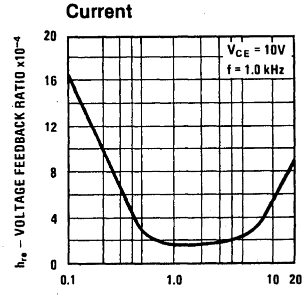
Small Signal Output Conductance vs Collector Current



Small Signal Current Gain vs Collector Current

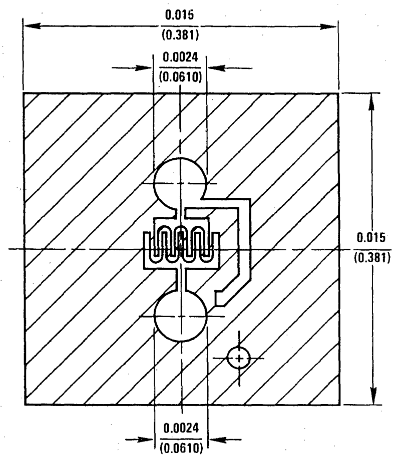


Small Signal Voltage Feedback Ratio vs Collector Current



National Semiconductor

Process 47 NPN RF-IF Amp



DESCRIPTION

Process 47 is an overlay, double-diffused, silicon epitaxial device, with a Faraday shield diffusion.

APPLICATION

This device was designed for common-emitter low noise amplifier and mixer applications in the 100 μA to 15 mA range to 300 MHz, and low frequency drift common-base VHF oscillator applications with high output levels for driving FET mixers.

PRINCIPAL DEVICE TYPES

TO-92, BEC: MPSH11
MPSH24
PE5030

Parameter	Conditions	Min	Typ	Max	Units	Notes
P_G	f = 45 MHz, V_{CE} = 10V, I_C = 4 mA	29	33		dB	*Figure 1*
P_G	f = 200 MHz, V_{CE} = 10V, I_C = 2 mA	17	19.5		dB	Unneutralized *Figure 3*
NF	f = 200 MHz, V_{CE} = 10V, I_C = 2 mA, R_S = 50Ω		2.0	3.5	dB	*Figure 3*
rb'Cc	f = 79.8 MHz, V_{CB} = 10V, I_E = 5 mA			15.0	ps	
h_{fe}	f = 100 MHz, V_{CE} = 15V, I_C = 7 mA	6	10			
C_{ib}	V_{EB} = 0.5V, I_C = 0		2.0	3.0	pF	TO-92
C_{CB}	V_{CB} = 10V, I_E = 0		0.33	0.40	pF	TO-92
g_{oe}	f = 45 MHz, V_{CE} = 15V, I_C = 7 mA			125	μmho	
roep	f = 10.7 MHz, V_{CE} = 10V, I_C = 2 mA	100k			Ω	
h_{FE}	V_{CE} = 15V, I_C = 7 mA	40	100	200		
$V_{CE(SAT)}$	I_C = 20 mA, I_B = 1 mA		0.3	1.0	V	
$V_{BE(SAT)}$	I_C = 10 mA, I_B = 5 mA			0.95	V	
BV_{CEO}	I_C = 1 mA	35			V	
BV_{CBO}	I_C = 10 μA	40			V	
BV_{EBO}	I_E = 10 μA	4.0			V	
I_{CBO}	V_{CB} = 30V			100	nA	
I_{EBO}	V_{EB} = 3V			100	nA	

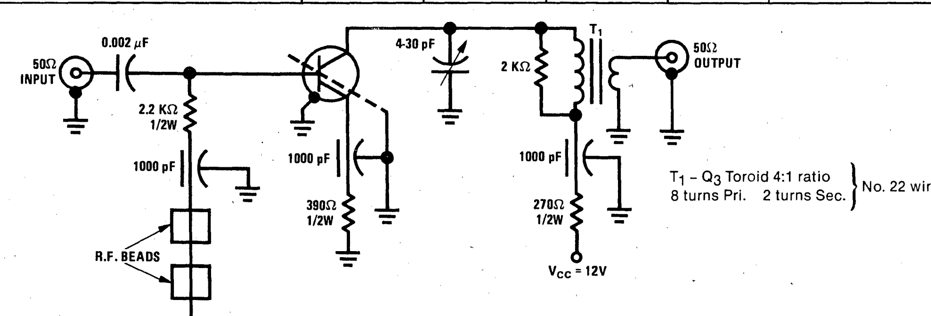
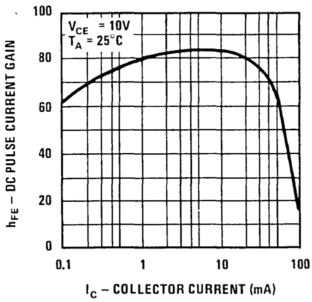
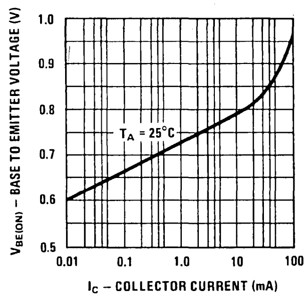


FIGURE 1. 45 MHz Power Gain Circuit

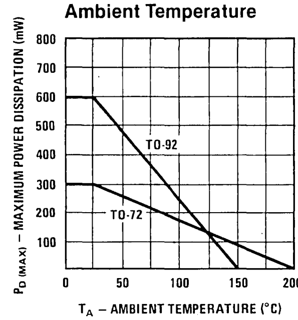
DC Current Gain vs Collector Current



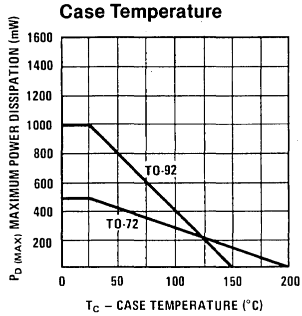
Base-Emitter ON Voltage vs Collector Current



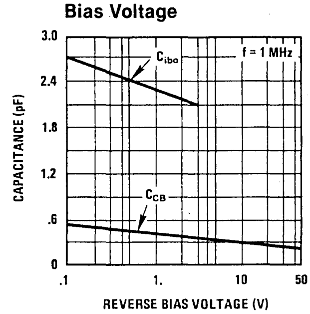
Maximum Power Dissipation vs Ambient Temperature



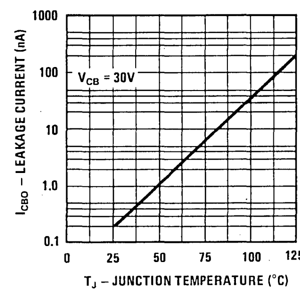
Maximum Power Dissipation vs Case Temperature



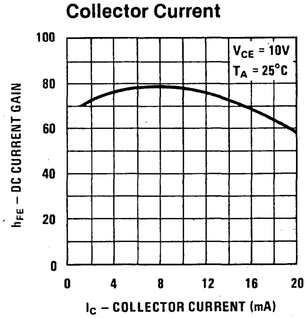
Capacitance vs Reverse Bias Voltage



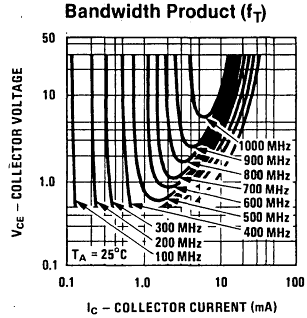
Collector-Base Diode Reverse Current vs Temperature



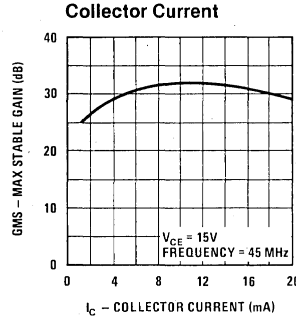
DC Current Gain vs Collector Current

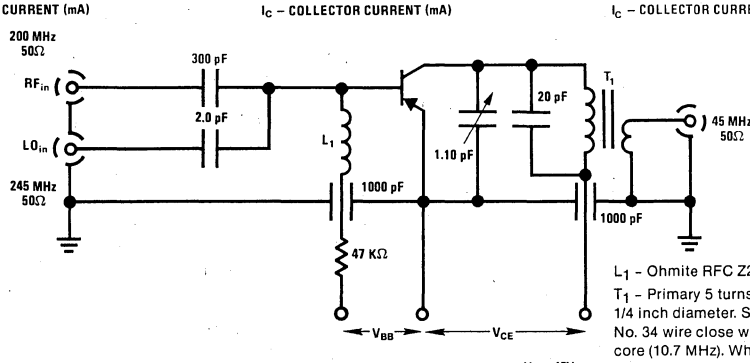


Contours of Constant Gain Bandwidth Product (f_T)



Maximum Stable Gain vs Collector Current





L_1 - Ohmite RFC Z235

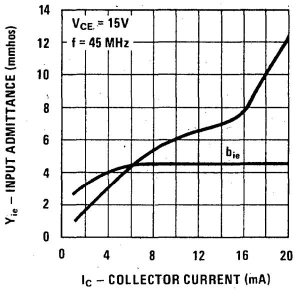
T_1 - Primary 5 turns No. 34 wire 1/4 inch diameter. Secondary 2 turns No. 34 wire close wound over a Q100 core (10.7 MHz). When terminated on secondary side with 50Ω primary measures 1.5k, – 25 pF.

FIGURE 2. 200 MHz Conversion Gain Test Circuit

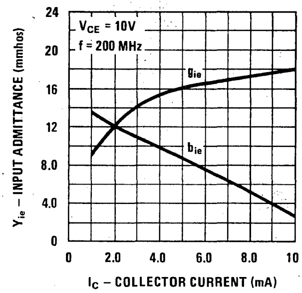
Process 47

COMMON-EMITTER VS FREQUENCY Y PARAMETERS

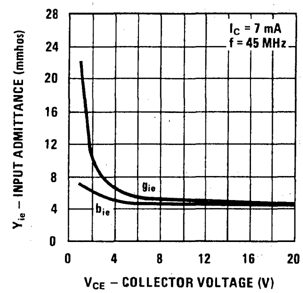
Input Admittance vs Collector Current



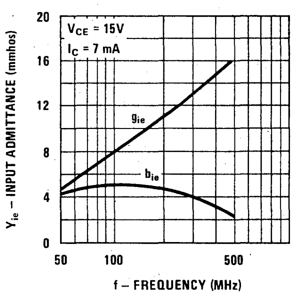
Input Admittance vs Collector Current



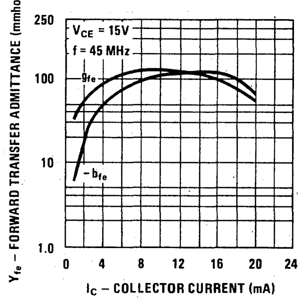
Input Admittance vs Collector Voltage



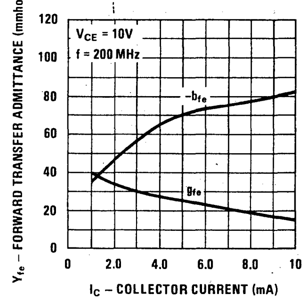
Input Admittance vs Frequency



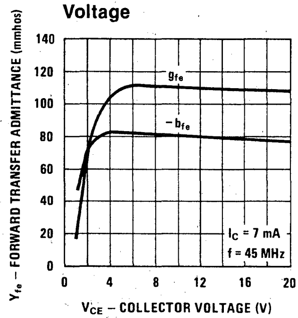
Forward Transfer Admittance vs Collector Current



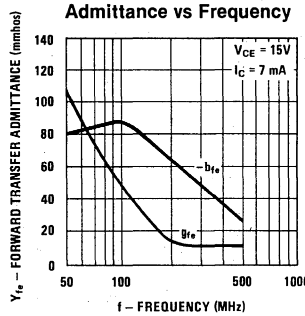
Forward Transfer Admittance vs Collector Current



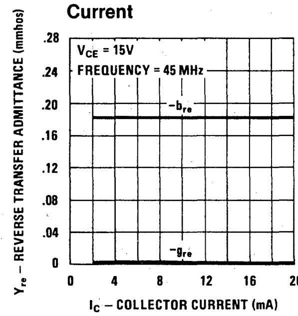
Forward Transfer Admittance vs Collector Voltage



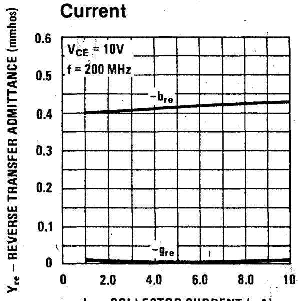
Forward Transfer Admittance vs Frequency



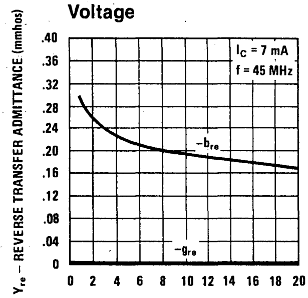
Reverse Transfer Admittance vs Collector Current



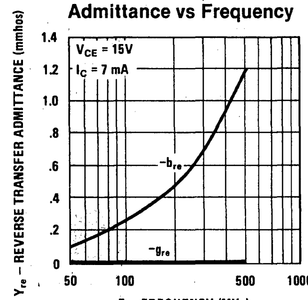
Reverse Transfer Admittance vs Collector Current



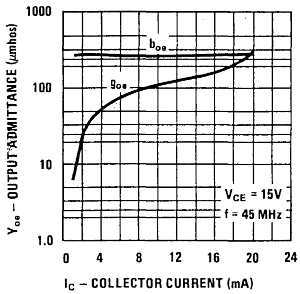
Reverse Transfer Admittance vs Collector Voltage



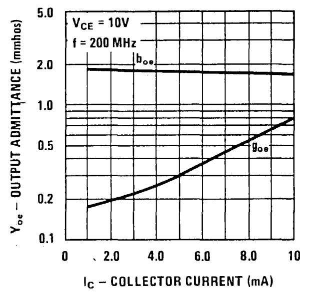
Reverse Transfer Admittance vs Frequency



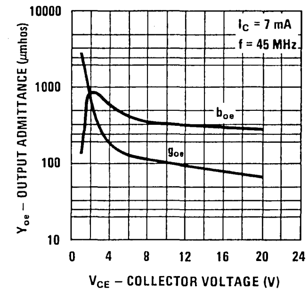
Output Admittance vs Collector Current



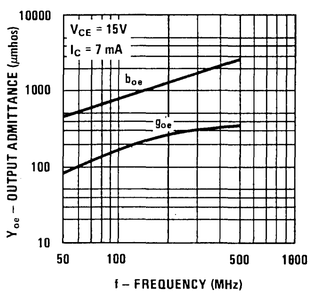
Output Admittance vs Collector Current



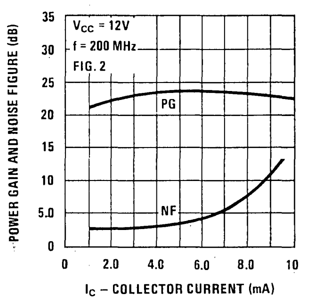
Output Admittance vs Collector Voltage



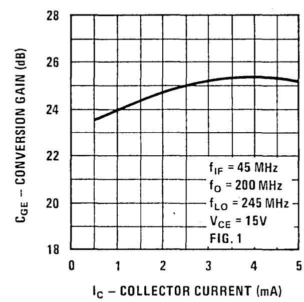
Output Admittance vs Frequency

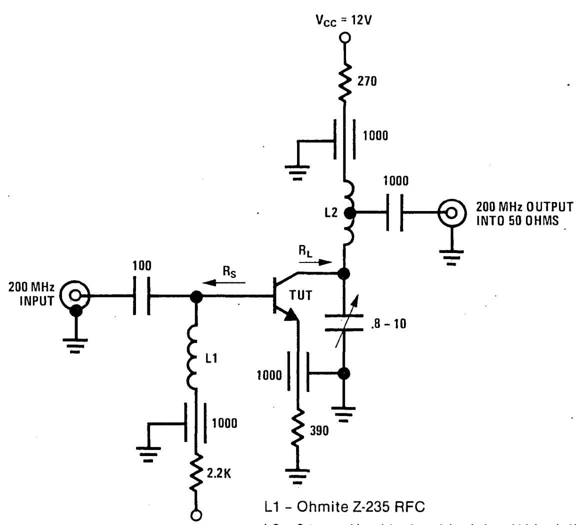


Power Gain and Noise Figure vs Collector Current



Conversion Gain vs Collector Current



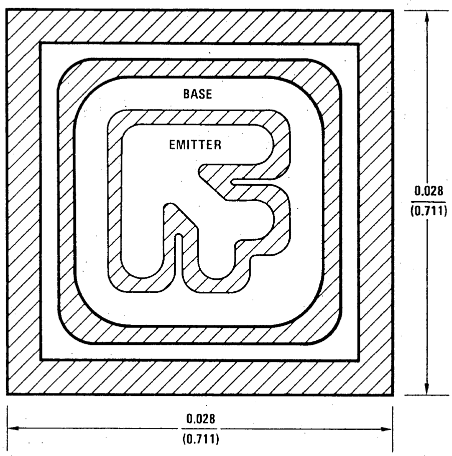


L1 - Ohmite Z-235 RFC
L2 - 6 turns No. 14 wire, 1 inch L × 1/4 inch ID tapped 1 1/2 turns from cold side
All capacitance in pF, all resistance in ohms.

FIGURE 3. Unneutralized 200 MHz PG NF Test Circuit

National Semiconductor

Process 48
NPN High Voltage Video Output



DESCRIPTION

Process 48 is a non-overlay, triple-diffused, silicon device with a field plate.

APPLICATION

This device was designed for application as a video output to drive color CRT.

PRINCIPAL DEVICE TYPES

TO-202, EBC: D40N1-5
NSD131-5
NSD457-9
NSE457-9

TO-202, BCE: NSE457-9

TO-237, EBC: 2N6733-5 (92PU391-3)

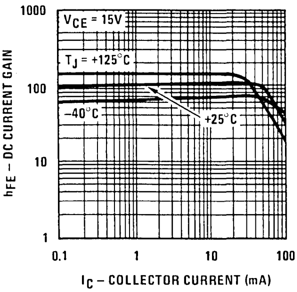
TO-237, ECB: 2N6711-13 (92PE487-9)
2N6719 (92PU10)

TO-39 (Steel): SE7056

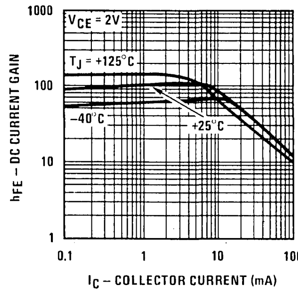
TO-92: MPSA42

Parameter	Conditions	Min	Typ	Max	Units	Notes
BV_{CEO}	$I_C = 1$ mA	300	370		V	
BV_{CBO}	$I_C = 100\ \mu A$		500		V	
BV_{EBO}	$I_E = 10\ \mu A$	7.0			V	
I_{CES}	$V_{CB} = 150V$			100	nA	
I_{EBO}	$V_{EB} = 6V$			100	nA	
h_{FE}	$I_C = 1$ mA, $V_{CE} = 10V$	30				
h_{FE}	$I_C = 10$ mA, $V_{CE} = 10V$	40	90	200		
h_{FE}	$I_C = 100$ mA, $V_{CE} = 10V$		20			
$V_{CE(SAT)}$	$I_C = 20$ mA, $I_B = 2$ mA		0.25	1.0	V	
$V_{BE(SAT)}$	$I_C = 20$ mA, $I_B = 2$ mA		0.74	1.0	V	
C_{CB}	$V_{CB} = 20V$		1.9	3.5	pF	TO-92
C_{ib}	$V_{EB} = 0.5V$			70	pF	
h_{fe}	$I_C = 15$ mA, $V_{CE} = 100V$, $I_C = 15$ mA, $f = 20$ MHz	2.5	4.0			
$P_{D(max)}$						
TO-202	$T_C = 25°C$ $T_A = 25°C$	10 2			W	
TO-237	$T_{COLLECTOR\ LEAD} = 25°C$ $T_A = 25°C$	2 850			W mW	
TO-92	$T_A = 25°C$	600			mW	
θ_{JC}						
TO-202	$T_C = 25°C$			12.5	°C/W	
TO-237	$T_{COLLECTOR\ LEAD} = 25°C$			62.5	°C/W	
θ_{JA}						
TO-202	$T_A = 25°C$			62.5	°C/W	
TO-237	$T_A = 25°C$			147	°C/W	
TO-92	$T_A = 25°C$			208	°C/W	
$T_{J(max)}$	All Plastic Parts	150			°C	

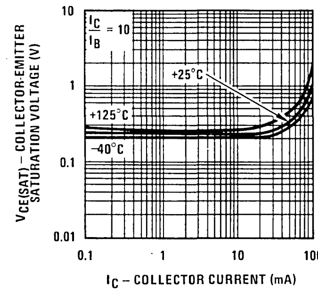
DC Current Gain vs Collector Current



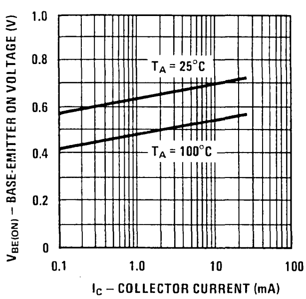
Typical Pulsed Current Gain vs Collector Current



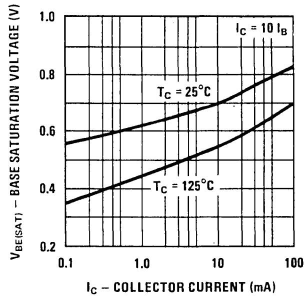
Collector-Emitter Saturation Voltage vs Collector Current



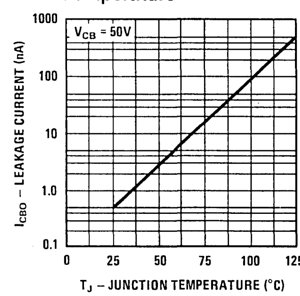
Base-Emitter ON Voltage vs Collector Current



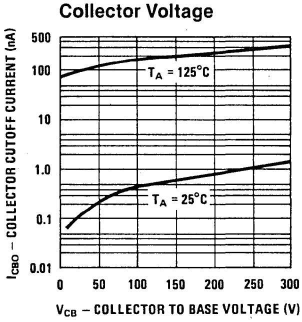
Base Saturation Voltage vs Collecter Current



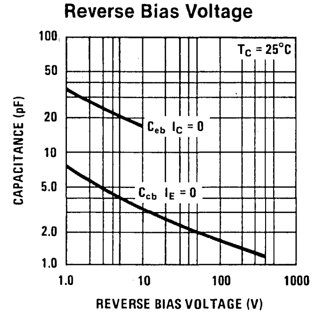
Collector-Base Diode Reverse Current vs Temperature



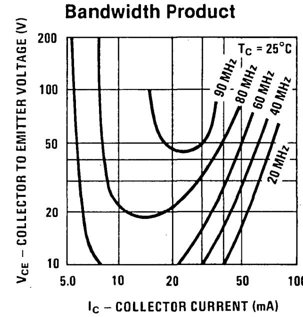
Collector Cutoff Current vs Collector Voltage



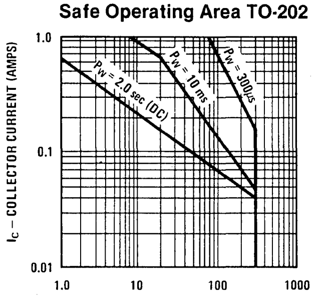
Collector-Base and Emitter-Base Capacitance vs Reverse Bias Voltage



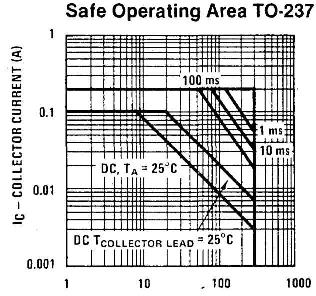
Contours of Constant Gain Bandwidth Product



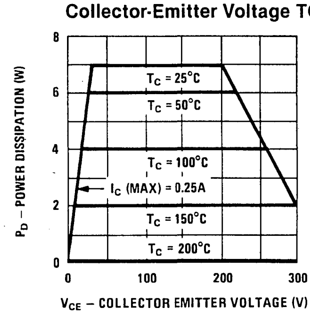
Safe Operating Area TO-202



Safe Operating Area TO-237

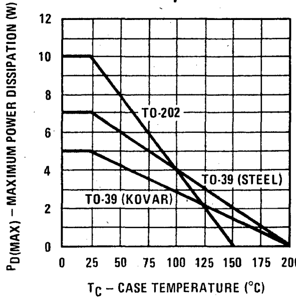


Guaranteed Maximum DC Power Dissipation vs Collector-Emitter Voltage TO-39

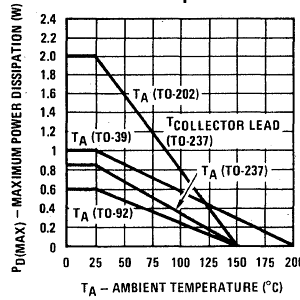


Process 48

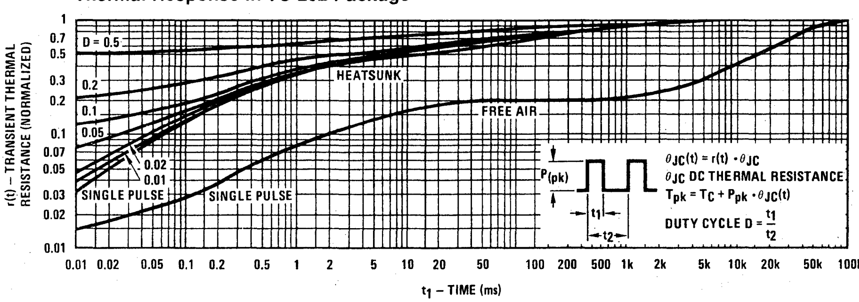
Maximum Power Dissipation vs Case Temperature



Maximum Power Dissipation vs Ambient Temperature

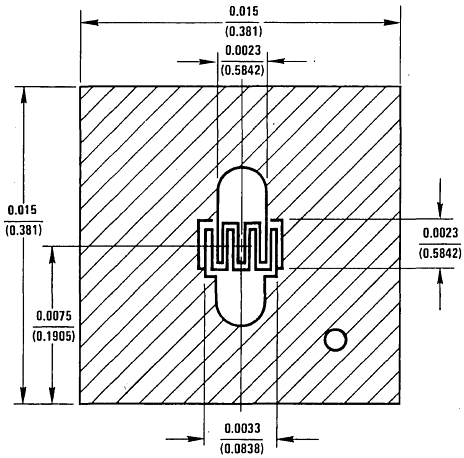


Thermal Response in TO-202 Package



National Semiconductor

Process 49 NPN RF Amp



DESCRIPTION

Process 49 is an overlay, double-diffused, silicon epitaxial device.

APPLICATION

This device was designed for general RF amplifer and mixer applications to 250 MHz with collector current in the 1 mA to 20 mA range.

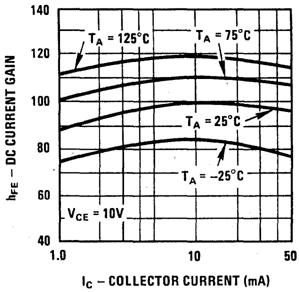
PRINCIPAL DEVICE TYPES

TO-92, BEC: MPS6544
MPSH20

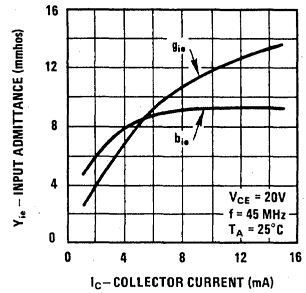
Parameter	Conditions	Min	Typ	Max	Units	Notes
P_G	f = 45 MHz, V_{CE} = 10V, I_C = 10 mA	25	30		dB	
f_T	V_{CE} = 10V, I_C = 10 mA	400	700		MHz	
rb'Cc	f = 79.8 MHz, V_{CE} = 10V, I_C = 8 mA			20.0	ps	
C_{CB}	f = 1.0 MHz, V_{CB} = 10V, I_E = 0		0.55	0.65	pF	
h_{FE}	V_{CE} = 10V, I_C = 10 mA	40	100	250		
h_{FE}	V_{CE} = 10V, I_C = = 4 mA	30				
$V_{BE(ON)}$	V_{CE} = 10V, I_C = 10 mA		0.80	0.90	V	
$V_{CE(SAT)}$	I_C = 30 mA, I_C = 3 mA		0.15	0.50	V	
roep	f = 4.5 MHz, V_{CE} = 10V, I_C = 2 mA	80k			Ω	
BV_{CEO}	I_C = 1 mA	35			V	
BV_{CBO}	I_C = 10 μA	45			V	
BV_{EBO}	I_E = 10 μA	4.0			V	
I_{CBO}	V_{CB} = 30V			100	nA	
I_{EBO}	V_{EB} = 3.0V			100	nA	

Process 49

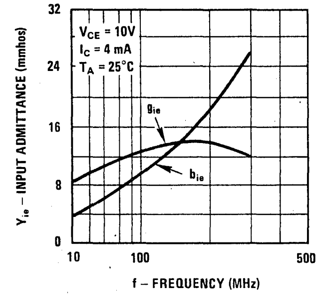
DC Current Gain vs Collector Current



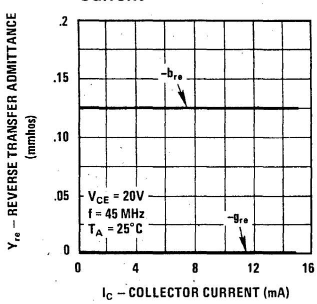
Input Admittance vs Collector Current



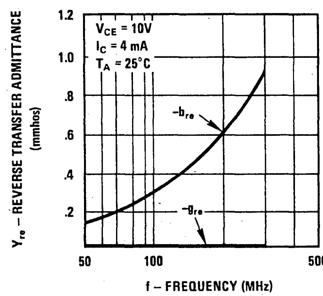
Input Admittance vs Frequency



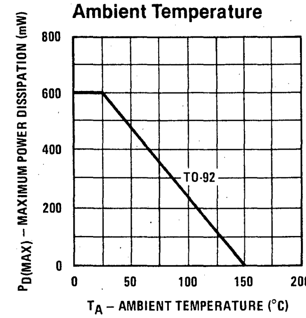
Reverse Transfer Admittance vs Collector Current



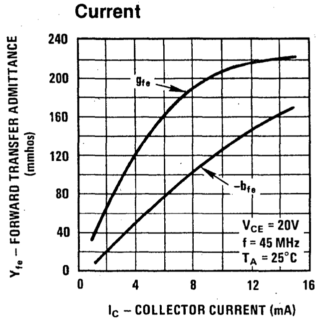
Reverse Transfer Admittance vs Frequency



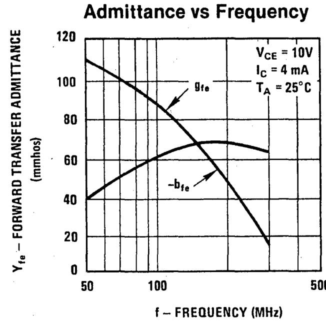
Maximum Power Dissipation vs Ambient Temperature



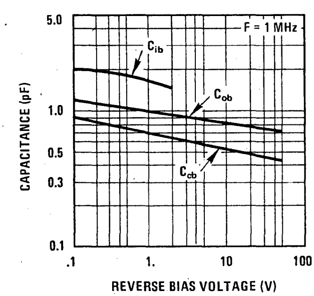
Forward Transfer Admittance vs Collector Current



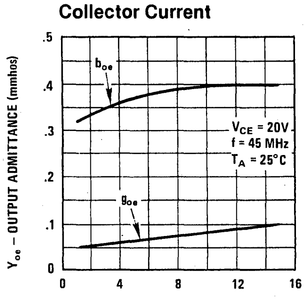
Forward Transfer Admittance vs Frequency



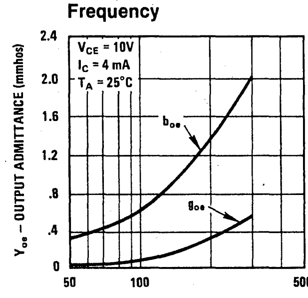
Capacitance vs Reverse Bias Voltage



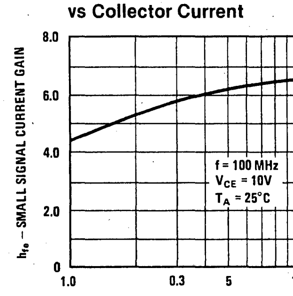
Output Admittance vs Collector Current



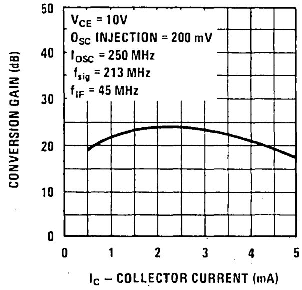
Output Admittance vs Frequency



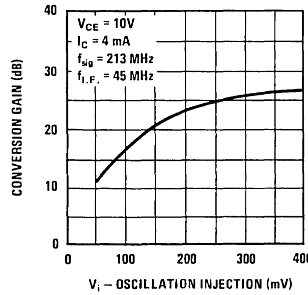
Small Signal Current Gain vs Collector Current

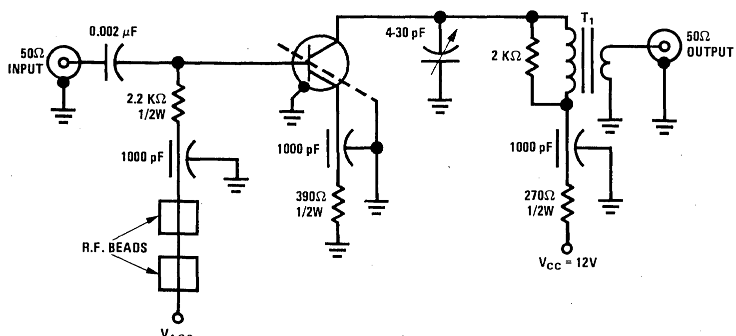


Conversion Gain vs Collector Current



Conversion Gain vs Oscillator Injection Level





T_1 - Q_3 Toroid 4:1 ratio
8 turns-Pri. 2 turns Sec.
} No. 22 wire

FIGURE 1. 45 MHz Power Gain Circuit

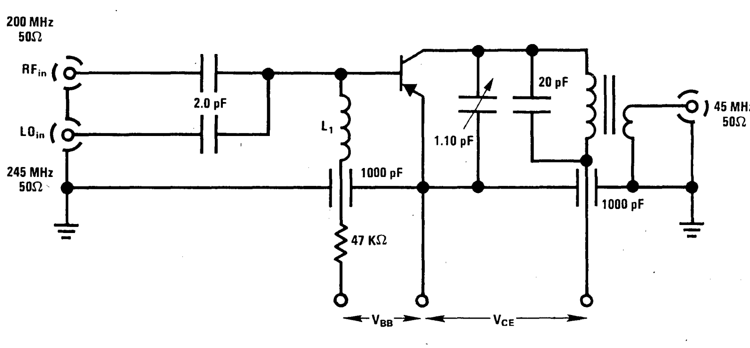
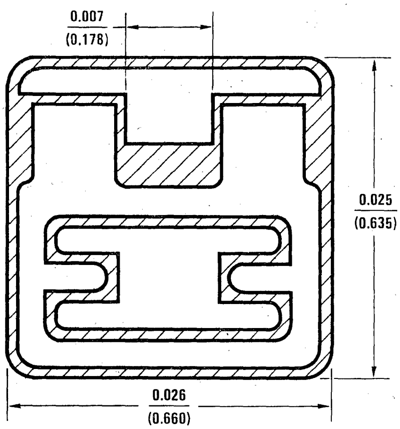


FIGURE 2. 200 MHz Conversion Gain Test Circuit

National Semiconductor

Process 61 PNP Darlington
PRELIMINARY



DESCRIPTION

Process 61 is a monolithic, double-diffused, silicon epitaxial Darlington. Complement to Process 05.

APPLICATION

This device is designed for applications requiring extremely high current gain at collector currents to 1.5A.

PRINCIPAL DEVICE TYPES

TO-202, EBC: D41K1-4
NSDU95, 95A

TO-237, EBC: 92PU95, 95A

TO-92, EBC: MPSA62-66

Parameter	Conditions	Min	Typ	Max	Units	Notes
NF	$I_C = 1$ mA, $V_{CE} = 5V$, $R_S = 100k$, f = 1 kHz		2		dB	
C_{CB}	$V_{CB} = 10V$, $I_E = 0$, f = 1 MHz		5	8	pF	
h_{FE}	$I_C = 10$ mA, $V_{CE} = 5V$	5,000				
h_{FE}	$I_C = 100$ mA, $V_{CE} = 5V$	5,000	40,000	200,000		
h_{FE}	$I_C = 1A$, $V_{CE} = 5V$	1500				
$V_{CE(SAT)}$	10 mA, 0.01 mA 100 mA, 0.1 mA			1.0 1.5	V	
$V_{BE(ON)}$	10 mA, 5V 100 mA, 5V		1.2 1.25	1.4 2.0	V	
h_{fe}	$I_C = 10$ mA, $V_{CE} = 5.0V$, f = 1 kHz		50,000			
BV_{CES}	$I_C = 100\ \mu A$	40			V	
BV_{EBO}	$I_E = 10\ \mu A$	12			V	
I_{CES}	$V_{CE} = 15V$, $V_{BE} = 0$			100	nA	
I_{CBO}	$V_{CB} = 15V$, $I_E = 0$			100	nA	
I_{EBO}	$V_{EB} = 10V$, $I_C = 0$			100	nA	
$P_{D(max)}$						
TO-202	$T_C = 25°C$ $T_A = 25°C$	10 2			W	
TO-237	$T_{COLLECTOR\ LEAD} = 25°C$ $T_A = 25°C$	2 850			W mW	
TO-92	$T_A = 25°C$	600			mW	
θ_{JC}						
TO-202	$T_C = 25°C$			12.5	°C/W	
TO-237	$T_{COLLECTOR\ LEAD} = 25°C$			62.5	°C/W	
θ_{JA}						
TO-202	$T_A = 25°C$			62.5	°C/W	
TO-237	$T_A = 25°C$			147	°C/W	
TO-92	$T_A = 25°C$			208	°C/W	
$T_{J(max)}$	All Plastic Parts	150			°C	

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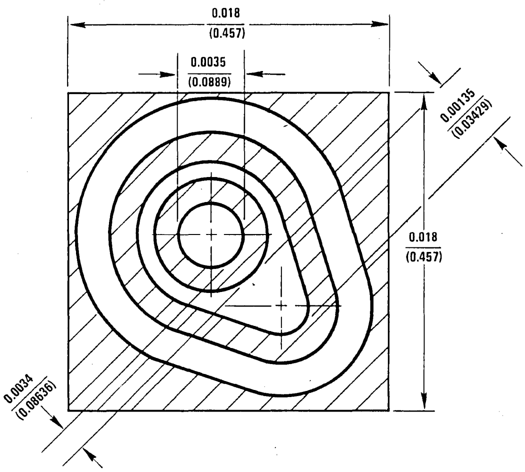
Process 62 PNP Small Signal



DESCRIPTION

Process 62 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 07.

APPLICATION

These devices are designed for low level, high gain, low noise general purpose amplifier applications to 20 mA collector current.

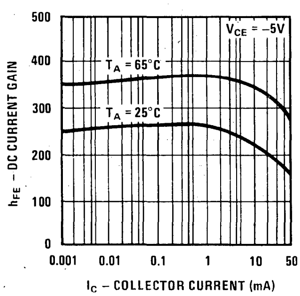
PRINCIPAL DEVICE TYPES

TO-18: 2N3550
TO-46: 2N2605
TO-92, ECB: 2N4058
TO-92, EBC: 2N5086

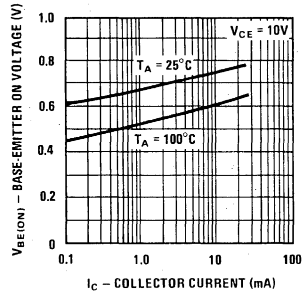
Parameter	Conditions	Min	Typ	Max	Units	Notes
NF	$V_{CE} = 5V$, $I_C = 10\ \mu A$, $R_S = 10\ k\Omega$, PBW = 15.70 kHz		1	3	dB	
h_{fe}	$V_{CE} = 5V$, $I_C = 500\ \mu A$, f = 20 MHz	3	6			
C_{ib}	$V_{EB} = 0.5V$			8	pF	
C_{ob}	$V_{CB} = 5V$		3.5	5	pF	
h_{FE}	$I_C = 1\ \mu A$, $V_{CE} = 5V$	45				
h_{FE}	$I_C = 10\ \mu A$, $V_{CE} = 5V$	60				
h_{FE}	$I_C = 100\ \mu A$, $V_{CE} = 5V$	75				
h_{FE}	$I_C = 500\ \mu A$, $V_{CE} = 5V$	90	270			
h_{FE}	$I_C = 1$ mA, $V_{CE} = 5V$	90	270	630		
h_{FE}	$I_C = 10$ mA, $V_{CE} = 5V$	75				
$V_{CE(SAT)}$	$I_C = 1$ mA, $I_B = 0.1$ mA			0.10	V	
$V_{CE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA			0.15	V	
$V_{BE(SAT)}$	$I_C = 1$ mA, $I_B = 0.1$ mA			0.75	V	
$V_{BE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA			0.90	V	
BV_{CEO}	$I_C = 1$ mA	50			V	
BV_{CBO}	$I_C = 10\ \mu A$	60			V	
BV_{EBO}	$I_E = 10\ \mu A$	8			V	
I_{CBO}	$V_{CB} = 40V$			100	nA	
I_{EBO}	$V_{EB} = 6V$			100	nA	

Process 62

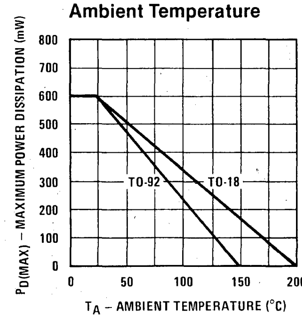
DC Current Gain vs Collector Current



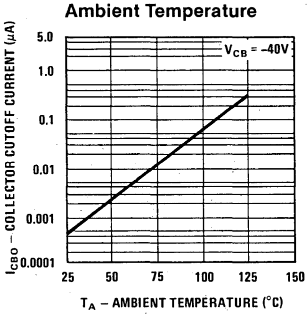
Base-Emitter ON Voltage vs Collector Current



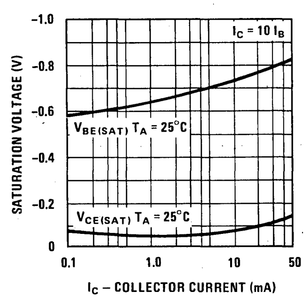
Maximum Power Dissipation vs Ambient Temperature



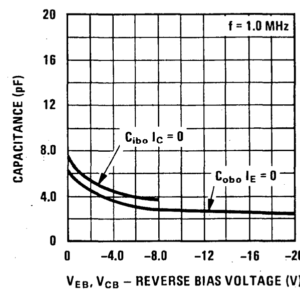
Collector Cutoff Current vs Ambient Temperature



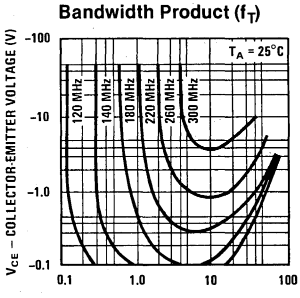
Collector and Base Saturation Voltage vs Collector Current



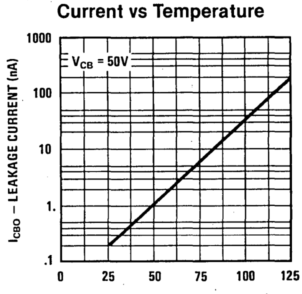
Input and Output Capacitance vs Reverse Bias Voltage



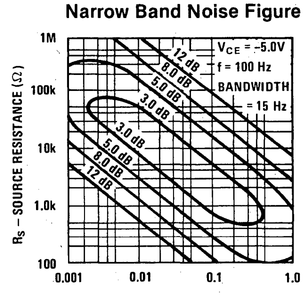
Contours of Constant Gain Bandwidth Product (f_T)



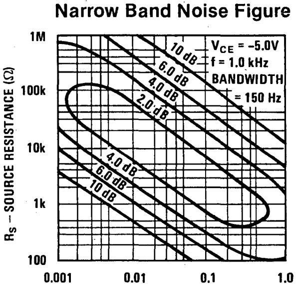
Collector-Base Diode Current vs Temperature



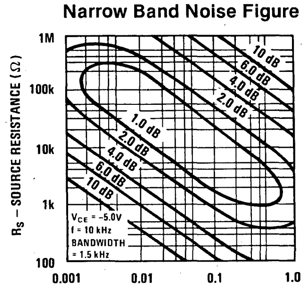
Contours of Constant Narrow Band Noise Figure



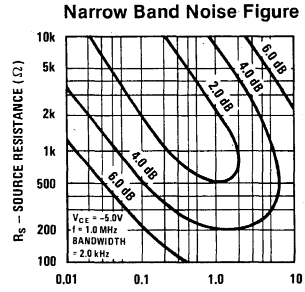
Contours of Constant Narrow Band Noise Figure



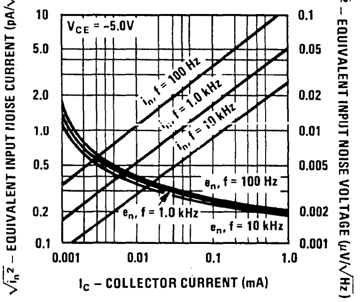
Contours of Constant Narrow Band Noise Figure



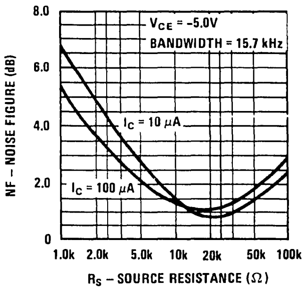
Contours of Constant Narrow Band Noise Figure



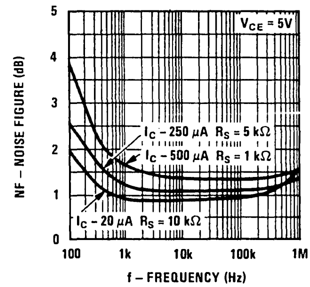
Equivalent Input Noise Voltage and Noise Current vs Collector Current



Wideband Noise Figure vs Source Resistance



Noise Figure vs Frequency

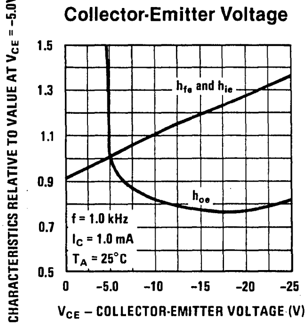


SMALL SIGNAL CHARACTERISTICS (f = 1.0 kHz)

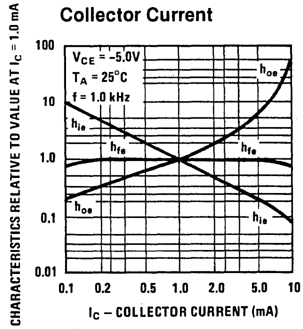
Symbol	Characteristic	Min	Typ	Max	Units	Conditions
h_{ie}	Input Resistance	2.5	8.0	20	kΩ	$I_C = 1.0$ mA, $V_{CE} = -5.0$V
h_{oe}	Output Conductance	5.0	19	50	μmho	$I_C = 1.0$ mA, $V_{CE} = -5.0$V
h_{re}	Voltage Feedback Ratio			10	$x10^{-4}$	$I_C = 1.0$ mA, $V_{CE} = -5.0$V
h_{fe}	Small Signal Current Gain	100	250	800		$I_C = 1.0$ mA, $V_{CE} = -5.0$V

TYPICAL COMMON EMITTER CHARACTERISTICS (f = 1.0 kHz)

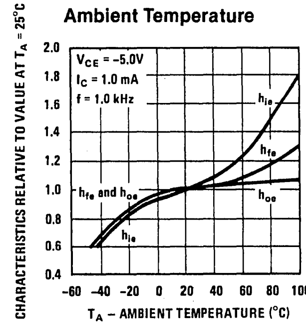
Common Emitter Characteristics vs Collector-Emitter Voltage



Common Emitter Characteristics vs Collector Current



Common Emitter Characteristics vs Ambient Temperature



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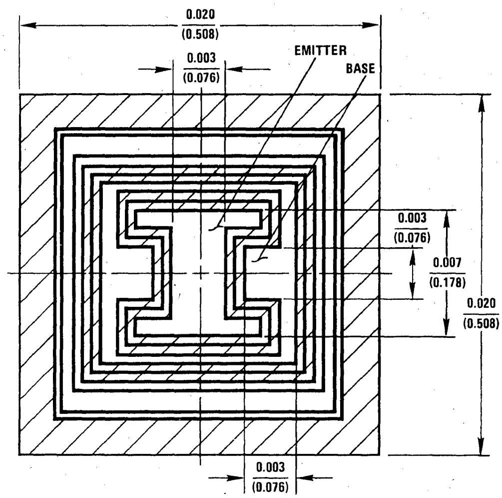
Process 63 PNP Medium Power



DESCRIPTION

Process 63 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 19.

APPLICATION

This device was designed for use as general purpose amplifiers and switches requiring collector currents to 500 mA.

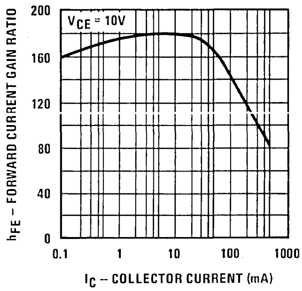
PRINCIPAL DEVICE TYPES

TO-5: 2N2905
TO-18: 2N2907
TO-92, EBC: 2N4403
TO-92, ECB: 2N3702
TO-237: TN2905

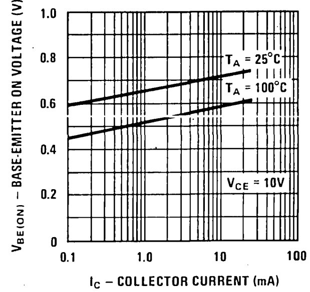
Parameter	Conditions	Min	Typ	Max	Units	Notes
t_{ON}	$I_C = 150$ mA, $I_{B1} = 15$ mA		30	45	ns	*Figure 1*
t_{OFF}	$I_C = 150$ mA, $I_{B2} = 15$ mA		220	290	ns	*Figure 2*
C_{CB}	$V_{CB} = 10V$		6	8	pF	
C_{EB}	$V_{EB} = 0.50V$			20	pF	
h_{fe}	$I_C = 20$ mA, $V_{CE} = 20V$, $f = 100$ MHz	1.5	2.5			
NF (spot)	$I_C = 100\ \mu A$, $V_{CE} = 10V$, $R_S = 1k$ $f = 1$ kHz		1.5		dB	
h_{FE}	$I_C = 1$ mA, $V_{CE} = 10V$	50				
h_{FE}	$I_C = 10$ mA, $V_{CE} = 10V$	50				
h_{FE}	$I_C = 150$ mA, $V_{CE} = 10V$	50	150	400		
h_{FE}	$I_C = 500$ mA, $V_{CE} = 10V$	30				
$V_{CE(SAT)}$	$I_C = 150$ mA, $I_B = 15$ mA			0.5	V	
$V_{CE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA			1.2	V	
$V_{BE(SAT)}$	$I_C = 150$ mA, $I_B = 15$ mA			1.3	V	
$V_{BE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA			1.6	V	
BV_{CEO}	$I_C = 10$ mA	35			V	
BV_{CBO}	$I_C = 100\ \mu A$	50			V	
BV_{EBO}	$I_E = 10\ \mu A$	6			V	
I_{CBO}	$V_{CB} = 35V$			100	nA	
I_{EBO}	$V_{EB} = 4V$			100	nA	

Process 63

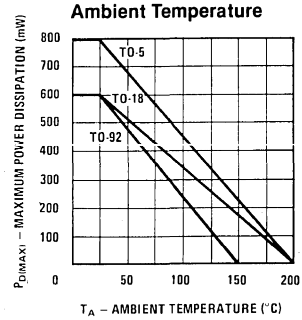
DC Pulsed Current Gain vs Collector Current



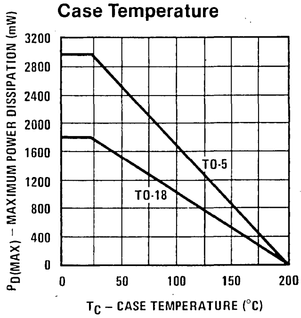
Base-Emitter ON Voltage vs Collector Current



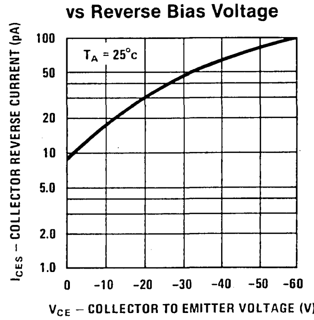
Maximum Power Dissipation vs Ambient Temperature



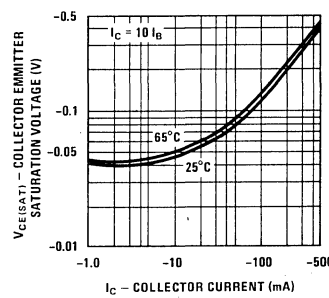
Maximum Power Dissipation vs Case Temperature



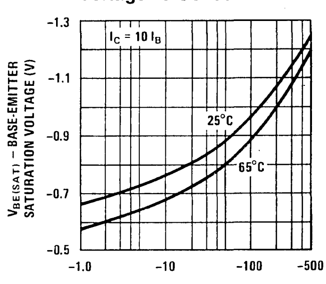
Collector Reverse Current vs Reverse Bias Voltage



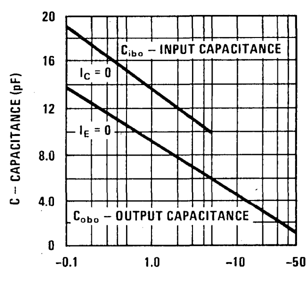
Pulsed Collector Saturation Voltage vs Collector Current



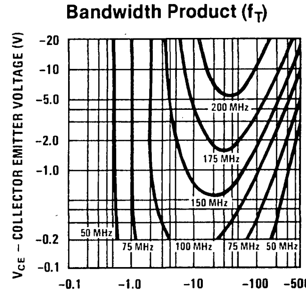
Pulsed Base Saturation Voltage vs Collector Current



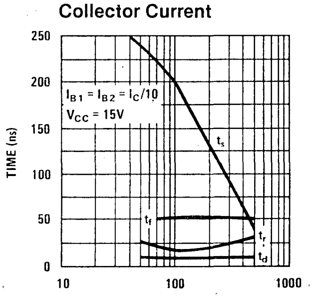
Input and Output Capacitances vs Reverse Bias Voltage



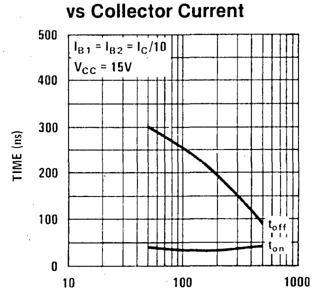
Contours of Constant Gain Bandwidth Product (f_T)



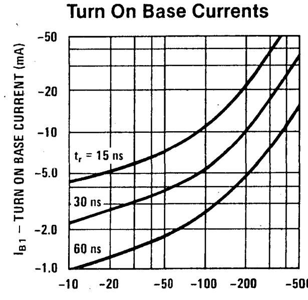
Switching Times vs Collector Current



Turn On and Turn Off Times vs Collector Current



Rise Time vs Collector and Turn On Base Currents



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Process 63

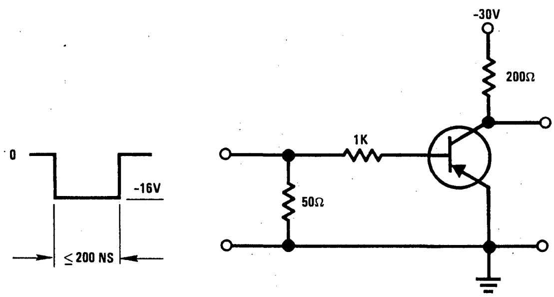


FIGURE 1. Saturated Turn On Switching Time Test Circuit

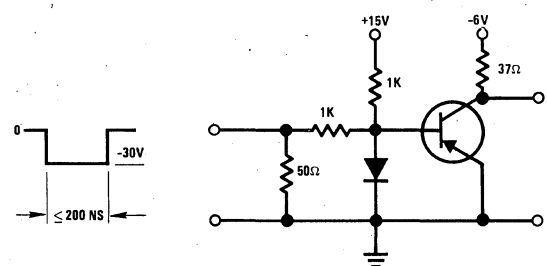
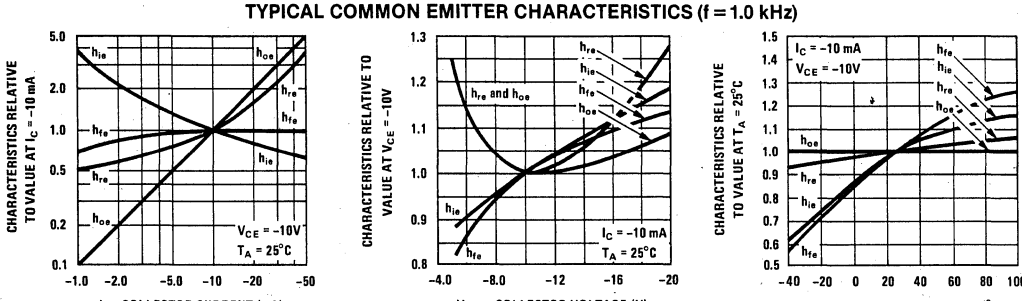


FIGURE 2. Saturated Turn Off Switching Time Test Circuit

SMALL SIGNAL CHARACTERISTICS (f = 1.0 kHz)

Symbol	Characteristic	Min	Typ	Max	Units	Conditions
h_{ie}	Input Resistance		480	2000	Ω	$I_C = 10$ mA, $V_{CE} = -10$V
h_{oe}	Output Conductance		80	1200	μmhos	$I_C = 10$ mA, $V_{CE} = -10$V
h_{re}	Voltage Feedback Ratio		162	1500	$x10^{-6}$	$I_C = 10$ mA, $V_{CE} = -10$V
h_{fe}	Small Signal Current Gain	100				$I_C = 10$ mA, $V_{CE} = -10$V

TYPICAL COMMON EMITTER CHARACTERISTICS (f = 1.0 kHz)



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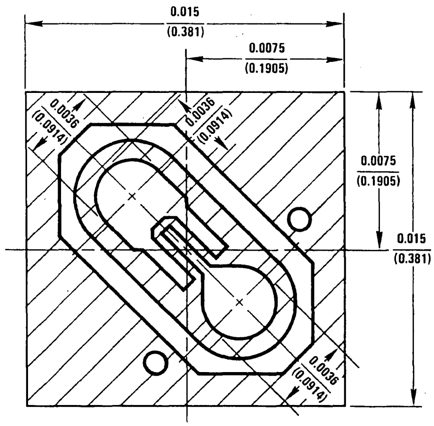
Process 64
PNP High Speed Switch



DESCRIPTION

Process 64 is an overlay, double-diffused, gold doped, silicon epitaxial device. Complement to Process 22.

APPLICATION

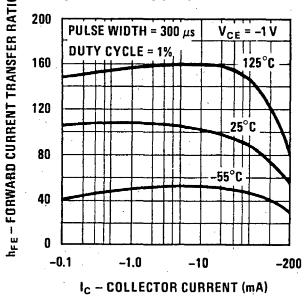
This device was designed for high speed saturated switching applications at collector currents to 200 mA.

PRINCIPAL DEVICE TYPES

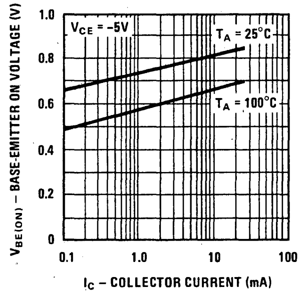
TO-52: 2N2894
TO-92, EBC: PN4313

Parameter	Conditions	Min	Typ	Max	Units	Notes
t_{ON}	$I_C = 30$ mA, $I_{B1} = 3$ mA		10	20	ns	*Figure 1*
t_{OFF}	$I_C = 30$ mA, $I_{B2} = 3$ mA		21	30	ns	*Figure 1*
t_s	$I_C = I_{B1} = I_{B2} = 10$ mA		15	20	ns	
C_{ob}	$V_{CE} = 5V$		3.0	4.5	pF	
C_{ib}	$V_{EB} = 0.5V$			6.0	pF	
h_{fe}	f = 100 MHz, $I_C = 30$ mA, $V_{CE} = 10V$	8	12			
h_{FE}	$I_C = 1$ mA, $V_{CE} = 1V$	20				
h_{FE}	$I_C = 10$ mA, $V_{CE} = 1V$	30				
h_{FE}	$I_C = 30$ mA, $V_{CE} = 1V$	40	90	150		
h_{FE}	$I_C = 100$ mA, $V_{CE} = 1V$	30				
$V_{CE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA			0.15	V	
$V_{CE(SAT)}$	$I_C = 30$ mA, $I_B = 3$ mA			0.2	V	
$V_{CE(SAT)}$	$I_C = 100$ mA, $I_B = 10$ mA			0.5	V	
$V_{BE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA			0.90	V	
$V_{BE(SAT)}$	$I_C = 30$ mA, $I_B = 3$ mA			1.20	V	
$V_{BE(SAT)}$	$I_C = 100$ mA, $I_B = 10$ mA			1.50	V	
BV_{CEO}	$I_C = 10$ mA	12			V	
BV_{CBO}	$I_C = 10\ \mu A$	12			V	
BV_{EBO}	$I_E = 10\ \mu A$	4.5			V	
I_{CBO}	$V_{CE} = 10V$			100	nA	
I_{EBO}	$V_{EB} = 3V$			100	nA	

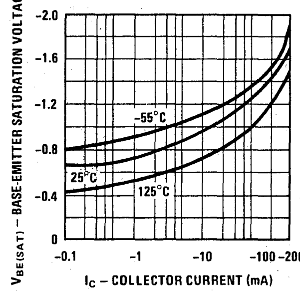
DC Current Gain vs Collector Current



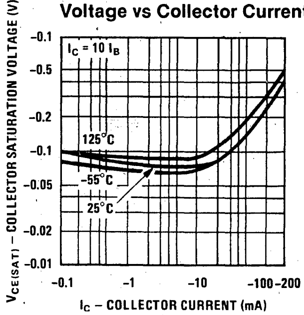
Base-Emitter ON Voltage vs Collector Current



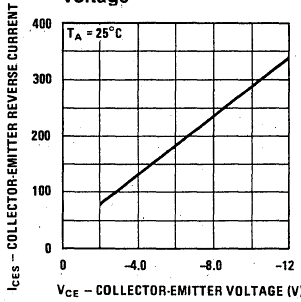
Base Saturation Voltage vs Collector Current



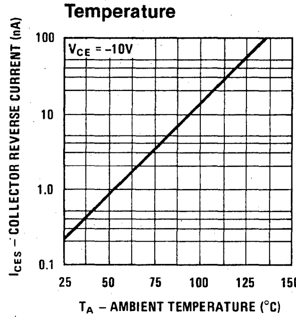
Collector Saturation Voltage vs Collector Current



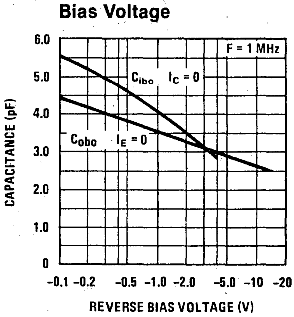
Collector-Base Reverse Current vs Reverse Bias Voltage



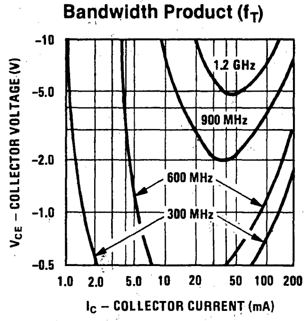
Collector-Base Diode Reverse Current vs Temperature



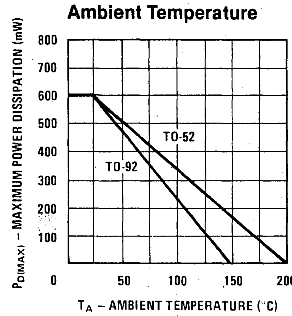
Input and Output Capacitance vs Reverse Bias Voltage



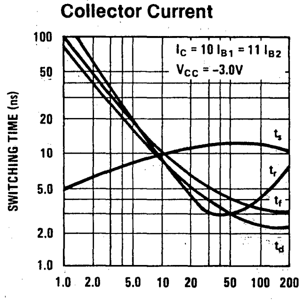
Contours of Constant Gain Bandwidth Product (f_T)



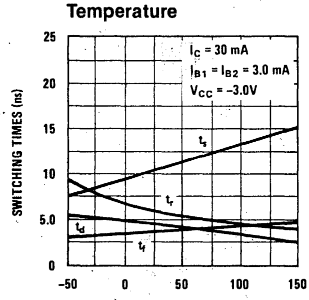
Maximum Power Dissipation vs Ambient Temperature



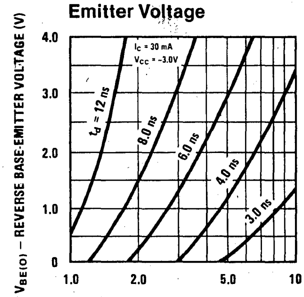
Switching Times vs Collector Current



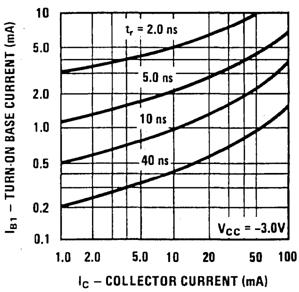
Switching Times vs Temperature



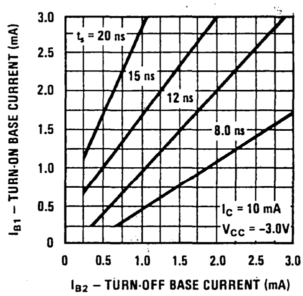
Delay Time vs Turn On Base Current and Reverse Base-Emitter Voltage



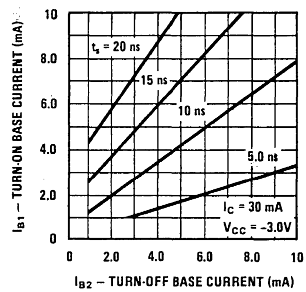
Rise Time vs Collector and Turn On Base Currents



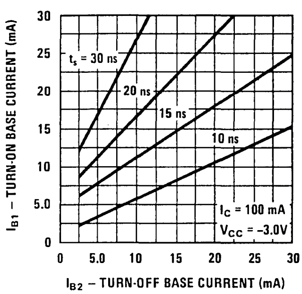
Storage Time vs Turn On and Turn Off Base Currents



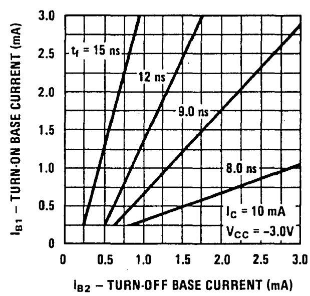
Storage Time vs Turn On and Turn Off Base Currents



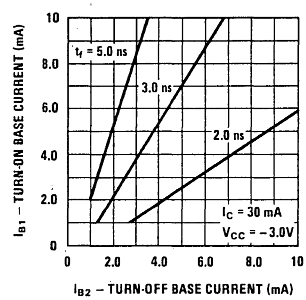
Storage Time vs Turn On and Turn Off Base Currents



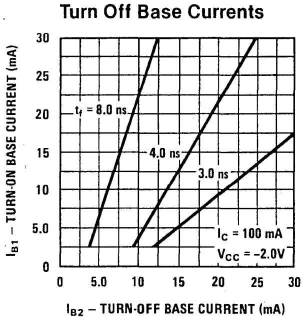
Fall Time vs Turn On and Turn Off Base Currents



Fall Time vs Turn On and Turn Off Base Currents



Fall Time vs Turn On and Turn Off Base Currents



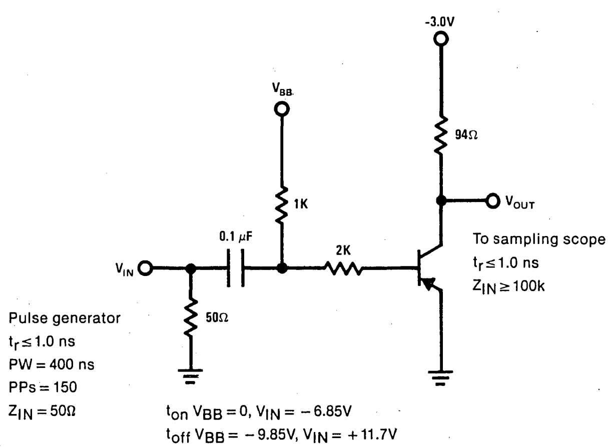
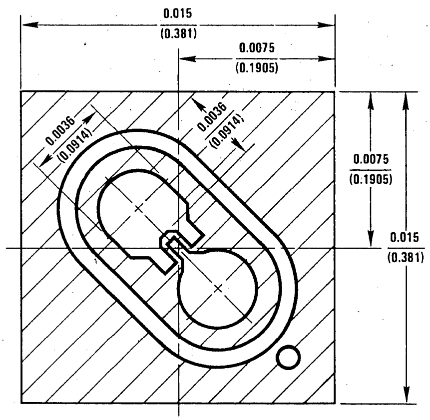


FIGURE 1. Switching Time Test Circuit

National Semiconductor

Process 65
PNP High Speed Switch



DESCRIPTION

Process 65 is an overlay, double diffused, gold doped, silicon epitaxial device. Complement to Process 21.

APPLICATION

This device was designed for very high speed saturate switching at collector currents to 50 mA.

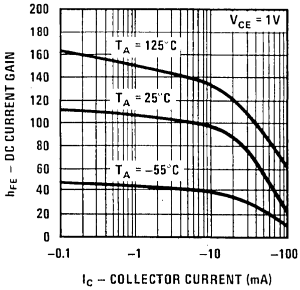
PRINCIPAL DEVICE TYPES

TO-18: 2N4208
TO-92, EBC: 2N5771
MPS3640

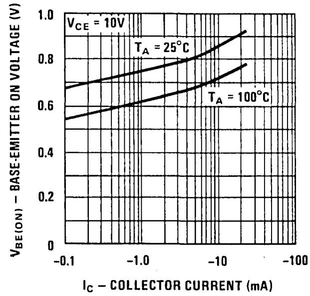
Parameter	Conditions	Min	Typ	Max	Units	Notes
t_{OFF}	$I_C = 10$ mA, $I_{B2} = 1$ mA		18	25	ns	*Figure 1*
t_{ON}	$I_C = 10$ mA, $I_{B1} = 1$ mA		11	15	ns	*Figure 1*
t_s	$I_C = I_{B1} = I_{B2} = 10$ mA		15	20	ns	
C_{ob}	$V_{CB} = 5V$		2	3	pF	
C_{ib}	$V_{EB} = 0.5V$			3.5	pF	
h_{FE}	$V_{CE} = 10V$, $I_C = 10$ mA, f = 100 MHz	6.5	9			
h_{FE}	$I_C = 1$ mA, $V_{CE} = 1V$	20				
h_{FE}	$I_C = 10$ mA, $V_{CE} = 1V$	30	85	150		
h_{FE}	$I_C = 50$ mA, $V_{CE} = 1V$	25	75			
h_{FE}	$I_C = 100$ mA, $V_{CE} = 1V$	20				
h_{FE}	$I_C = 1$ mA, $V_{CE} = 0.5V$	20				
h_{FE}	$I_C = 10$ mA, $V_{CE} = 0.3V$	20				
$V_{CE(SAT)}$	$I_C = 1$ mA, $I_B = 0.1$ mA			0.15	V	
$V_{CE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA			0.20	V	
$V_{CE(SAT)}$	$I_C = 50$ mA, $I_B = 5$ mA			0.50	V	
$V_{BE(SAT)}$	$I_C = 1$ mA, $I_B = 0.1$ mA			0.8	V	
$V_{BE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA			0.95	V	
$V_{BE(SAT)}$	$I_C = 0$ mA, $I_B = 5$ mA			1.5	V	
BV_{CEO}	$I_C = 3$ mA	12			V	
BV_{CBO}	$I_C = 100$ μA	15			V	
BV_{EBO}	$I_C = 10$ μA	4.5			V	
I_{CBO}	$V_{CB} = 10V$			100	nA	
I_{EBO}	$V_{EB} = 3V$			100	nA	

Process 65

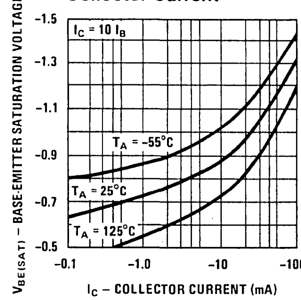
DC Current Gain vs Collector Current



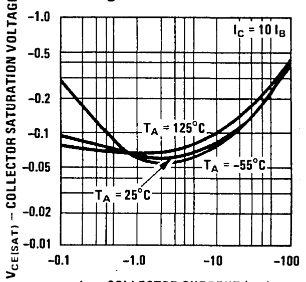
Base-Emitter ON Voltage vs Collector Current



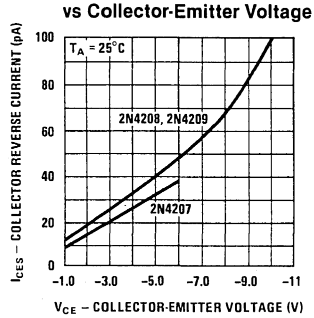
Base Saturation Voltage vs Collector Current



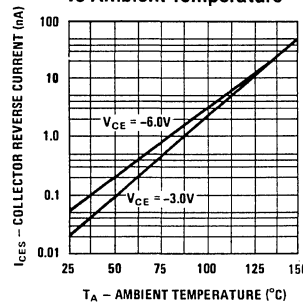
Collector Saturation Voltage vs Collector Current



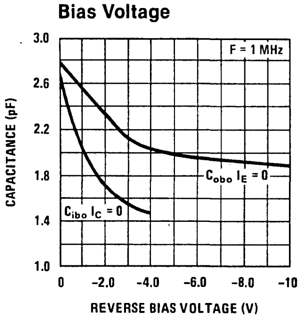
Collector Reverse Current vs Collector-Emitter Voltage



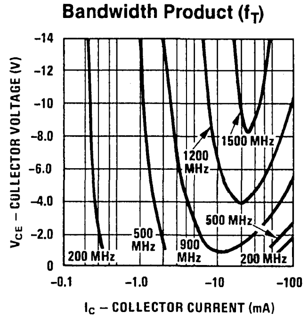
Collector Reverse Current vs Ambient Temperature



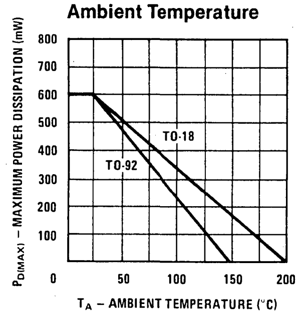
Input and Output Capacitance vs Reverse Bias Voltage



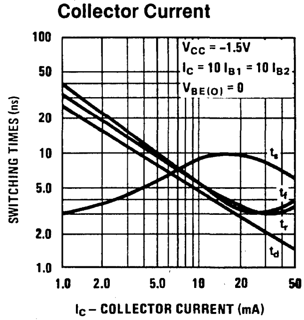
Contours of Constant Gain Bandwidth Product (f_T)



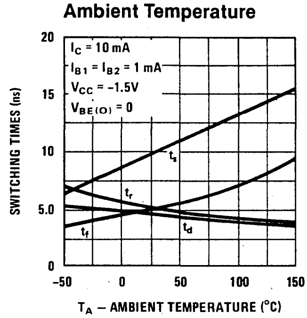
Maximum Power Dissipation vs Ambient Temperature



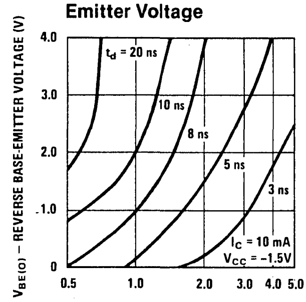
Switching Times vs Collector Current



Switching Times vs Ambient Temperature

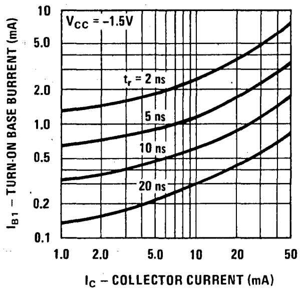


Delay Time vs Turn On Base Current and Reverse Base-Emitter Voltage

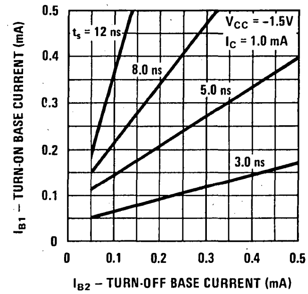


Process 65

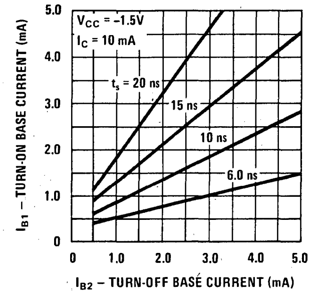
Rise Time vs Collector and Turn On Base Currents



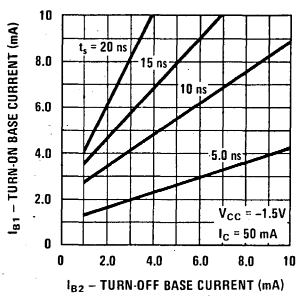
Storage Time vs Turn On and Turn Off Base Currents



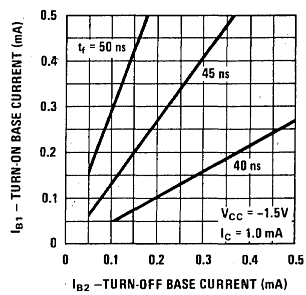
Storage Time vs Turn On and Turn Off Base Currents



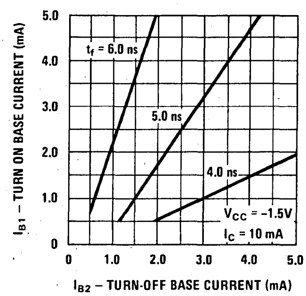
Storage Time vs Turn On and Turn Off Base Currents



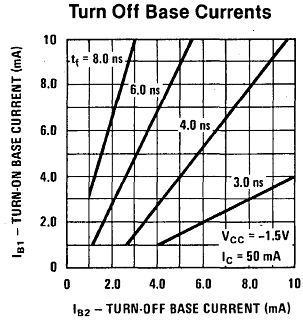
Fall Time vs Turn On and Turn Off Base Currents

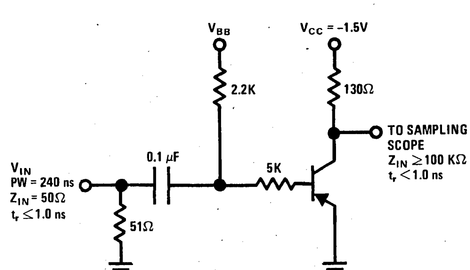


Fall Time vs Turn On and Turn Off Base Currents



Fall Time vs Turn On and Turn Off Base Currents





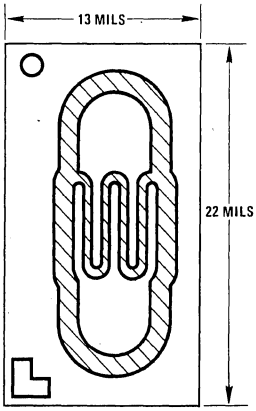
t_{on} | t_{off}
V_{BB} = Ground | $V_{BB} = -8.0V$
$V_{IN} = -5.8V$ | $V_{IN} = +9.8V$

$I_C \approx 10$ mA, $I_{B1} \approx 1.0$ mA, $I_{B2} \approx 1.0$ mA

FIGURE 1. t_{ON} and t_{OFF} Test Circuit

National Semiconductor

Process 66 PNP Small Signal



DESCRIPTION

Process 66 is an overlay, double-diffused, silicon epitaxial device. Complement to Process 23.

APPLICATION

This device was designed for general purpose amplifier and switching applications at collector currents of 10 μA to 100 mA.

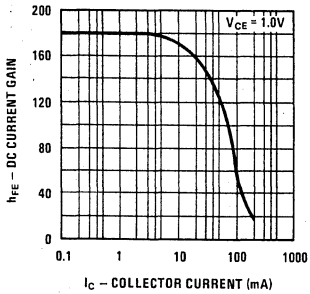
PRINCIPAL DEVICE TYPE

TO-92, EBC: 2N3906

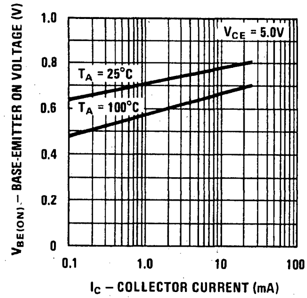
Parameter	Conditions	Min	Typ	Max	Units	Notes
t_{OFF}	$I_C = 10$ mA, $I_{B2} = 1$ mA		150	300	ns	
t_{ON}	$I_C = 10$ mA, $I_{B1} = 1$ mA		30	70	ns	
C_{ob}	$V_{CB} = 5V$		3.0	4.5	pF	
C_{ib}	$V_{EB} = 0.5V$			15	pF	
h_{fe}	f = 100 MHz, $V_{CE} = 20V$, $I_C = 10$ mA	2.5	4.5			
NF (wideband)	$I_C = 100\ \mu A$, $V_{CE} = 5V$, $R_S = 1\ k\Omega$		2.0		dB	
h_{FE}	$I_C = 0.1$ mA, $V_{CE} = 1V$	40				
h_{FE}	$I_C = 1$ mA, $V_{CE} = 1V$	50				
h_{FE}	$I_C = 10$ mA, $V_{CE} = 1V$	50	150	350		
h_{FE}	$I_C = 50$ mA, $V_{CE} = 1V$	40				
h_{FE}	$I_C = 100$ mA, $V_{CE} = 1V$	20				
$V_{CE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA			0.25	V	
$V_{CE(SAT)}$	$I_C = 50$ mA, $I_B = 5$ mA			0.40	V	
$V_{BE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA			0.85	V	
$V_{BE(SAT)}$	$I_C = 50$ mA, $I_B = 5$ mA			0.95	V	
BV_{CEO}	$I_C = 1$ mA	35			V	
BV_{CBO}	$I_C = 10\ \mu A$	45			V	
BV_{EBO}	$I_C = 10\ \mu A$	5.0			V	
I_{CBO}	$V_{CB} = 25V$			100	nA	
I_{EBO}	$V_{EB} = 4V$			100	nA	

Process 66

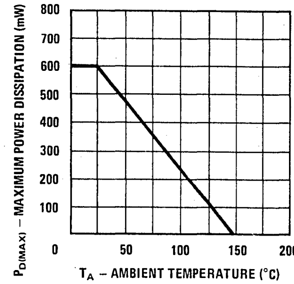
DC Current Gain vs Collector Current



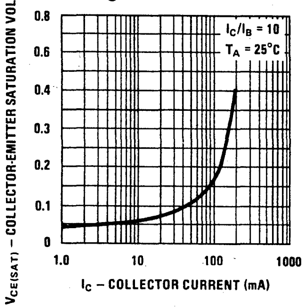
Base-Emitter ON Voltage vs Collector Current



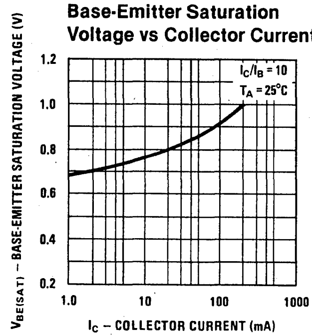
Maximum Power Dissipation vs Ambient Temperature TO-92



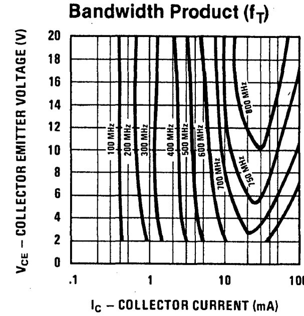
Collector-Emitter Saturation Voltage vs Collector Current



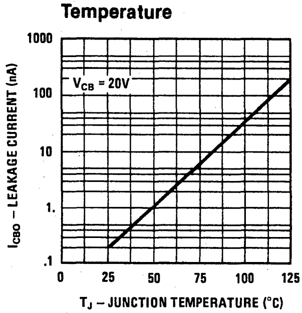
Base-Emitter Saturation Voltage vs Collector Current



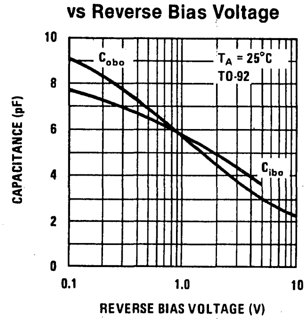
Contours of Constant Gain Bandwidth Product (f_T)



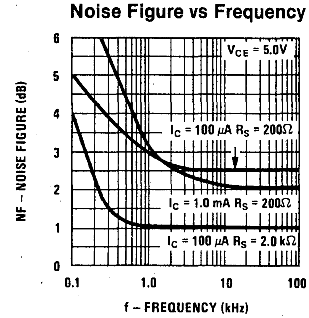
Collector-Base Diode Reverse Current vs Temperature



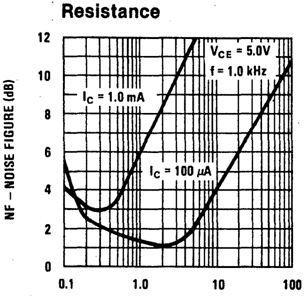
Common Base Open Circuit Input and Output Capacitance vs Reverse Bias Voltage



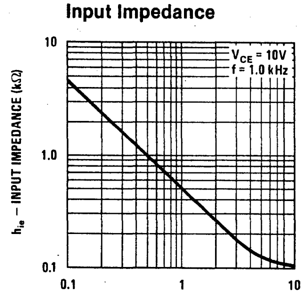
Noise Figure vs Frequency



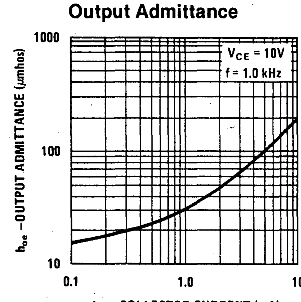
Noise Figure vs Source Resistance



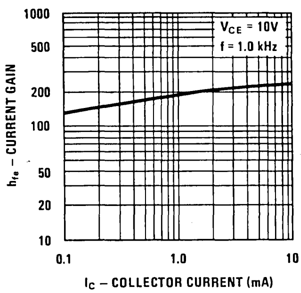
Input Impedance



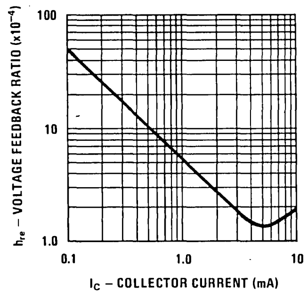
Output Admittance



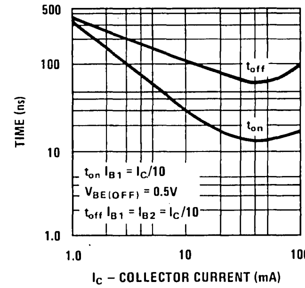
Current Gain



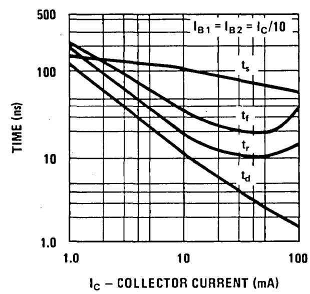
Voltage Feedback Ratio



Turn On and Turn Off Times vs Collector Current

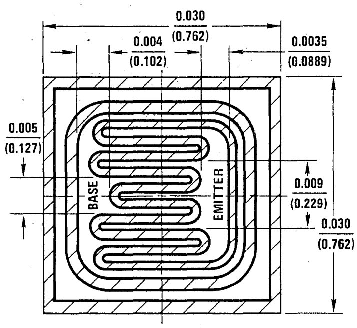


Switching Times vs Collector Current



National Semiconductor

Process 67 PNP Medium Power



DESCRIPTION

Process 67 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 12.

APPLICATION

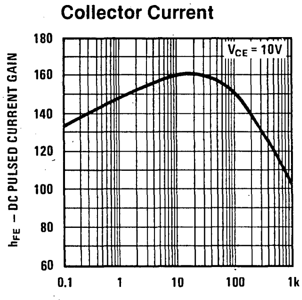
This device is designed for general purpose amplifier and switching applications at currents to 1A and collector voltages up to 70V.

PRINCIPAL DEVICE TYPES

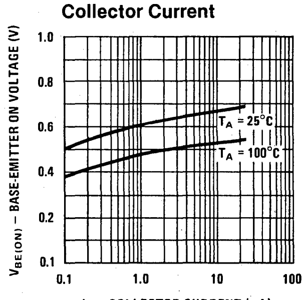
TO-39: 2N4033 **TO-92:** MPS4356, MPSA55 **TO-237:** TN4033

Parameter	Conditions	Min	Typ	Max	Units	Notes
t_{ON}	$I_C = 500$ mA, $I_{B1} = 50$ mA		35		ns	
t_{OFF}	$I_C = 500$ mA, $I_{B2} = 50$ mA		250		ns	
C_{ob}	$V_{CB} = 10V$		11	15	pF	
C_{ib}	$V_{EB} = 0.50V$			90	pF	
h_{fe}	$V_{CE} = 10V$, $I_C = 50$ mA, f = 100 MHz	1	2			
NF (spot)	$I_C = 100\ \mu A$, $R_S = 1k$, $V_{CE} = 10V$, f = 1 kHz		1		dB	
h_{FE}	$I_C = 0.10$ mA, $V_{CE} = 10V$	40				
h_{FE}	$I_C = 1.0$ mA, $V_{CE} = 10V$	45				
h_{FE}	$I_C = 10$ mA, $V_{CE} = 10V$	50				
h_{FE}	$I_C = 100$ mA, $V_{CE} = 10V$	50	150	350		
h_{FE}	$I_C = 500$ mA, $V_{CE} = 10V$	35				
$V_{CE(SAT)}$	$I_C = 150$ mA, $I_B = 15$ mA			0.2	V	
$V_{CE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA			0.6	V	
$V_{BE(SAT)}$	$I_C = 150$ mA, $I_B = 15$ mA			1.0	V	
$V_{BE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA			1.2	V	
BV_{CEO}	$I_C = 10$ mA	60			V	
BV_{CBO}	$I_C = 100\ \mu A$	70			V	
BV_{EBO}	$I_E = 10\ \mu A$	7			V	
I_{CBO}	$V_{CB} = 50V$			100	nA	
I_{EBO}	$V_{EB} = 5V$			100	nA	

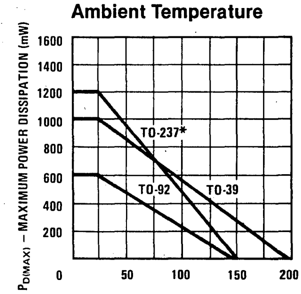
DC Pulsed Current Gain vs Collector Current



Base-Emitter ON Voltage vs Collector Current

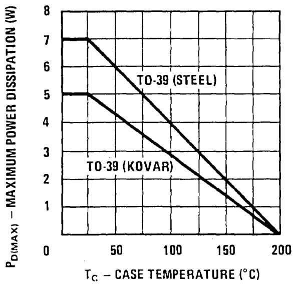


Maximum Power Dissipation vs Ambient Temperature

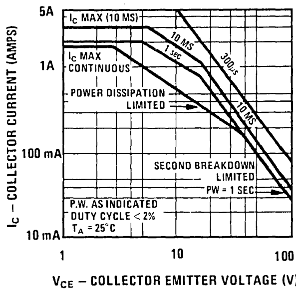


* One square inch of copper run

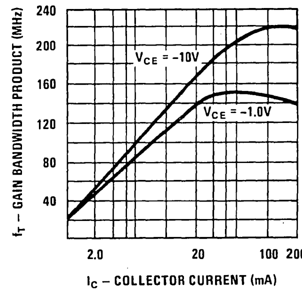
Maximum Power Dissipation vs Case Temperature



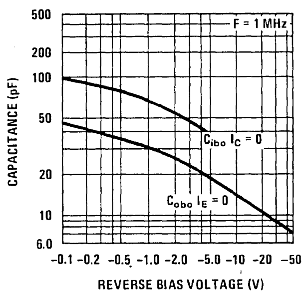
Safe Operating Area TO-39 with "Wake Field" Type 296-4 Heat Sink



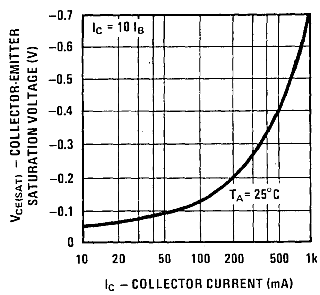
Gain Bandwidth Product vs Collector Current



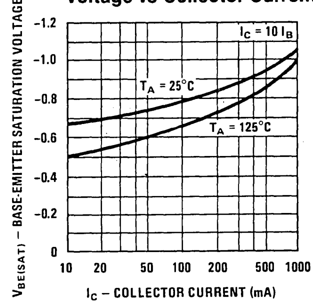
Common Base Open Circuit Input and Output Capacitance vs Reverse Bias Voltage



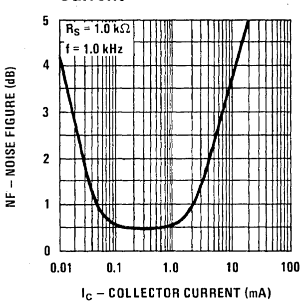
Collector-Emitter Saturation Voltage vs Collector Current



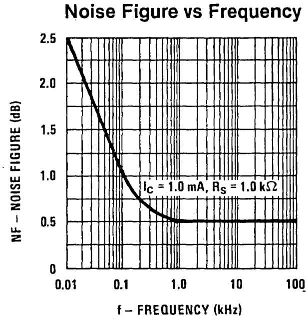
Base-Emitter Saturation Voltage vs Collector Current



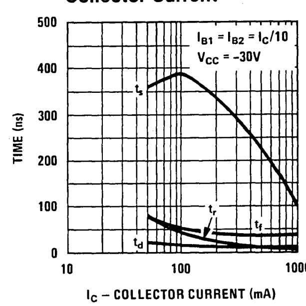
Noise Figure vs Collector Current



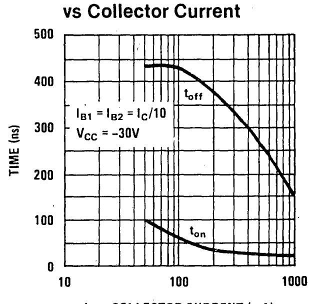
Noise Figure vs Frequency



Switching Times vs Collector Current

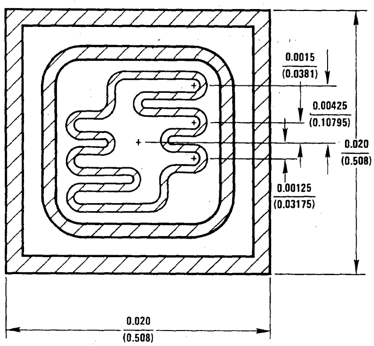


Turn On and Turn Off Times vs Collector Current



National Semiconductor

Process 68 PNP Medium Power



DESCRIPTION

Process 68 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 09.

APPLICATION

This device was designed for general purpose amplifier applications at collector currents to 1A.

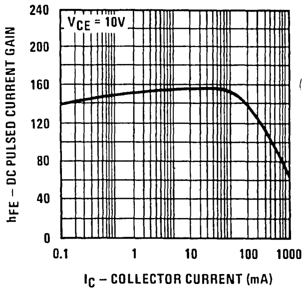
PRINCIPAL DEVICE TYPES

TO-92, EBC: CS9012
MPS6563

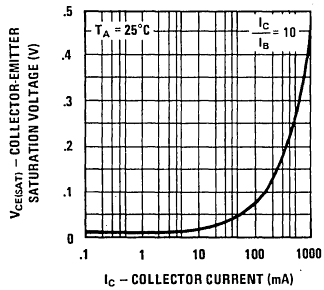
Parameter	Conditions	Min	Typ	Max	Units	Notes
C_{ob}	$V_{CB}=10V$, f = 1 MHz		9	12	pF	
C_{ib}	$V_{EB}=0.5V$, f = 1 MHz			35	pF	
NF	$V_{CE}=10V$, $I_C=1$ mA, $R_S=100\Omega$, f = 1 kHz		1.0		dB	
f_T	$V_{CE}=10V$, $I_C=50$ mA	175			MHz	
h_{FE}	$V_{CE}=1V$, $I_C=1$ mA	50				
h_{FE}	$V_{CE}=1V$, $I_C=100$ mA	50	150	300		
h_{FE}	$V_{CE}=1V$, $I_C=500$ mA	30				
$V_{CE(SAT)}$	$I_C=150$ mA, $I_B=15$			0.2	V	
$V_{CE(SAT)}$	$I_C=500$ mA, $I_B=50$ mA		0.3	0.5	V	
$V_{BE(SAT)}$	$I_C=150$ mA, $I_B=15$ mA			1.0	V	
$V_{BE(SAT)}$	$I_C=500$ mA, $I_B=50$ mA			1.2	V	
I_{CBO}	$V_{CE}=30V$			100	nA	
I_{EBO}	$V_{EB}=5V$			100	nA	
BV_{CBO}	$I_C=100\ \mu A$	35			V	
BV_{EBO}	$I_E=10\ \mu A$	7			V	
BV_{CEO}	$I_C=10$ mA	25			V	

Process 68

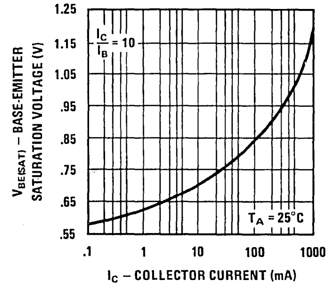
DC Pulsed Current Gain vs Collector Current



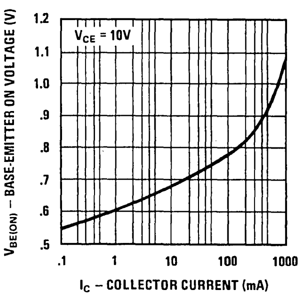
Collector-Emitter Saturation Voltage vs Collector Current



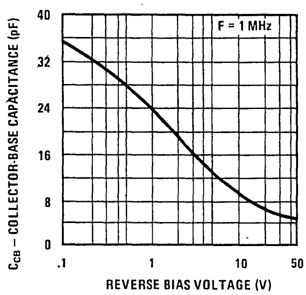
Base-Emitter Saturation Voltage vs Collector Current



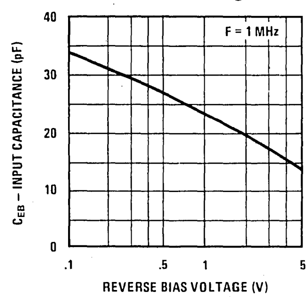
Base-Emitter ON Voltage vs Collector Current



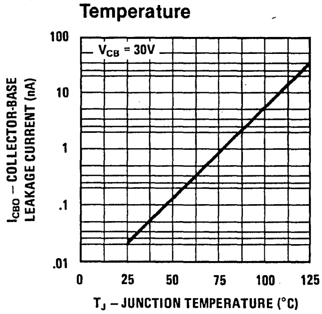
Collector-Base Capacitance vs Reverse Bias Voltage



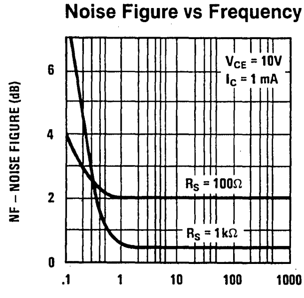
Input Capacitance vs Reverse Bias Voltage



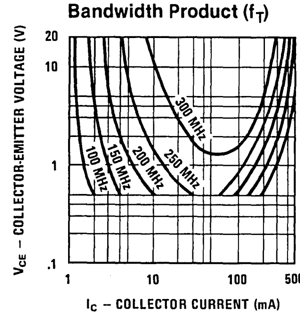
Collector-Base Diode Reverse Current vs Temperature



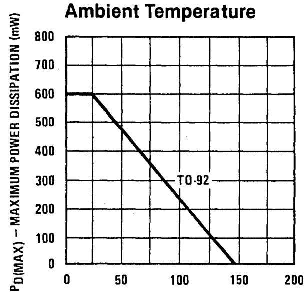
Noise Figure vs Frequency



Contours of Constant Gain Bandwidth Product (f_T)



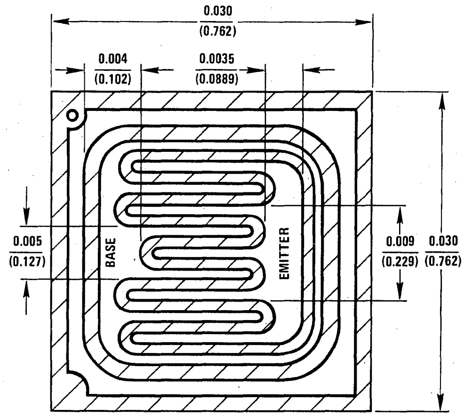
Maximum Power Dissipation vs Ambient Temperature



8

National Semiconductor

Process 70 PNP Memory Driver



DESCRIPTION

Process 70 is a non-overlay, double-diffused, gold doped, silicon epitaxial device. Complement to Process 25.

APPLICATION

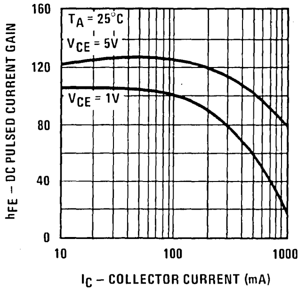
This device was designed primarily for high speed saturated switching applications.

PRINCIPAL DEVICE TYPES

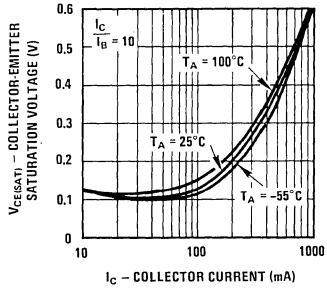
TO-39: 2N3467
TO-237: TN3467

Parameter	Conditions	Min	Typ	Max	Units	Notes
t_{ON}	$I_C = 500$ mA, $I_{B1} = 50$ mA		20	40	ns	*Figure 1*
t_{OFF}	$I_C = 500$ mA, $I_{B2} = 50$ mA		60	90	ns	*Figure 2*
C_{ob}	$V_{CB} = -10V$		15	20	pF	
C_{ib}	$V_{EB} = -0.5V$			80	pF	
h_{FE}	$I_C = 100$ mA, $V_{CE} = -1V$	40	100	200		
h_{FE}	$I_C = 500$ mA, $V_{CE} = -1V$	30		120		
h_{FE}	$I_C = 1A$, $V_{CE} = -1V$	15				
$V_{CE(SAT)}$	$I_C = 150$ mA, $I_B = 15$ mA			0.3	V	
$V_{CE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA			0.6	V	
$V_{CE(SAT)}$	$I_C = 1A$, $I_B = 100$ mA			1.0	V	
$V_{BE(SAT)}$	$I_C = 150$ mA, $I_B = 50$ mA			1.2	V	
$V_{BE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA			1.2	V	
$V_{BE(SAT)}$	$I_C = 1A$, $I_B = 100$ mA			1.7	V	
BV_{CEO}	$I_C = 10$ mA	40			V	
BV_{CBO}	$I_C = 100\ \mu A$	50			V	
BV_{EBO}	$I_E = 10\ \mu A$	6			V	
I_{CBO}	$V_{CB} = 30V$			100	nA	
I_{EBO}	$V_{EB} = 4V$			100	nA	

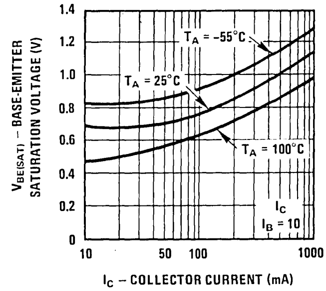
DC Pulsed Current Gain vs Collector Current



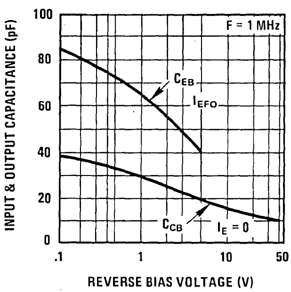
Collector-Emitter Saturation Voltage vs Collector Current



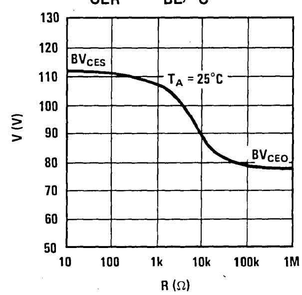
Base-Emitter Saturation Voltage vs Collector Current



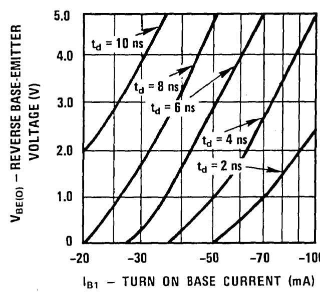
Input and Output Capacitance vs Reverse Bias Voltage



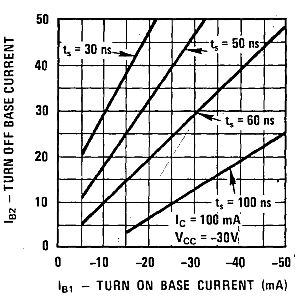
BV_{CER} vs R_{BE}, I_C = 10 mA



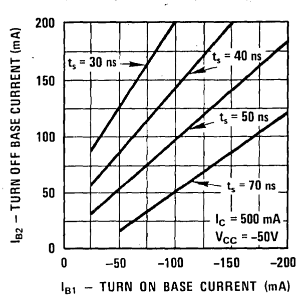
Delay Time vs Turn On Base Current and Reverse Base-Emitter Voltage



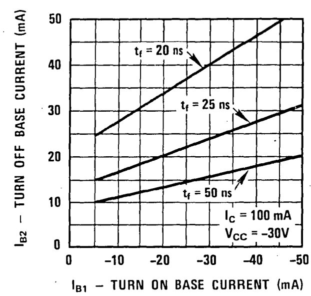
Storage Time vs Turn On and Turn Off Base Currents

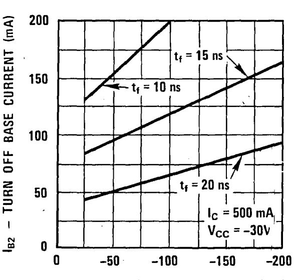


Storage Time vs Turn On and Turn Off Base Currents

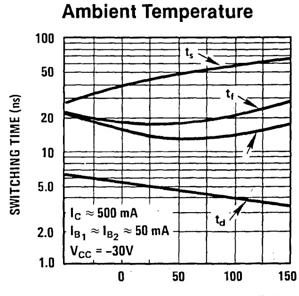


Fall Time vs Turn On and Turn Off Base Currents

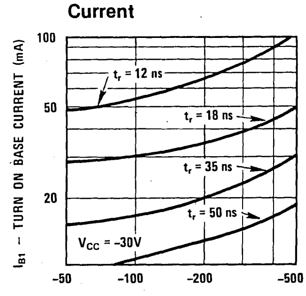




Switching Times vs Ambient Temperature

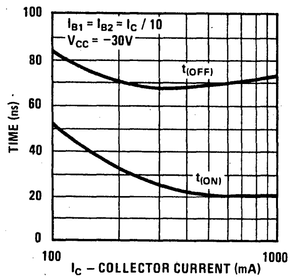


Rise Time vs Collector Current and Turn On Base Current

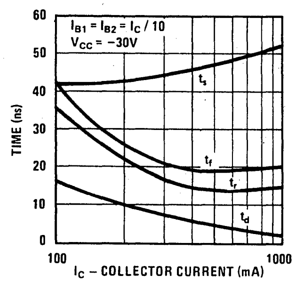


Process 70

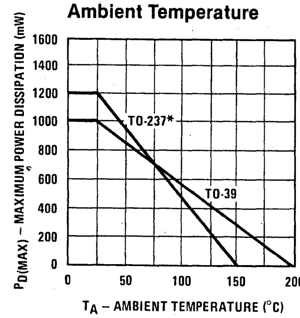
Turn On and Turn Off Times vs Collector Current



Switching Times vs Collector Current

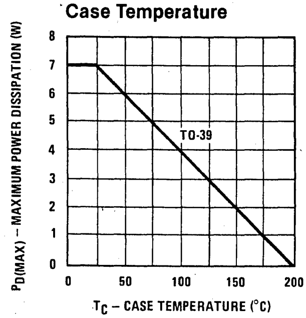


Maximum Power Dissipation vs Ambient Temperature



* One square inch of copper run

Maximum Power Dissipation vs Case Temperature



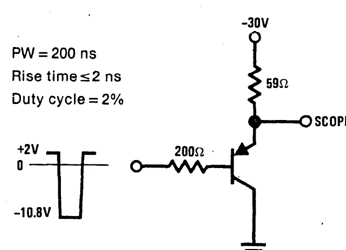


FIGURE 1. t_{ON} Equivalent Test Circuit

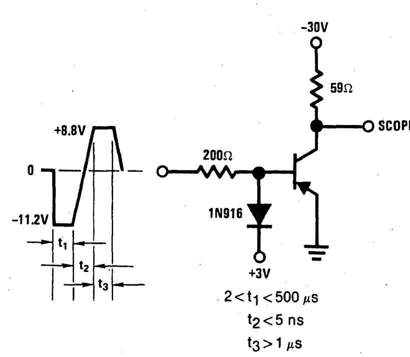
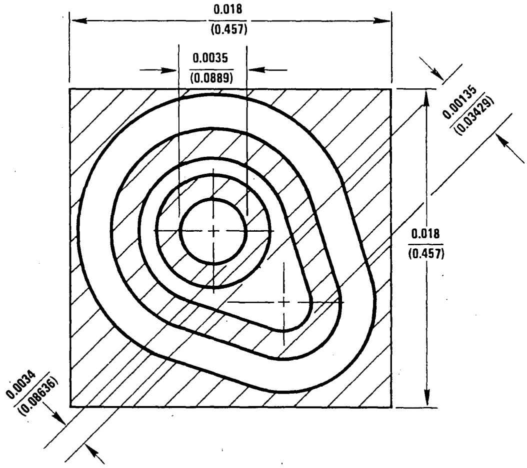


FIGURE 2. t_{OFF} Equivalent Test Circuit

National Semiconductor

Process 71 PNP Small Signal



DESCRIPTION

Process 71 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 04.

APPLICATION

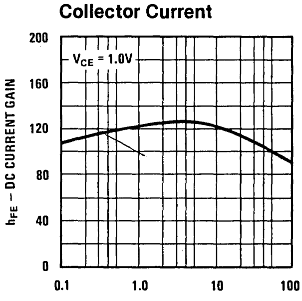
This device was designed for general purpose amplifier applications at collector currents to 50 mA.

PRINCIPAL DEVICE TYPES

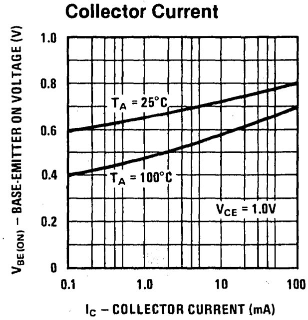
TO-18: BC177 Series
TO-92, CBE: BC560 Series

Parameter	Conditions	Min	Typ	Max	Units	Notes
NF (spot)	$I_C = 200\ \mu A$, $V_C = 5V$, $R_S = 2k$, $f = 1\ kHz$		1.0	4.0	dB	
h_{fe}	$I_C = 10\ mA$, $V_{CE} = 5V$, $f = 100\ MHz$	2.0	4.0			
C_{ob}	$V_{CB} = 10V$		4	6	pF	
C_{ib}	$V_{EB} = 0.50V$			12	pF	
h_{FE}	$I_C = 100\ \mu A$, $V_{CE} = 5V$	70				
h_{FE}	$I_C = 1\ mA$, $V_{CE} = 5V$	80	200	560		
h_{FE}	$I_C = 10\ mA$, $V_{CE} = 5V$	70				
h_{FE}	$I_C = 50\ mA$, $V_{CE} = 5V$	50				
$V_{CE(SAT)}$	$I_C = 1\ mA$, $I_B = 0.10\ mA$			0.10	V	
$V_{CE(SAT)}$	$I_C = 10\ mA$, $I_B = 1\ mA$			0.11	V	
$V_{BE(SAT)}$	$I_C = 1\ mA$, $I_B = 0.10\ mA$			0.95	V	
$V_{BE(SAT)}$	$I_C = 10\ mA$, $I_B = 1\ mA$			1.0	V	
BV_{CEO}	$I_C = 1\ mA$	30			V	
BV_{CBO}	$I_C = 10\ \mu A$	40			V	
BV_{EBO}	$I_E = 10\ \mu A$	6			V	
I_{CBO}	$V_{CB} = 30V$			100	nA	
I_{EBO}	$V_{EB} = 5V$			100	nA	

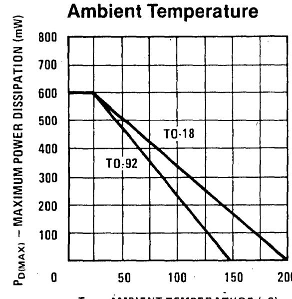
DC Current Gain vs Collector Current



Base-Emitter ON Voltage vs Collector Current

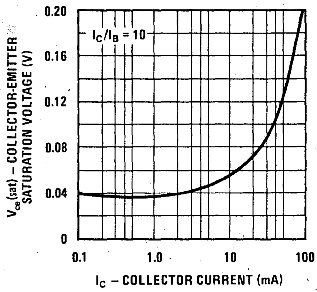


Maximum Power Dissipation vs Ambient Temperature

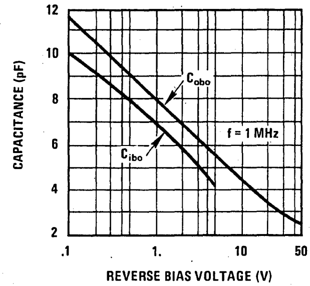


Process 71

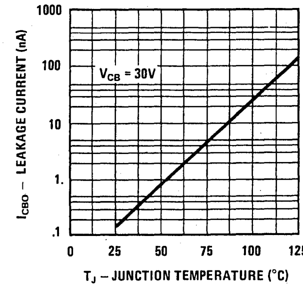
Collector-Emitter Saturation Voltage vs Collector Current



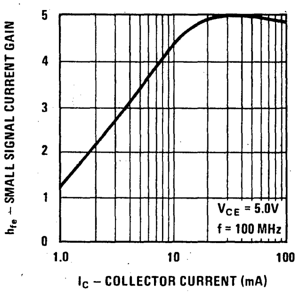
Capacitance vs Reverse Bias Voltage



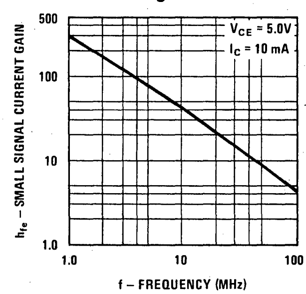
Collector-Base Diode Reverse Current vs Temperature



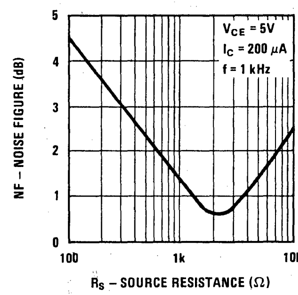
Small Signal Current Gain vs Collector Current



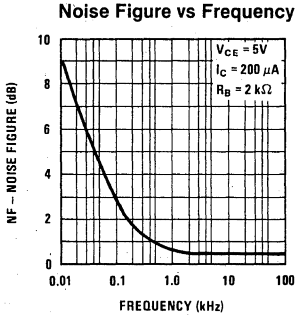
Capacitance vs Reverse Bias Voltage



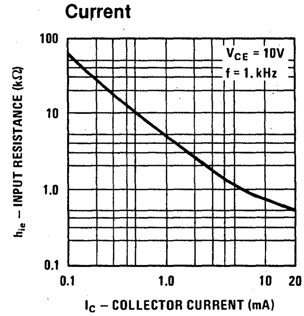
Noise Figure vs Source Resistance



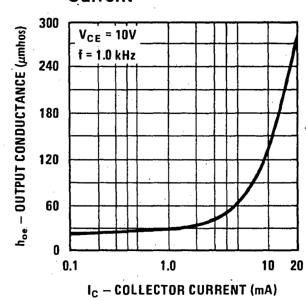
Noise Figure vs Frequency



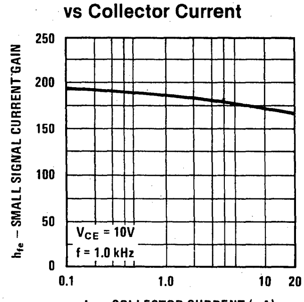
Small Signal Input Resistance vs Collector Current



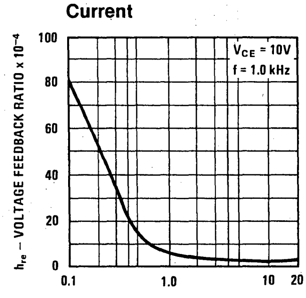
Small Signal Output Conductance vs Collector Current



Small Signal Current Gain vs Collector Current

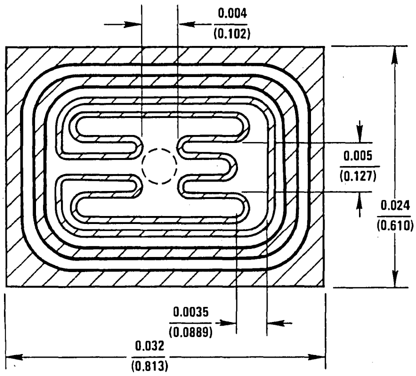


Small Signal Voltage Feedback Ratio vs Collector Current



National Semiconductor

Process 74 PNP High Voltage



DESCRIPTION

Process 74 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 16.

APPLICATION

This device was designed as a general purpose amplifier and switch for applications requiring high voltages.

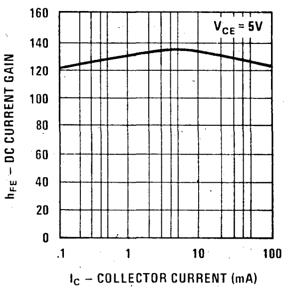
PRINCIPAL DEVICE TYPES

TO-92, EBC: 2N5401
MPSL51

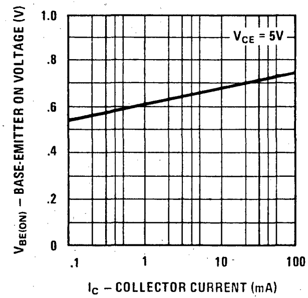
Parameter	Conditions	Min	Typ	Max	Units	Notes
f_T	$I_C = 10$ mA, $V_{CE} = 10V$, f = 100 MHz	100	160		MHz	
C_{ob}	$V_{CB} = 10V$, f = 1 MHz		8	12	pF	
h_{FE}	$I_C = 1$ mA, $V_{CE} = 5V$	40				
h_{FE}	$I_C = 10$ mA, $V_{CE} = 5V$	50	120	250		
h_{FE}	$I_C = 50$ mA, $V_{CE} = 5V$	20				
$V_{BE(SAT)}$	$I_C = 50$ mA, $I_B = 5$ mA			0.95	V	
$V_{CE(SAT)}$	$I_C = 50$ mA, $I_B = 5$ mA			0.50	V	
BV_{CEO}	$I_C = 1$ mA	120			V	
BV_{CBO}	$I_C = 10\ \mu A$	140			V	
BV_{EBO}	$I_E = 10\ \mu A$	6			V	
I_{CBO}	$V_{CB} = 100V$			100	nA	
I_{EBO}	$V_{EB} = 4V$			100	nA	

Process 74

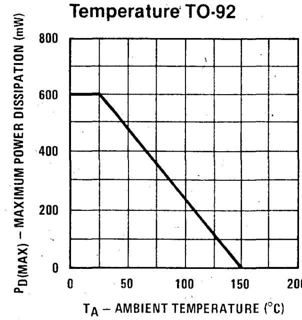
DC Current Gain vs Collector Current



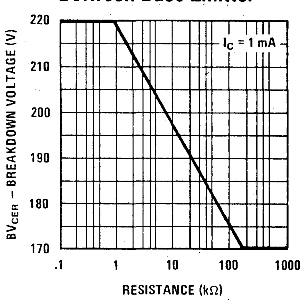
Base-Emitter ON Voltage vs Collector Current



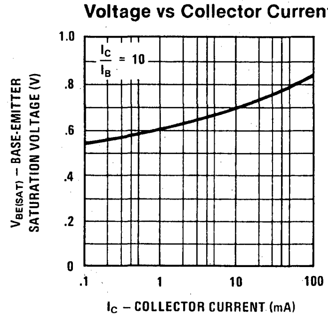
Maximum Power Dissipation vs Ambient Temperature TO-92



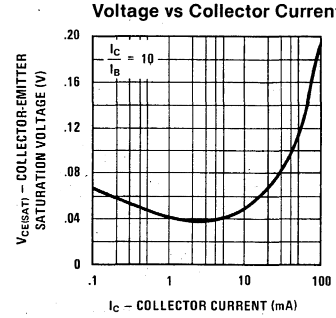
Collector-Emitter Breakdown Voltage with Resistance Between Base-Emitter



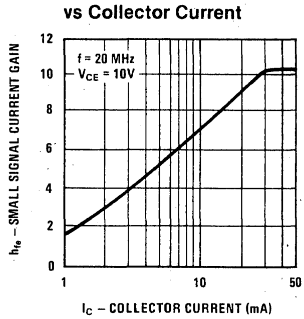
Base-Emitter Saturation Voltage vs Collector Current



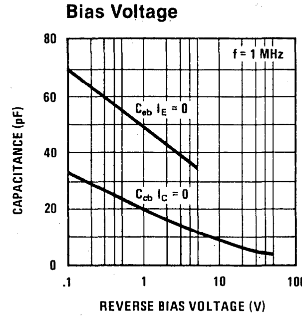
Collector-Emitter Saturation Voltage vs Collector Current



Small Signal Current Gain vs Collector Current

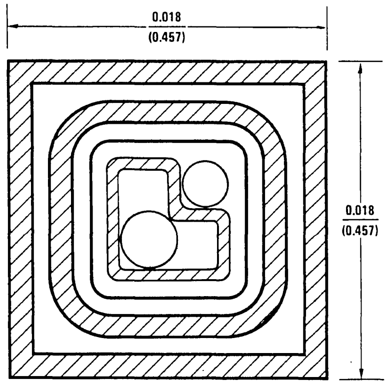


Input and Output Capacitance vs Reverse Bias Voltage



National Semiconductor

Process 76
PNP High Voltage Video Output



DESCRIPTION

Process 76 is a non-overlay, planar epitaxial silicon transistor with a field plate.

APPLICATION

This device was designed as video output to drive color CRT, mainly in complementary configuration. Complement to Process 17.

PRINCIPAL DEVICE TYPES

TO-202, ECB: NSE870
NSE872

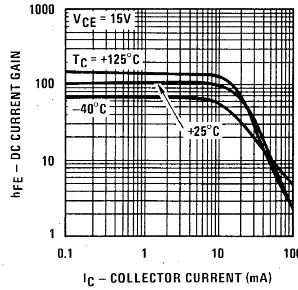
TO-237, ECB: 92PU870
92PU872

Parameter	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 1$ mA (Note 1)	220	300		V
BV_{CES}	$I_C = 0.1$ mA		350		V
BV_{EBO}	$I_E = 0.1$ mA	6			V
I_{CES}	$V_{CE} = 150V$			200	nA
I_{EBO}	$V_{EB} = 5V$			100	nA
h_{FE1}	$V_{CE} = 15V$, $I_C = 0.1$ mA		70		
h_{FE2}	$V_{CE} = 15V$, $I_C = 25$	40	80	200	
h_{FE3}	$V_{CE} = 15V$, $I_C = 50$		25		
$V_{CE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA		0.3	1.0	V
$V_{BE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA		0.8		V
f_T	$V_{CE} = 15V$, $I_C = 10$ mA, f = 20 MHz		0		MHz
C_{ob}	$V_{CB} = 10V$, f = 1 MHz		[illegible]		MHz
C_{ib}	$V_{EB} = 1V$, f = 1 MHz		0.5		pF
$P_{D(max)}$					
TO-202	$T_C = 25°C$ $T_A = 25°C$	8 1.8			W
TO-237	$T_{COLLECTOR} = 25°C$ $T_A = 25°C$	2 0.85			W
θ_{JC}					
TO-202				15.6	°C/W
TO-237				69.4	°C/W
θ_{JA}					
TO-202				62.5	°C/W
TO-237				147	°C/W
$T_{J(max)}$	All Plastic Parts			150	°C

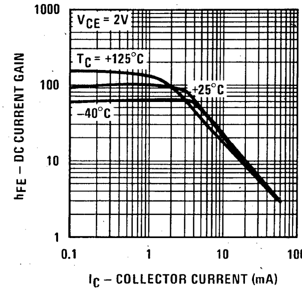
Note 1: Pulsed measurement, 300 μs pulse width

Process 76

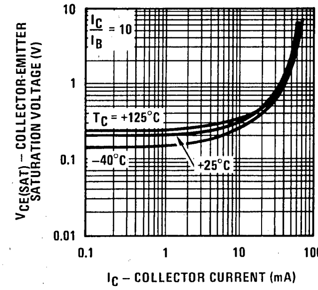
DC Current Gain vs Collector Current



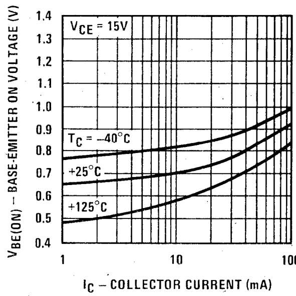
Pulsed Current Gain vs Collector Current



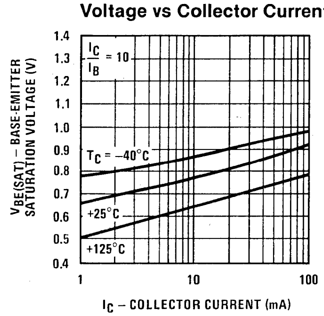
Collector-Emitter Saturation Voltage vs Collector Current



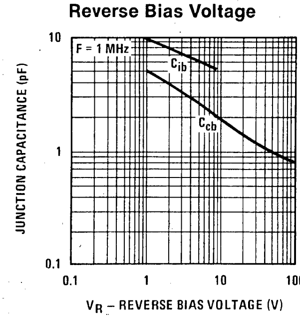
Base-Emitter ON Voltage vs Collector Current



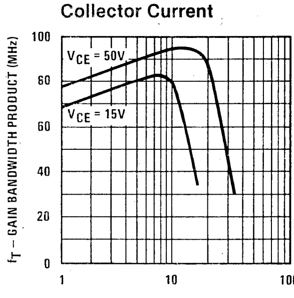
Base-Emitter Saturation Voltage vs Collector Current



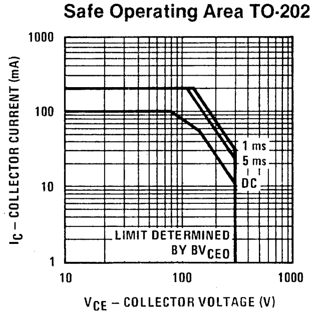
Junction Capacitance vs Reverse Bias Voltage



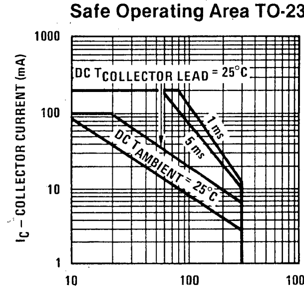
Gain Bandwidth Product vs Collector Current



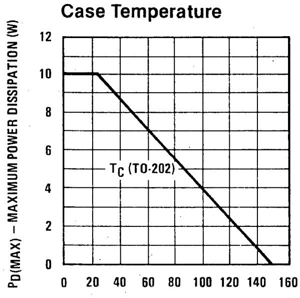
Safe Operating Area TO-202



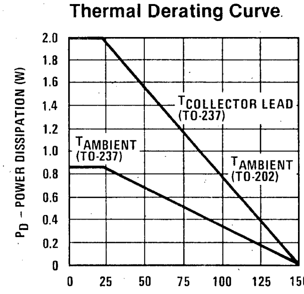
Safe Operating Area TO-237



Maximum Power Dissipation vs Case Temperature

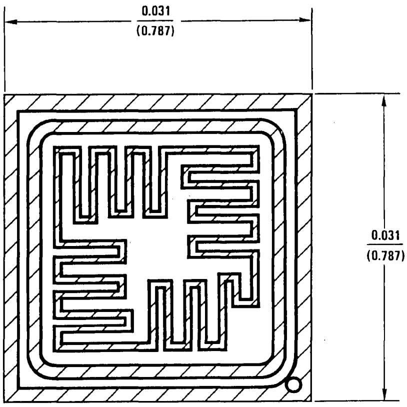


Thermal Derating Curve



National Semiconductor

Process 77 PNP Medium Power



DESCRIPTION

Process 77 is a double-diffused, silicon epitaxial planar device. Complement to Process 37.

APPLICATION

This device was designed for general purpose medium power amplifier and switching circuits that require collector currents to 2A.

PRINCIPAL DEVICE TYPES

TO-202, EBC: D41E7, NSDU51, -A, NSDU52

TO-202, BCE: NSE170

TO-237, EBC: 2N6726, 7 (92PU51, -A)

TO-237, ECB: NA22/32 Series

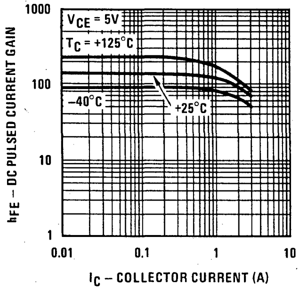
TO-92, EBC: ED1802

TO-126, ECB: MJE170, MJE710

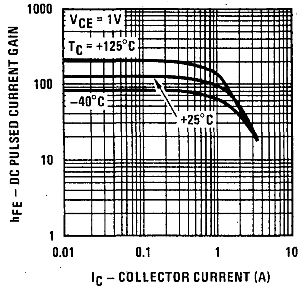
Parameter	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 10$ mA	25			V
BV_{CBO}	$I_C = 100\ \mu A$	35			V
BV_{EBO}	$I_E = 10\ \mu A$	5			V
I_{CBO}	$V_{CB} = 20V$			100	nA
I_{EBO}	$V_{EB} = 4V$		10	100	nA
h_{FE}	$I_C = 100$ A, $V_{CE} = 1V$	50	150	300	
h_{FE}	$I_C = 1$ mA, $V_{CE} = 1V$	35			
$V_{CE(SAT)}$	$I_C = 0.5A$, $I_B = 50$ mA			0.5	V
$V_{BE(SAT)}$	$I_C = 0.5A$, $I_B = 50$ mA			1.3	V
f_T	$I_C = 100$ mA, $V_{CE} = 10V$	100	200		MHz
C_{ob}	$V_{CE} = 10V$, $f = 1$ MHz		28	35	pF
$P_{D(max)}$					
TO-126	$T_C = 25°C$ $T_A = 25°C$	15 1.5			W
TO-202	$T_C = 25°C$ $T_A = 25°C$	10 2			W
TO-237	$T_{COLLECTOR\ LEAD} = 25°C$ $T_A = 25°C$	2 850			W mW
TO-92	$T_A = 25°C$	600			mW
θ_{JC}					
TO-220	$T_C = 25°C$				°C/W
TO-126	$T_C = 25°C$			8.33	°C/W
TO-202	$T_C = 25°C$			12.5	°C/W
TO-237	$T_{COLLECTOR\ LEAD} = 25°C$			62.5	°C/W
θ_{JA}					
TO-126	$T_A = 25°C$			83.3	°C/W
TO-202	$T_A = 25°C$			62.5	°C/W
TO-237	$T_A = 25°C$			147	°C/W
TO-92	$T_A = 25°C$			208	°C/W
$T_{J(max)}$	All Plastic Parts	150			°C

Process 77

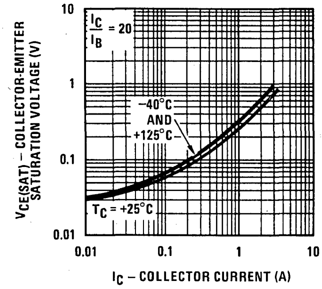
DC Pulsed Current Gain vs Collector Current



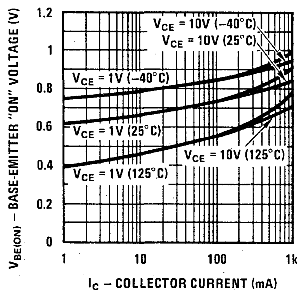
DC Pulsed Current Gain vs Collector Current



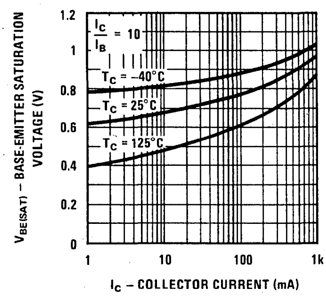
Collector-Emitter Saturation Voltage vs Collector Current



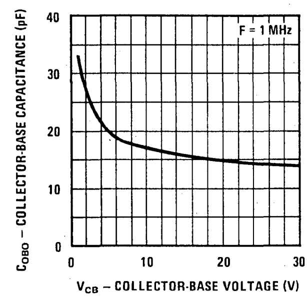
Base-Emitter ON Voltage vs Collector Current



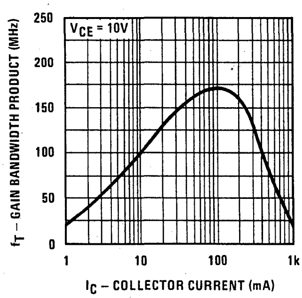
Base-Emitter Saturation Voltage vs Collector Current



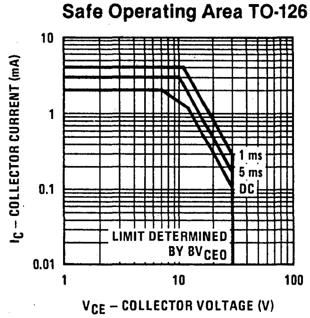
Collector-Base Capacitance vs Collector-Base Voltage



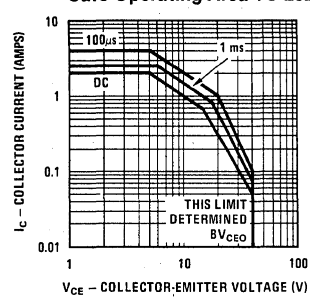
Gain Bandwidth Product vs Collector Current



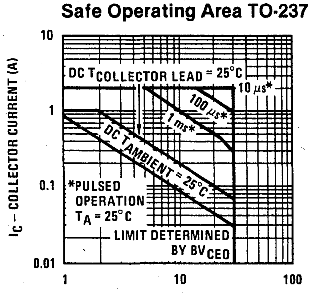
Safe Operating Area TO-126



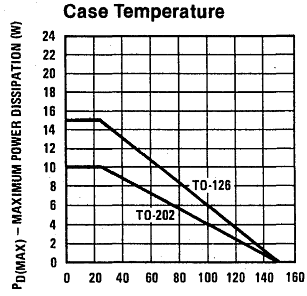
Safe Operating Area TO-202



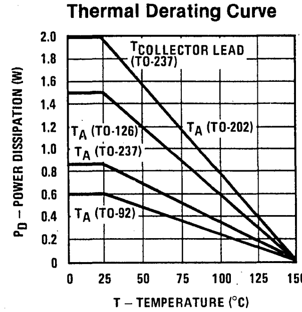
Safe Operating Area TO-237



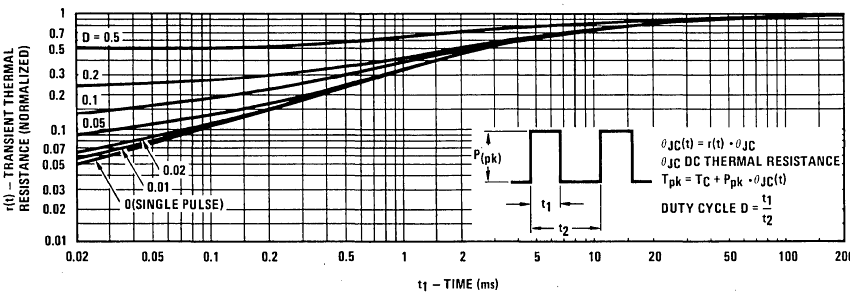
Maximum Power Dissipation vs Case Temperature



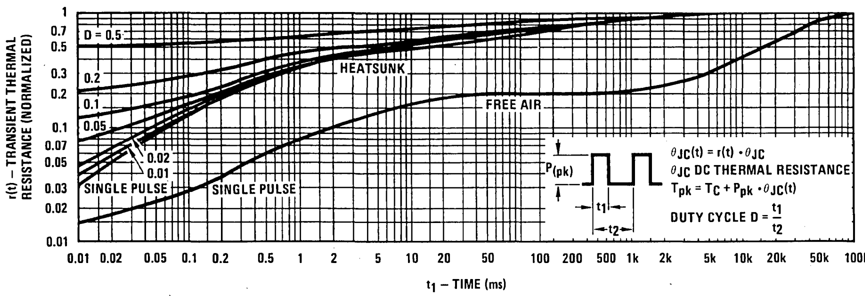
Thermal Derating Curve



Thermal Response in TO-126 Package

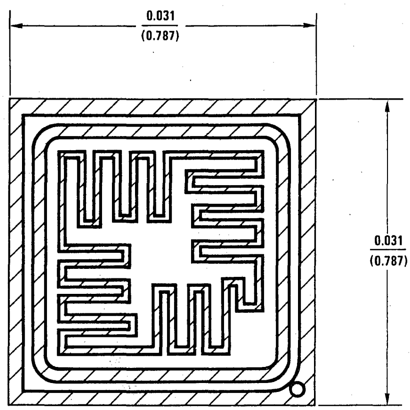


Thermal Response in TO-202 Package



National Semiconductor

Process 78 PNP Medium Power



DESCRIPTION

Process 78 is a double-diffused, silicon epitaxial planar device. Complement to Process 38.

APPLICATION

This device was designed for general purpose medium power amplifier and switching circuits that require collector currents to 1.5A.

PRINCIPAL DEVICE TYPES

TO-202, EBC: 2N6554
D41D1-14
D41E5, 7
NSDU55, 56

TO-202, BCE: NSE170, 171

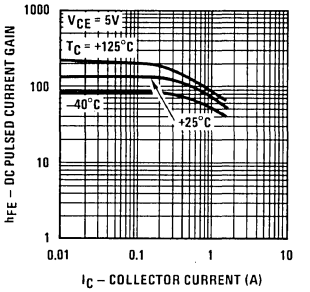
TO-237, EBC: 2N6728 (92PU55)

TO-237, ECB: 2N6708, 9 (92PE77A, B)

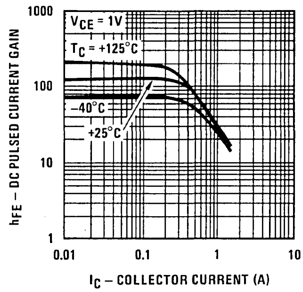
TO-126, ECB: BD344
MJE171
MJE711

Parameter	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 10$ mA	40			V
BV_{CBO}	$I_C = 100\ \mu A$	50			V
BV_{EBO}	$I_E = 10\ \mu A$	5			V
I_{CBO}	$V_{CB} = 40V$			100	nA
I_{EBO}	$V_{EB} = 4V$			100	nA
h_{FE}	$I_C = 100$ mA, $V_{CE} = 1V$	50	150	300	
h_{FE}	$I_C = 500$ mA, $V_{CE} = 1V$	35			
$V_{CE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA			0.6	V
$V_{BE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA			1.3	V
f_T	$I_C = 100$ mA, $V_{CE} = 10V$	80	150		MHz
C_{ob}	$V_{CB} = 10V$		20	25	pF
$P_{D(max)}$					
TO-126	$T_C = 25°C$ $T_A = 25°C$	15 1.5			W
TO-202	$T_C = 25°C$ $T_A = 25°C$	10 2			W
TO-237	$T_{COLLECTOR\ LEAD} = 25°C$ $T_A = 25°C$	2 850			W mW
TO-92	$T_A = 25°C$	600			mW
θ_{JC}					
TO-220	$T_C = 25°C$				°C/W
TO-126	$T_C = 25°C$			8.33	°C/W
TO-202	$T_C = 25°C$			12.5	°C/W
TO-237	$T_{COLLECTOR\ LEAD} = 25°C$			62.5	°C/W
θ_{JA}					
TO-126	$T_A = 25°C$			83.3	°C/W
TO-202	$T_A = 25°C$			62.5	°C/W
TO-237	$T_A = 25°C$			147	°C/W
TO-92	$T_A = 25°C$			208	°C/W
$T_{J(max)}$	All Plastic Parts	150			°C

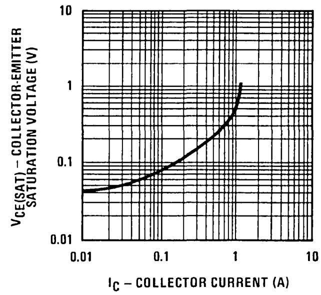
Pulsed Current Gain vs Collector Current



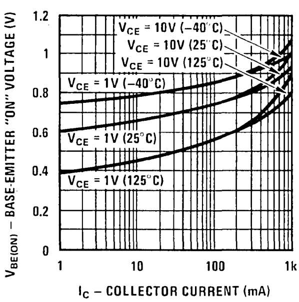
Pulsed Current Gain vs Collector Current



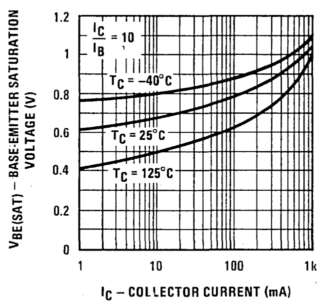
Collector-Emitter Saturation Voltage vs Collector Current



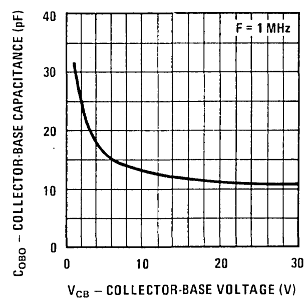
Base-Emitter ON Voltage vs Collector Current



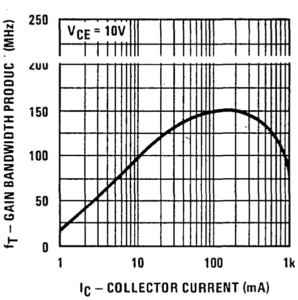
Base-Emitter Saturation Voltage vs Collector Current



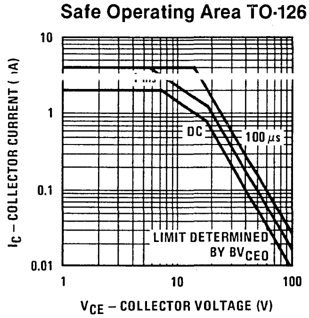
Collector-Base Capacitance vs Collector-Base Voltage



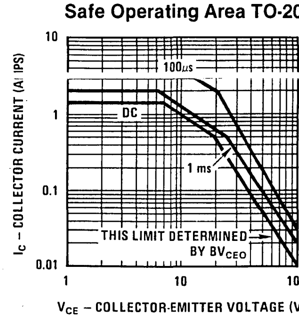
Gain Bandwidth Product vs Collector Current



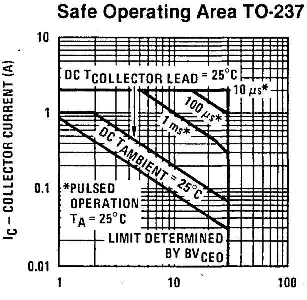
Safe Operating Area TO-126



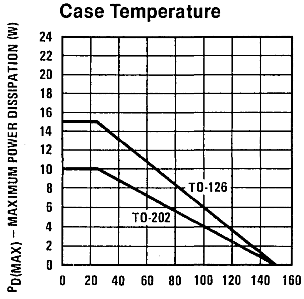
Safe Operating Area TO-202



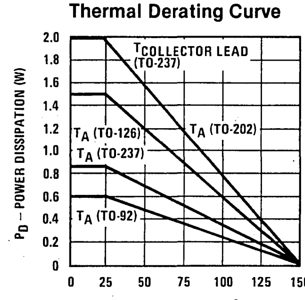
Safe Operating Area TO-237



Maximum Power Dissipation vs Case Temperature

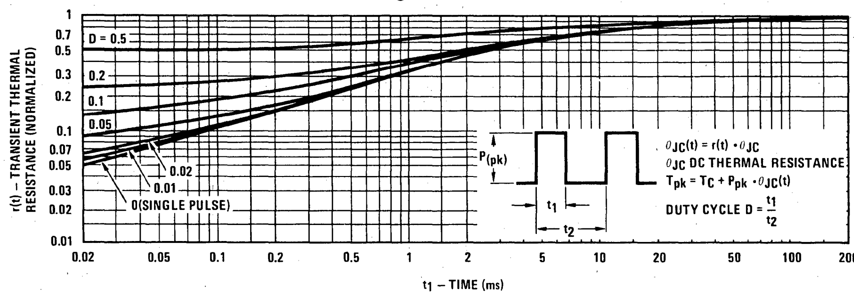


Thermal Derating Curve

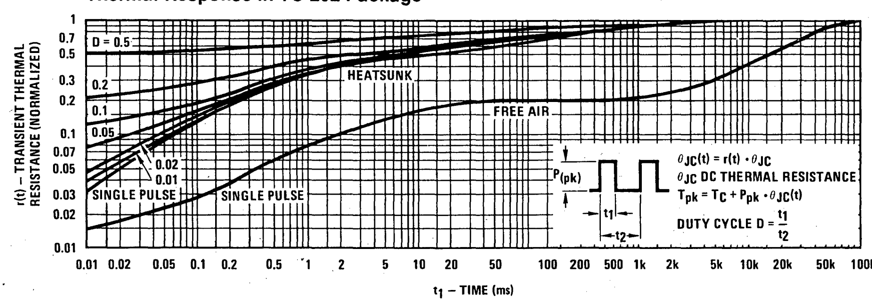


Process 78

Thermal Response in TO-126 Package

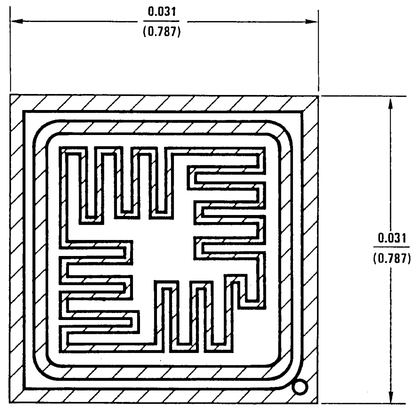


Thermal Response in TO-202 Package



National Semiconductor

Process 79 PNP Medium Power



DESCRIPTION

Process 79 is a double-diffused, silicon epitaxial planar device. Complement to Process 39.

APPLICATION

This device was designed for general purpose medium power amplifier and switching circuits that require collector currents to 1A.

PRINCIPAL DEVICE TYPES

TO-202, EBC: 2N6555-56
NSD204-6
NSDU57

TO-237, EBC: 2N6729,30
(92PU56, 57)

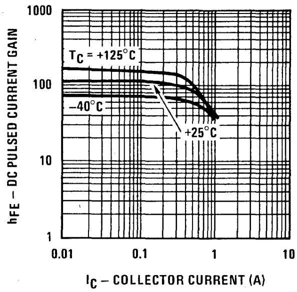
TO-237, ECB: 2N6710
(92PE77C)

TO-126, ECB: BD348
MJE172
MJE712

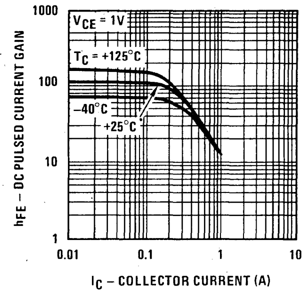
Parameter	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 10$ mA	70			V
BV_{CBO}	$I_C = 100\ \mu A$	80			V
BV_{EBO}	$I_E = 10\ \mu A$	5			V
I_{CBO}	$V_{CB} = 60V$			100	nA
I_{EBO}	$V_{EB} = 4V$			100	nA
h_{FE}	$I_C = 100$ mA, $V_{CE} = 1V$	40	120	240	
h_{FE}	$I_C = 500$ mA, $V_{CE} = 1V$	20			
$V_{CE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA			0.8	V
$V_{BE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA			1.4	V
f_T	$I_C = 100$ mA, $V_{CE} = 10V$	70	125		MHz
C_{ob}	$V_{CB} = 10V$		14	18	pF
$P_{D(max)}$					
TO-126	$T_C = 25°C$ $T_A = 25°C$	15 1.5			W
TO-202	$T_C = 25°C$ $T_A = 25°C$	10 2			W
TO-237	$T_{COLLECTOR\ LEAD} = 25°C$ $T_A = 25°C$	2 850			W mW
TO-92	$T_A = 25°C$	600			mW
θ_{JC}					
TO-220	$T_C = 25°C$				°C/W
TO-126	$T_C = 25°C$			8.33	°C/W
TO-202	$T_C = 25°C$			12.5	°C/W
TO-237	$T_{COLLECTOR\ LEAD} = 25°C$			62.5	°C/W
θ_{JA}					
TO-126	$T_A = 25°C$			83.3	°C/W
TO-202	$T_A = 25°C$			62.5	°C/W
TO-237	$T_A = 25°C$			147	°C/W
TO-92	$T_A = 25°C$			208	°C/W
$T_{J(max)}$	All Plastic Parts	150			°C

Process 79

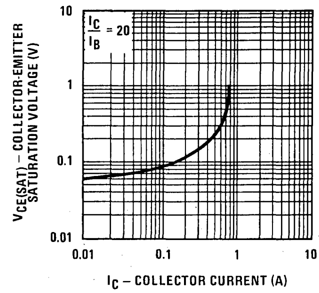
Pulsed Current Gain vs Collector Current



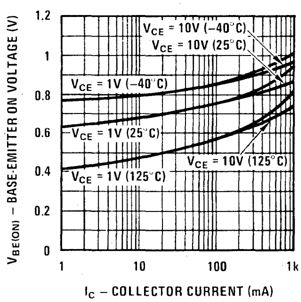
Pulsed Current Gain vs Collector Current



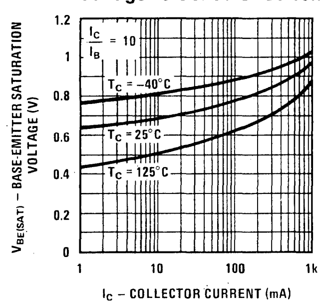
Collector-Emitter Saturation Voltage vs Collector Current



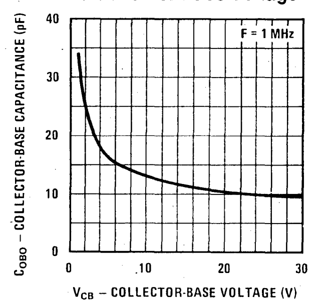
Base-Emitter ON Voltage vs Collector Current



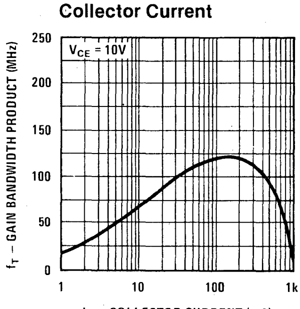
Base-Emitter Saturation Voltage vs Collector Current



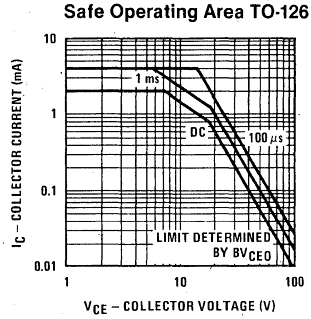
Collector-Base Capacitance vs Collector-Base Voltage



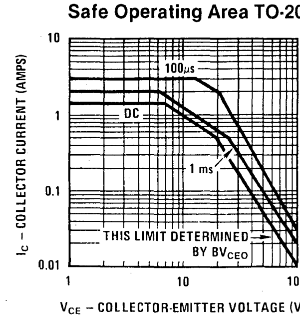
Gain Bandwidth Product vs Collector Current



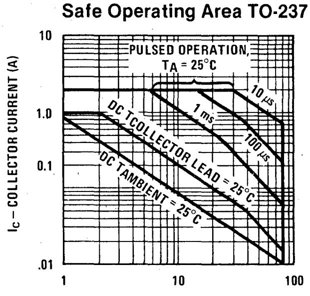
Safe Operating Area TO-126



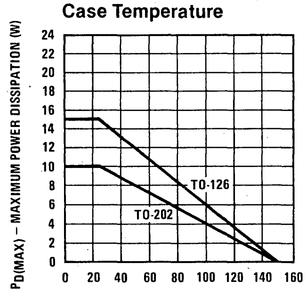
Safe Operating Area TO-202



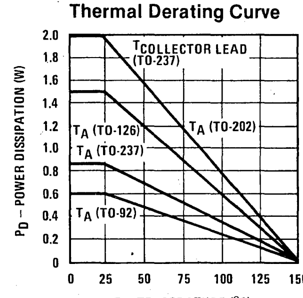
Safe Operating Area TO-237



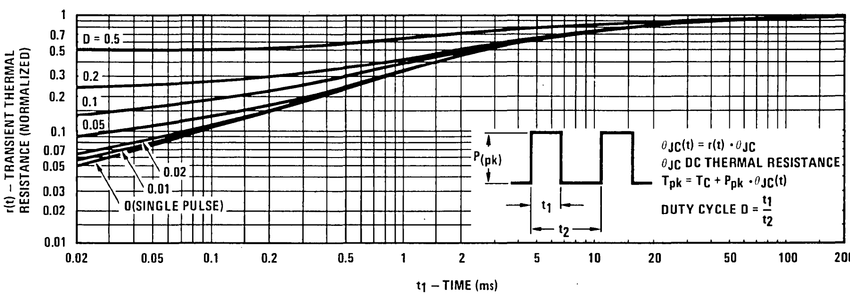
Maximum Power Dissipation vs Case Temperature



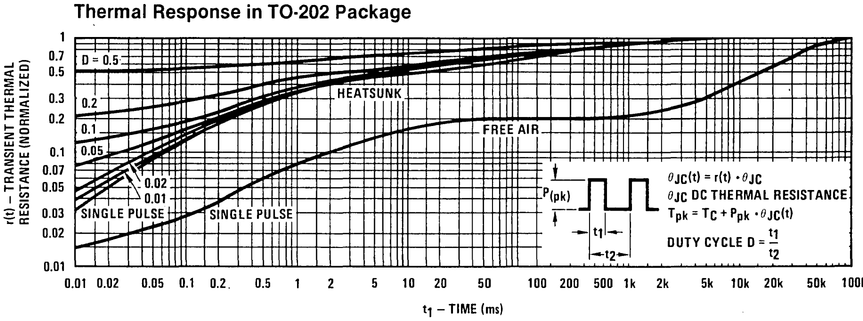
Thermal Derating Curve



Thermal Response in TO-126 Package



Thermal Response in TO-202 Package



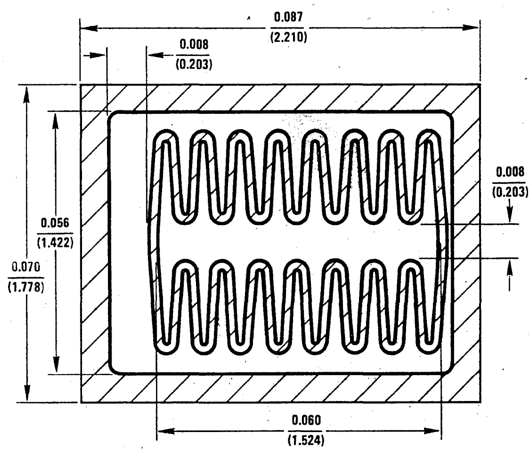
Section 9

Process Characteristics Power Transistors

9

National Semiconductor

Process 34 NPN Planar Power



DESCRIPTION

This device is a nonoverlay double-diffused, silicon epitaxial planar transistor.

APPLICATION

This device was designed for general purpose amplifier applications utilizing collector currents to 5A.

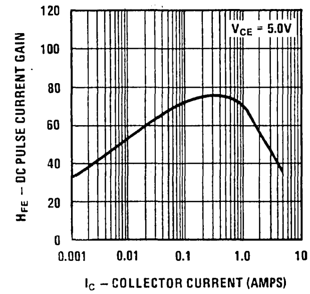
PRINCIPAL DEVICE TYPES

TO-39, EBC: 2N2891
TO-237, EBC: TN3440

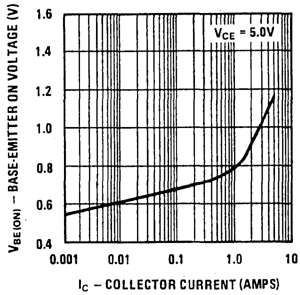
Parameter	Conditions	Min	Typ	Max	Units	Notes
t_{ON}	$I_C = 1$ A, $I_{B1} = 0.1$A		90	120	ns	
t_{OFF}	$I_C = 1$A, $I_{B2} = 0.1$A		200	260	ns	
C_{ob}	$V_{CB} = 10$V, f = 1 MHz		60	70	pF	
C_{ib}	$V_{EB} = 0.5$V, f = 1MHz			500	pF	
h_{fe}	$I_C = 200$ mA, $V_{CE} = 10$V, f = 20 MHz	4.0	5.0			
h_{FE}	$I_C = 1$ mA, $V_{CE} = 5$V	40				
h_{FE}	$I_C = 10$ mA, $V_{CE} = 5$V	40				
h_{FE}	$I_C = 100$ mA, $V_{CE} = 5$V	40				
h_{FE}	$I_C = 500$ mA, $V_{CE} = 5$V	40	80	150		
h_{FE}	$I_C = 1$A, $V_{CE} = 5$V	20				
h_{FE}	$I_C = 5$A, $V_{CE} = 5$V	15				
$V_{CE(SAT)}$	$I_C = 100$ mA, $I_B = 10$mA		0.05	0.10	V	TO-39
$V_{CE(SAT)}$	$I_C = 1$A, $I_B = 100$ mA		0.20	0.30	V	TO-39
$V_{BE(SAT)}$	$I_C = 100$ mA, $I_B = 10$ mA		0.70	0.85	V	TO-39
$V_{BE(SAT)}$	$I_C = 1$A, $I_B = 100$ mA		0.90	1.10	V	TO-39
BV_{CEO}	$I_C = 10$ mA	80				
BV_{CBO}	$I_C = 100$ μA	100				
BV_{EBO}	$I_E = 10$ μA	8				
I_{CBO}	$V_{CB} = 60$V			100	nA	
I_{EBO}	$V_{EB} = 6$V			100	nA	

Process 34

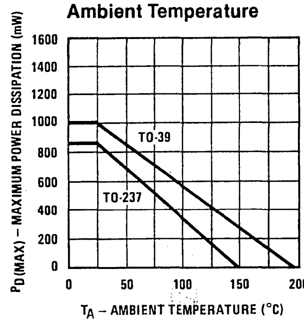
Pulsed DC Current Gain vs Collector Current



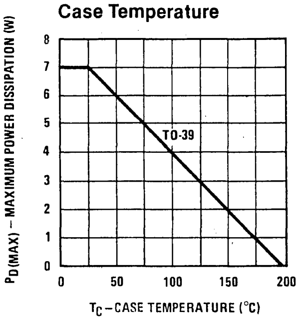
Base-Emitter ON Voltage vs Collector Current



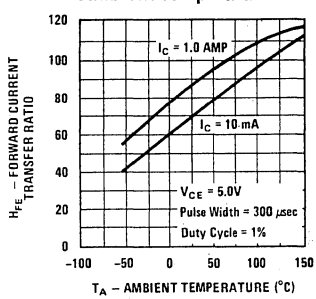
Maximum Power Dissipation vs Ambient Temperature



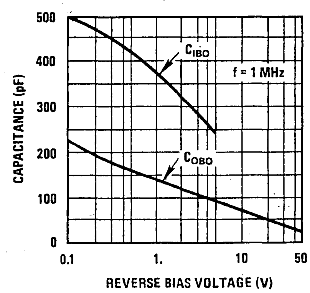
Maximum Power Dissipation vs Case Temperature



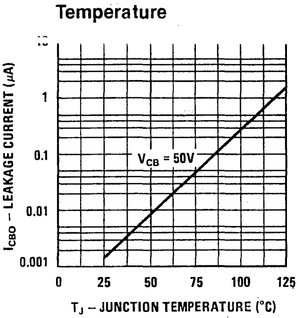
Pulsed DC Current Gain vs Ambient Temperature



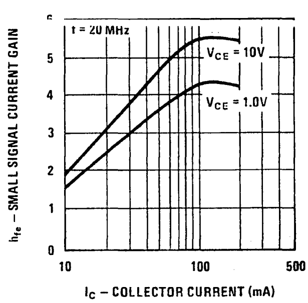
Capacitance vs Reverse Bias Voltage



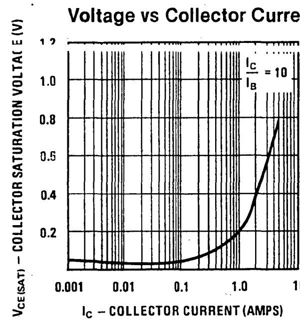
Collector-Base Diode Reverse Current vs Temperature



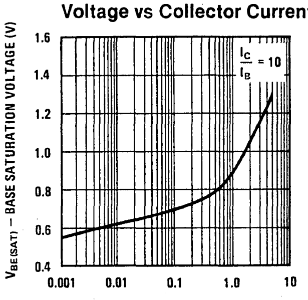
Small Signal Current Gain vs Collector Current



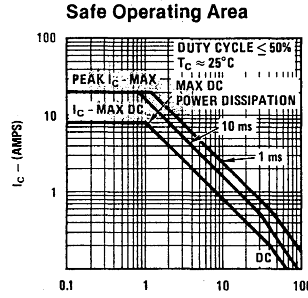
Collector-Emitter Saturation Voltage vs Collector Current



Base-Emitter Saturation Voltage vs Collector Current

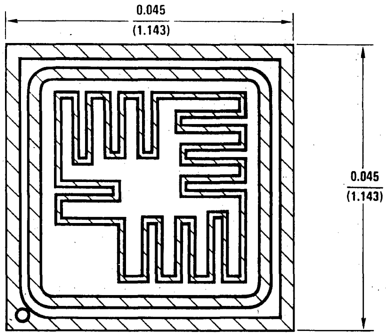


Safe Operating Area



National Semiconductor

Process 36 NPN High Voltage Power



DESCRIPTION

Process 36 is a non-overlay double-diffused silicon epitaxial planar device with a field plate.

APPLICATION

This device is designed for use in horizontal driver, class A off-line amplifier and off-line switching applications.

PRINCIPAL DEVICE TYPES

TO-202, EBC: D40P1, 3, 5; NSD36-36C

TO-237, EBC: 2N6720-23 (92PU36-36C)

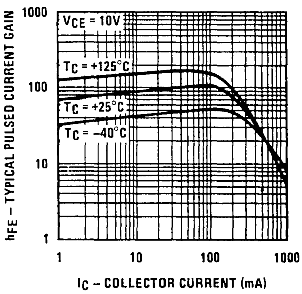
TO-126, ECB: 2N5655-57; MJE340-44; MJE3439-40

Parameter	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_{CE} = 1$ mA (Note 1)	200	300		V
BV_{CBO}	$I_{CB} = 100\ \mu A$	225	325		V
BV_{EBO}	$I_{EB} = 10\ \mu A$	6			V
I_{CEO}	$V_{CE} = 200V$			50	μA
I_{CBO}	$V_{CB} = 225V$			1	μA
I_{EBO}	$V_{EB} = 5V$			1	μA
h_{FE}	$I_C = 50$ mA, $V_{CE} = 10V$ (Note 1)		110		
	$I_C = 100$ mA, $V_{CE} = 10V$ (Note 1)	30	120	300	
	$I_C = 250$ mA, $V_{CE} = 10V$ (Note 1)		60		
	$I_C = 500$ mA, $V_{CE} = 10V$ (Note 1)		25		
$V_{CE(SAT)}$	$I_C = 100$ mA, $I_B = 10$ mA (Note 1)		0.2	0.5	V
$V_{CE(SAT)}$	$I_C = 500$ mA, $I_B = 100$ mA (Note 1)		0.3	0.7	V
$V_{BE(SAT)}$	$I_C = 500$ mA, $I_B = 100$ mA (Note 1)		0.9	1.2	V
$V_{BE(ON)}$	$I_C = 100$ mA, $V_{CE} = 10V$ (Note 1)		0.7	1.0	V
f_t	$I_C = 50$ mA, $V_{CE} = 10V$	20	60		MHz
C_{ob}	$V_{CB} = 10V$, f = 1 MHz			15	pF
C_{ib}	$V_{BE} = 0.5V$, f = 1 MHz			125	pF
$P_{D(max)}$					
TO-126	$T_C = 25°C$	25			W
	$T_A = 25°C$	1.5			W
TO-202	$T_C = 25°C$	15			W
	$T_A = 25°C$	2			W
TO-237	$T_{COLLECTOR\ LEAD} = 25°C$	2			W
	$T_A = 25°C$	850			mW
TO-39	$T_C = 25°C$	10			W
	$T_A = 25°C$	1			W
θ_{JC}					
TO-126	$T_C = 25°C$			5.0	°C/W
TO-202	$T_C = 25°C$			8.33	°C/W
TO-237	$T_{COLLECTOR\ LEAD} = 25°C$			62.5	°C/W
TO-39	$T_C = 25°C$			17.5	°C/W
θ_{JA}					
TO-126	$T_A = 25°C$			83.3	°C/W
TO-202	$T_A = 25°C$			62.5	°C/W
TO-237	$T_A = 25°C$			147	°C/W
TO-39	$T_A = 25°C$			175	°C/W
$T_{J(max)}$					
	All Plastic Parts	150			°C
	TO-39	200			°C

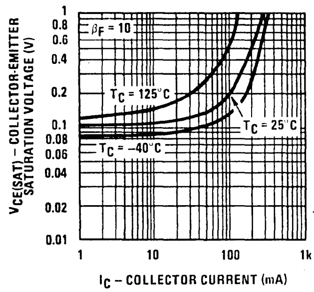
* Pulse test, pulse width = 300 μs

Process 36

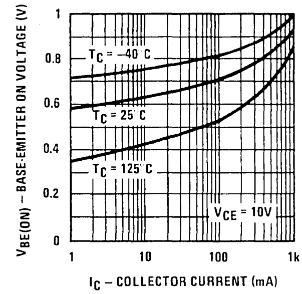
Typical Pulsed Current Gain vs Collector Current



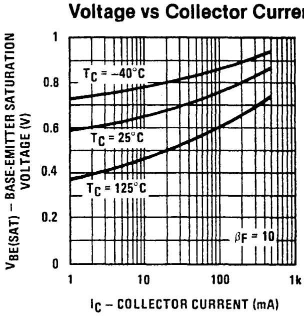
Collector-Emitter Saturation Voltage vs Collector Current



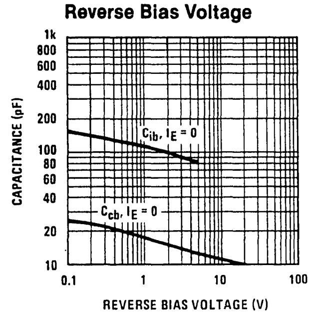
Base-Emitter ON Voltage vs Collector Current



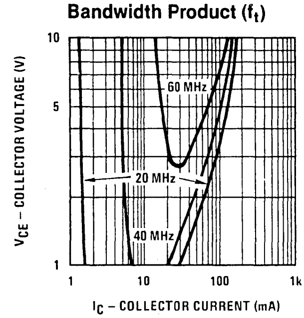
Base-Emitter Saturation Voltage vs Collector Current



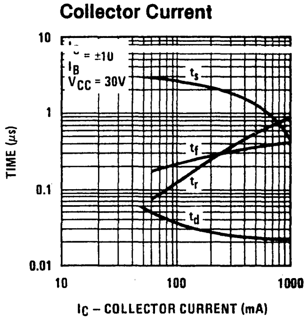
Collector-Base and Emitter-Base Capacitance vs Reverse Bias Voltage



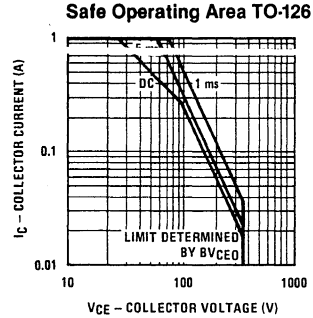
Contours of Constant Gain Bandwidth Product (f_t)



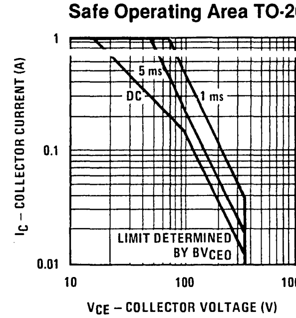
Typical Switching Time vs Collector Current



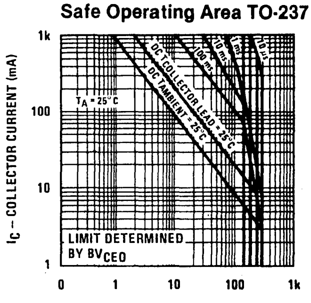
Safe Operating Area TO-126



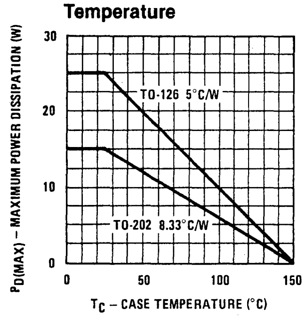
Safe Operating Area TO-202



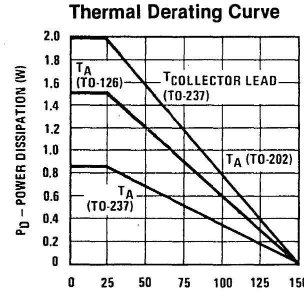
Safe Operating Area TO-237



Maximum Power Dissipation vs Case Temperature

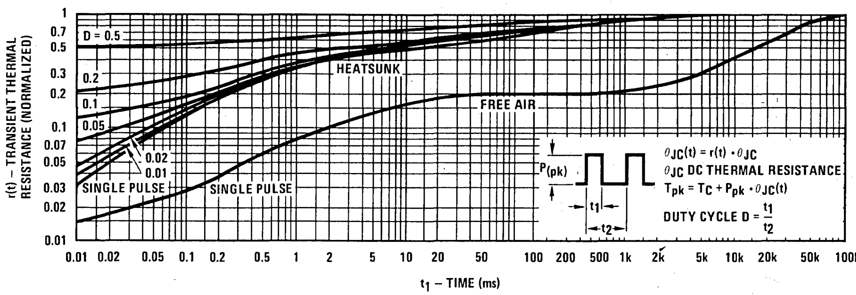


Thermal Derating Curve



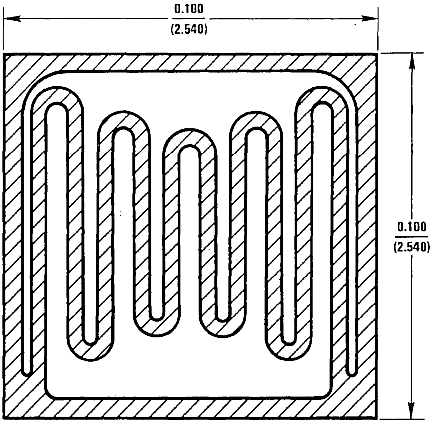
Process 36

Thermal Response in TO-202 Package



National Semiconductor

Process 4A Epitaxial Power



DESCRIPTION

Process 4A is a double epitaxial silicon NPN mesa device with diffused emitter. Complement to Process 5A.

APPLICATION

This device was designed for general purpose power amplifier and switching circuits where a large safe operating area is required.

PRINCIPAL DEVICE TYPES

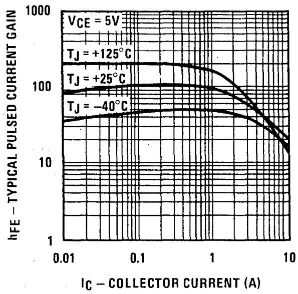
TO-220, BCE: 2N6099
2N6101
2N6486-88
BD347
MJE2801T
MJE3055T
TIP41-41C

Parameter	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 200$ mA (Note 1)	40		120	V
BV_{CBO}	$I_C = 1$ mA	60			V
BV_{EBO}	$I_E = 1$ mA	5	7		V
I_{CEO}	$V_{CE} = BV_{CEO} - 10V$			200	μA
I_{CBO}	$V_{CB} = BV_{CEO}$			20	μA
I_{EBO}	$V_{EB} = 5V$			500	μA
h_{FE}	$I_C = 2.5A$, $V_{CE} = 2V$ (Note 1)	20		160	
$V_{CE(SAT)}$	$I_C = 4A$, $I_B = 0.4A$ (Note 1)		0.4	0.6	V
$V_{BE(ON)}$	$I_C = 5A$, $V_{CE} = 2V$ (Note 1)		1.1	1.3	V
f_t	$I_C = 0.5A$, $V_{CE} = 5V$	2			MHz
t_d	$I_C = 5A$, $I_{B1} = I_{B2} = 0.5A$, $V_{CC} = 40V$		0.07		μs
t_r	$I_C = 5A$, $I_{B1} = I_{B2} = 0.5A$, $V_{CC} = 40V$		0.8		μs
t_s	$I_C = 5A$, $I_{B1} = I_{B2} = 0.5A$, $V_{CC} = 40V$		0.4		μs
t_f	$I_C = 5A$, $I_{B1} = I_{B2} = 0.5A$, $V_{CC} = 40V$		0.5		μs
$P_{D(max)}$					
TO-220	$T_C = 25°C$ $T_A = 25°C$	60 2			W
θ_{JC}					
TO-220	$T_C = 25°C$			2.08	°C/W
θ_{JA}					
TO-220	$T_A = 25°C$			62.5	°C/W
$T_{J(max)}$	All Plastic Parts	150			°C

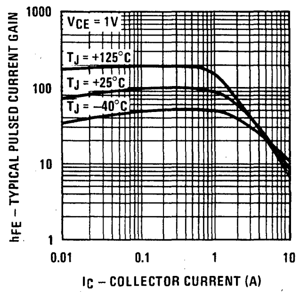
Note 1: Pulsed measurement = 300 μs pulse width.

Process 4A

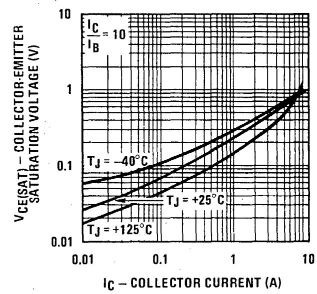
Typical Pulsed Current Gain vs Collector Current



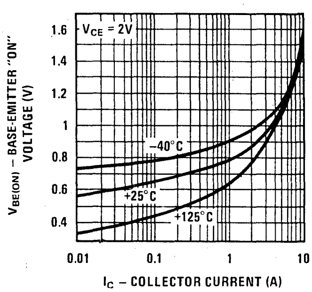
Typical Pulsed Current Gain vs Collector Current



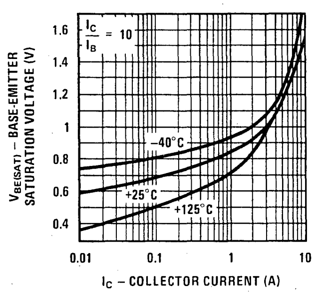
Collector-Emitter Saturation Voltage vs Collector Current



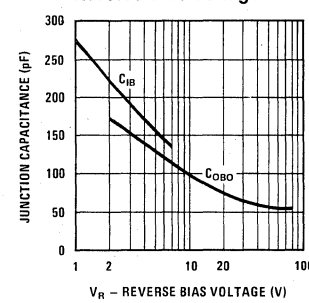
Base-Emitter ON Voltage vs Collector Current



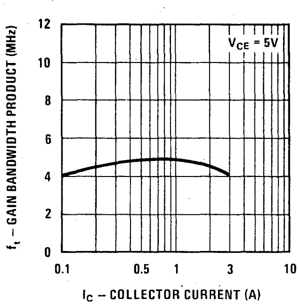
Base-Emitter Saturation Voltage vs Collector Current



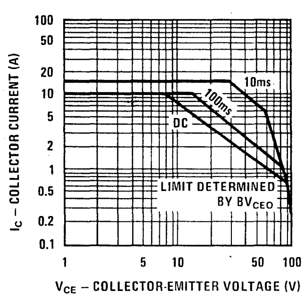
Junction Capacitance vs Reverse Bias Voltage



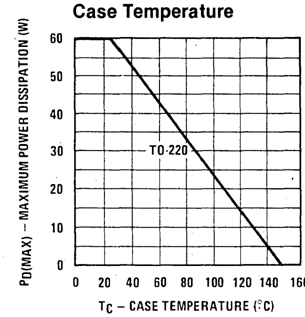
Gain Bandwidth Product vs Collector Current



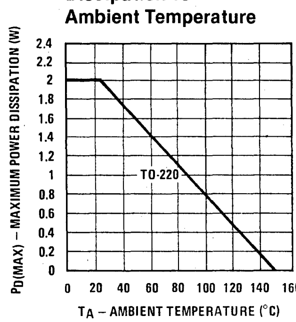
Safe Operating Area TO-220



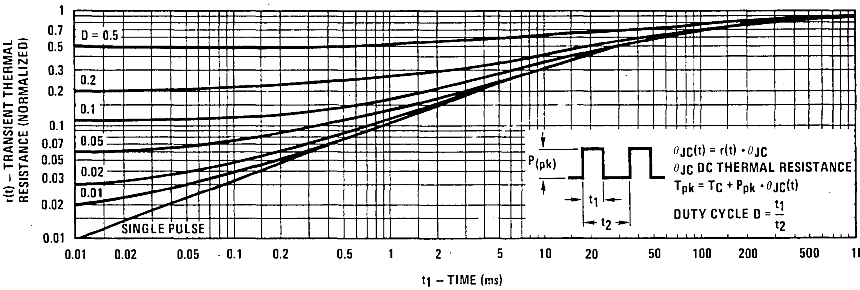
Maximum Power Dissipation vs Case Temperature



Maximum Power Dissipation vs Ambient Temperature

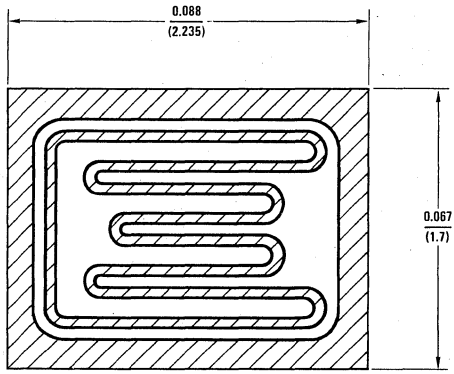


Thermal Response in TO-220 Package



National Semiconductor

Process 4E NPN Epitaxial Power



DESCRIPTION

Process 4E is a double epitaxial silicon mesa device with diffused emitter. Complement to Process 5E.

APPLICATION

This device was designed for general purpose power amplifier and switching circuits where a large safe operating area is required.

PRINCIPAL DEVICE TYPES

TO-220, BCE: 2N5294, 96, 98
2N5490, 92, 94, 96
2N6121-23
2N6129-31
2N6288, 90, 92

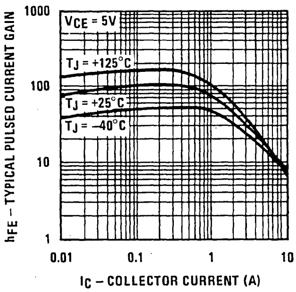
TO-126, ECB: 2N5190-92

Parameter	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 100$ mA (Note 1)	30		120	V
BV_{CBO}	$I_C = 1$ mA	50			V
BV_{EBO}	$I_E = 1$ mA	5	8		V
I_{CEO}	$V_{CE} = BV_{CEO} - 10V$			300	μA
I_{CBO}	$V_{CB} = BV_{CEO}$			100	μA
I_{EBO}	$V_{EB} = 5V$			1000	μA
h_{FE}	$I_C = 1.5A$, $V_{CE} = 2.0V$ (Note 1)	20		200	
$V_{CE(SAT)}$	$I_C = 4.0A$, $I_B = 0.4A$ (Note 1)			1.0	V
$V_{BE(ON)}$	$I_C = 4.0A$, $V_{CE} = 2.0V$ (Note 1)			1.3	V
f_t	$I_C = 0.5A$, $V_{CE} = 2V$	4			MHz
t_d	$I_C = 1.0A$, $I_{B1} = 0.1A$, $I_{B2} = 0.1A$, $V_{CC} = 30V$		0.10		μs
t_r	$I_C = 1.0A$, $I_{B1} = 0.1A$, $I_{B2} = 0.1A$, $V_{CC} = 30V$		0.25		μs
t_s	$I_C = 1.0A$, $I_{B1} = 0.1A$, $I_{B2} = 0.1A$, $V_{CC} = 30V$		0.35		μs
t_f	$I_C = 1.0A$, $I_{B1} = 0.1A$, $I_{B2} = 0.1A$, $V_{CC} = 30V$		0.23		μs
$P_{D(max)}$					
TO-220	$T_C = 25°C$ $T_A = 25°C$	50 2			W
TO-126	$T_C = 25°C$ $T_A = 25°C$	40 1.5			W
θ_{JC}					
TO-220	$T_C = 25°C$			2.5	°C/W
TO-126	$T_C = 25°C$			3.12	°C/W
θ_{JA}					
TO-220	$T_A = 25°C$			62.5	°C/W
TO-126	$T_A = 25°C$			83.3	°C/W
$T_{J(max)}$	All Plastic Parts	150			°C

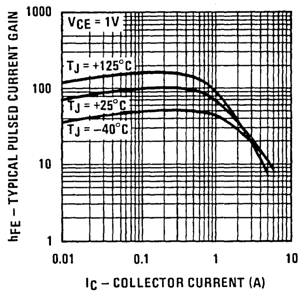
Note 1: Pulsed measurement = 300 μs pulse width.

Process 4E

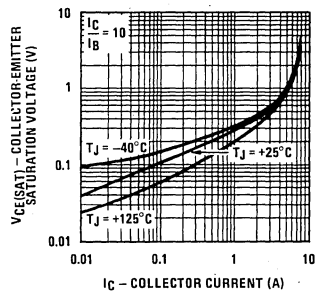
Typical Pulsed Current Gain vs Collector Current



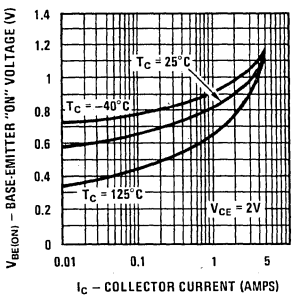
Typical Pulsed Current Gain vs Collector Current



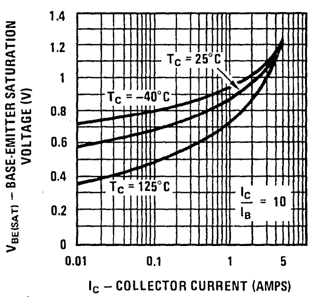
Collector-Emitter Saturation Voltage vs Collector Current



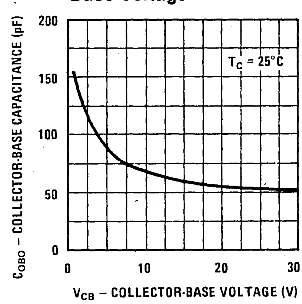
Base-Emitter ON Voltage vs Collector Current



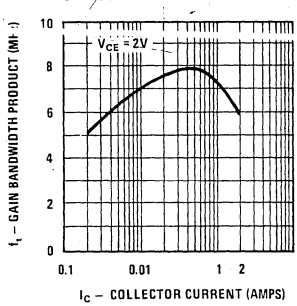
Base-Emitter Saturation Voltage vs Collector Current



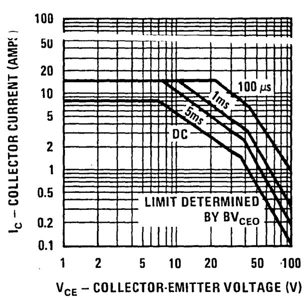
Typical Collector-Base Capacitance vs Collector-Base Voltage



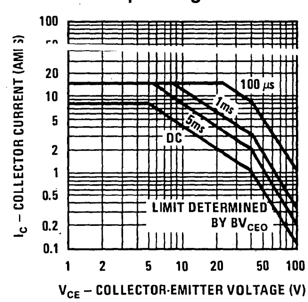
Gain Bandwidth Product vs Collector Current



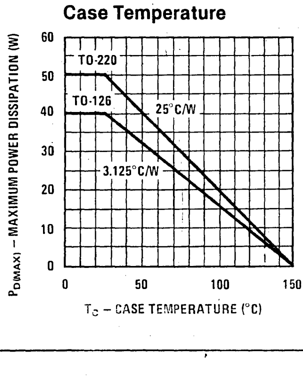
Safe Operating Area TO-220



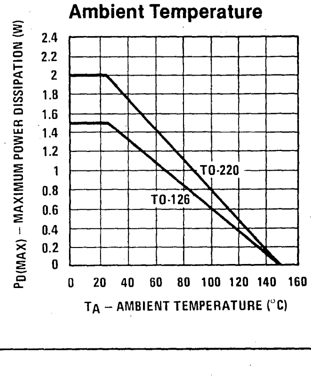
Safe Operating Area TO-126



Maximum Power Dissipation vs Case Temperature

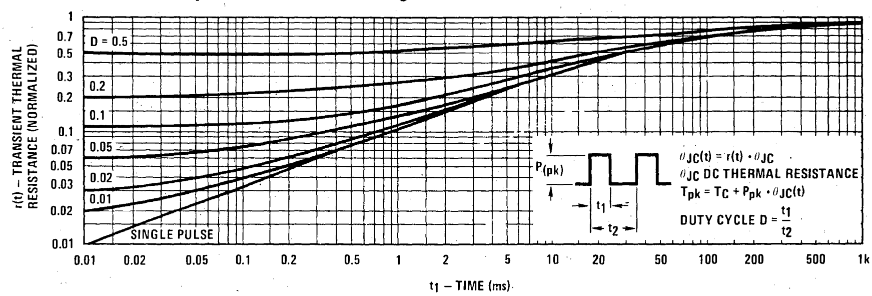


Maximum Power Dissipation vs Ambient Temperature

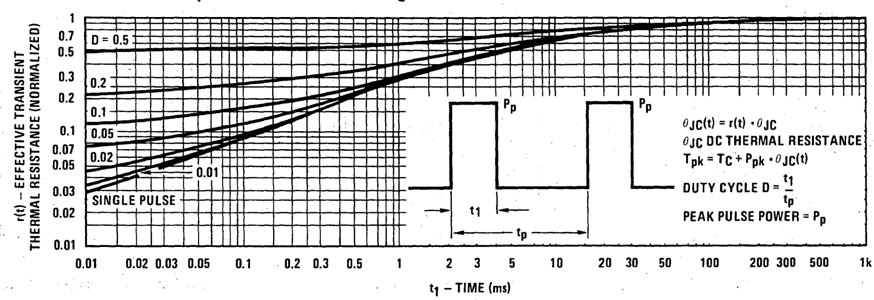


Process 4E

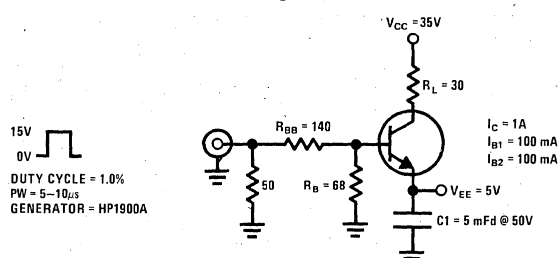
Thermal Response in TO-220 Package



Thermal Response in TO-126 Package

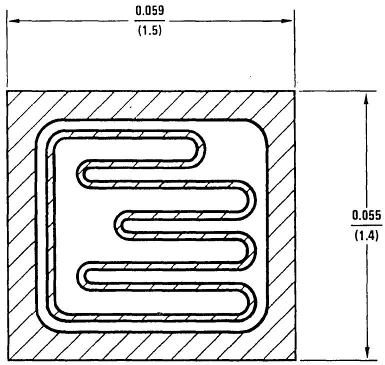


Switching Circuit



National Semiconductor

Process 4F NPN Epitaxial Power



DESCRIPTION

Process 4F is a double epitaxial silicon mesa device with diffused emitter. Complement to Process 5F.

APPLICATION

This device was designed for general purpose power amplifier and switching circuits where a large safe operating area is required.

PRINCIPAL DEVICE TYPES

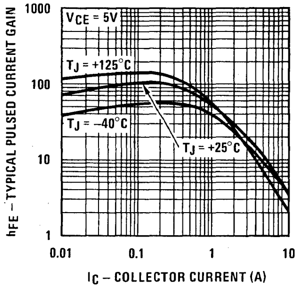
TO-220, BCE: TIP29-29C
TIP31-31C
TIP61-61C

TO-126, ECB: 2N4921-23
MJE520, 21

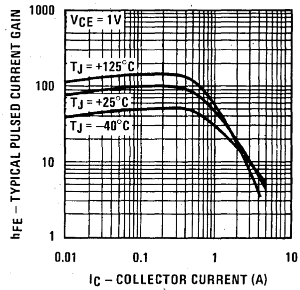
Parameter	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 100$ mA (Note 1)	30		120	V
BV_{CBO}	$I_C = 1$ mA	60		240	V
BV_{EBO}	$I_E = 1$ mA	5	8		V
I_{CEO}	$V_{CE} = BV_{CEO} - 10V$			300	µA
I_{CBO}	$V_{CB} = BV_{CEO}$			10	µA
I_{EBO}	$V_{EB} = 5V$			100	µA
h_{FE}	$I_C = 1.0A$, $V_{CE} = 1V$ (Note 1)	15		200	
$V_{CE(SAT)}$	$I_C = 2.0A$, $I_B = 0.2A$ (Note 1)			1.0	V
$V_{BE(ON)}$	$I_C = 2.0A$, $V_{CE} = 2.0V$ (Note 1)			1.0	V
f_t	$I_C = 0.5A$, $V_{CE} = 2V$	4			MHz
t_d	$I_C = 1A$, $I_{B1} = I_{B2} = 0.1A$, $V_{CC} = 30V$		0.05		µs
t_r	$I_C = 1A$, $I_{B1} = I_{B2} = 0.1A$, $V_{CC} = 30V$		0.25		µs
t_s	$I_C = 1A$, $I_{B1} = I_{B2} = 0.1A$, $V_{CC} = 30V$		0.75		µs
t_f	$I_C = 1A$, $I_{B1} = I_{B2} = 0.1A$, $V_{CC} = 30V$		0.25		µs
$P_{D(max)}$					
TO-220	$T_C = 25°C$	40			W
	$T_A = 25°C$	2			
TO-126	$T_C = 25°C$	30			W
	$T_A = 25°C$	1.5			
θJC					
TO-220	$T_C = 25°C$			3.12	°C/W
TO-126	$T_C = 25°C$			4.16	°C/W
θJA					
TO-220	$T_A = 25°C$			62.5	°C/W
TO-126	$T_A = 25°C$			83.3	°C/W
$T_{J(max)}$					
	All Plastic Parts	150			°C

Note 1: Pulsed measurement = 300 µs pulse width.

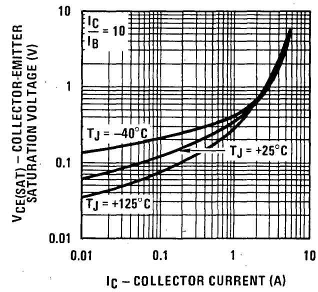
Typical Pulsed Current Gain vs Collector Current



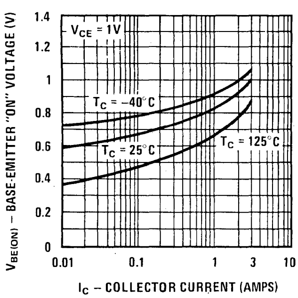
Typical Pulsed Current Gain vs Collector Current



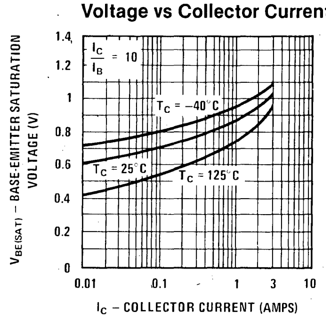
Collector-Emitter Saturation Voltage vs Collector Current



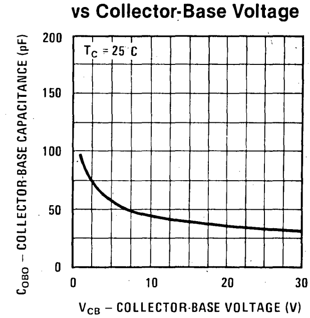
Base-Emitter ON Voltage vs Collector Current



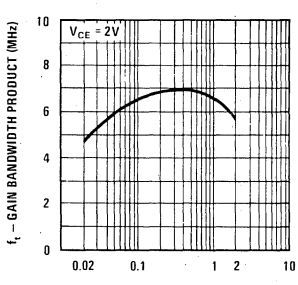
Base-Emitter Saturation Voltage vs Collector Current



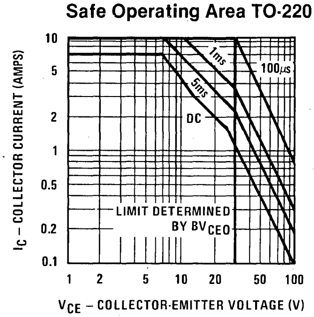
Collector-Base Capacitance vs Collector-Base Voltage



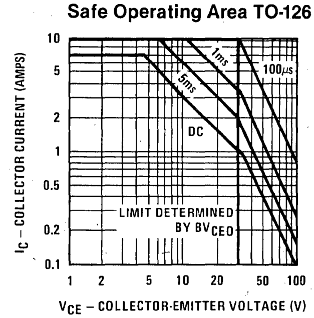
Gain Bandwidth Product vs Collector Current



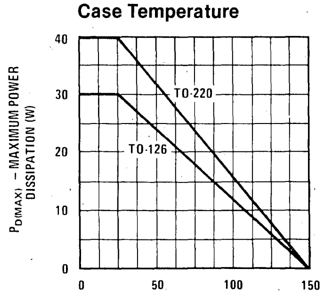
Safe Operating Area TO-220



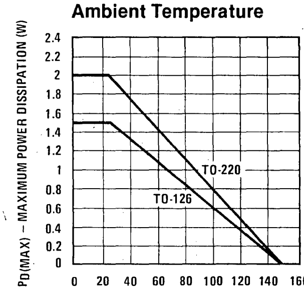
Safe Operating Area TO-126



Maximum Power Dissipation vs Case Temperature

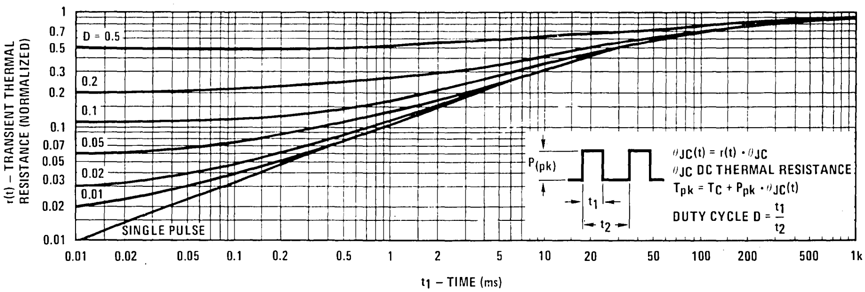


Maximum Power Dissipation vs Ambient Temperature

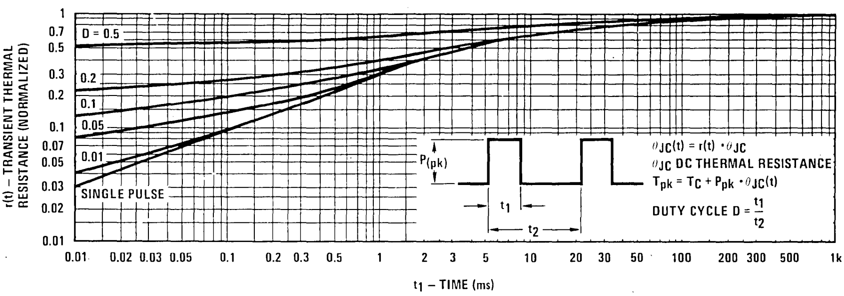


Process 4F

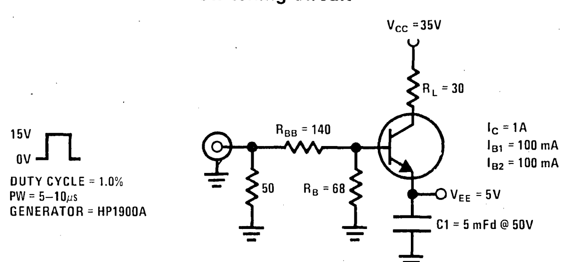
Thermal Response in TO-220 Package



Thermal Response in TO-126 Package

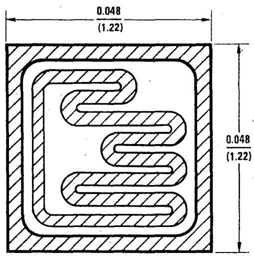


Switching Circuit



National Semiconductor

Process 4H NPN Epitaxial Power



DESCRIPTION

Process 4H is a double epitaxial silicon mesa transistor with diffused emitter.

APPLICATION

This device was designed for general purpose power amplifier and switching circuits where a large safe operating area is required.

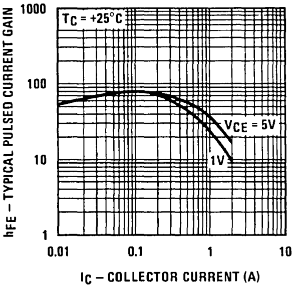
PRINCIPAL DEVICE TYPES

TO-126, EBC: 2N4921-3

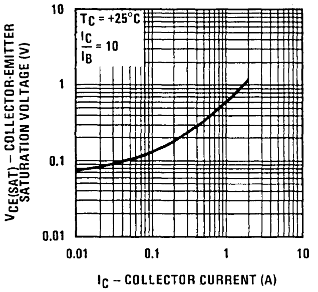
Parameter	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 50$ mA (Note 1)	30		120	V
BV_{CBO}	$I_C = 1$ mA	60			V
BV_{EBO}	$I_E = 1$ mA	5	8		V
I_{CEO}	$V_{CE} = BV_{CEO} - 10V$			300	μA
I_{CBO}	$V_{CB} = BV_{CEO}$			10	μA
I_{EBO}	$V_{EB} = 5V$			100	μA
h_{FE}	$I_C = 100$ mA, $V_{CE} = 5V$	30	80	200	
$V_{CE(SAT)}$	$I_C = 0.5A$, $I_B = 50$ mA		0.3		V
$V_{BE(SAT)}$	$I_C = 0.5A$, $I_B = 50$ mA		0.86		V
f_t	$V_{CE} = 10V$, $I_C = 250$ mA	3			MHz
C_{OB}	$V_{CB} = 10V$		20		pF
$P_{D(max)}$					
TO-126	$T_C = 25°C$ $T_A = 25°C$	30 1.5			W
θ_{JC}					
TO-126	$T_C = 25°C$			4.16	°C/W
θ_{JA}					
TO-126	$T_A = 25°C$			83.3	°C/W
$T_{J(max)}$					
	All Plastic Parts	150			°C

Note 1: Pulse test, pulse width = 300 μs

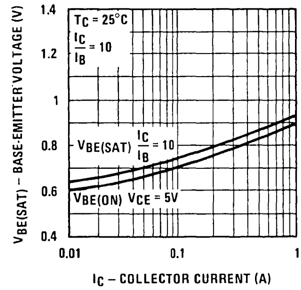
Typical Pulsed Current Gain vs Collector Current



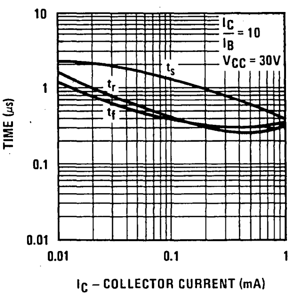
Collector-Emitter Saturation Voltage vs Collector Current



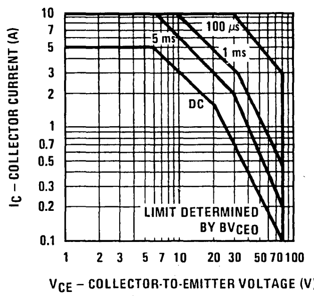
Base-Emitter Voltage vs Collector Current



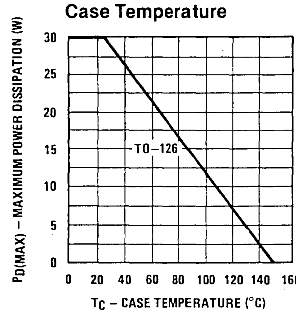
Typical Switching Time vs Collector Current



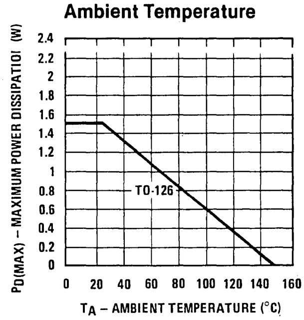
Safe Operating Area TO-126



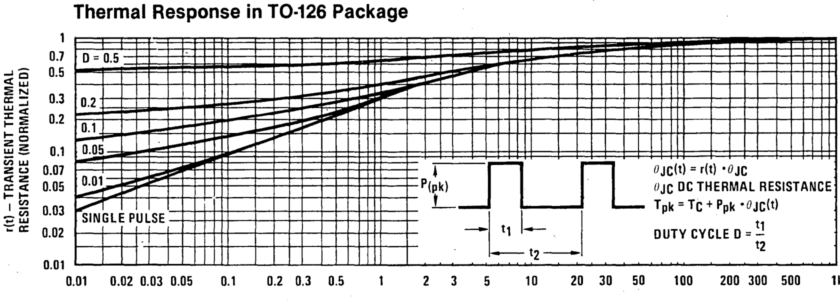
Maximum Power Dissipation vs Case Temperature



Maximum Power Dissipation vs Ambient Temperature

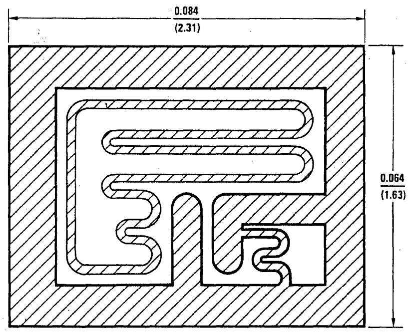


Thermal Response in TO-126 Package



National Semiconductor

Process 4J
NPN Epitaxial Power Darlington



DESCRIPTION

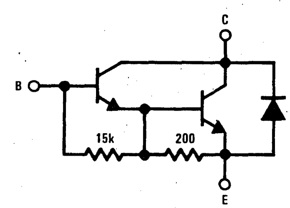
Process 4J is a double epitaxial silicon mesa device. Complement to Process 5J.

APPLICATION

This device was designed for use in driver and output stages of complementary audio amplifier circuits. It is also well suited for solenoid driver applications.

PRINCIPAL DEVICE TYPES

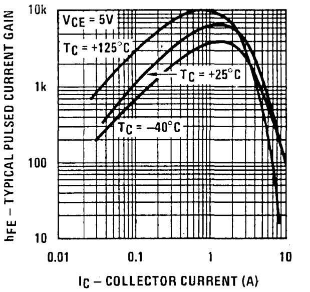
TO-220, BCE: 2N6386
NSP2100-03
TIP110-12
TO-126, ECB: 2N6037-39
MJE800-03



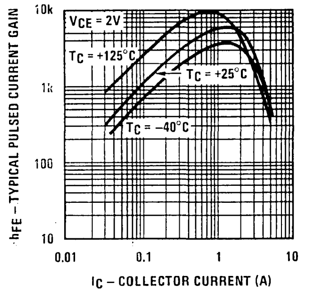
Parameter	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 100$ mA (Note 1)	40		120	V
BV_{CBO}	$I_C = 100\ \mu A$	70			V
BV_{EBO}	$I_E = 2$ mA	5			V
I_{CEO}	$V_{CE} = 1/2\ BV_{CEO}$			0.5	mA
I_{CBO}	$V_{CB} = BV_{CEO}$			20	μA
I_{EBO}	$V_{EB} = 5V$			2.0	mA
h_{FE}	$I_C = 2A$, $V_{CE} = 3V$ (Note 1)	750		20,000	
$V_{CE(SAT)}$	$I_C = 5A$, $I_B = 20$ mA (Note 1)			3.0	V
$V_{BE(ON)}$	$I_C = 5A$, $V_{CE} = 3V$ (Note 1)			2.5	V
C_{OBO}	$V_{CB} = 10V$		30		pF
$\|h_{fe}\|$	$I_C = 1A$, $V_{CE} = 3V$, f = 1 MHz		9		
t_{ON}	$I_C = 6A$, $V_{CE} = 30V$		1.25		μs
t_{OFF}	$I_C = 6A$, $V_{CE} = 30V$		2.75		μs
$P_{D(max)}$					
TO-220	$T_C = 25°C$ $T_A = 25°C$	50 2			W
TO-126	$T_C = 25°C$ $T_A = 25°C$	40 1.5			W
θ_{JC}					
TO-220	$T_C = 25°C$			2.5	°C/W
TO-126	$T_C = 25°C$			3.12	°C/W
θ_{JA}					
TO-220	$T_A = 25°C$			62.5	°C/W
TO-126	$T_A = 25°C$			83.3	°C/W
$T_{J(max)}$					
	All Plastic Parts	150			°C

Note 1: Pulsed measurement = 300 μs pulse width.

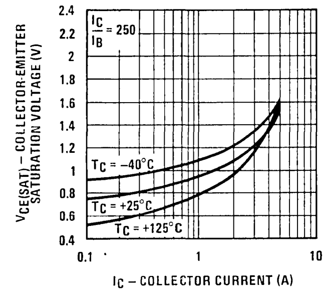
Typical Pulsed Current Gain vs Collector Current



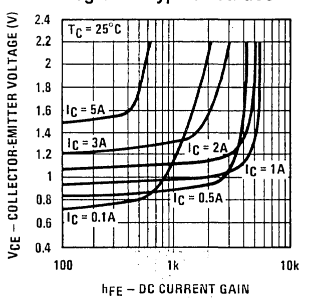
Typical Pulsed Current Gain vs Collector Current



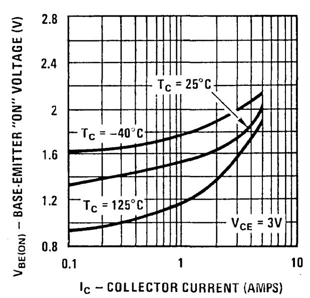
Collector-Emitter Saturation Voltage vs Collector Current



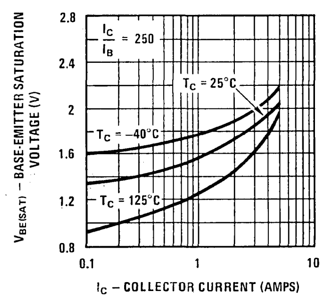
Collector Saturation Region — Typical Values



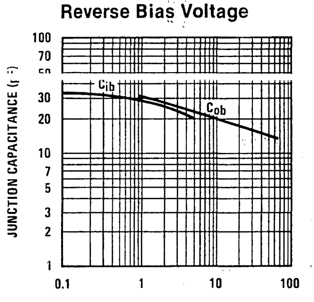
Base-Emitter ON Voltage vs Collector Current



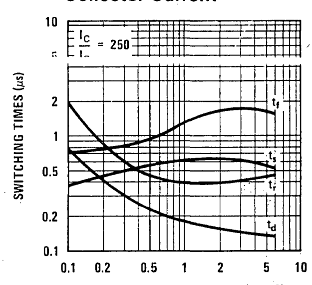
Base-Emitter Saturation Voltage vs Collector Current



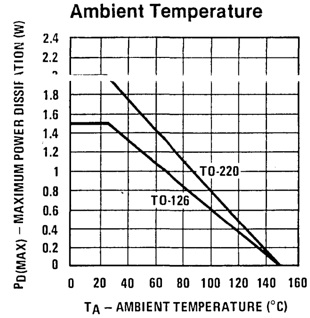
Junction Capacitance vs Reverse Bias Voltage



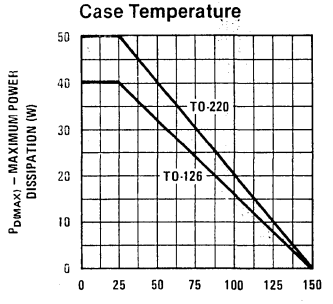
Switching Times vs Collector Current



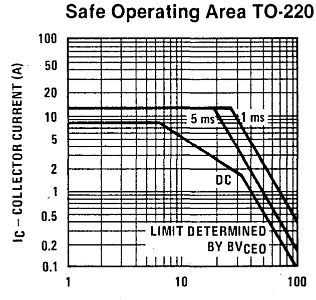
Maximum Power Dissipation vs Ambient Temperature



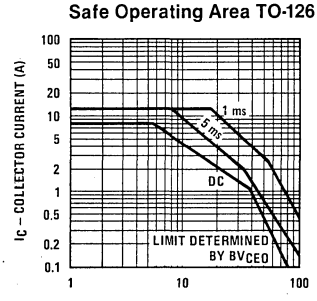
Maximum Power Dissipation vs Case Temperature



Safe Operating Area TO-220

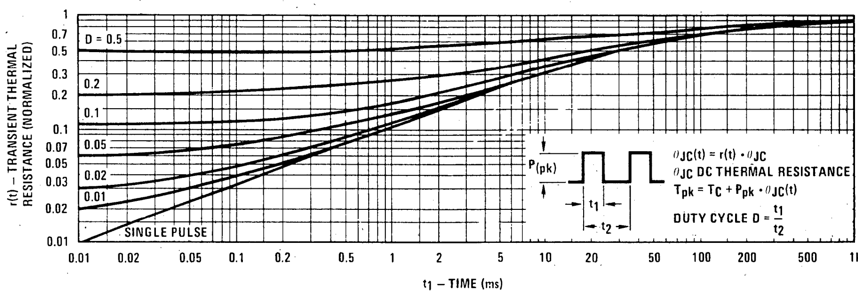


Safe Operating Area TO-126

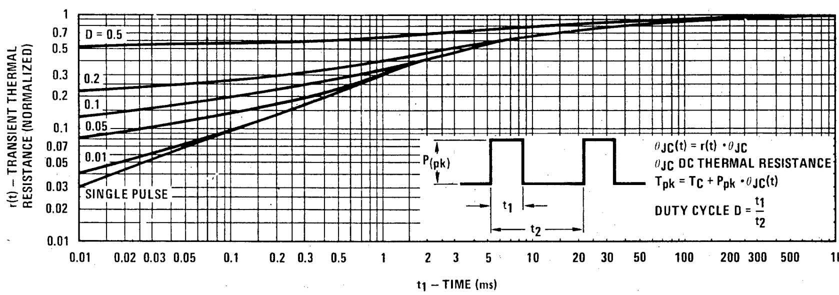


Process 4J

Thermal Response in TO-220 Package

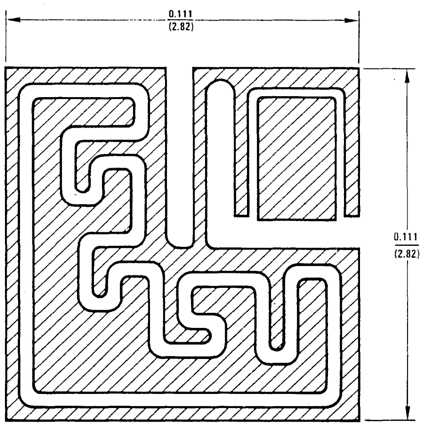


Thermal Response in TO-126 Package



National Semiconductor

Process 4K
NPN Epitaxial Power Darlington



DESCRIPTION

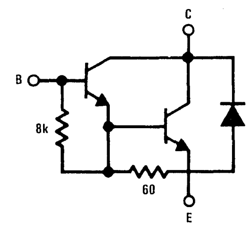
Process 4K is a double epitaxial silicon mesa Darlington transistor. Complement to Process 5K.

APPLICATION

The 4K was designed for general purpose amplifier and low-speed switching applications.

PRINCIPAL DEVICE TYPES

TO-220, BCE: SE9300-02
TIP121, 22
TIP130-32

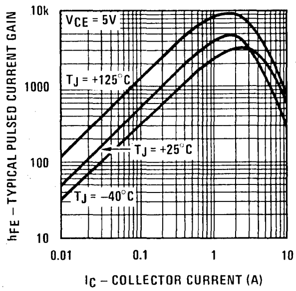


Parameter	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 100$ mA (Note 1)	40		120	V
BV_{CBO}	$I_C = 200\ \mu A$	70			V
BV_{EBO}	$I_E = 5$ mA	5			V
I_{CEO}	$V_{CE} = 1/2\ BV_{CEO}$			0.5	mA
I_{CBO}	$V_{CB} = BV_{CEO}$			100	μA
I_{EBO}	$V_{BE} = 5V$			2.0	mA
h_{FE}	$I_C = 4A$, $V_{CE} = 3V$ (Note 1)	750		18,000	
h_{FE}	$I_C = 8A$, $V_{CE} = 3V$ (Note 1)	100			
$V_{CE(SAT)}$	$I_C = 4A$, $I_B = 16$ mA (Note 1)			2	V
$V_{CE(SAT)}$	$I_C = 8A$, $I_B = 80$ mA (Note 1)			3	V
$V_{BE(SAT)}$	$I_C = 8A$, $I_B = 80$ mA (Note 1)			4	V
$V_{BE(ON)}$	$I_C = 4A$, $V_{CE} = 3V$ (Note 1)			2.8	V
C_{OBO}	$V_{CB} = 10V$			200	pF
$\|h_{fe}\|$	$I_C = 3A$, $V_{CE} = 3V$, f = 1 MHz	4			
$P_{D(max)}$					
TO-220	$T_C = 25°C$ $T_A = 25°C$	60 2			W
θ_{JC}					
TO-220	$T_C = 25°C$			2.08	°C/W
θ_{JA}					
TO-220	$T_A = 25°C$			62.5	°C/W
$T_{J(max)}$					
	All Plastic Parts	150			°C

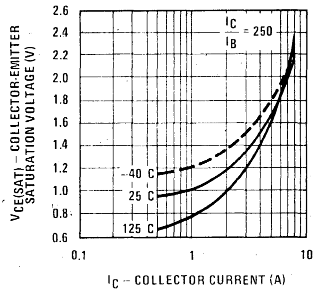
Note 1: Pulsed measurement = 300 μs pulse width.

Process 4K

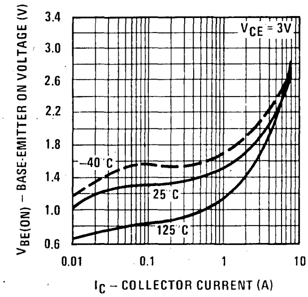
Typical Pulsed Current Gain vs Collector Current



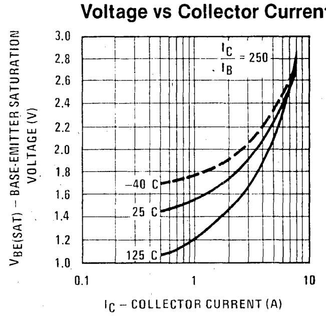
Collector-Emitter Saturation Voltage vs Collector Current



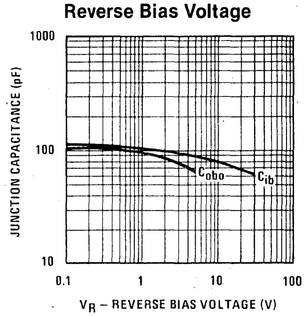
Base-Emitter ON Voltage vs Collector Current



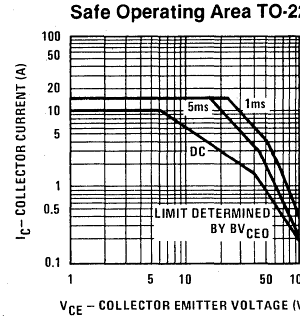
Base-Emitter Saturation Voltage vs Collector Current



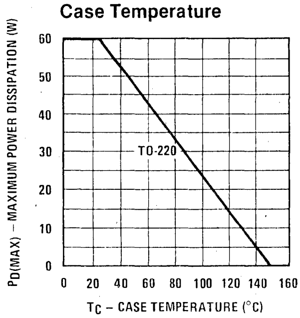
Junction Capacitance vs Reverse Bias Voltage



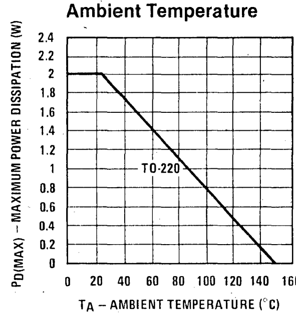
Safe Operating Area TO-220



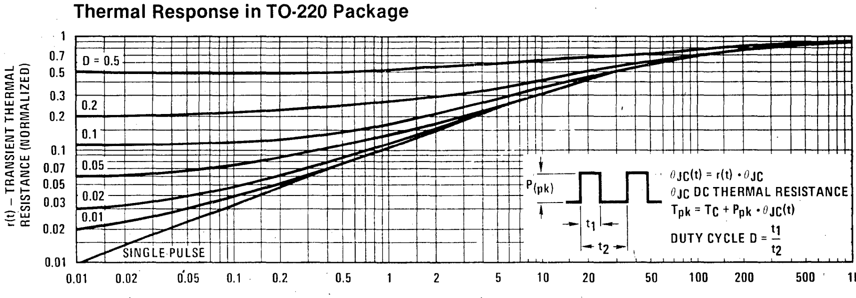
Maximum Power Dissipation vs Case Temperature



Maximum Power Dissipation vs Ambient Temperature

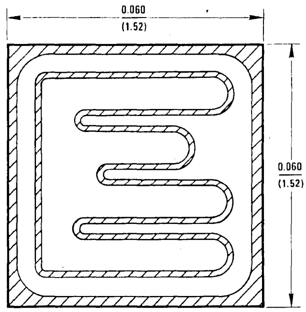


Thermal Response in TO-220 Package



National Semiconductor

Process 4P NPN Planar Power



DESCRIPTION

Process 4P is a double-diffused silicon epitaxial planar device. Complement to Process 5P.

APPLICATION

This device was designed for power amplifier, regulator and switching circuits where speed is important.

PRINCIPAL DEVICE TYPES

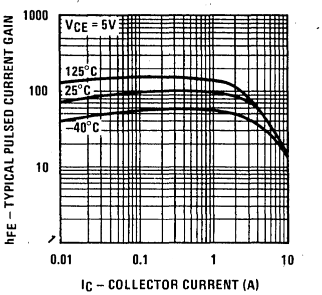
TO-220, BCE: D44C1-12
TO-126, ECB: MJE220-25
MJE240-44
TO-202, BCE: D42C1-12

Parameter	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 100$ mA (Note 1)	50		120	V
BV_{CES}	$I_C = 1$ mA	75			V
BV_{EBO}	$I_E = 1$ mA	5	8		V
I_{CES}	$V_{CE} = 50V$			5	μA
I_{EBO}	$V_{EB} = 5V$			5	μA
h_{FE}	$V_{CE} = 5V$, $I_C = 20$ mA	30			
h_{FE}	$V_{CE} = 5V$, $I_C = 0.5A$	50	80	200	
h_{FE}	$V_{CE} = 5V$, $I_C = 5A$ (Note 1)	10			
$V_{CE(SAT)}$	$I_C = 3A$, $I_B = 0.3A$		0.5	1	V
$V_{BE(SAT)}$	$I_C = 3A$, $I_B = 0.3A$		1		V
f_t	$V_{CE} = 5V$, $I_C = 0.5A$	50			MHz
C_{OB}	$V_{CB} = 10V$		45		pF
C_{IB}	$V_{EB} = 1V$		400		pF
t_r	$I_C = 2A$, $V_{CE} = 30V$ $I_{B1} = I_{B2} = 0.2A$		60		ns
t_s			750		ns
t_f			80		ns
$P_{D(max)}$					
TO-220	$T_C = 25°C$	40			W
TO-126	$T_C = 25°C$	30			W
TO-202	$T_C = 25°C$	15			W
θJC					
TO-220	$T_C = 25°C$			3.2	°C/W
TO-126	$T_C = 25°C$			4.16	°C/W
TO-202	$T_C = 25°C$			8.33	°C/W
θJA					
TO-220	$T_A = 25°C$			62.5	°C/W
TO-202	$T_A = 25°C$			62.5	°C/W
TO-126	$T_A = 25°C$			83.3	°C/W
$T_{J(max)}$	All Plastic Parts	150			°C

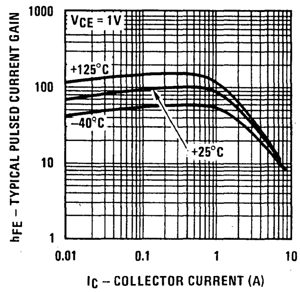
Note 1: Pulsed measurement = 300 μs pulse width.

Process 4P

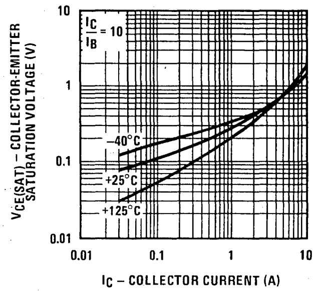
Typical Pulsed Current Gain vs Collector Current



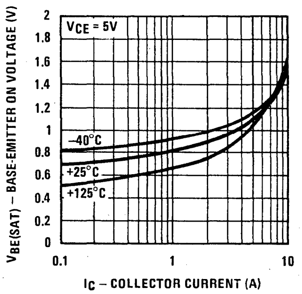
Typical Pulsed Current Gain vs Collector Current



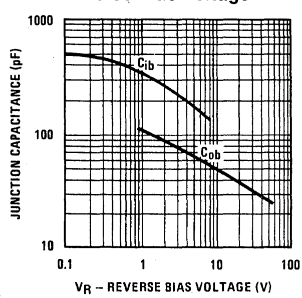
Collector-Emitter Saturation Voltage vs Collector Current



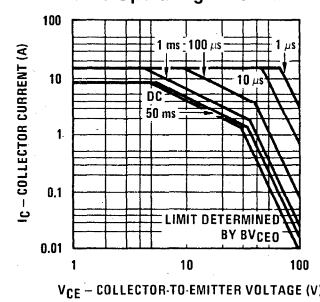
Base-Emitter ON Voltage vs Collector Current



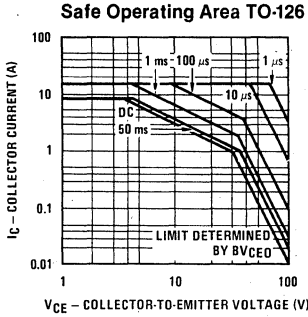
Junction Capacitance vs Reverse Bias Voltage



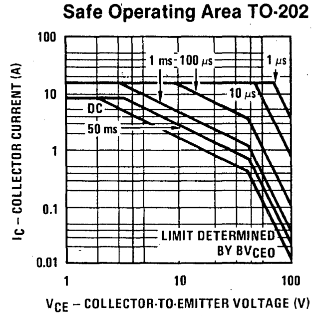
Safe Operating Area TO-220



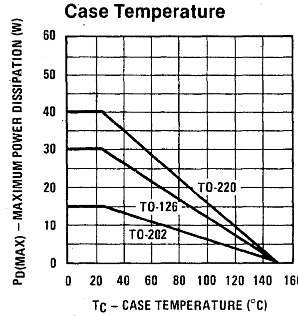
Safe Operating Area TO-126



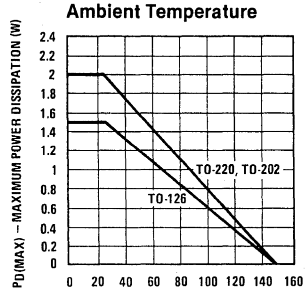
Safe Operating Area TO-202



Maximum Power Dissipation vs Case Temperature

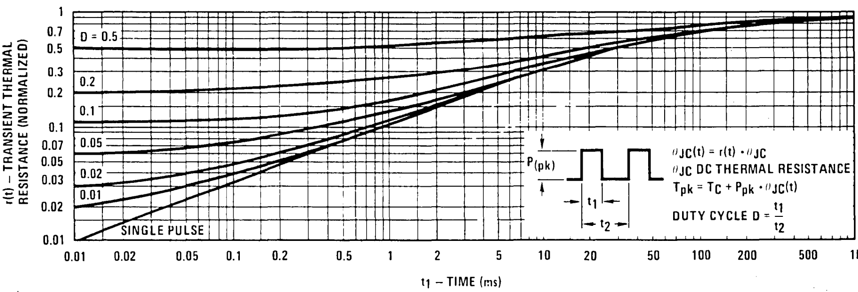


Maximum Power Dissipation vs Ambient Temperature

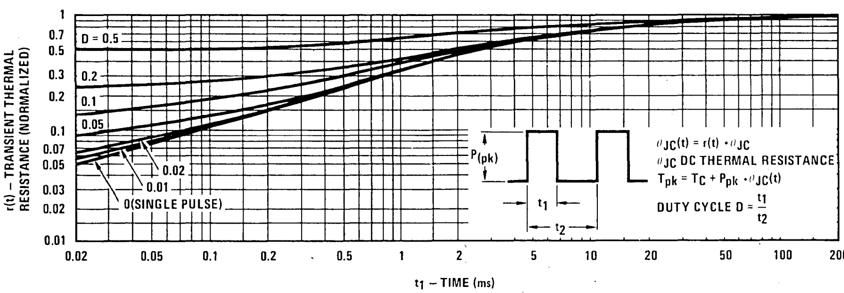


Process 4P

Thermal Response in TO-220 Package



Thermal Response in TO-126 Package



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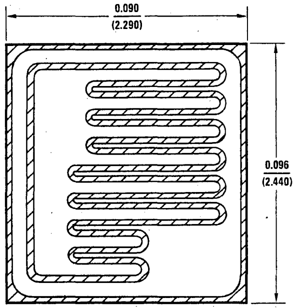
National Semiconductor

Process 4Q NPN Planar Power



DESCRIPTION

Process 4Q is a double diffused silicon epitaxial planar device. Complement to Process 5Q.

APPLICATION

This device was designed for power amplifier, regulator and switching circuits where speed is important.

PRINCIPAL DEVICE TYPES

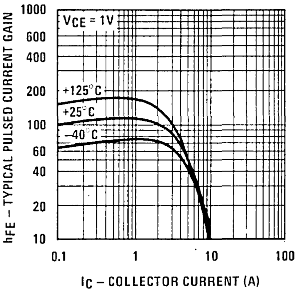
TO-220, BCE: D44H1
D44H2
D44H4
D44H5
D44H7
D44H8
D44H10
D44H11

Parameter	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 100$ mA (Note 1)	50		120	V
BV_{CES}	$I_C = 1$ mA	75			V
BV_{EBO}	$I_E = 1$ mA	5	8		V
I_{CES}	$V_{CE} = 50V$			5	μA
I_{EBO}	$V_{EB} = 5V$			5	μA
h_{FE}	$V_{CE} = 5V$, $I_C = 20$ mA	30			
h_{FE}	$V_{CE} = 5V$, $I_C = 1A$ (Note 1)	50	100	300	
h_{FE}	$V_{CE} = 5V$, $I_C = 8A$ (Note 1)	20			
$V_{CE(SAT)}$	$I_C = 8A$, $I_B = 0.8A$ (Note 1)		0.6	1	V
$V_{BE(SAT)}$	$I_C = 8A$, $I_B = 0.8A$ (Note 1)		1.2		V
f_t	$V_{CE} = 5V$, $I_C = 0.5A$	50			MHz
C_{OB}	$V_{CB} = 10V$		110		pF
C_{IB}	$V_{EB} = 1V$		730		pF
t_r	$I_C = 5A$, $V_{CE} = 30V$		30		ns
t_s	$I_{B1} = I_{B2} = 0.5A$		500		ns
t_f			60		ns
$P_{D(max)}$					
TO-220	$T_C = 25°C$	60			W
θ_{JC}					
TO-220	$T_C = 25°C$			2.08	°C/W
θ_{JA}					
TO-220	$T_A = 25°C$			62.5	°C/W
$T_{J(max)}$					
	All Plastic Parts	150			°C

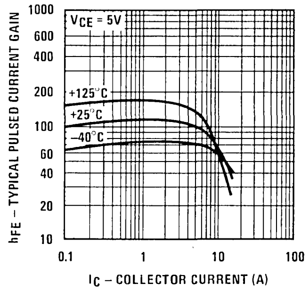
Note 1: Pulsed measurement = 300 μs pulse width.

Process 4Q

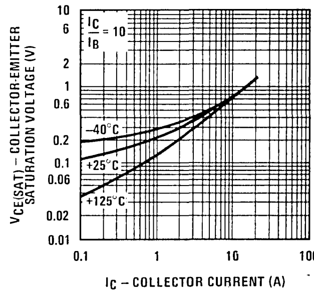
Typical Pulsed Current Gain vs Collector Current



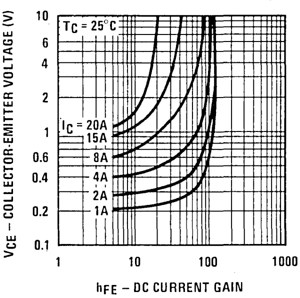
Typical Pulsed Current Gain vs Collector Current



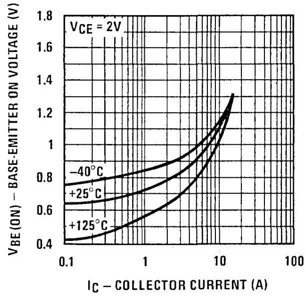
Collector-Emitter Saturation Voltage vs Collector Current



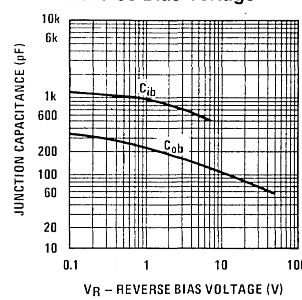
Collector Saturation Region



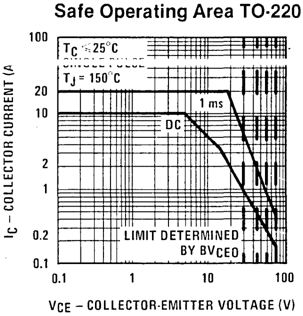
Base-Emitter ON Voltage vs Collector Current



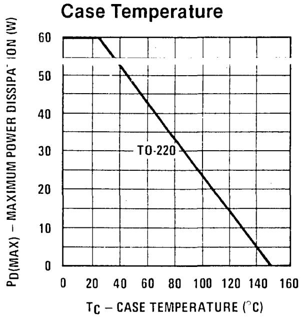
Junction Capacitance vs Reverse Bias Voltage



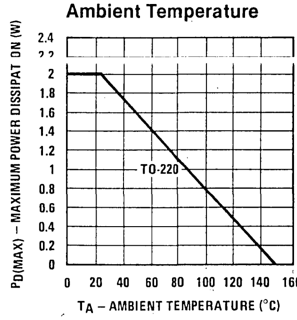
Safe Operating Area TO-220



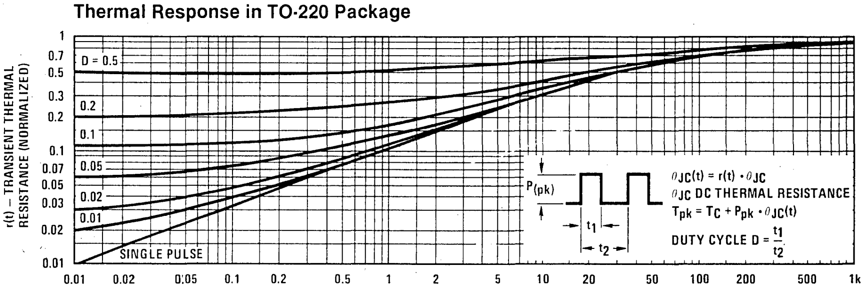
Maximum Power Dissipation vs Case Temperature



Maximum Power Dissipation vs Ambient Temperature



Thermal Response in TO-220 Package



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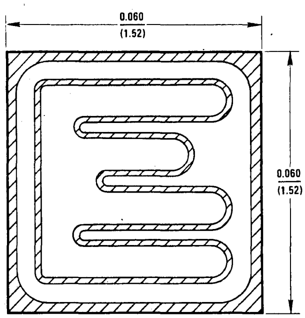
National Semiconductor

Process 4R NPN Planar Power



DESCRIPTION

Process 4R is a double diffused silicon epitaxial planar device. Complement to Process 5R.

APPLICATION

This device was designed for power amplifier, regulator and switching circuits where speed is important.

PRINCIPAL DEVICE TYPES

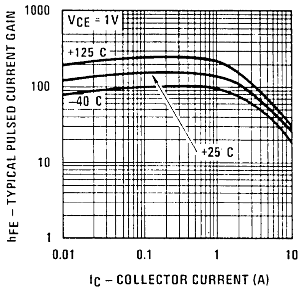
TO-126, ECB: MJE200

Parameter	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 100$ mA (Note 1)	20		40	V
BV_{CES}	$I_C = 1$ mA	35			V
BV_{EBO}	$I_E = 1$ mA	5	1		V
I_{CES}	$V_{CE} = 20V$			5	μA
I_{EBO}	$V_{EB} = 5V$			5	μA
h_{FE}	$V_{CE} = 5V$, $I_C = 20$ mA	50	180		
h_{FE}	$V_{CE} = 5V$, $I_C = 0.5A$	50	180	350	
h_{FE}	$V_{CE} = 5V$, $I_C = 10A$ (Note 1)	25	50		
$V_{CE(SAT)}$	$I_C = 3A$, $I_B = 0.3A$		0.5	1	V
$V_{BE(SAT)}$	$I_C = 3A$, $I_B = 0.3A$		1		V
f_t	$V_{CE} = 5V$, $I_C = 0.5A$	50			MHz
C_{OB}	$V_{CB} = 10V$		63		pF
C_{IB}	$V_{EB} = 1V$		450		pF
$P_{D(max)}$					
TO-126	$T_C = 25°C$	30			W
θ_{JC}					
TO-126	$T_C = 25°C$			4.16	°C/W
θ_{JA}					
TO-126	$T_A = 25°C$			83.3	°C/W
$T_{J(max)}$					
	All Plastic Parts	150			°C

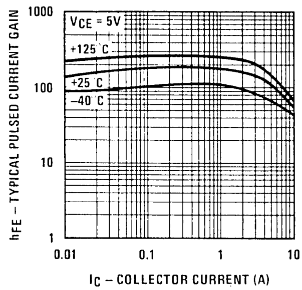
Note 1: Pulsed measurement = 300 μs pulse width.

Process 4R

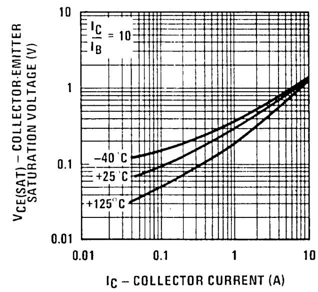
Typical Pulsed Current Gain vs Collector Current



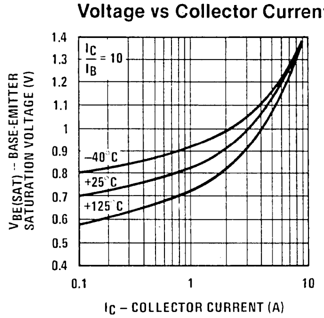
Typical Pulsed Current Gain vs Collector Current



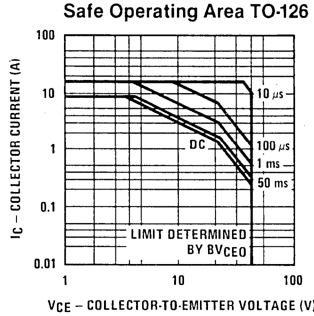
Collector-Emitter Saturation Voltage vs Collector Current



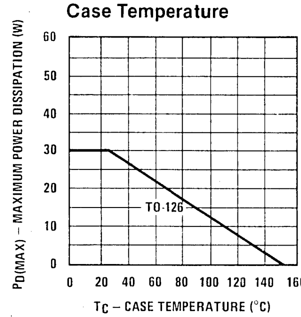
Base-Emitter Saturation Voltage vs Collector Current



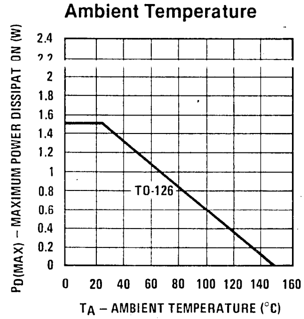
Safe Operating Area TO-126



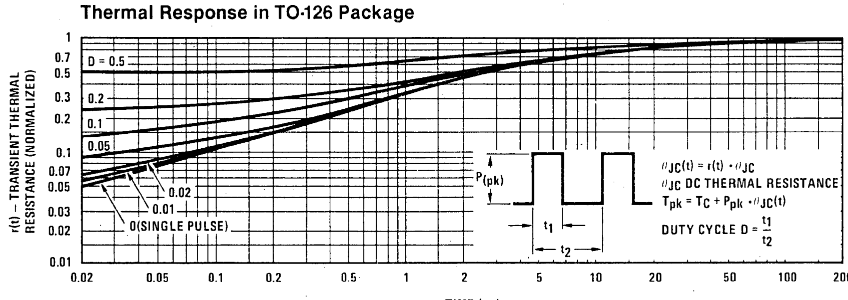
Maximum Power Dissipation vs Case Temperature



Maximum Power Dissipation vs Ambient Temperature

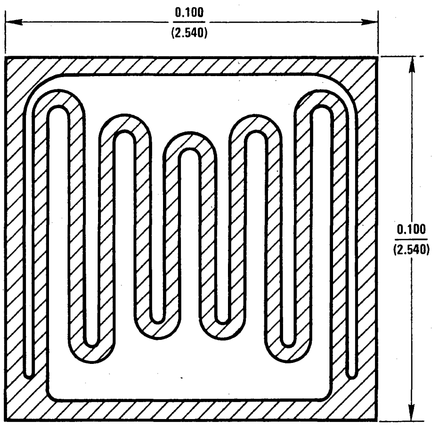


Thermal Response in TO-126 Package



National Semiconductor

Process 5A PNP Epitaxial Power



DESCRIPTION

Process 5A is a double epitaxial silicon PNP mesa device with a diffused emitter. Complement to Process 4A.

APPLICATION

This device was designed for general purpose power amplifier and switching circuits where a large safe operating area is required.

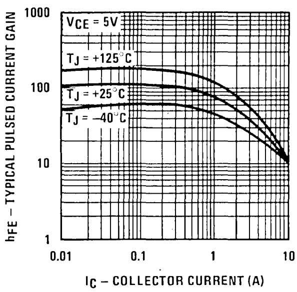
PRINCIPAL DEVICE TYPES

TO-220, BCE: 2N6489-91
BD346
MJE2901T
MJE2955T
TIP42-42C

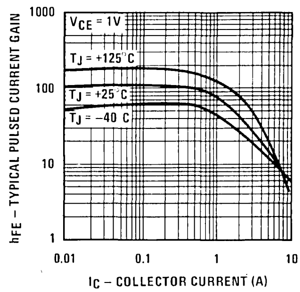
Parameter	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 200$ mA (Note 1)	40		120	V
BV_{CBO}	$I_C = 1$ mA	60			V
BV_{EBO}	$I_E = 1$ mA	5	7		V
I_{CEO}	$V_{CE} = BV_{CEO} - 10V$			200	μA
I_{CBO}	$V_{CB} = BV_{CEO}$			20	μA
I_{EBO}	$V_{EB} = 5V$			500	μA
h_{FE}	$I_C = 2.5A$, $V_{CE} = 2V$ (Note 1)	20		200	
$V_{CE(SAT)}$	$I_C = 4A$, $I_B = 0.4A$ (Note 1)		0.5	0.6	V
$V_{BE(ON)}$	$I_C = 5A$, $V_{CE} = 2V$ (Note 1)		1.2	1.3	V
f_t	$I_C = 0.5A$, $V_{CE} = 5V$	2			MHz
t_d	$I_C = 5A$, $I_{B1} = I_{B2} = 0.5A$, $V_{CC} = 40V$		0.03		μs
t_r	$I_C = 5A$, $I_{B1} = I_{B2} = 0.5A$, $V_{CC} = 40V$		0.27		μs
t_s	$I_C = 5A$, $I_{B1} = I_{B2} = 0.5A$, $V_{CC} = 40V$		0.3		μs
t_f	$I_C = 5A$, $I_{B1} = I_{B2} = 0.5A$, $V_{CC} = 40V$		0.37		μs
$P_{D(max)}$ TO-220	$T_C = 25°C$ $T_A = 25°C$	60 2			W
θJC TO-220	$T_C = 25°C$			2.08	°C/W
θJA TO-220	$T_A = 25°C$			62.5	°C/W
$T_{J(max)}$	All Plastic Parts	150			°C

Note 1: Pulsed measurement = 300 μs pulse width.

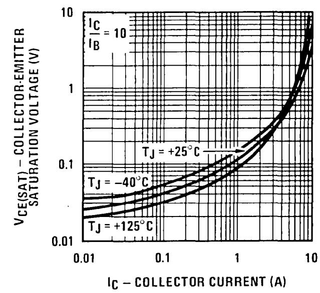
Typical Pulsed Current Gain vs Collector Current



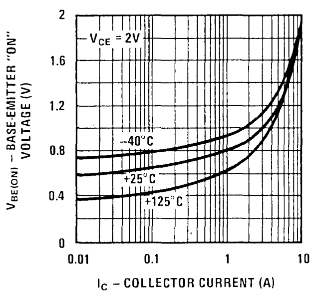
Typical Pulsed Current Gain vs Collector Current



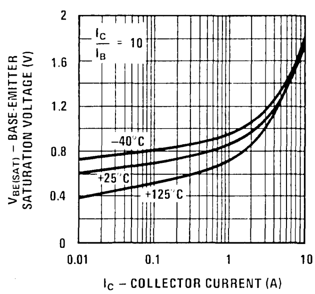
Collector-Emitter Saturation Voltage vs Collector Current



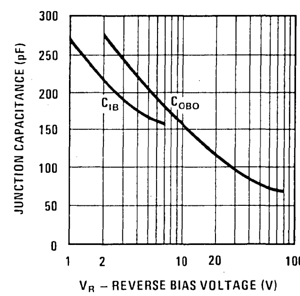
Base-Emitter ON Voltage vs Collector Current



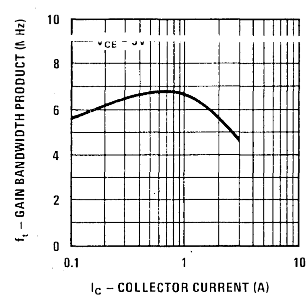
Base-Emitter Saturation Voltage vs Collector Current



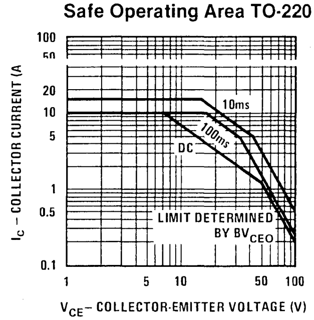
Junction Capacitance vs Reverse Bias Voltage



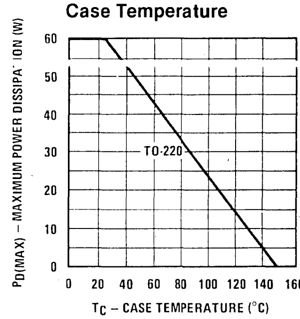
Gain Bandwidth Product vs Collector Current



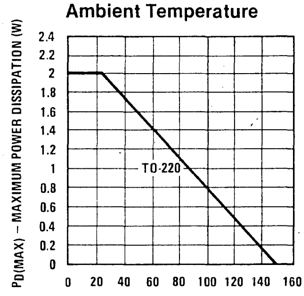
Safe Operating Area TO-220



Maximum Power Dissipation vs Case Temperature

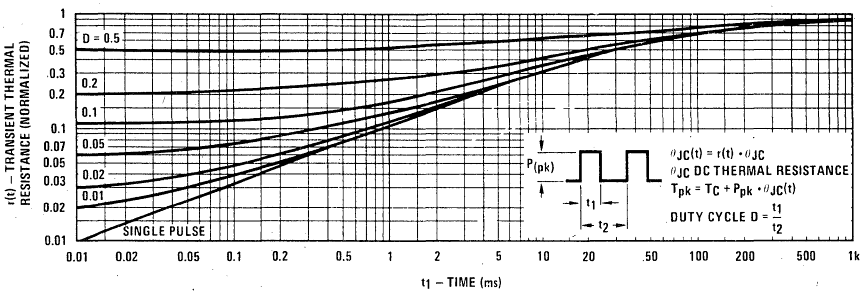


Maximum Power Dissipation vs Ambient Temperature



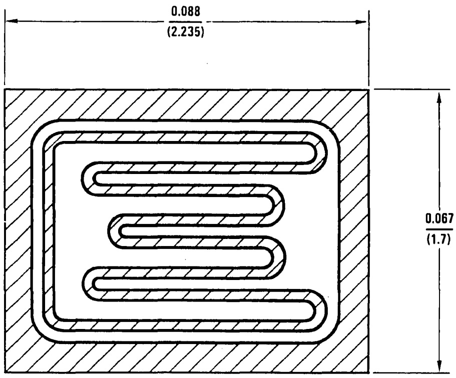
Process 5A

Thermal Response in TO-220 Package



National Semiconductor

Process 5E PNP Epitaxial Power



DESCRIPTION

Process 5E is a double epitaxial silicon mesa device with diffused emitter. Complement to Process 4E.

APPLICATION

This device was designed for general purpose power amplifier and switching circuits where a large safe operating area is required.

PRINCIPAL DEVICE TYPES

TO-220, BCE: 2N6107-09
2N6124-26
2N6132-34

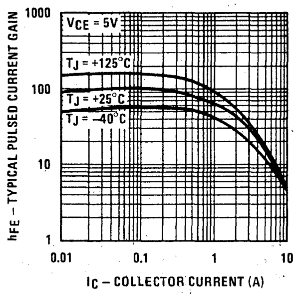
TO-126, ECB: 2N5193-95
MJE371

Parameter	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 100$ mA (Note 1)	30		120	V
BV_{CBO}	$I_C = 1$ mA	40			V
BV_{EBO}	$I_E = 1$ mA	5	8		V
I_{CEO}	$V_{CE} = BV_{CEO}$			300	μA
I_{CBO}	$V_{CB} = BV_{CEO}$			100	μA
I_{EBO}	$V_{EB} = 5V$			1000	μA
h_{FE}	$I_C = 1.5A$, $V_{CE} = 2.0V$ (Note 1)	20		170	
$V_{CE(SAT)}$	$I_C = 4.0A$, $I_B = 0.4A$ (Note 1)			1.0	V
$V_{BE(ON)}$	$I_C = 4.0A$, $V_{CE} = 2.0V$ (Note 1)			1.3	V
f_t	$I_C = 0.5A$, $V_{CE} = 2V$	4			MHz
t_d	$I_C = 1.0A$, $I_{B1} = 0.1A$, $I_{B2} = 0.1A$, $V_{CC} = 30V$		0.10		μs
t_r	$I_C = 1.0A$, $I_{B1} = 0.1A$, $I_{B2} = 0.1A$, $V_{CC} = 30V$		0.25		μs
t_s	$I_C = 1.0A$, $I_{B1} = 0.1A$, $I_{B2} = 0.1A$, $V_{CC} = 30V$		0.40		μs
t_f	$I_C = 1.0A$, $I_{B1} = 0.1A$, $I_{B2} = 0.1A$, $V_{CC} = 30V$		0.23		μs
$P_{D(max)}$					
TO-220	$T_C = 25°C$ $T_A = 25°C$	50 2			W
TO-126	$T_C = 25°C$ $T_A = 25°C$	40 1.5			W
θJC					
TO-220	$T_C = 25°C$			2.5	°C/W
TO-126	$T_C = 25°C$			3.12	°C/W
θJA					
TO-220	$T_A = 25°C$			62.5	°C/W
TO-126	$T_A = 25°C$			83.3	°C/W
$T_{J(max)}$	All Plastic Parts	150			°C

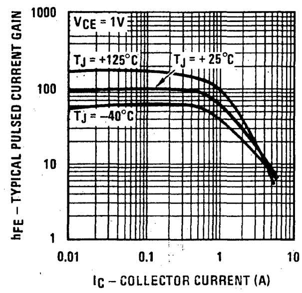
Note 1: Pulsed measurement = 300 μs pulse width.

Process 5E

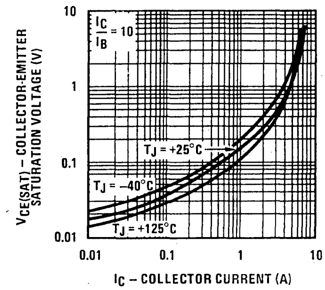
Typical Pulsed Current Gain vs Collector Current



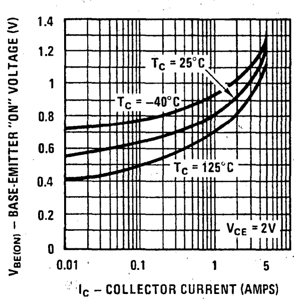
Typical Pulsed Current Gain vs Collector Current



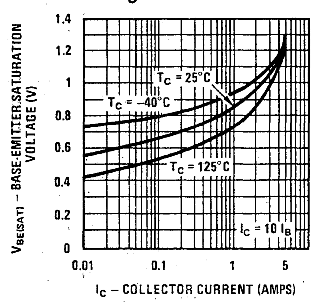
Collector-Emitter Saturation Voltage vs Collector Current



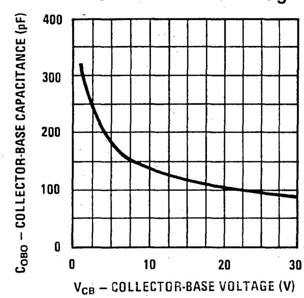
Base-Emitter ON Voltage vs Collector Current



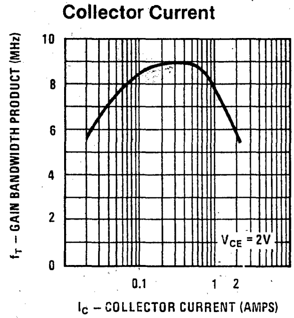
Base-Emitter Saturation Voltage vs Collector Current



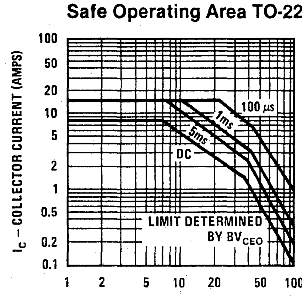
Collector-Base Capacitance vs Collector-Base Voltage



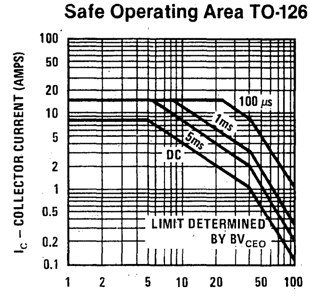
Gain Bandwidth Product vs Collector Current



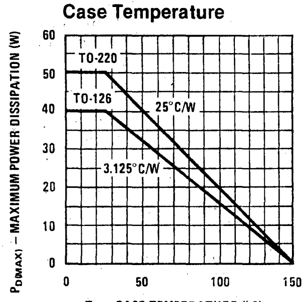
Safe Operating Area TO-220



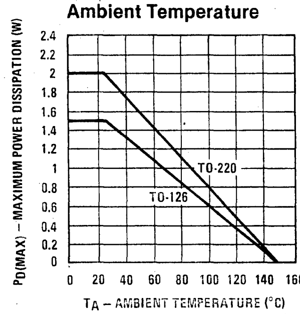
Safe Operating Area TO-126



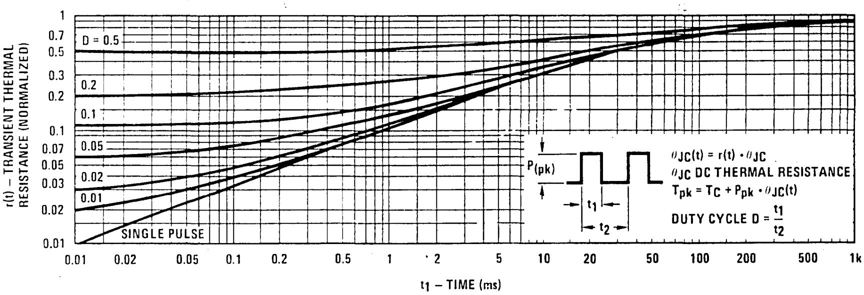
Maximum Power Dissipation vs Case Temperature



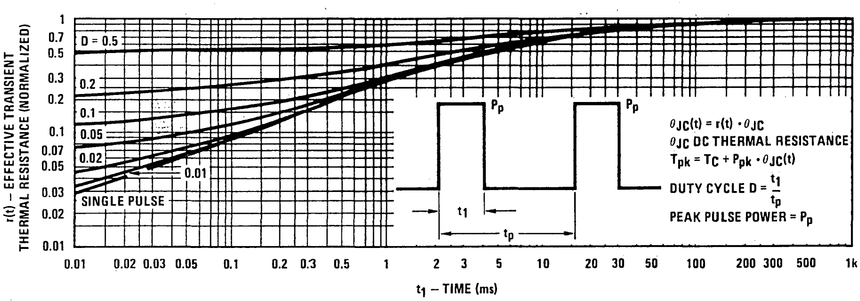
Maximum Power Dissipation vs Ambient Temperature



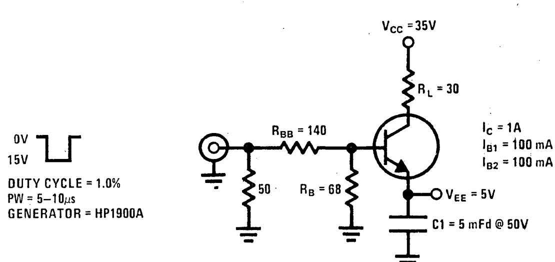
Thermal Response in TO-220 Package



Thermal Response in TO-126 Package

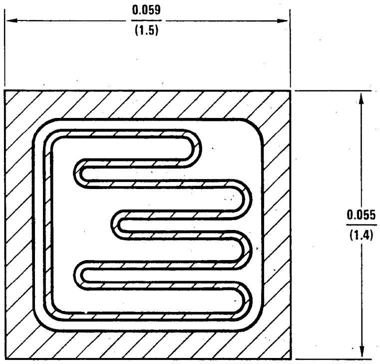


Switching Circuit



National Semiconductor

Process 5F PNP Epitaxial Power



DESCRIPTION

Process 5F is a double epitaxial silicon mesa device with diffused emitter. Complement to Process 4F.

APPLICATION

This device was designed for general purpose power amplifier and switching circuits where a large safe operating area is required.

PRINCIPAL DEVICE TYPES

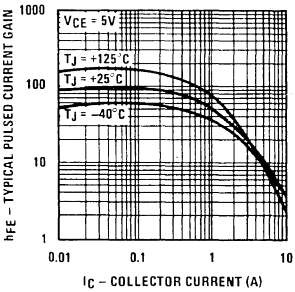
TO-220, BCE: TIP30-30C
TIP32-32C
TIP62-62C
TO-126, ECB: 2N4918-20
MJE370

Parameter	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 100$ mA (Note 1)	30		120	V
BV_{CBO}	$I_C = 1$ mA	50			V
BV_{EBO}	$I_E = 1$ mA	5	6.5		V
I_{CEO}	$V_{CE} = BV_{CEO} - 10V$			300	μA
I_{CBO}	$V_{CB} = BV_{CEO}$			10	μA
I_{EBO}	$V_{EB} = 5V$			100	μA
h_{FE}	$I_C = 1.0A$, $V_{CE} = 1.0V$ (Note 1)	10		120	
$V_{CE(SAT)}$	$I_C = 2.0A$, $I_B = 0.2A$ (Note 1)			1.0	V
$V_{BE(ON)}$	$I_C = 2.0A$, $V_{CE} = 2.0V$ (Note 1)			1.1	V
f_t	$I_C = 0.5A$, $V_{CE} = 2V$	4			MHz
t_d			0.03		μs
t_r	$I_C = 1A$, $I_{B1} = I_{B2} = 0.1A$,		0.20		μs
t_s	$V_{CC} = 30V$		0.26		μs
t_f			0.20		μs
$P_{D(max)}$					
TO-220	$T_C = 25°C$ $T_A = 25°C$	40 2			W
TO-126	$T_C = 25°C$ $T_A = 25°C$	30 1.5			W
θJC					
TO-220	$T_C = 25°C$			3.12	°C/W
TO-126	$T_C = 25°C$			4.16	°C/W
θJA					
TO-220	$T_A = 25°C$			62.5	°C/W
TO-126	$T_A = 25°C$			83.3	°C/W
$T_{J(max)}$					
	All Plastic Parts	150			°C

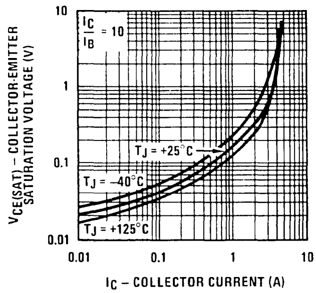
Note 1: Pulsed measurement = 300 μs pulse width.

Process 5F

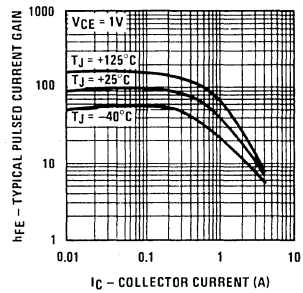
Typical Pulsed Current Gain vs Collector Current



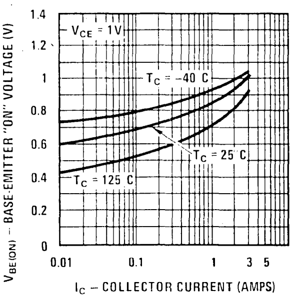
Collector-Emitter Saturation Voltage vs Collector Current



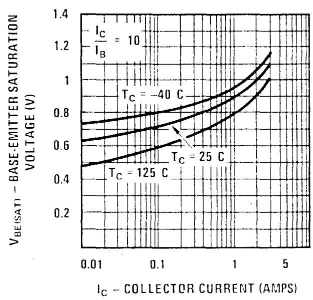
Typical Pulsed Current Gain vs Collector Current



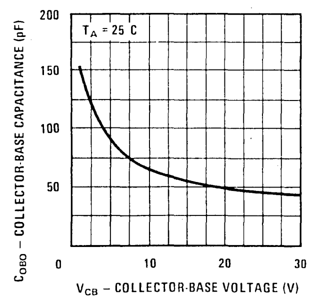
Base-Emitter ON Voltage vs Collector Current



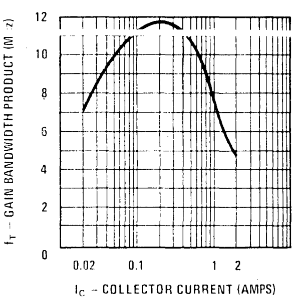
Base-Emitter Voltage vs Collector Current



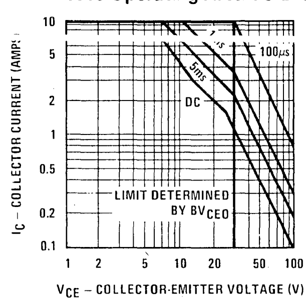
Typical Collector Capacitance vs Collector-Base Voltage



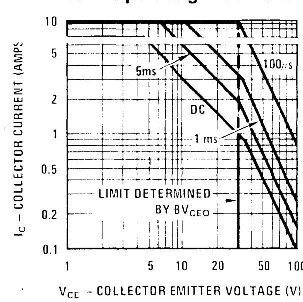
Gain Bandwidth Product vs Collector Current



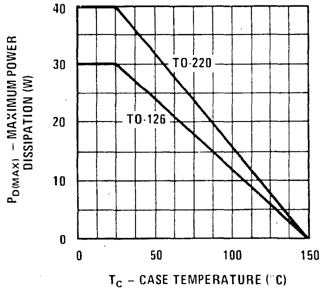
Safe Operating Area TO-220



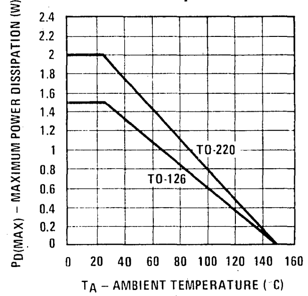
Safe Operating Area TO-126



Maximum Power Dissipation vs Case Temperature

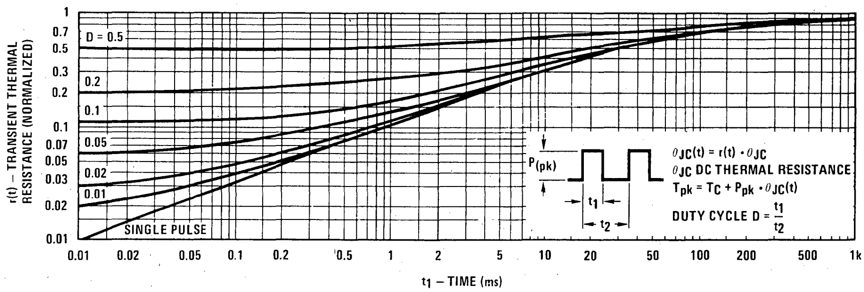


Maximum Power Dissipation vs Ambient Temperature

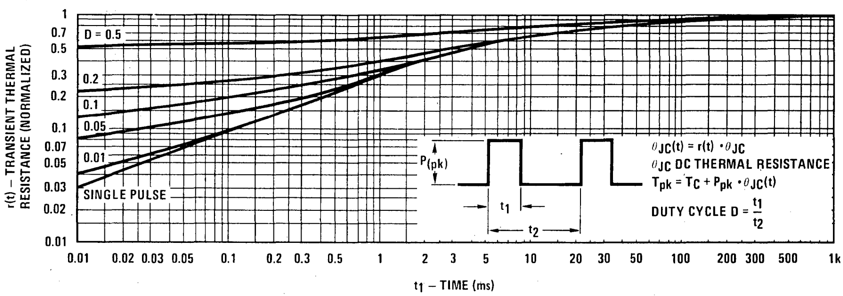


Process 5F

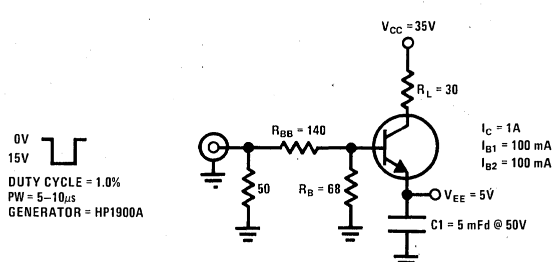
Thermal Response in TO-220 Package



Thermal Response in TO-126 Package

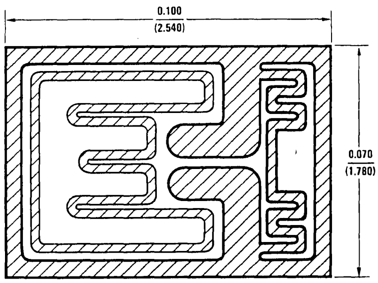


Switching Circuit



National Semiconductor

Process 5J
PNP Epitaxial Power Darlington



DESCRIPTION

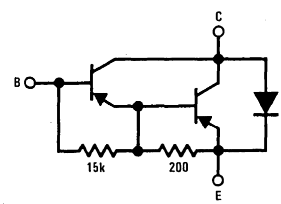
Process 5J is a double epitaxial silicon mesa device. Complement to Process 4J.

APPLICATION

This device was designed for use in driver and output stages of complementary audio amplifier circuits. It is also well suited for solenoid driver applications.

PRINCIPAL DEVICE TYPES

TO-126, ECB: 2N6034-36
MJE700-03
TO-220, BCE: NSP2090-93
TIP115-17

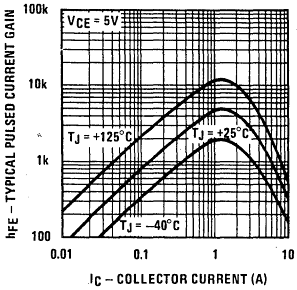


Parameter	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 100$ mA (Note 1)	40		120	V
BV_{CBO}	$I_C = 20\ \mu A$	50			V
BV_{EBO}	$I_E = 2$ mA	5			V
I_{CEO}	$V_{CE} = 1/2\ BV_{CEO}$			0.5	mA
I_{CBO}	$V_{CB} = BV_{CEO}$			200	µA
I_{EBO}	$V_{EB} = 5V$			2.0	mA
h_{FE}	$I_C = 2A$, $V_{CE} = 3V$ (Note 1)	750		20,000	
$V_{CE(SAT)}$	$I_C = 5A$, $I_B = 20$ mA (Note 1)			3.3	V
$V_{BE(ON)}$	$I_C = 5A$, $V_{CE} = 3V$ (Note 1)			2.8	V
C_{OBO}	$V_{CB} = 10V$		35		pF
$\lvert h_{fe} \rvert$	$I_C = 1A$, $V_{CE} = 3V$, f = 1 MHz		4		
t_{ON}	$I_C = 6A$, $V_{CE} = 30V$		2.0		µs
t_{OFF}	$I_C = 6A$, $V_{CE} = 30V$		2.6		µs
$P_{D(max)}$					
TO-220	$T_C = 25°C$ $T_A = 25°C$	50 2			W
TO-126	$T_C = 25°C$ $T_A = 25°C$	40 1.5			W
θJC					
TO-220	$T_C = 25°C$			2.5	°C/W
TO-126	$T_C = 25°C$			3.12	°C/W
θJA					
TO-220	$T_A = 25°C$			62.5	°C/W
TO-126	$T_A = 25°C$			83.3	°C/W
$T_{J(max)}$					
	All Plastic Parts	150			°C

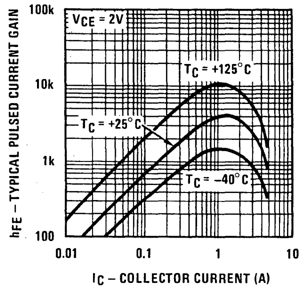
Note 1: Pulse test, pulse width = 300 µs

Process 5J

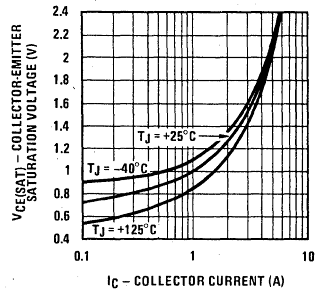
Typical Pulsed Current Gain vs Collector Current



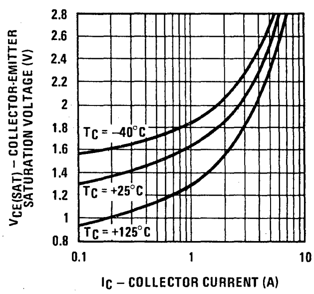
Typical Pulsed Current Gain vs Collector Current



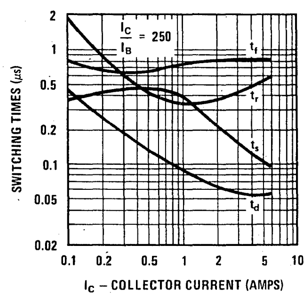
Collector-Emitter Saturation Voltage vs Collector Current



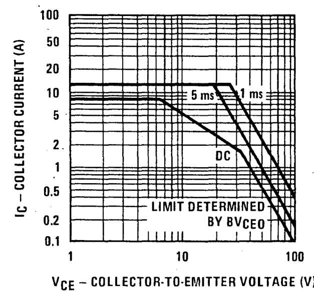
Base-Emitter Saturation Voltage vs Collector Current



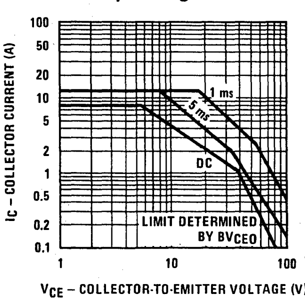
Switching Times vs Collector Current



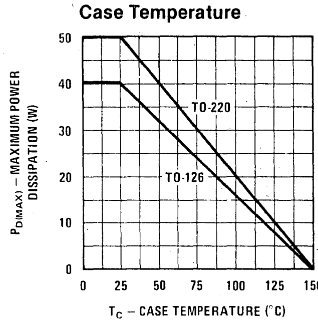
Safe Operating Area TO-220



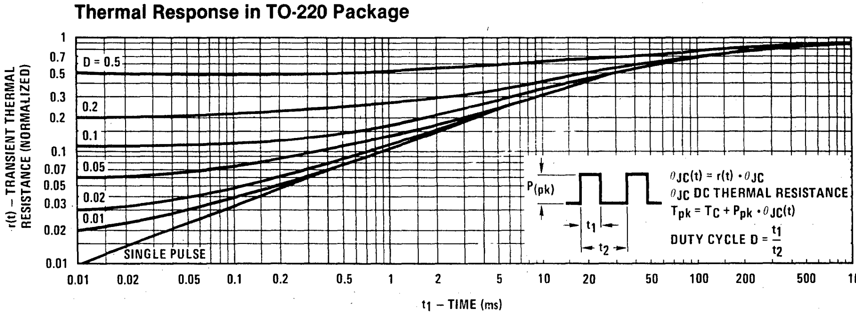
Safe Operating Area TO-126



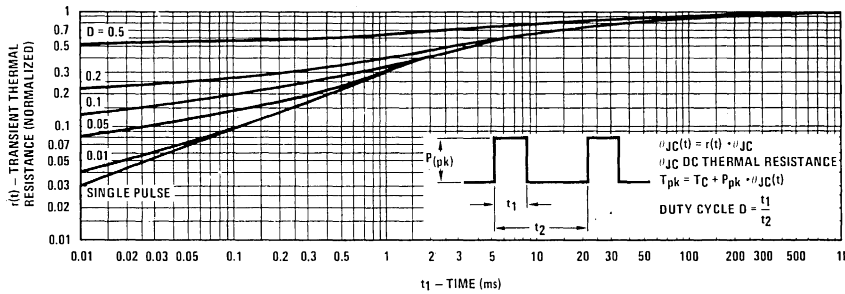
Maximum Power Dissipation vs Case Temperature

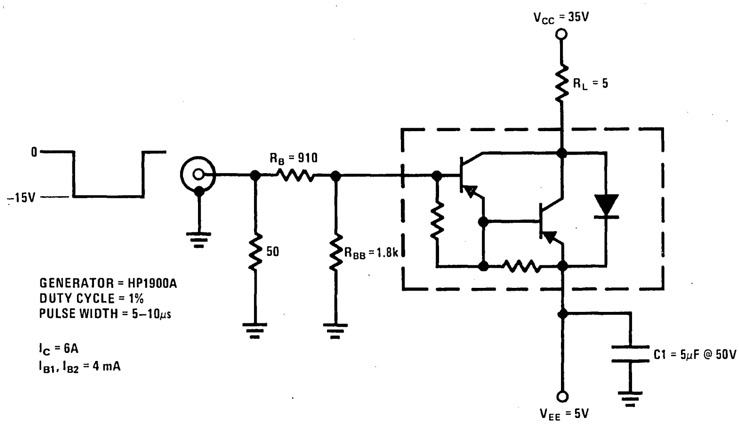


Thermal Response in TO-220 Package



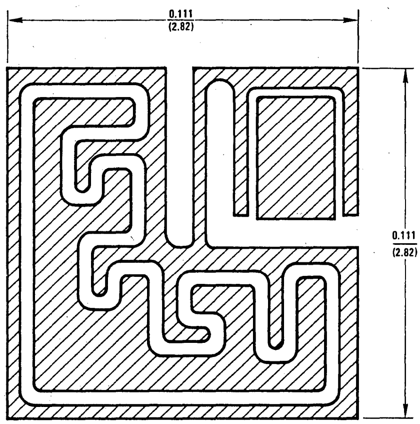
Thermal Response in TO-126 Package





National Semiconductor

Process 5K
PNP Epitaxial Power Darlington



DESCRIPTION

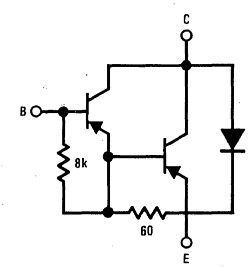
Process 5K is a double epitaxial silicon mesa Darlington transistor. Complement to Process 4K.

APPLICATION

The 5K was designed for general purpose amplifier and low-speed switching applications.

PRINCIPAL DEVICE TYPES

TO-220, BCE: SE9401, 02
TIP105–107
TIP125–27
TIP135–37

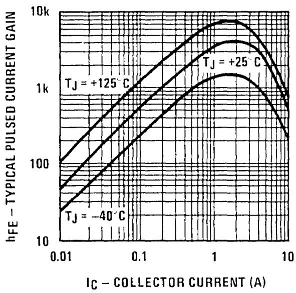


Parameter	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 100$ mA (Note 1)	40		120	V
BV_{CBO}	$I_C = 200\ \mu A$	50			V
BV_{EBO}	$I_E = 5$ mA	5			V
I_{CEO}	$V_{CE} = 1/2\ BV_{CEO}$			0.5	mA
I_{CBO}	$V_{CB} = BV_{CEO}$			100	μA
I_{EBO}	$V_{BE} = 5V$			2.0	mA
h_{FE}	$I_C = 4A$, $V_{CE} = 3V$ (Note 1)	750		18,000	
h_{FE}	$I_C = 8A$, $V_{CE} = 3V$ (Note 1)	100			
$V_{CE(SAT)}$	$I_C = 4A$, $I_B = 16$ mA (Note 1)			2	V
$V_{CE(SAT)}$	$I_C = 8A$, $I_B = 80$ mA (Note 1)			3	V
$V_{BE(SAT)}$	$I_C = 8A$, $I_B = 80$ mA (Note 1)			4	V
$V_{BE(ON)}$	$I_C = 4A$, $V_{CE} = 3V$ (Note 1)			2.8	V
C_{OBO}	$V_{CB} = 10V$			300	pF
$\|h_{fe}\|$	$I_C = 3A$, $V_{CE} = 3V$, $f = 1$ MHz	4			
$P_{D(max)}$					
TO-220	$T_C = 25°C$ $T_A = 25°C$	60 2			W
θ_{JC}					
TO-220	$T_C = 25°C$			2.08	°C/W
θ_{JA}					
TO-220	$T_A = 25°C$			62.5	°C/W
$T_{J(max)}$					
	All Plastic Parts	150			°C

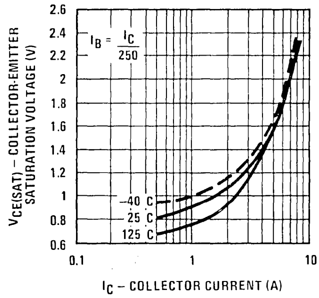
Note 1: Pulsed measurement = 300 μs pulse width.

Process 5K

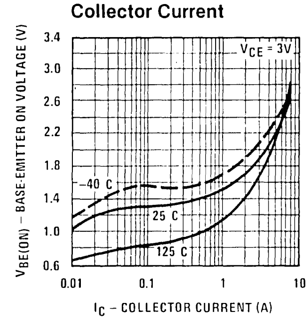
Typical Pulsed Current Gain vs Collector Current



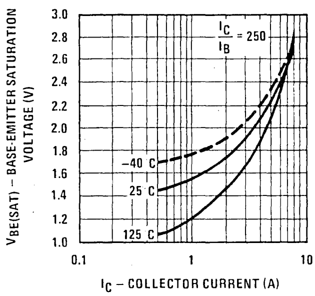
Collector-Emitter Saturation Voltage vs Collector Current



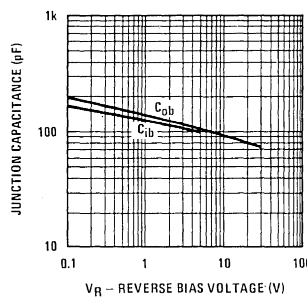
Base-Emitter ON Voltage vs Collector Current



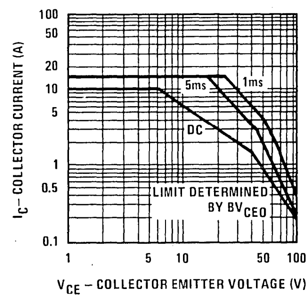
Base-Emitter Saturation Voltage vs Collector Current



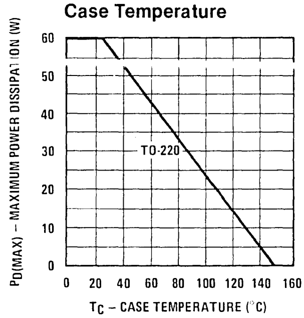
Junction Capacitance vs Reverse Bias Voltage



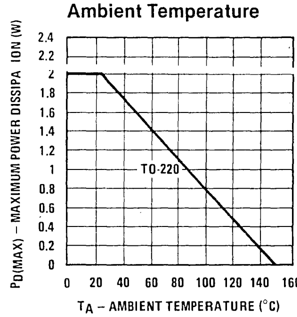
Safe Operating Area TO-220



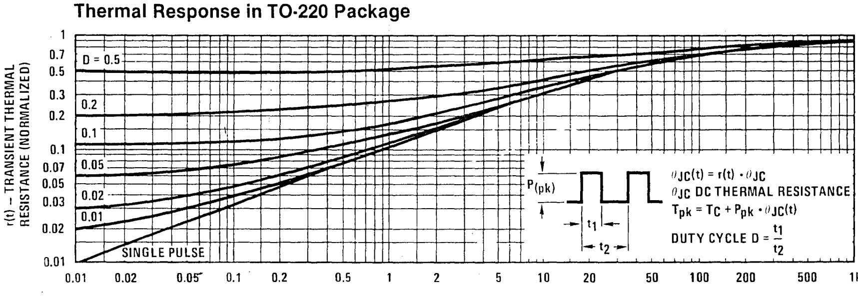
Maximum Power Dissipation vs Case Temperature



Maximum Power Dissipation vs Ambient Temperature

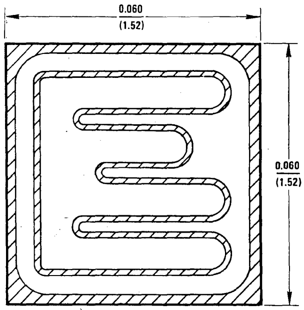


Thermal Response in TO-220 Package



National Semiconductor

Process 5P PNP Planar Power



DESCRIPTION

Process 5P is a double diffused silicon epitaxial planar device. Complement to Process 4P.

APPLICATION

This device was designed for power amplifier, regulator and switching circuits where speed is important.

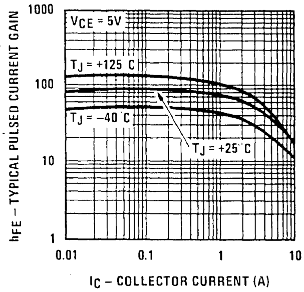
PRINCIPAL DEVICE TYPES

TO-220, BCE: D45C1-12
TO-126, ECB: MJE230-35
MJE250-54
TO-202, BCE: D43C1-12

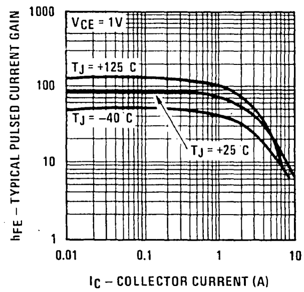
Parameter	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 100$ mA (Note 1)	50		120	V
BV_{CES}	$I_C = 1$ mA				V
BV_{EBO}	$I_E = 1$ mA	5	8		V
I_{CES}	$V_{CE} = 50V$			5	μA
I_{EBO}	$V_{EB} = 5V$			5	μA
h_{FE}	$V_{CE} = 5V$, $I_C = 20$ mA	30			
h_{FE}	$V_{CE} = 5V$, $I_C = 0.5A$	50	80	200	
h_{FE}	$V_{CE} = 5V$, $I_C = 5A$ (Note 1)	10			
$V_{CE(SAT)}$	$I_C = 3A$, $I_B = 0.3A$		0.35	1	V
$V_{BE(SAT)}$	$I_C = 3A$, $I_B = 0.3A$		1.1		V
f_t	$V_{CE} = 5V$, $I_C = 0.5A$	40			MHz
C_{OB}	$V_{CB} = 10V$		75		pF
C_{IB}	$V_{EB} = 1V$		400		pF
t_r	$I_C = 2A$, $V_{CE} = 30V$		60		ns
t_s	$I_{B1} = I_{B2} = 0.2A$		500		ns
t_f			50		ns
$P_{D(max)}$					
TO-220	$T_C = 25°C$	40			W
TO-126	$T_C = 25°C$	30			W
TO-202	$T_C = 25°C$	15			W
θ_{JC}					
TO-220	$T_C = 25°C$			3.2	°C/W
TO-126	$T_C = 25°C$			4.16	°C/W
TO-202	$T_C = 25°C$			8.33	°C/W
θ_{JA}					
TO-220	$T_A = 25°C$			62.5	°C/W
TO-202	$T_A = 25°C$			62.5	°C/W
TO-126	$T_A = 25°C$			83.3	°C/W
$T_{J(max)}$					
	All Plastic Parts	150			°C

Note 1: Pulsed measurement = 300 μs pulse width.

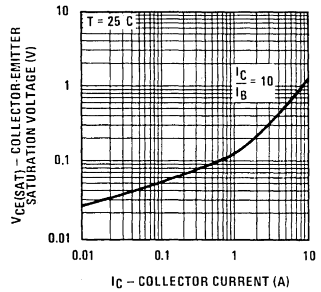
Typical Pulsed Current Gain vs Collector Current



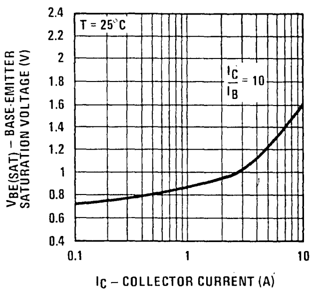
Typical Pulsed Current Gain vs Collector Current



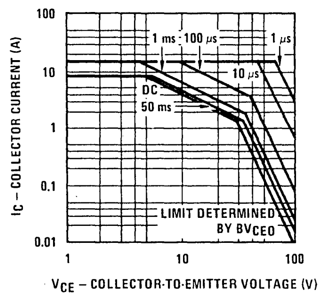
Collector-Emitter Saturation Voltage vs Collector Current



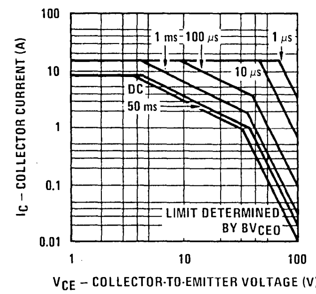
Base-Emitter Saturation Voltage vs Collector Current



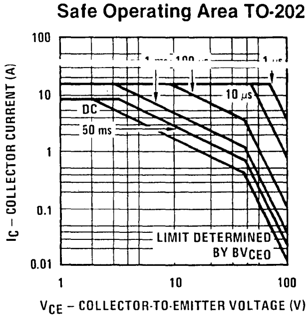
Safe Operating Area TO-220



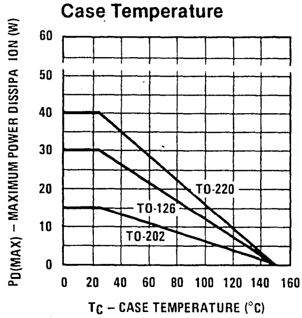
Safe Operating Area TO-126



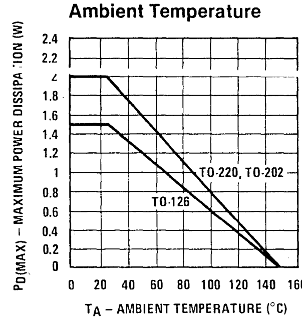
Safe Operating Area TO-202



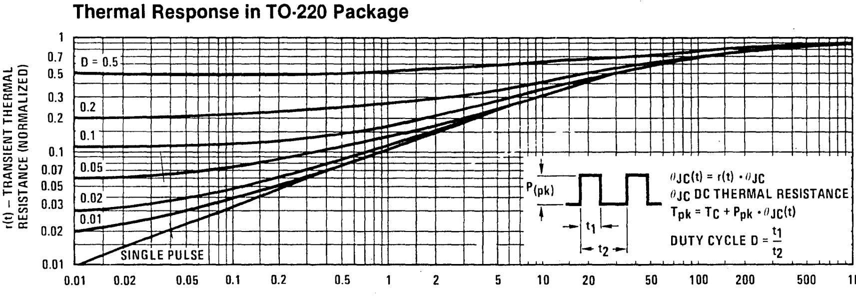
Maximum Power Dissipation vs Case Temperature



Maximum Power Dissipation vs Ambient Temperature

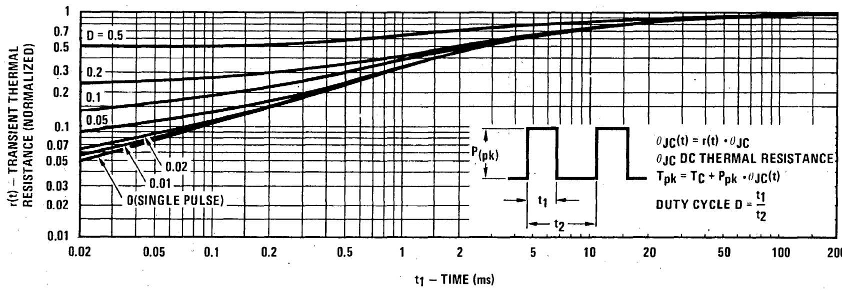


Thermal Response in TO-220 Package



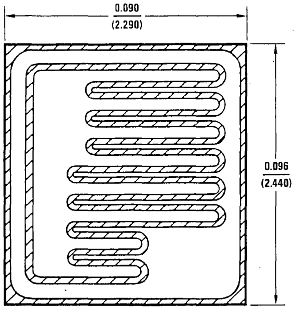
Process 5P

Thermal Response in TO-126 Package



National Semiconductor

Process 5Q PNP Planar Power



DESCRIPTION

Process 5Q is a double diffused silicon epitaxial planar device. Complement to Process 4Q.

APPLICATION

This device was designed for power amplifier, regulator and switching circuits where speed is important.

PRINCIPAL DEVICE TYPES

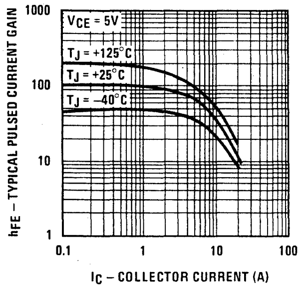
TO-220, BCE: D45H1
D45H2
D45H4
D45H5
D45H7
D45H8
D45H10
D45H11

Parameter	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 100$ mA (Note 1)	50		120	V
BV_{CES}	$I_C = 1$ mA	60			V
BV_{EBO}	$I_E = 1$ mA	5	8		V
I_{CES}	$V_{CE} = 50V$			5	μA
I_{EBO}	$V_{EB} = 5V$			5	μA
h_{FE}	$V_{CE} = 5V$, $I_C = 20$ mA	30			
h_{FE}	$V_{CE} = 5V$, $I_C = 1A$ (Note 1)	50	100	300	
h_{FE}	$V_{CE} = 5V$, $I_C = 8A$ (Note 1)	20			
$V_{CE(SAT)}$	$I_C = 8A$, $I_B = 0.8A$ (Note 1)		0.6	1	V
$V_{BE(SAT)}$	$I_C = 8A$, $I_B = 0.8A$ (Note 1)		1.2		V
f_t	$V_{CE} = 5V$, $I_C = 0.5A$	40			MHz
C_{OB}	$V_{CB} = 10V$		170		pF
C_{IB}	$V_{EB} = 1V$		870		pF
t_r	$I_C = 5A$, $V_{CE} = 30V$		40		ns
t_s	$I_{B1} = I_{B2} = 0.5A$		500		ns
t_f			60		ns
$P_{D(max)}$					
TO-220	$T_C = 25°C$	60			W
θ_{JC}					
TO-220	$T_C = 25°C$			2.08	°C/W
θ_{JA}					
TO-220	$T_A = 25°C$			62.5	°C/W
$T_{J(max)}$					
	All Plastic Parts	150			°C

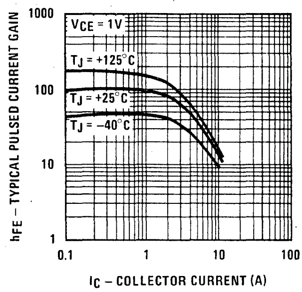
Note 1: Pulsed measurement = 300 μs pulse width.

Process 5Q

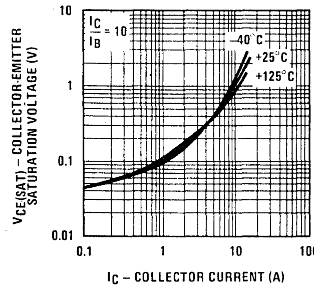
Typical Pulsed Current Gain vs Collector Current



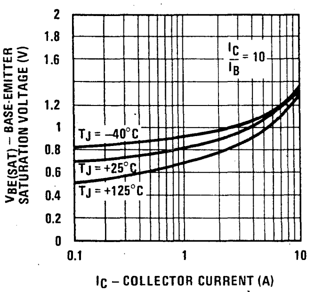
Typical Pulsed Current Gain vs Collector Current



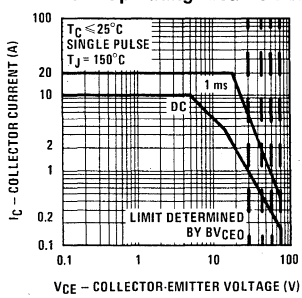
Collector-Emitter Saturation Voltage vs Collector Current



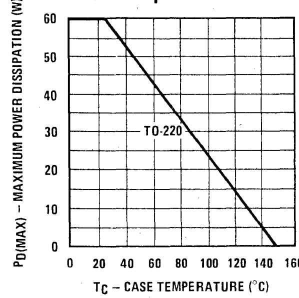
Base-Emitter Saturation Voltage vs Collector Current



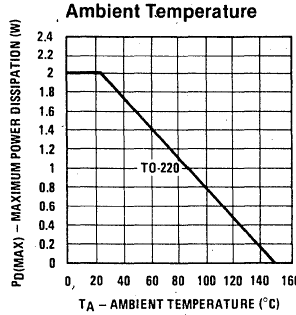
Safe Operating Area TO-220



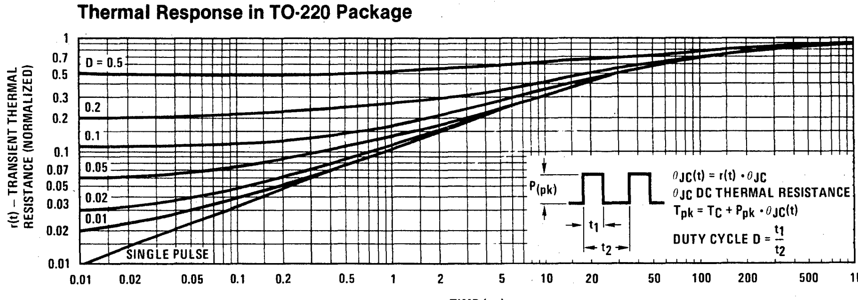
Maximum Power Dissipation vs Case Temperature



Maximum Power Dissipation vs Ambient Temperature

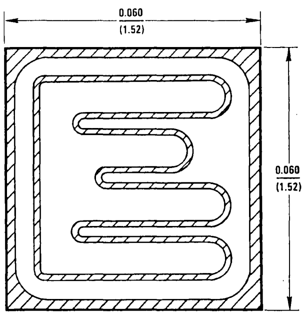


Thermal Response in TO-220 Package



National Semiconductor

Process 5R PNP Planar Power



DESCRIPTION

Process 5R is a double diffused silicon epitaxial planar device. Complement to Process 4R.

APPLICATION

This device was designed for power amplifier, regulator and switching circuits where speed is important.

PRINCIPAL DEVICE TYPES

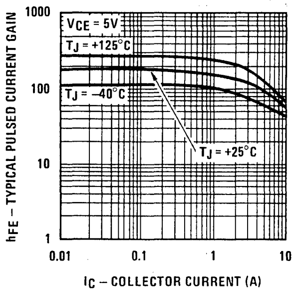
TO-126, ECB: MJE210

Parameter	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 100$ mA (Note 1)	20		40	V
BV_{CES}	$I_C = 1$ mA	25			V
BV_{EBO}	$I_E = 1$ mA	5	7		V
I_{CES}	$V_{CE} = 20V$			5	μA
I_{EBO}	$V_{EB} = 5V$			5	μA
h_{FE}	$V_{CE} = 5V$, $I_C = 20$ mA	50	180		
h_{FE}	$V_{CE} = 5V$, $I_C = 0.5A$	50	180	350	
h_{FE}	$V_{CE} = 5V$, $I_C = 10A$ (Note 1)	25	50		
$V_{CE(SAT)}$	$I_C = 3A$, $I_B = 0.3A$		0.35	8	V
$V_{BE(SAT)}$	$I_C = 3A$, $I_B = 0.3A$		1		V
f_t	$V_{CE} = 5V$, $I_C = 0.5A$	50			MHz
C_{OB}	$V_{CB} = 10V$		95		pF
C_{IB}	$V_{EB} = 1V$		450		pF
$P_{D(max)}$					
TO-126	$T_C = 25°C$	30			W
θJC					
TO-126	$T_C = 25°C$			4.16	°C/W
θJA					
TO-126	$T_A = 25°C$			83.3	°C/W
$T_{J(max)}$					
	All Plastic Parts	150			°C

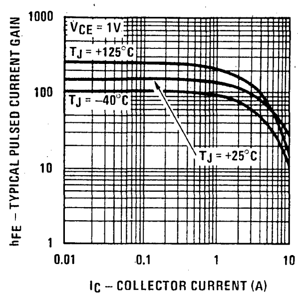
Note 1: Pulsed measurement = 300 μs pulse width.

Process 5R

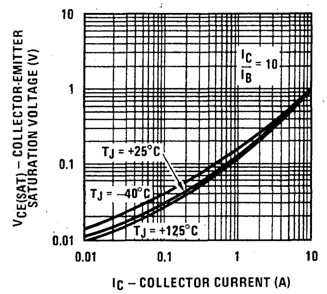
Typical Pulsed Current Gain vs Collector Current



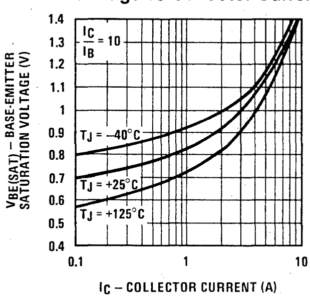
Typical Pulsed Current Gain vs Collector Current



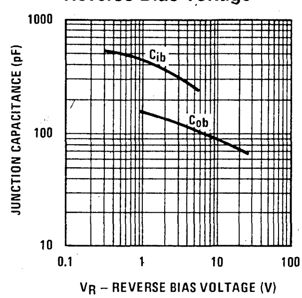
Collector-Emitter Saturation Voltage vs Collector Current



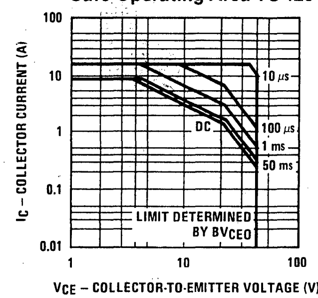
Base-Emitter Saturation Voltage vs Collector Current



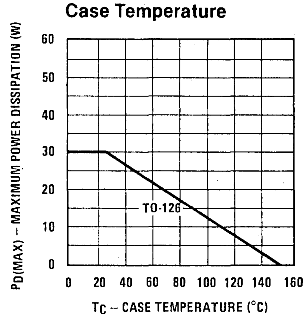
Junction Capacitance vs Reverse Bias Voltage



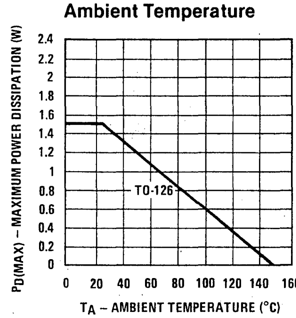
Safe Operating Area TO-126



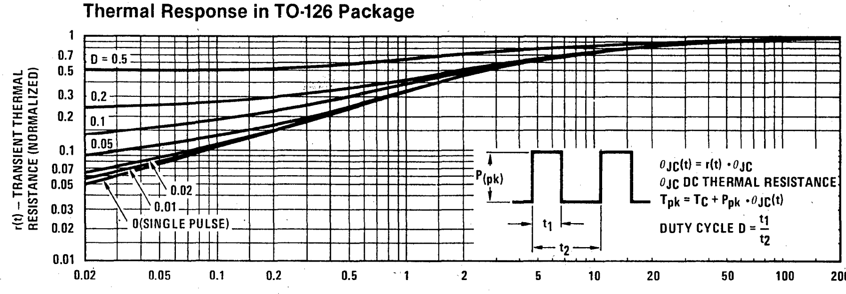
Maximum Power Dissipation vs Case Temperature



Maximum Power Dissipation vs Ambient Temperature



Thermal Response in TO-126 Package



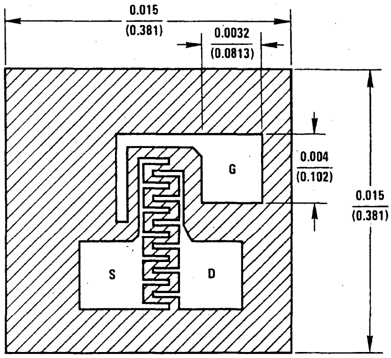
Section 10

Process Characteristics JFETs

10

National Semiconductor

Process 50 N-Channel JFET



GATE IS ALSO BACKSIDE CONTACT

DESCRIPTION

Process 50 is designed primarily for RF amplifier and mixer applications. It will operate up to 450 MHz with low noise figure and good power gain. These devices offer outstanding performance at VHF aircraft and communications frequencies. Their major advantage is low crossmodulation and intermodulation, low noise figure and good power gain. The device is also a good choice for analog switching where low capacitance is very important.

CHARACTERISTIC	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Gate-Source Breakdown Voltage	BV_{GSS}	V_{DS} = 0V, I_G = −1 μA	−25	−40		V
Zero Gate Voltage Drain Current	I_{DSS}	V_{DS} = 15V, V_{GS} = 0V	1.0	10	20	mA
Forward Trans-conductance	g_{fs}	V_{DS} = 15V, V_{GS} = 0	3.0	5.5	7.0	mmhos
Forward Trans-conductance	g_{fs}	V_{DG} = 15V, I_D = 200 μA		1.1		mmhos
Reverse Gate Leakage	I_{GSS}	V_{GS} = −20V, V_{DS} = 0		−5.0	−100	pA
"ON" Resistance	r_{DS}	V_{DS} = 100 mV, V_{GS} = 0	100	175	500	Ω
Pinch Off Voltage	$V_{GS(OFF)}$	V_{DS} = 15V, I_D = 1 nA	−0.7	−3.5	−6.0	V
Output Conductance	g_{os}	V_{DG} = 15V, I_D = 1 mA, f = 1 kHz		10		μmhos
Feedback Capacitance	C_{rss}	V_{DG} = 15V, V_{GS} = 0		0.7	0.9	pF
Input Capacitance	C_{iss}	V_{DS} = 15V, V_{GS} = 0		3.5	4.0	pF
Noise Voltage	e_n	V_{DG} = 15V, I_D = 1 mA, f = 100 Hz		8.0		nV/√Hz
Noise Figure	NF	V_{DG} = 15V, I_D = 5 mA, R_G = 1 kΩ, f = 400 MHz		2.2	4.0	dB
Power Gain	G_{PS}	V_{DG} = 15V, I_D = 5 mA, f = 400 MHz		12		dB

This process is available in the following device types. *Denotes preferred parts.

TO-72 (CASE 25)

2N3823
2N3966
2N4223
2N4224
2N4416
*2N4416A
2N5078
2N5103
2N5104
2N5105
2N5556
2N5557
2N5558

TO-92 (CASE 92)

*2N5484
*2N5485
*2N5486
2N5555
2N5668
2N5669
2N5670
*J304
*J305
PN4223
PN4224
*PN4416
PN5163
MPF102
MPF106
MPF107
MPF110
MPF111

TO-92 (CASE 94)

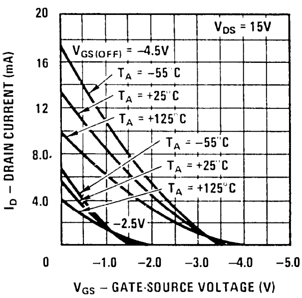
2N3819
2N5248
BF244A
BF244B
BF244C
TIS58
TIS59

TO-92 (CASE 97)

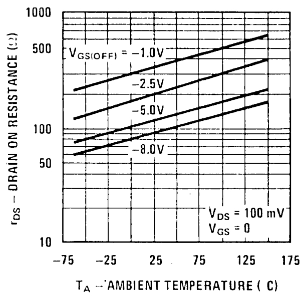
2N5949
2N5950
2N5951
2N5952
2N5953
BC264A
BC264B
BC264C
BC264D
BF245A
BF245B
BF245C
BF256A
BF256B
BF256C

Process 50

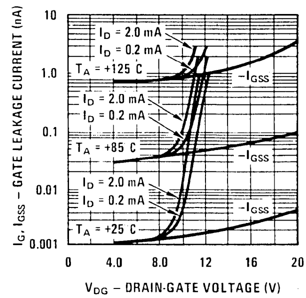
Transfer Characteristics



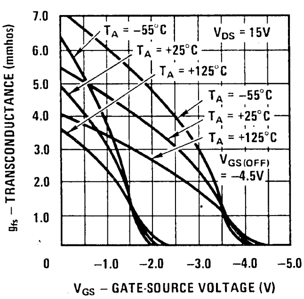
Channel Resistance vs Temperature



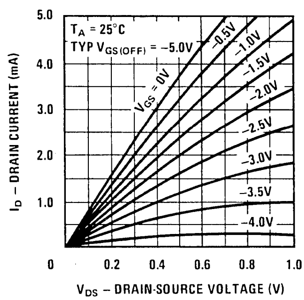
Leakage Current vs Voltage



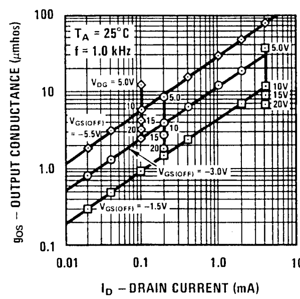
Transconductance Characteristics



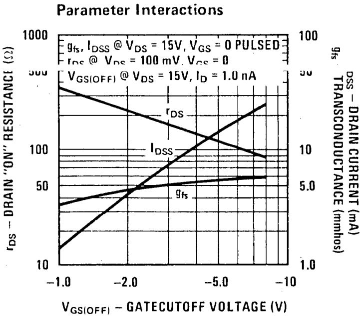
Common Drain-Source Characteristics



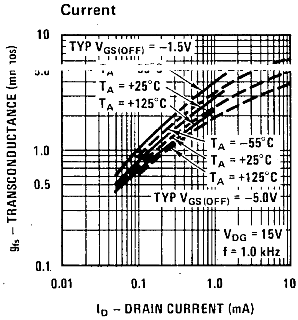
Output Conductance vs Drain Current



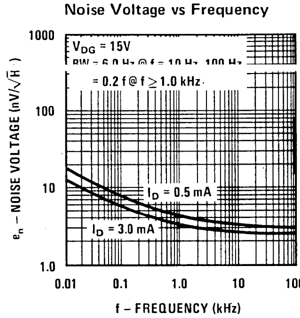
Parameter Interactions



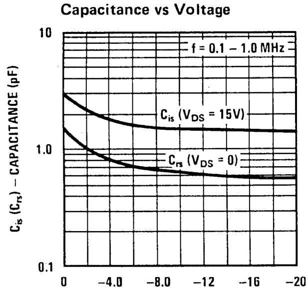
Transconductance vs Drain Current



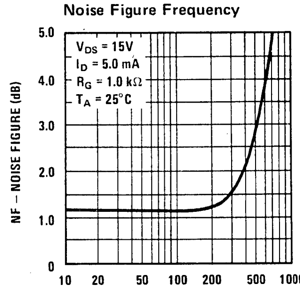
Noise Voltage vs Frequency



Capacitance vs Voltage



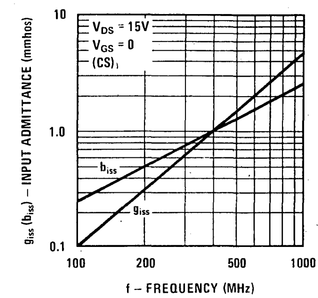
Noise Figure Frequency



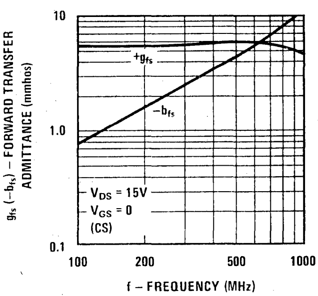
Process 50

COMMON SOURCE

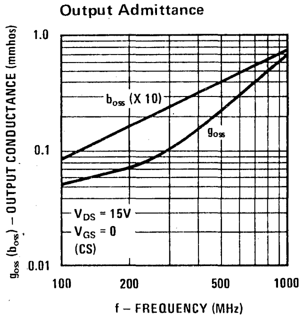
Input Admittance



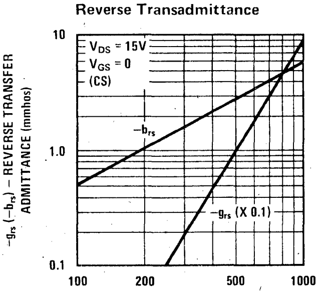
Forward Transadmittance



Output Admittance

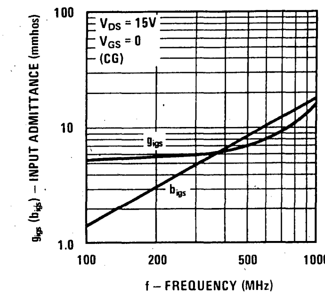


Reverse Transadmittance

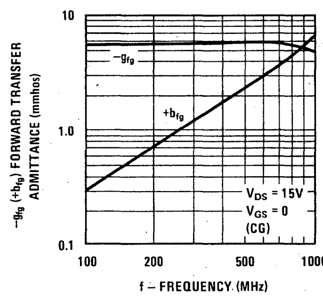


COMMON GATE

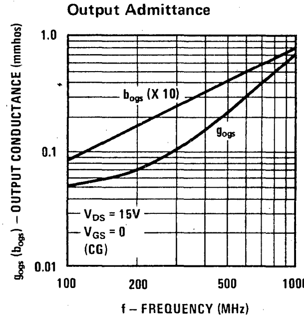
Input Admittance



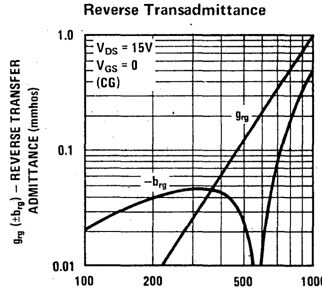
Forward Transadmittance



Output Admittance

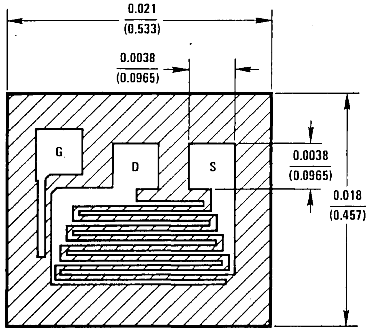


Reverse Transadmittance



National Semiconductor

Process 51 N-Channel JFET



GATE IS ALSO BACKSIDE CONTACT

DESCRIPTION

Process 51 is designed primarily for electronic switching applications such as low ON resistance analog switching. It features excellent C_{iss} $R_{DS(ON)}$ time constant. The inherent zero offset voltage and low leakage current make these devices excellent for chopper stabilized amplifiers, sample and hold circuits, and reset switches. Low feed-through capacitance also allows them to handle video signals to 100 MHz.

Characteristic	Parameter	Test Conditions	Min	Typ	Max	Units
Gate-Source Breakdown Voltage	BV_{GSS}	$V_{DS} = 0V$, $I_G = -1\ \mu A$	−30	−45		V
Zero Gate Voltage Drain Current	I_{DSS}	$V_{DS} = 20V$, $V_{GS} = 0$ Pulse Test	5.0	65	170	mA
Reverse Gate Leakage	I_{GSS}	$V_{GS} = -20V$, $V_{DS} = 0$		−15	−200	pA
ON Resistance	r_{DS}	$V_{DS} = 100$ mV, $V_{GS} = 0$	20	35	100	Ω
Forward Transconductance	g_{fs}	$V_{DG} = 15V$, $I_D = 2$ mA			8.5	mmhos
Pinch Off Voltage	$V_{GS(OFF)}$	$V_{DS} = 20V$, $I_D = 1$ nA	−0.5	−4.5	−9.0	V
Drain OFF Current	$I_{D(OFF)}$	$V_{DS} = 20V$, $V_{GS} = -10V$		15	200	pA
Feedback Capacitance	C_{rss}	$V_{DG} = 15V$, $I_D = 5$ mA, f = 1 MHz		3.5	4.0	pF
Input Capacitance	C_{iss}	$V_{DG} = 15V$, $I_D = 5$ mA, f = 1 MHz		10	16	pF
Noise Voltage	e_n	$V_{DG} = 15V$, $I_D = 1$ mA, f = 100 Hz		6.0		$nV/\sqrt{Hz}$
Turn-On Time	t_{on}	$V_{DD} = 10V$, $I_D = 6.6$ mA		12	20	ns
Turn-Off Time	t_{off}	$V_{DD} = 10V$, $I_D = 6.6$ mA		40	80	ns

This process is available in the following device types. *Denotes preferred parts.

TO-18 (CASE 02)
2N3970
2N3971
2N3972
*2N4091
*2N4092
*2N4093
*2N4391
*2N4392
*2N4393
*2N4856
2N4856A
*2N4857
2N4857A
*2N4858
2N4858A
2N4859
2N4859A
2N4860
2N4860A
2N4861
2N4861A

TO-72 (CASE 25)
*NF5101
*NF5102
*NF5103

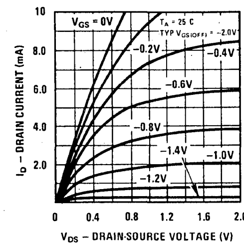
TO-92 (CASE 92)
*2N5638
*2N5639
*2N5640
2N5653
2N5654
*J111
*J112
*J113
*PF5101
*PF5102
*PF5103
*PN4091
*PN4092
*PN4093
*PN4391
*PN4392
*PN4393
*PN4856
*PN4857
*PN4858
*PN4859
*PN4860
*PN4861
U1897
U1898
U1899
MPF820

TO-92 (CASE 94)
BF246A
BF246B
BF246C

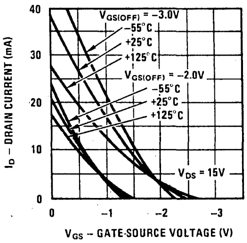
TO-92 (CASE 97)
BF247A
BF247B
BF247C
*TIS73
*TIS74
*TIS75

Process 51

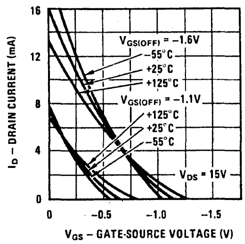
Common Drain-Source Characteristics



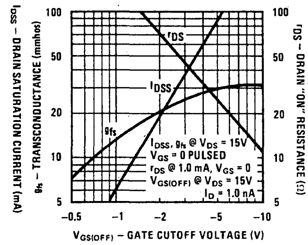
Transfer Characteristics



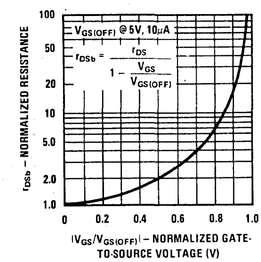
Transfer Characteristics



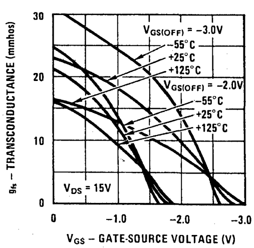
Parameter Interactions



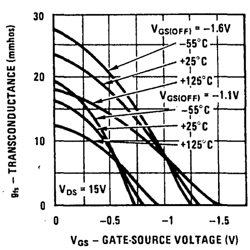
Normalized Drain Resistance vs Bias Voltage



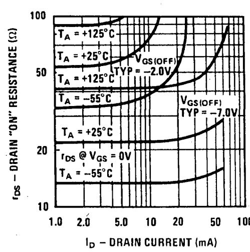
Transfer Characteristics



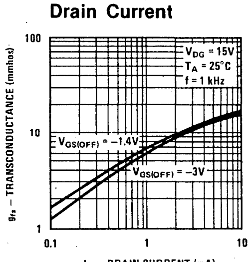
Transfer Characteristics



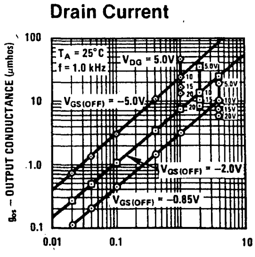
Resistance vs Drain Current



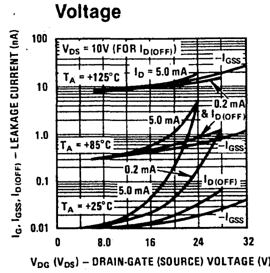
Transconductance vs Drain Current



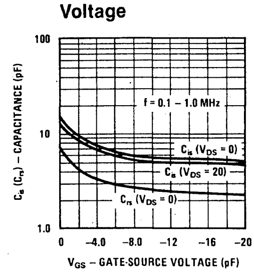
Output Conductance vs Drain Current



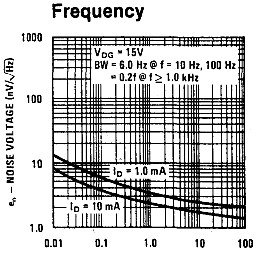
Leakage Current vs Voltage



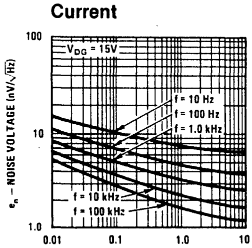
Capacitance vs Voltage



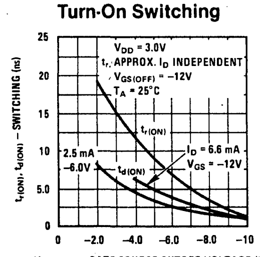
Noise Voltage vs Frequency



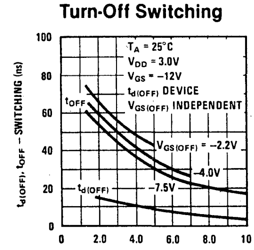
Noise Voltage vs Current



Turn-On Switching

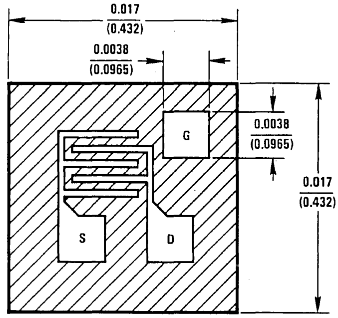


Turn-Off Switching



National Semiconductor

Process 52 N-Channel JFET



GATE IS ALSO BACKSIDE CONTACT

DESCRIPTION

Process 52 is designed primarily for low level audio and general purpose applications. These devices provide excellent performance as input stages for piezoelectric transducers or other high impedance signal sources. Their high output impedance and high voltage breakdown lend them to high gain audio and video amplifier applications. Source and drain are interchangeable.

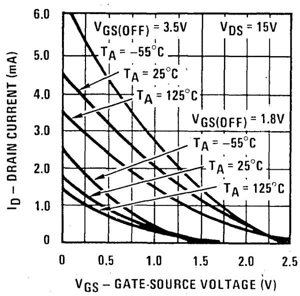
Characteristic	Parameter	Test Conditions	Min	Typ	Max	Units
Gate-Source Breakdown Voltage	BV_{GSS}	$V_{DS} = 0V$, $I_G = -1\ \mu A$	−40	−70		V
Drain Saturation Current	I_{DSS}	$V_{DS} = 20V$, $V_{GS} = 0V$	0.2	1.5	12	mA
Forward Transconductance	g_{fs}	$V_{DS} = 20V$, $V_{GS} = 0V$	1.0	2.5	5.0	mmho
Forward Transconductance	g_{fs}	$V_{DS} = 20V$, $I_D = 200\ \mu A$		700		μmho
Reverse Gate Leakage Current	I_{GSS}	$V_{GS} = -30V$, $V_{DS} = 0V$		−10		pA
Drain ON Resistance	r_{DS}	$V_{DS} = 100\ mV$, $V_{GS} = 0V$	250	400	2000	Ω
Gate Cutoff Voltage	$V_{GS(OFF)}$	$V_{DS} = 15V$, $I_D = 1\ nA$	−0.3	1.0	−8.0	V
Output Conductance	g_{os}	$V_{DG} = 15V$, $I_D = 200\ \mu A$		2.0		μmho
Feedback Capacitance	C_{rss}	$V_{DG} = 15V$, $V_{GS} = 0V$, $f = 1\ MHz$		1.3	1.8	pF
Input Capacitance	C_{iss}	$V_{DG} = 15V$, $V_{GS} = 0V$, $f = 1\ MHz$		5	6	pF
Noise Voltage	e_n	$V_{DG} = 15V$, $I_D = 200\ \mu A$, $f = 100\ Hz$		10		$nV/\sqrt{Hz}$

This process is available in the following device types. *Denotes preferred parts.

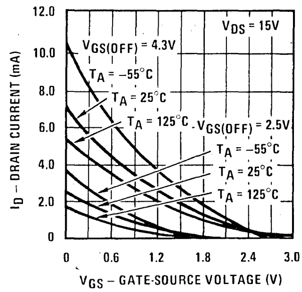
TO-18 (CASE 02)	TO-72 (CASE 25)	TO-92 (CASE 92)
2N3069	*2N3684	*J201
2N3070	*2N3685	*J202
2N3071	*2N3686	*J203
2N3368	*2N3687	*PN3684
2N3369		*PN3685
2N3370		*PN3686
2N3458		*PN3687
2N3459		*PN4302
2N3460		*PN4303
*2N4338		*PN4304
*2N4339		
*2N4340		
*2N4341		

Process 52

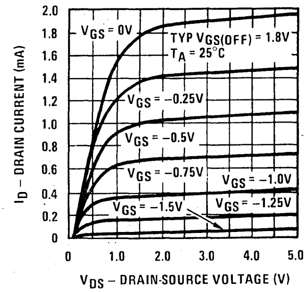
Transfer Characteristics



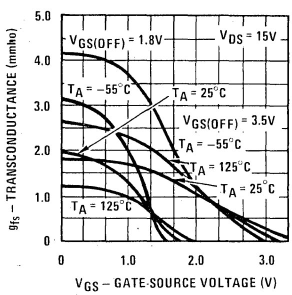
Transfer Characteristics



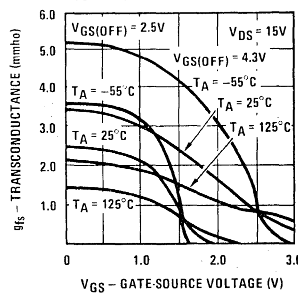
Common Drain-Source Characteristics



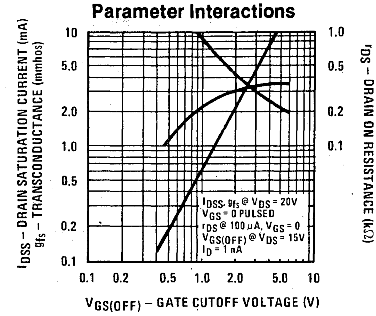
Transfer Characteristics



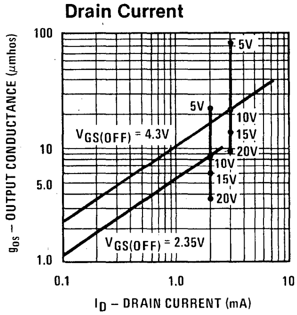
Transfer Characteristics



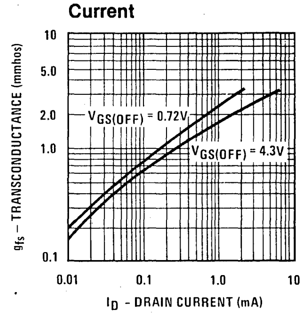
Parameter Interactions



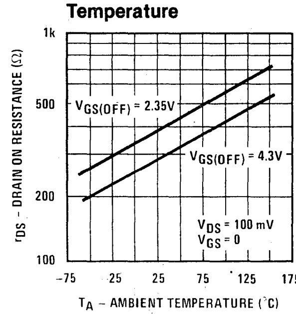
Output Conductance vs Drain Current



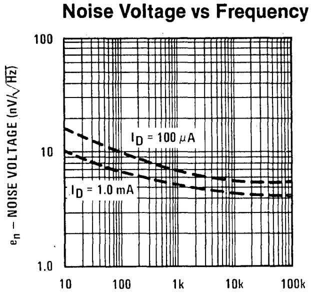
Transconductance vs Drain Current



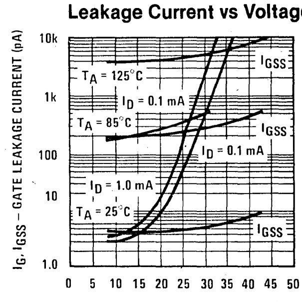
Channel Resistance vs Temperature



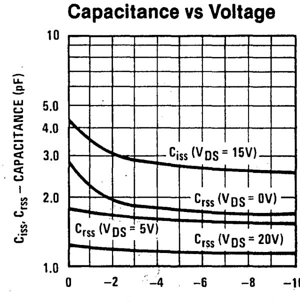
Noise Voltage vs Frequency



Leakage Current vs Voltage



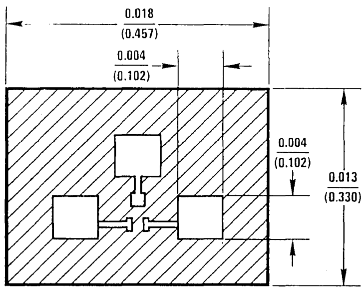
Capacitance vs Voltage



![National Semiconductor]

National Semiconductor

Process 53 N-Channel JFET



GATE IS ALSO BACKSIDE CONTACT

DESCRIPTION

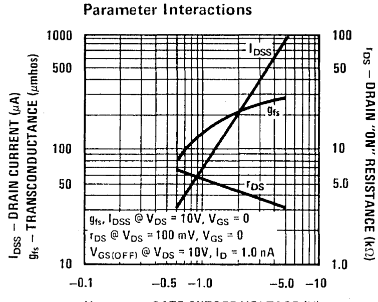
Process 53 is designed primarily for low current DC and audio applications. These devices provide excellent performance as input stages for sub pico-amp instrumentation or any high impedance signal sources.

CHARACTERISTIC	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Gate-Source Breakdown Voltage	BV_{GSS}	V_{DS} = 0V, I_G = −1 μA	−40	−60		V
Zero Gate Voltage Drain Current	I_{DSS}	V_{DS} = 10V, V_{GS} = 0	0.02	0.25	1.0	mA
Forward Trans-conductance	g_{fs}	V_{DS} = 10V, V_{GS} = 0	80	250	350	μmho
Forward Trans-conductance	g_{fs}	V_{DG} = 15V, I_D = 50 μA		120		μmho
Reverse Gate Leakage	I_{GSS}	V_{GS} = −20V, V_{DS} = 0		0.3	10	pA
Pinch Off Voltage	$V_{GS(OFF)}$	V_{DS} = 10V, I_D = 1 nA	−0.5	−2.2	−6.0	V
Feedback Capacitance	C_{rss}	V_{DG} = 15V, V_{GS} = 0, f = 1 MHz		0.85	1.0	pF
Input Capacitance	C_{iss}	V_{DS} = 15V, V_{GS} = 0, f = 1 MHz		2.0	2.5	pF
Output Conductance	g_{os}	V_{DG} = 10V, I_D = 50 μA		0.9	5.0	μmhos
Noise Voltage	e_n	V_{DG} = 10V, I_D = 50 μA, f = 100 Hz		45	150	nV/√Hz

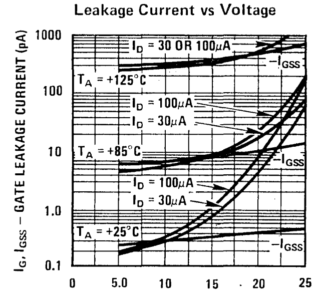
This process is available in the following device types.
*Denotes preferred parts.

TO-72 (CASE 25)	TO-92 (CASE 92)
2N4117	PN4117
*2N4117A	PN4117A
2N4118	PN4118
*2N4118A	PN4118A
2N4119	PN4119
*2N4119A	PN4119A
*NF5301	PF5301
NF5301-1	PF5301-1
NF5301-2	PF5301-2
NF5301-3	PF5301-3

Parameter Interactions

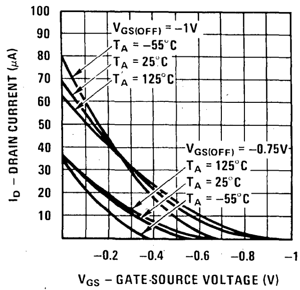


Leakage Current vs Voltage

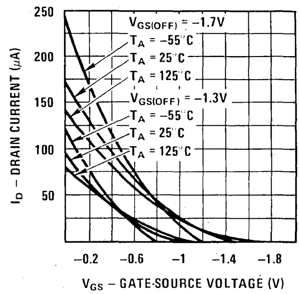


Process 53

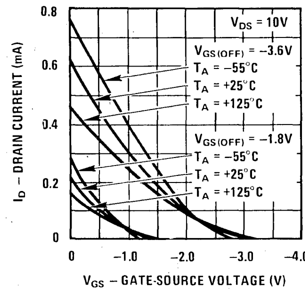
Transfer Characteristics



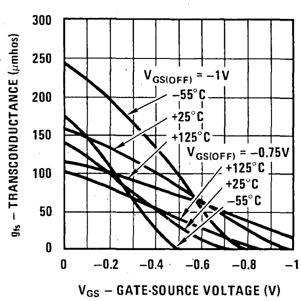
Transfer Characteristics



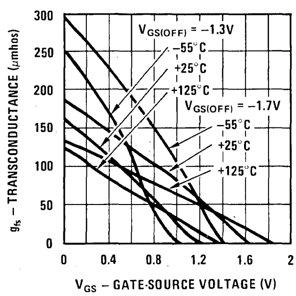
Transfer Characteristics



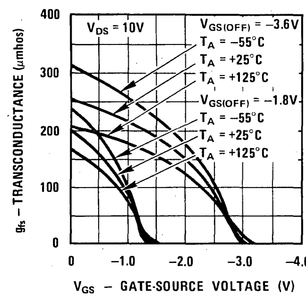
Transfer Characteristics



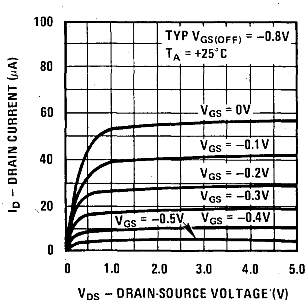
Transfer Characteristics



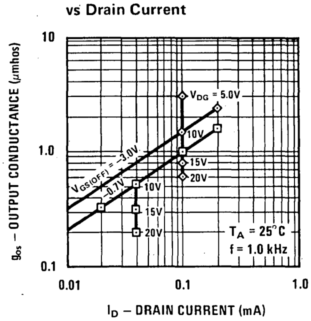
Transfer Characteristics



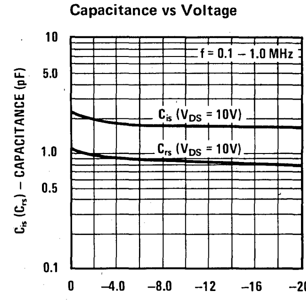
Common Drain-Source Characteristics



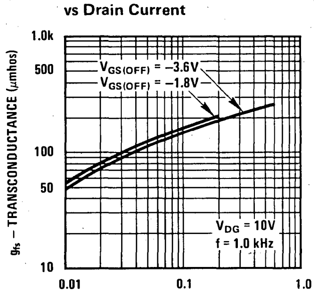
Output Conductance vs Drain Current



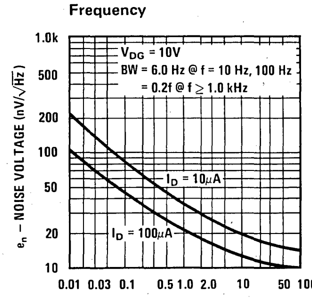
Capacitance vs Voltage



Transconductance vs Drain Current

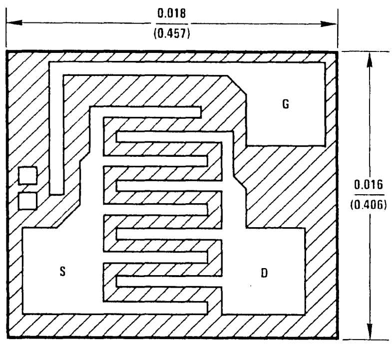


Noise Voltage vs Frequency



National Semiconductor

Process 55 N-Channel JFET



GATE IS ALSO BACKSIDE CONTACT

DESCRIPTION

Process 55 is a general purpose low level audio amplifier and switching transistor. Wafer processing is similar to process 52 but process 55 uses a larger geometry. This results in higher Y_{fs}, I_{DSS}, and capacitance and lower $R_{DS(ON)}$. It is useful for audio and video frequency amplifiers and RF amplifiers under 50 MHz. It may also be used for analog switching applications.

CHARACTERISTIC	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Gate-Source Breakdown Voltage	BV_{GSS}	V_{DS} = 0V, I_G = −1 μA	−40	−70		V
Zero Gate Voltage Drain Current	I_{DSS}	V_{DS} = 20V, V_{GS} = 0	0.5	5.0	20	mA
Forward Trans-conductance	g_{fs}	V_{DS} = 20V, V_{GS} = 0	2.0	4.5	7.0	mmho
Forward Trans-conductance	g_{fs}	V_{DG} = 15V, I_D = 200 μA		1200		μmhos
Reverse Gate Leakage	I_{GSS}	V_{GS} = −30V, V_{DS} = 0		−10	−100	pA
"ON" Resistance	r_{DS}	V_{DS} = 100 mV, V_{GS} = 0	140	250	600	Ω
Pinch Off Voltage	$V_{GS(OFF)}$	V_{DS} = 20V, I_D = 1 nA	−0.5	−2.0	−8.0	V
Feedback Capacitance	C_{rss}	V_{DG} = 15V, V_{GS} = 0, f = 1 MHz		1.5	2.0	pF
Input Capacitance	C_{iss}	V_{DS} = 15V, V_{GS} = 0, f = 1 MHz		6.0	7.0	pF
Output Conductance	g_{os}	V_{DG} = 15V, I_D = 200 μA		2		μmhos
Noise Voltage	e_n	V_{DG} = 15V, I_D = 200 μA, f = 100 Hz		10		nV/√Hz

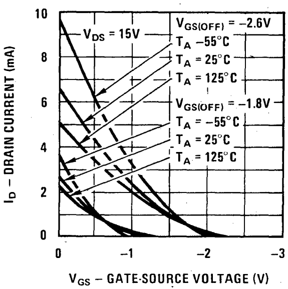
This process is available in the following device types. *Denotes preferred parts.

TO-72 (CASE 25)
2N3821
2N3822
2N3824
2N3967
2N3967A
2N3968
2N3968A
2N3969
2N3969A
2N4220
2N4220A
2N4221
2N4221A
2N4222
2N4222A
*2N5358
*2N5359
*2N5360
*2N5361
*2N5362
*2N5363
*2N5364

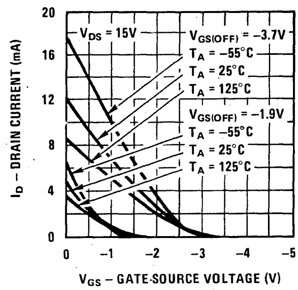
TO-92 (CASE 92)
*2N5457
*2N5458
*2N5459
MPF103
MPF104
MPF105
MPF108
MPF109
MPF112
PN4220
PN4221
PN4222

Process 55

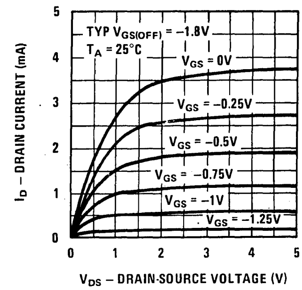
Transfer Characteristics



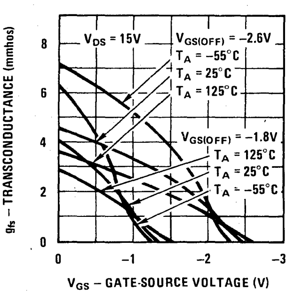
Transfer Characteristics



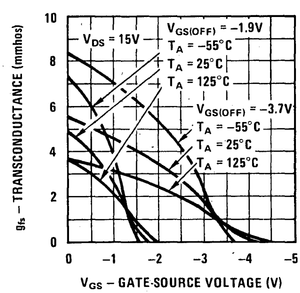
Common Drain-Source Characteristics



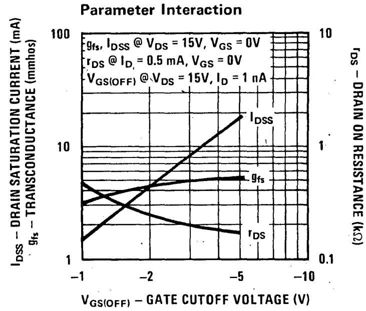
Transfer Characteristics



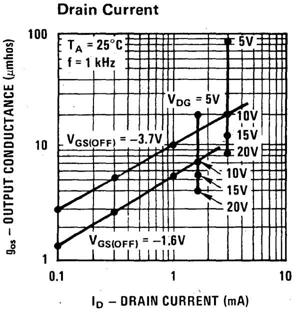
Transfer Characteristics



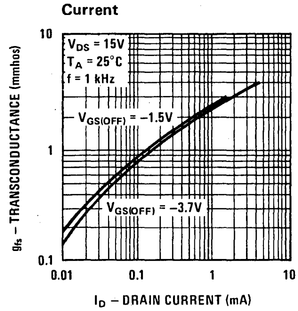
Parameter Interaction



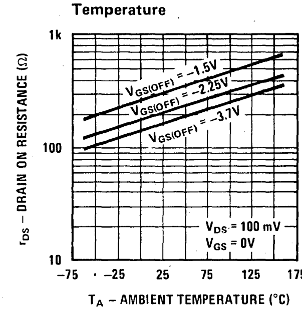
Output Conductance vs Drain Current



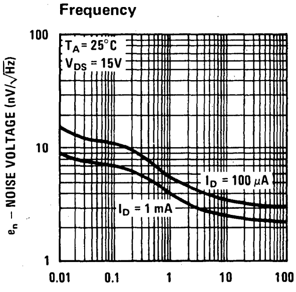
Transconductance vs Drain Current



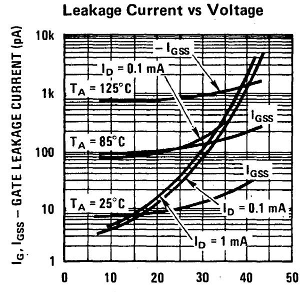
Channel Resistance vs Temperature



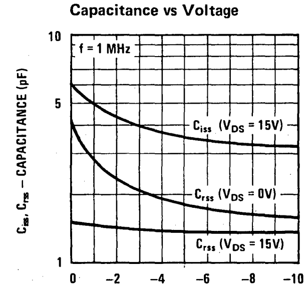
Noise Voltage vs Frequency



Leakage Current vs Voltage

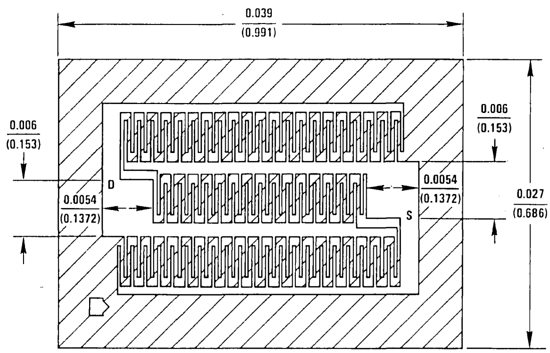


Capacitance vs Voltage



National Semiconductor

Process 58 N-Channel JFET



GATE IS ALSO BACKSIDE CONTACT

DESCRIPTION

Process 58 was developed for analog or digital switching applications where very low $r_{DS(ON)}$ is mandatory. Switching times are very fast and $R_{DS(ON)} C_{iss}$ time constant is low. The 6Ω typical on resistance is very useful in precision multiplex systems where switch resistance must be held to an absolute minimum. With r_{DS} increasing only 0.7%/ °C, accuracy is retained over a wide temperature excursion.

CHARACTERISTIC	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Gate-Source Breakdown Voltage	BV_{GSS}	V_{DS} = 0V, I_G = −1 μA	−25	−30		V
Zero Gate Voltage Drain Current	I_{DSS}	V_{DS} = 5V, V_{GS} = 0 Pulse Test	100	400	1000	mA
Reverse Gate Leakage	I_{GSS}	V_{GS} = −15V, V_{DS} = 0		−50	−500	pA
"ON" Resistance	r_{DS}	V_{DS} = 100 mV, V_{GS} = 0	3.0	6.0	20	Ω
Pinch Off Voltage	$V_{GS(OFF)}$	V_{DS} = 5V, I_D = 3 nA	−0.5	−5.0	−12	V
Drain "OFF" Current	$I_{D(OFF)}$	V_{DS} = 5V, V_{GS} = −10V		0.05	20	nA
Feedback Capacitance	C_{rss}	V_{DG} = 15V, I_D = 2 mA, f = 1 MHz		12	25	pF
Input Capacitance	C_{iss}	V_{DG} = 15V, I_D = 2 mA, f = 1 MHz		25	50	pF
Forward Transconductance	g_{fs}	V_{DG} = 10V, I_D = 2 mA		10		mmhos
Output Conductance	g_{os}	V_{DG} = 10V, I_D = 2 mA		100		μmhos
Noise Voltage	e_n	V_{DG} = 15V, I_D = 2 mA, f = 100 Hz		6.0		nV/√Hz

This process is available in the following device types. *Denotes preferred parts.

TO-52 (CASE 07)

*2N5432
*2N5433
*2N5434

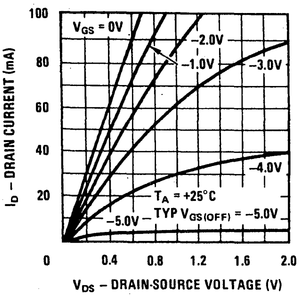
TO-92 (CASE 92)

*J108
*J109
*J110
PN5432
PN5433
PN5434

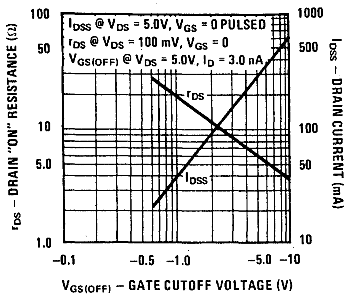
10

Process 58

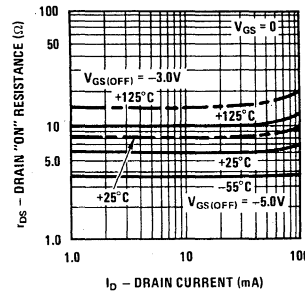
Common Drain-Source Characteristics



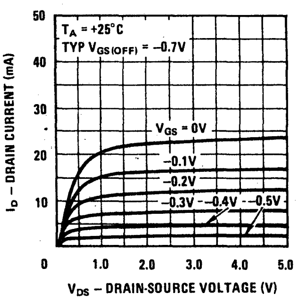
Parameter Interactions



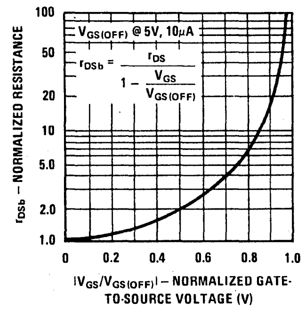
"ON" Resistance vs Drain Current



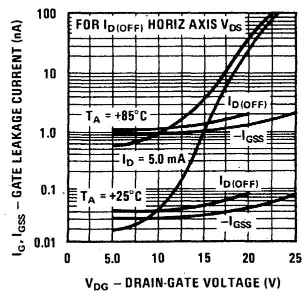
Common Drain-Source Characteristics



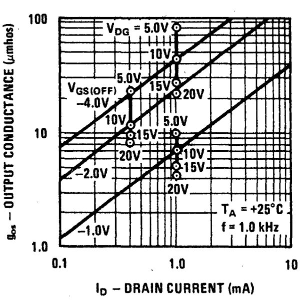
Normalized Drain Resistance vs Bias Voltage



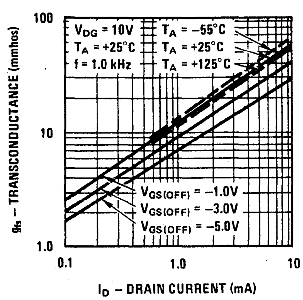
Leakage Current vs Voltage



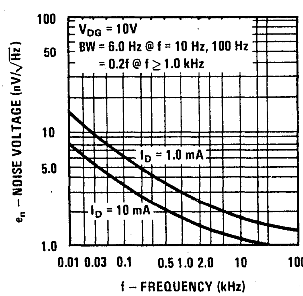
Output Conductance vs Drain Current



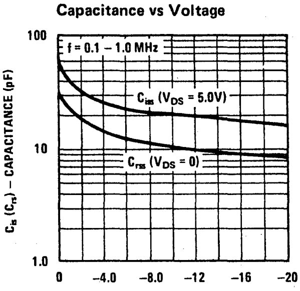
Transconductance vs Drain Current



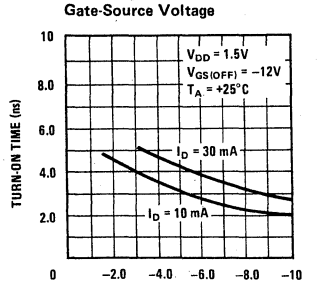
Noise Voltage vs Frequency



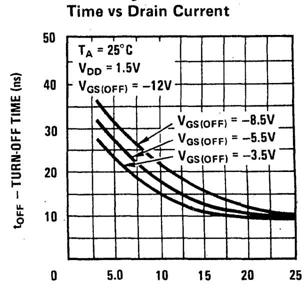
Capacitance vs Voltage



Switching Turn-On vs Gate-Source Voltage

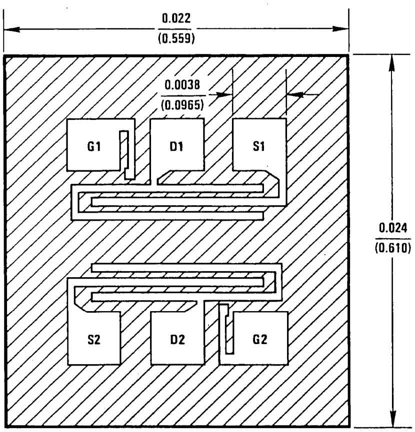


Switching Turn-On Time vs Drain Current



National Semiconductor

Process 83 N-Channel Monolithic Dual JFET



DESCRIPTION

Process 83 is a monolithic dual JFET with a diode isolated substrate. It is intended for operational amplifier input buffer applications. Processing results in low input bias current and virtually unmeasurable offset current. Likewise matching characteristics are virtually independent of operating current and voltage, providing design flexibility. Most GP 2N types are sorted from this family.

Characteristic	Parameter	Test Conditions	Min	Typ	Max	Units
Gate-Source Breakdown Voltage	BV_{GSS}	$V_{DS} = 0V, I_G = -1\ \mu A$	−50	−70		V
Zero Gate Voltage Drain Current	I_{DSS}	$V_{DS} = 15V, V_{GS} = 0$	0.5	2.5	8.0	mA
Forward Transconductance	g_{fs}	$V_{DS} = 15V, V_{GS} = 0$	1.0	2.5	5.0	mmho
Pinch Off Voltage	$V_{GS(OFF)}$	$V_{DS} = 15V, I_D = 1$ nA	−0.5	−2.0	−4.5	V
Gate Current	I_G	$V_{DG} = 20V, I_D = 0.2$ mA		3.0	50	pA
Forward Transconductance	g_{fs}	$V_{DG} = 15V, I_D = 0.2$ mA	600	850		μmhos
Output Conductance	g_{os}	$V_{DG} = 15V, I_D = 0.2$ mA		1.0	5.0	μmhos
ON Resistance	r_{DS}	$V_{DS} = 100$ mV, $V_{GS} = 0$		450		Ω
Noise Voltage	e_n	$V_{DG} = 15V, I_D = 0.2$ mA, f = 100 Hz		10	50	$nV/\sqrt{Hz}$
Differential Match	$\lvert V_{GS1} - V_{GS2} \rvert$	$V_{DG} = 15V, I_D = 0.2$ mA		7.0	25	mV
Differential Match	$\Delta V_{GS1\text{-}2}$	$V_{DG} = 15V, I_D = 0.2$ mA		10	50	μV/°C
Common-Mode Rejection	CMRR	$V_{DG} = 15V, I_D = 0.2$ mA	80	95		dB
Feedback Capacitance	C_{rs}	$V_{DG} = 15V, I_D = 0.2$ mA, f = 1 MHz		1.0	1.2	pF
Input Capacitance	C_{is}	$V_{DG} = 15V, I_D = 0.2$ mA, f = 1 MHz		3.4	4.0	pF

This process is available in the following device types. *Denotes preferred parts.

TO-71 (CASE 12)

2N3921	2N4085	2N5454
2N3922	2N5045	*2N5545
*2N3954	2N5046	*2N5546
*2N3954A	2N5047	*2N5547
*2N3955	*2N5196	U231
*2N3955A	*2N5197	U232
*2N3956	*2N5198	U233
*2N3957	*2N5199	U234
*2N3958	2N5452	U235
2N4084	2N5453	

8-Pin MiniDIP (CASE 60)

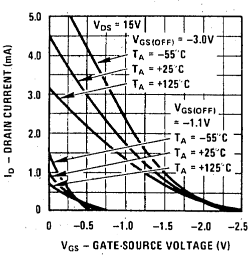
J410
J411
J412

8-Pin MiniDIP (CASE 67)

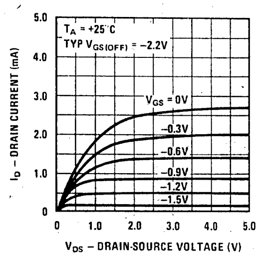
*NPD8301
*NPD8302
*NPD8303

Process 83

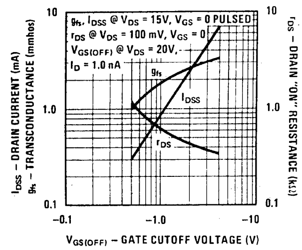
Transfer Characteristics



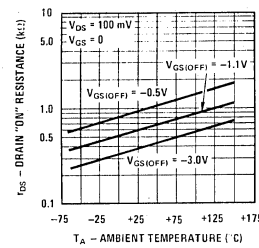
Common Drain-Source Characteristics



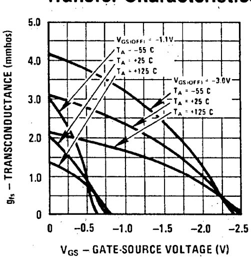
Parameter Interactions



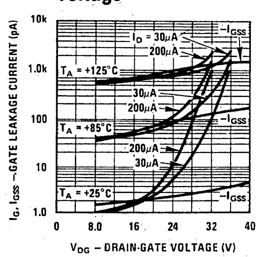
Channel Resistance vs Temperature



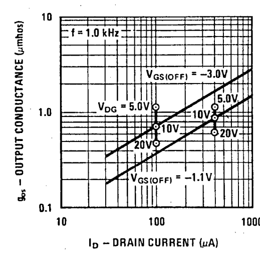
Transfer Characteristics



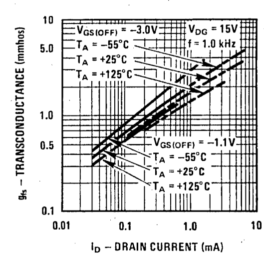
Leakage Current vs Voltage



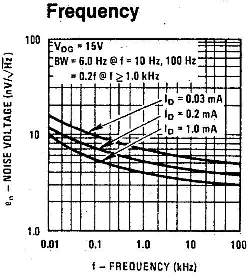
Output Conductance vs Drain Current



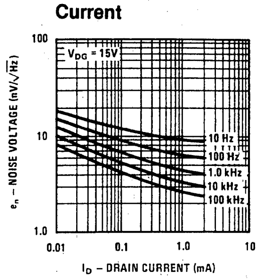
Transconductance vs Drain Current



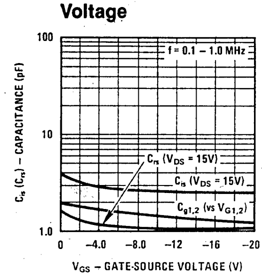
Noise Voltage vs Frequency



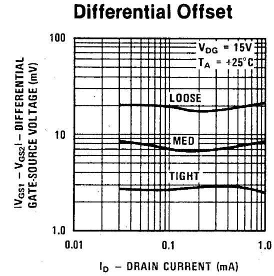
Noise Voltage vs Current



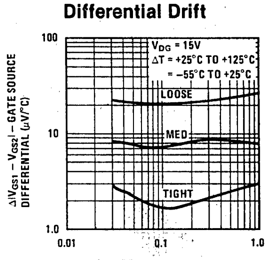
Capacitance vs Voltage



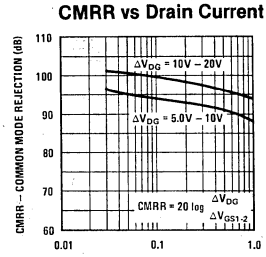
Differential Offset



Differential Drift

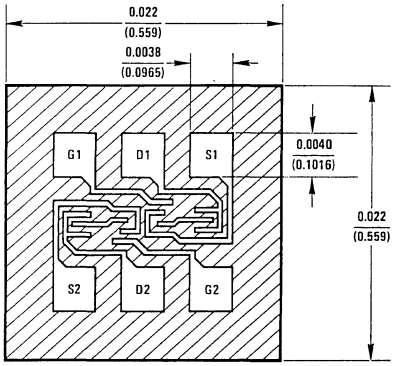


CMRR vs Drain Current



National Semiconductor

Process 84 N-Channel Monolithic Dual JFET



DESCRIPTION

Process 84 is a monolithic dual JFET with a diode isolated substrate. It is designed for the most critical operational amplifier input stages or electrometer single ended preamp. Ideal for medical applications and instrumentation inputs where subpicoamp inputs are important. Device design considered high CMRR, subpicoamp leakage over wide input swings, low capacitance, and tight match over wide current range.

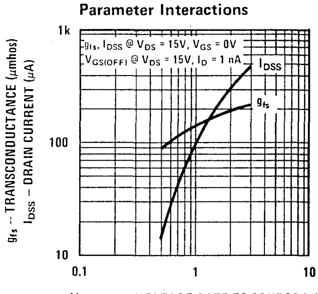
CHARACTERISTIC	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Gate-Source Breakdown Voltage	BV_{GSS}	$V_{DS} = 0V, I_G = -1\ \mu A$	−40	−60		V
Drain Saturation Current	I_{DSS}	$V_{DS} = 15V, V_{GS} = 0V$	20	300	1000	μA
Forward Transconductance	g_{fs}	$V_{DS} = 15V, V_{GS} = 0V$	90	180	300	μmhos
Forward Transconductance	g_{fs}	$V_{DS} = 15V, I_D = 30\ \mu A$	50	120	150	μmhos
Gate Cutoff Voltage	$V_{GS(OFF)}$	$V_{DS} = 15V, I_D = 1\ nA$	0.5	2	4.5	V
Reverse Gate Leakage Current	I_{GSS}	$V_{DS} = 0V, V_{GS} = -20V$		1	5	pA
Gate Leakage Current	I_G	$V_{DG} = 10V, I_D = 30\ \mu A$		0.5	3	pA
Feedback Capacitance	C_{rss}	$V_{DS} = 15V, V_{GS} = 0, f = 1\ MHz$		0.3	0.4	pF
Input Capacitance	C_{iss}	$V_{DS} = 15V, V_{GS} = 0, f = 1\ MHz$		2	3	pF
Noise Voltage	e_n	$V_{DS} = 15V, I_D = 30\ \mu A, f = 1\ kHz$		30	50	$nV/\sqrt{Hz}$
Noise Voltage	e_n	$V_{DS} = 15V, I_D = 30\ \mu A, f = 10\ Hz$		180		$nV/\sqrt{Hz}$
Output Conductance	g_{os}	$V_{DS} = 10V, I_D = 30\ \mu A$		0.01	0.1	μmhos
Differential Gate-Source Voltage	$\|V_{GS1} - V_{GS2}\|$	$V_{DS} = 10V, I_D = 30\ \mu A$		12	25	mV
Differential Gate-Source Voltage Drift	ΔV_{GS1-2}	$V_{DS} = 10V, I_D = 30\ \mu A$		10	50	μV/°C
Common-Mode Rejection Ratio	CMRR	$V_{DS} = 10V, I_D = 30\ \mu A$		112		dB

This process is available in the following device types. *Denotes preferred parts.

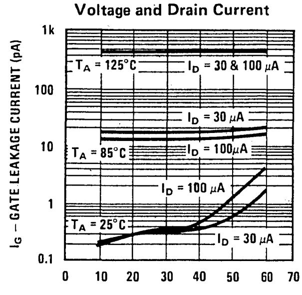
TO-78 (CASE 24)

2N5902 *2N5906
2N5903 *2N5907
2N5904 *2N5908
2N5905 *2N5909

Parameter Interactions

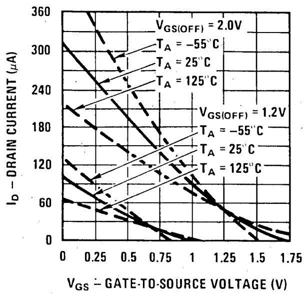


Leakage Current vs Voltage and Drain Current

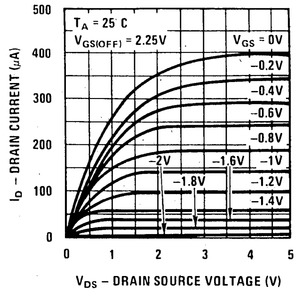


Process 84

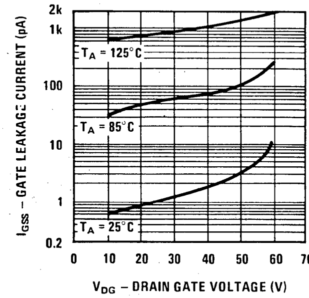
Transfer Characteristics



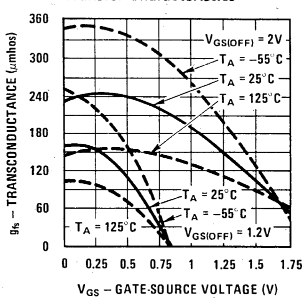
Common Drain-Source Characteristics



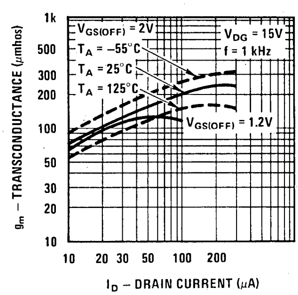
Leakage Current vs Voltage



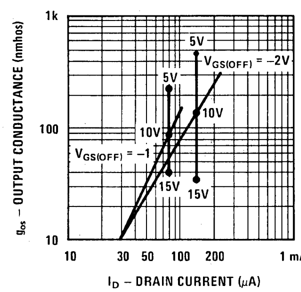
Transfer Characteristics



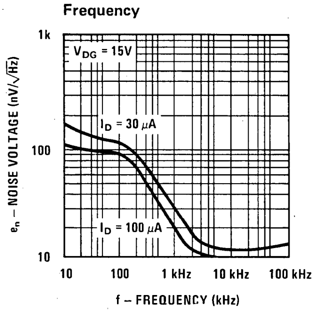
Transconductance vs Drain Current



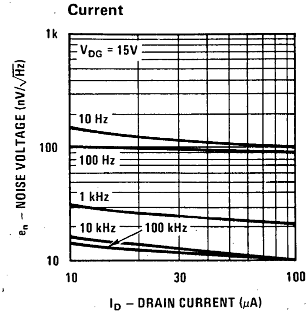
Output Conductance vs Drain Current



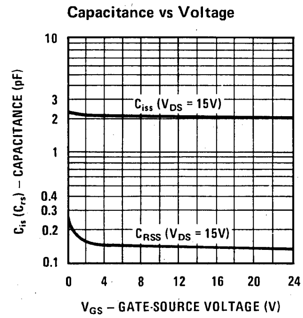
Noise Voltage vs Frequency



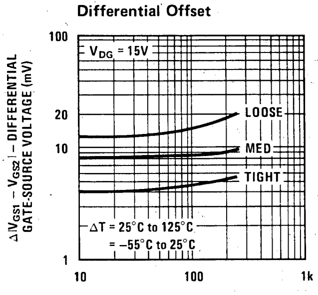
Noise Voltage vs Current



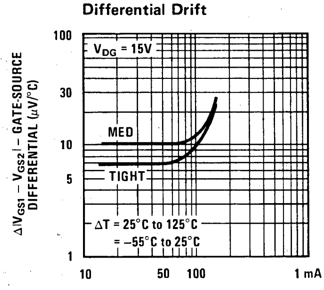
Capacitance vs Voltage



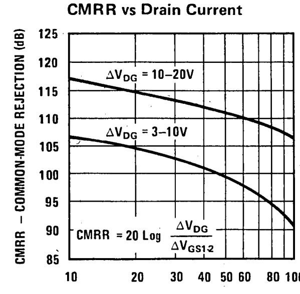
Differential Offset



Differential Drift

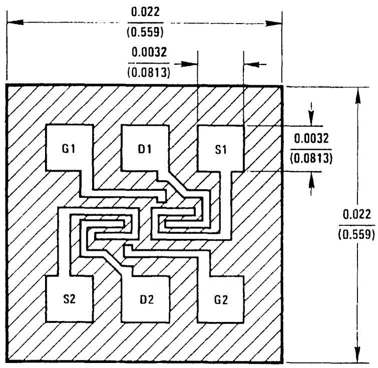


CMRR vs Drain Current



National Semiconductor

Process 86 N-Channel Monolithic Dual JFET



DESCRIPTION

Process 86 is a monolithic dual JFET with a diode isolated substrate. It is intended for critical amplifier input stages requiring low noise, sub picoamp bias currents and high gain. Exacting process control results in consistent parameter distribution with tight match and low drift.

This process is available in the following device types. *Denotes preferred parts.

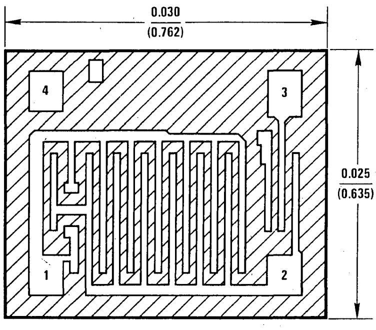
TO-78 (CASE 24)

U421
U422
U423
U424
U425
U426

PROCESS IN DEVELOPMENT

National Semiconductor

Process 87 Analog Switches



Note: Pin 4 is also backside gate

DESCRIPTION

The AM1000 series are junction FET integrated circuit analog switches. These devices commutate faster and with less voltage spiking than any other analog switch presently available. By comparison, discrete JFET switches require elaborate drive circuits to obtain reasonable performance for high toggle rates. Encapsulated in a four pin TO-72 package, these units require a minimum of circuit board area. Switching transients are greatly reduced by a monolithic integrated circuit process. The resulting analog switch device provides the following features:

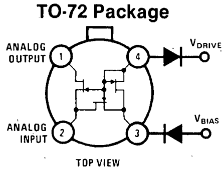
- Low ON Resistance — 30Ω
- High Analog Signal Frequency — 100 MHz
- High Toggle Rate — 4 MHz
- Low Leakage Current — 250 pA
- Large Analog Signal Swing — ± 15V
- Break Before Make Action

The AM1000 series of analog switches are particularly suitable for the following applications:

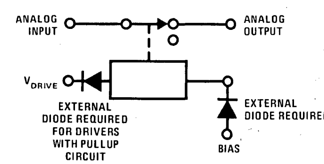
- High Speed Commutators
- Multiplexers
- Sample and Hold Circuits
- Reset Switching
- Video Switching

SCHEMATIC AND CONNECTION DIAGRAM

TO-72 Package

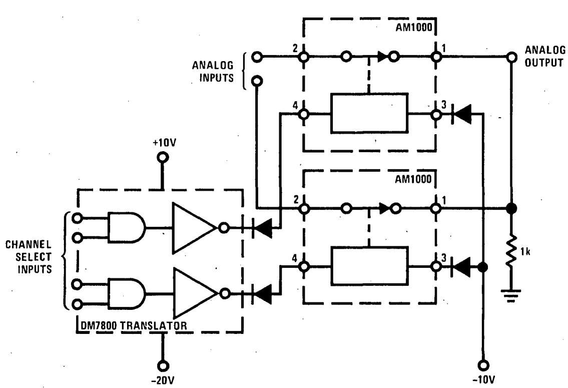


EQUIVALENT CIRCUIT

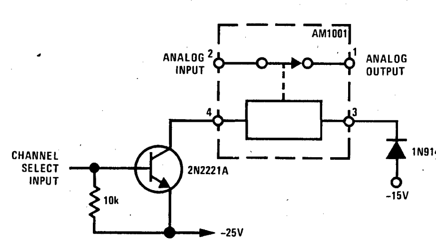


TYPICAL APPLICATIONS

± 10 Volt Swing Analog Switch 0.5% Accuracy



± 15 Volt Swing Analog Switch



TO-18 (CASE 25)

AM1000
AM1001
AM1002

ABSOLUTE MAXIMUM RATINGS

Process 87

	AM1001	AM1000 AM1002
V_{IN} (Note 1)	50V	40V
V_{OUT} (Note 1)	50V	40V
V_{DRIVE} (Note 1)	−50V	−40V
V_{BIAS} (Note 1)	50V	40V

Power Dissipation @ $T_A = 25°C$	300 mW
Linear Derating Factor	1.7 mW/°C
Power Dissipation @ $T_C = 125°C$	150 mW
Linear Derating Factor	6 mW/°C
Maximum Junction Operating Temperature	−55°C to +150°C
Storage Temperature	200°C
Lead Temperature (Soldering, 10 seconds)	300°C

ELECTRICAL CHARACTERISTICS

ON CHARACTERISTICS (Note 2)

Parameter	Conditions		Min	Typ	Max	Units
R_{ON}	$V_{DRIVE} = 15V$, $V_{BIAS} = -15V$ $I_{IN} = 1$ mA, $V_{OUT} = 0V$	AM1001	15	40	50	Ω
R_{ON}	$V_{DRIVE} = 10V$, $V_{BIAS} = -10V$ $I_{IN} = 1$ mA, $V_{OUT} = 0V$	AM1000	15	25	30	Ω
		AM1002	15	50	100	Ω

OFF CHARACTERISTICS

Parameter	Conditions	AM1000, AM1001			AM1002			Units
		Min	Typ	Max	Min	Typ	Max	
$I_{OUT(OFF)}$	$V_{DRIVE} = -20V$, $V_{BIAS} = -10V$ $V_{IN} = 10V$, $V_{OUT} = 10V$							
	$T_A = 25°C$		0.05	0.25		0.5	1	nA
	$T_A = 125°C$		0.025	0.25		0.2	1	μA
$I_{OUT(OFF)}$	$V_{DRIVE} = -20V$, $V_{BIAS} = -10V$ $V_{IN} = 10V$, $V_{OUT} = -10V$							
	$T_A = 25°C$		0.05	0.25		0.5	1	nA
	$T_A = 125°C$		0.05	0.25		0.2	1	μA

DRIVE CHARACTERISTICS (Note 3)

Parameter	Conditions	Min	Typ	Max	Units
I_{DRIVE} (Switch OFF)	$V_{DRIVE} = -20V$, $V_{BIAS} = -10V$ AM1000, AM1001, AM1002 $V_{IN} = \pm 10V$, $V_{OUT} = \pm 10V$		5	10	mA

SWITCHING CHARACTERISTICS

Parameter	Conditions	AM1000 Max	AM1001 Max	AM1002 Max	Units
t_{ON}	See Switching Time Test Circuit	100	150	200	ns
t_{OFF}		100	100	100	ns

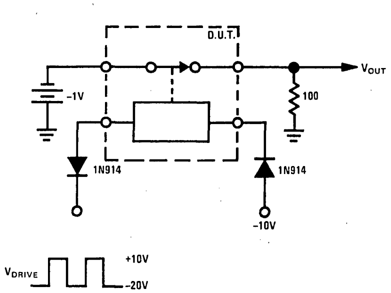
Note 1: The maximum voltage ratings may be applied between any pin or pins simultaneously. Power dissipation may be exceeded in some modes if the voltage pulse exceeds 10 ms. Normal operation will not cause excessive power dissipation even in a DC switching application.

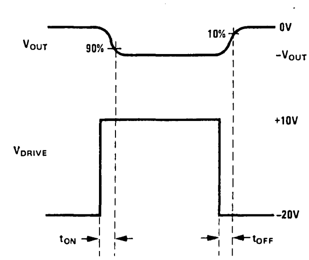
Note 2: All parameters are measured with external silicon diodes. See electrical connection diagram for proper diode placement.

Note 3: I_{BIAS} (Switch OFF) is equal to I_{DRIVE} (Switch OFF). $I_{(BIAS)}$ (Switch ON), is equal to external diode leakage.

Note 4: Rise and fall times of V_{DRIVE} shall be 15 ns maximum for switching time testing.

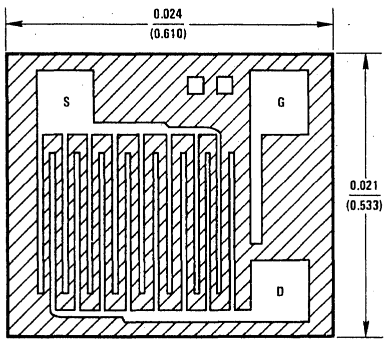
SWITCHING TIME TEST CIRCUIT AND WAVEFORMS





National Semiconductor

Process 88 P-Channel JFET



GATE IS ALSO BACKSIDE CONTACT

DESCRIPTION

Process 88 is designed primarily for electronic switching applications where a P channel device is desirable. Inherent zero offset voltage, low leakage and low $R_{DS(ON)}$ C_{iss} time constant make this device excellent for low level analog switching, sample and hold circuits and chopper stabilized amplifiers. This device is the complement to Process 51.

CHARACTERISTIC	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Gate-Source Breakdown Voltage	BV_{GSS}	V_{DS} = 0V, I_G = 1 μA	30	40		V
Zero Gate Voltage Drain Current	I_{DSS}	V_{DS} = −15V, V_{GS} = 0	−5.0	−30	−90	mA
Forward Transconductance	g_{fs}	V_{DS} = −15V, V_{GS} = 0	4.0	13	17	mmhos
Forward Transconductance	g_{fs}	V_{DG} = −15V, I_D = −2 mA		3.5		mmhos
Gate Leakage	I_{GSS}	V_{GS} = 20V, V_{DS} = 0		0.05	1.0	nA
"ON" Resistance	r_{DS}	V_{DS} = −100 mV, V_{GS} = 0	50	80	200	Ω
Pinch Off Voltage	$V_{GS(OFF)}$	V_{DS} = −15V, I_D = −1 nA	0.5	5.0	10	V
Drain "OFF" Current	$I_{D(OFF)}$	V_{DS} = −15V, V_{GS} = 10V		−0.05	−10	nA
Feedback Capacitance	C_{rss}	V_{DG} = −15V, I_D = −2 mA, f = 1 MHz		4.0	5.0	pF
Input Capacitance	C_{iss}	V_{DS} = −15V, I_D = −2 mA, f = 1 MHz		14	15	pF
Output Conductance	g_{os}	V_{DG} = −15V, I_D = −2 mA		100	300	μmhos
Noise Voltage	e_n	V_{DG} = −15V, I_D = −2 mA, f = 100 Hz		20		$nV/\sqrt{Hz}$

This process is available in the following device types. *Denotes preferred parts.

TO-18 (CASE 11)

2N2609
2N5018
2N5019
*2N5114
*2N5115
*2N5116

TO-92 (CASE 94)

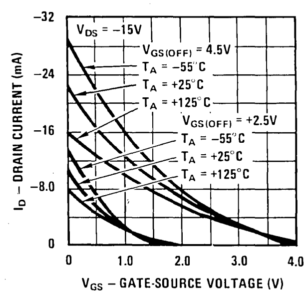
*J174
*J175
*J176
*J177
*J270
*J271

TO-92 (CASE 92)

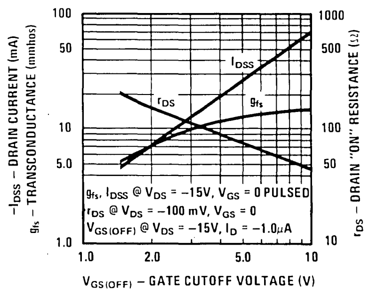
*P1086
*P1087

Process 88

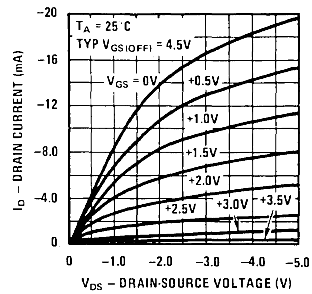
Transfer Characteristics



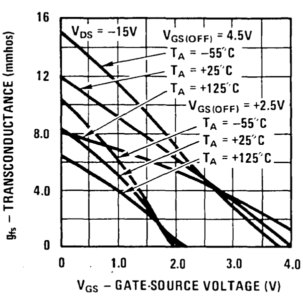
Parameter Interactions



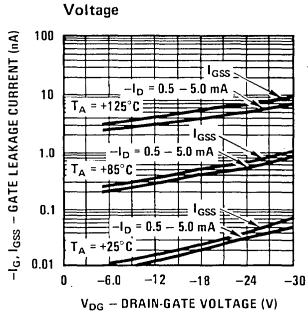
Common Drain-Source Characteristics



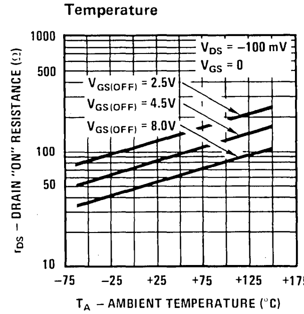
Transfer Characteristics



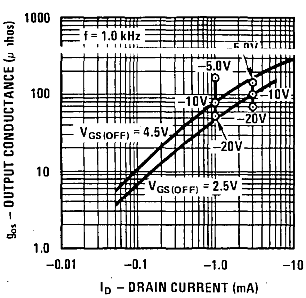
Leakage Current vs Voltage



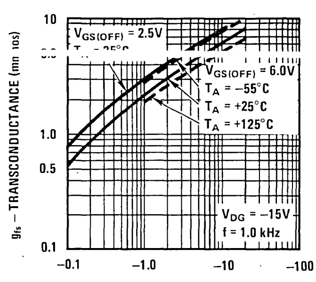
Channel Resistance vs Temperature



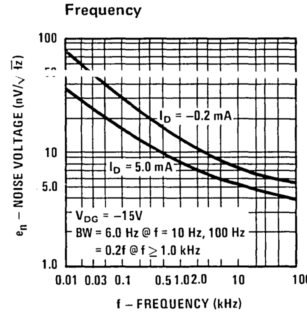
Output Conductance vs Drain Current



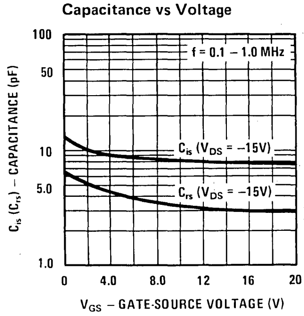
Transconductance vs Drain Current



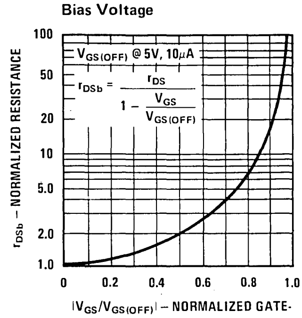
Noise Voltage vs Frequency



Capacitance vs Voltage

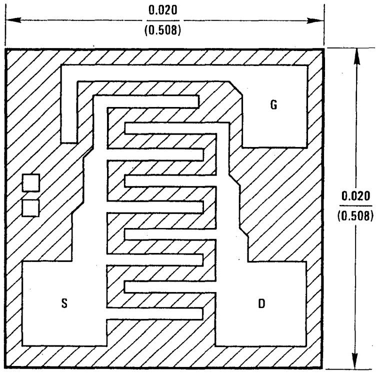


Normalized Drain Resistance vs Bias Voltage



National Semiconductor

Process 89 P-Channel JFET



DESCRIPTION

Process 89 is designed primarily for low level amplifier applications. This device is the complement to Process 52. Commonly used in voltage variable resistor applications.

CHARACTERISTIC	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Gate-Source Breakdown Voltage	BV_{GSS}	$V_{DS} = 0V$, $I_G = 1\ \mu A$	20	40		V
Zero Gate Voltage Drain Current	I_{DSS}	$V_{DS} = -15V$, $V_{GS} = 0$	−0.3	−4.0	−20	mA
Forward Transconductance	g_{fs}	$V_{DS} = -15V$, $V_{GS} = 0$	1.0	2.5	4.0	mmhos
Forward Transconductance	g_{fs}	$V_{DG} = -15V$, $I_D = -0.2$ mA		700		μmhos
Gate Leakage	I_{GSS}	$V_{GS} = 20V$, $V_{DS} = 0$		0.02	1.0	nA
Pinch Off Voltage	$V_{GS(OFF)}$	$V_{DS} = -15V$, $I_D = -1$ nA	0.5	3.0	9.0	V
Feedback Capacitance	C_{rss}	$V_{DG} = -15V$, $V_{GS} = 0$, f = 1 MHz		2.0	2.5	pF
Input Capacitance	C_{is}	$V_{DS} = -15V$, $I_D = -2$ mA, f = 1 MHz		7.0	8.5	pF
"ON" Resistance	r_{DS}	$V_{DS} = -100$ mV, $V_{GS} = 0$		450		Ω
Output Conductance	g_{os}	$V_{DG} = -15V$, $I_D = -0.2$ mA		5.0	15	μmhos
Noise Voltage	e_n	$V_{DG} = -15V$, $I_D = -0.2$ mA, f = 100 Hz		30		$nV/\sqrt{Hz}$

This process is available in the following device types. *Denotes preferred parts.

TO-18 (CASE 11)

2N2608
2N4381
2N5020
2N5021

TO-72 (CASE 23)

2N3329
2N3330
2N3331
2N3332

TO-92 (CASE 92)

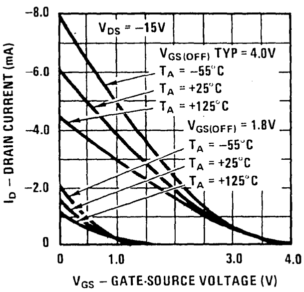
*2N5460
*2N5461
*2N5462
PN4342
PN4360
PN5033

TO-92 (CASE 94)

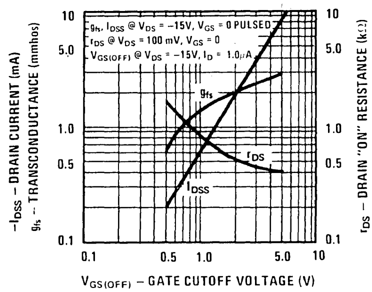
2N3820

Process 89

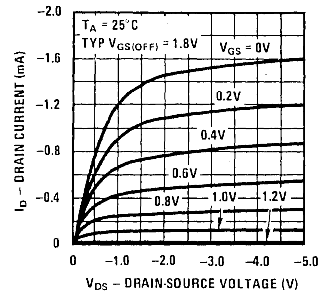
Transfer Characteristics



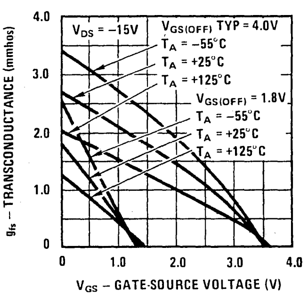
Parameter Interactions



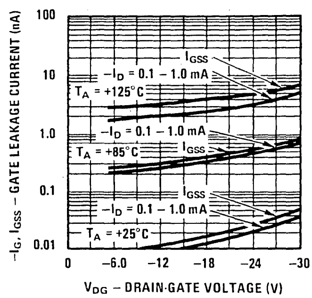
Common Drain-Source Characteristics



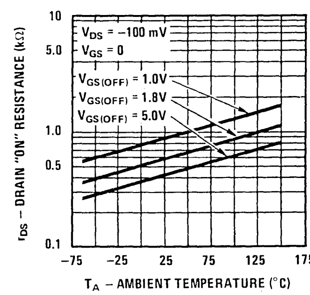
Transfer Characteristics



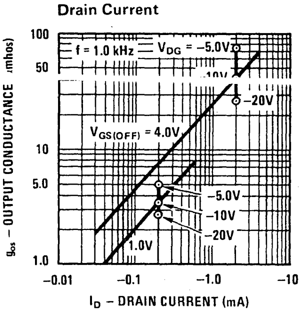
Leakage Current vs Voltage



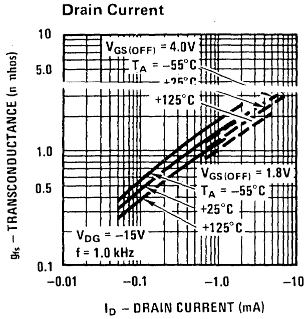
Channel Resistance vs Temperature



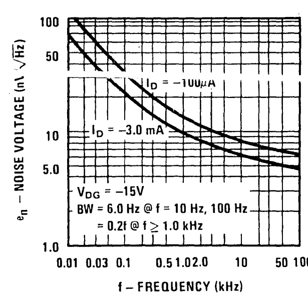
Output Conductance vs Drain Current



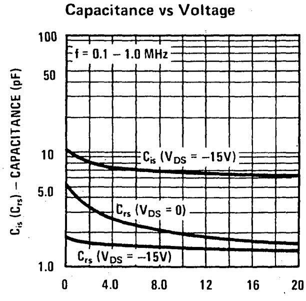
Transconductance vs Drain Current



Noise Voltage vs Frequency

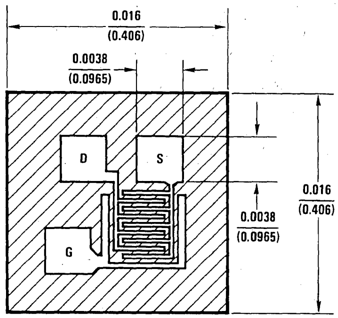


Capacitance vs Voltage



National Semiconductor

Process 90 N-Channel JFET



GATE IS ALSO BACKSIDE CONTACT

DESCRIPTION

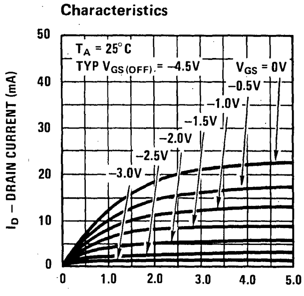
Process 90 is designed for VHF/UHF mixer/amplifier and applications where Process 50 is not adequate. Has sufficient gain and low noise, common gate configuration at 450 MHz, for sensitive receivers. The high transconductance and square law characteristics insures low crossmodulation and intermodulation distortions. Common-gate operation simplifies circuitry. Consider Process 92 for even higher performance.

CHARACTERISTIC	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Gate-Source Breakdown Voltage	BV_{GSS}	V_{DS} = 0V, I_G = −1 μA	−20	−30		V
Zero Gate Voltage Drain Current	I_{DSS}	V_{DS} = 10V, V_{GS} = 0	3	18	40	mA
Forward Transconductance	g_{fs}	V_{DS} = 10V, V_{GS} = 0	5.5	8.0	10	mmhos
Forward Transconductance	g_{fs}	V_{DS} = 10V, I_D = 5 mA	4.5	5.8		mmhos
Reverse Gate Current	I_{GSS}	V_{GS} = −15V, V_{DS} = 0		−5.0	−100	pA
"ON" Resistance	r_{DS}	V_{DS} = 100 mV, V_{GS} = 0		90		Ω
Pinch Off Voltage	$V_{GS(OFF)}$	V_{DS} = 10V, I_D = 1 nA	−1.5	−3.5	−6.0	V
Output Conductance	g_{os}	V_{DG} = 10V, I_D = 5 mA		45	100	μmhos
Feedback Capacitance	C_{rs}	V_{DG} = 10V, I_D = 5 mA		1.0	1.2	pF
Input Capacitance	C_{is}	V_{DG} = 10V, I_D = 5 mA		4.0	5.0	pF
Noise Voltage	e_n	V_{DG} = 10V, I_D = 5 mA, f = 100 Hz		13		nV/√Hz
Noise Figure	NF	V_{DG} = 10V, I_D = 5 mA, f = 450 MHz		3.0		dB
Power Gain	G_{pg} (CG)	V_{DG} = 10V, I_D = 5 mA, f = 450 MHz		11		dB

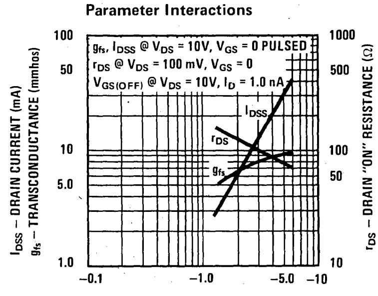
This process is available in the following device types. *Denotes preferred parts.

TO-52 (CASE 07)	TO-72 (CASE 29)	TO-92 (CASE 92)	TO-92 (CASE 97)
U312	*2N5397	J114	*2N5245
	2N5398	*J210	*2N5246
		*J211	*2N5247
		*J212	
		*J300	
		MPF256	

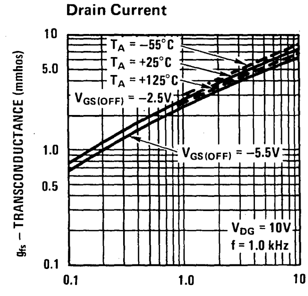
Common Drain-Source Characteristics



Parameter Interactions

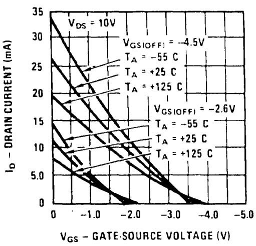


Transconductance vs Drain Current

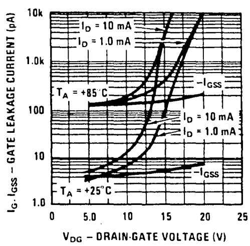


COMMON SOURCE | COMMON GATE

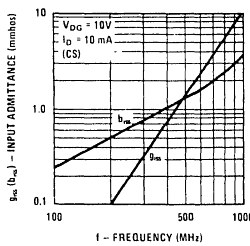
Transfer Characteristics



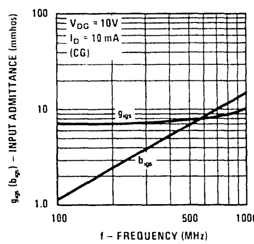
Leakage Current vs Voltage



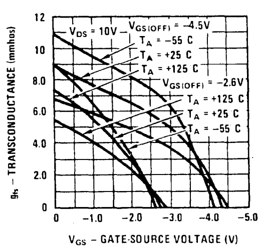
Input Admittance



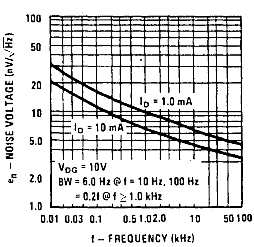
Input Admittance



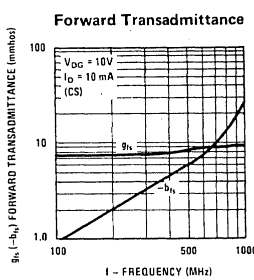
Transfer Characteristics



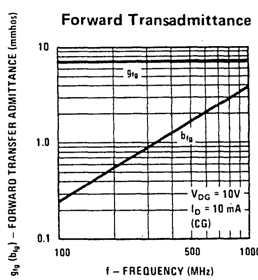
Noise Voltage vs Frequency



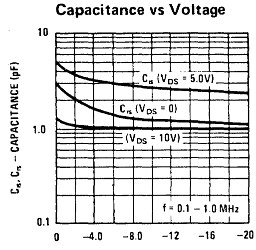
Forward Transadmittance



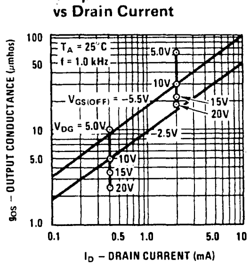
Forward Transadmittance



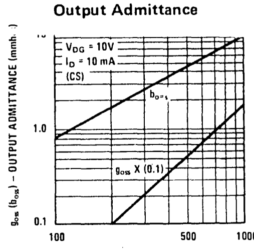
Capacitance vs Voltage



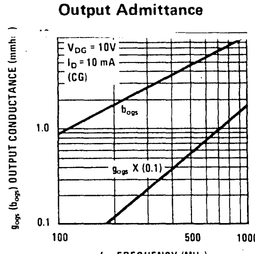
Output Conductance vs Drain Current



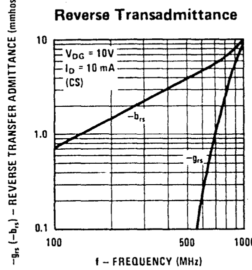
Output Admittance



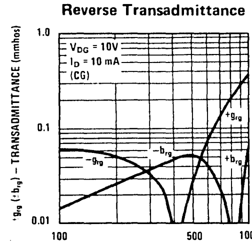
Output Admittance



Reverse Transadmittance

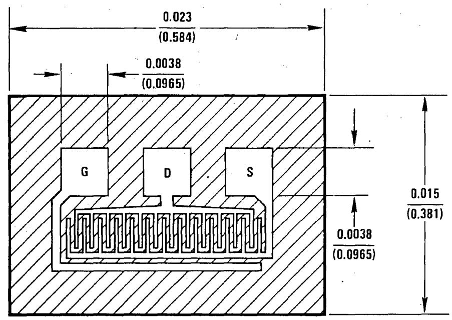


Reverse Transadmittance



National Semiconductor

Process 92 N-Channel JFET



GATE IS ALSO BACKSIDE CONTACT

DESCRIPTION

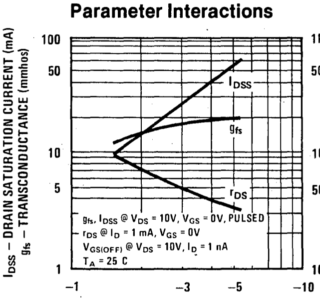
Process 92 is designed for VHF/UHF amplifier, oscillator, and mixer applications. As a common gate amplifier, 16 dB at 100 MHz and 12 dB at 450 MHz can be realized. Worst case 75 ohm input impedance provides ideal input match.

Characteristic	Parameter	Test Conditions	Min	Typ	Max	Units
Gate-Source Breakdown Voltage	BV_{GSS}	$V_{DS} = 0V, I_G = -1\ \mu A$	−20	−30		V
Zero Gate Voltage Drain Current	I_{DSS}	$V_{DS} = 10V, V_{GS} = 0$, Pulsed	10	38	80	mA
Forward Transconductance	g_{fs}	$V_{DS} = 10V, V_{GS} = 0$, Pulsed		19		mmhos
Forward Transconductance	g_{fs}	$V_{DG} = 10V, I_D = 10$ mA	10	13	18	mmhos
Reverse Gate Current	I_{GSS}	$V_{GS} = -15V, V_{DS} = 0$		−15	−100	pA
ON Resistance	r_{DS}	$V_{DS} = 100$ mV, $V_{GS} = 0$	35	45	80	Ω
Pinch Off Voltage	$V_{GS(OFF)}$	$V_{DS} = 10V, I_D = 1$ nA	−1.5	−4.0	−6.5	V
Output Conductance	g_{os}	$V_{DG} = 10V, I_D = 10$ mA		160	250	μmhos
Feedback Capacitance	C_{gd}	$V_{DG} = 10V, I_D = 10$ mA, f = 1 MHz		2.0	2.5	pF
Input Capacitance	C_{gs}	$V_{DG} = 10V, I_D = 10$ mA, f = 1 MHz		4.1	5.0	pF
Noise Voltage	e_n	$V_{DG} = 10V, I_D = 10$ mA, f = 100 Hz		6.0		$nV/\sqrt{Hz}$
Noise Figure	NF	$V_{DG} = 10V, I_D = 10$ mA, f = 450 MHz		3.0		dB
Power Gain	G_{pg}	$V_{DG} = 10V, I_D = 10$ mA, f = 450 MHz		12		dB

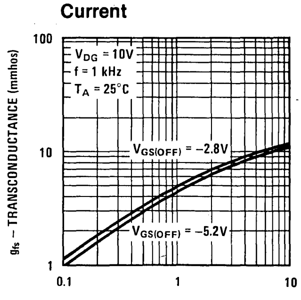
This process is available in the following device types. *Denotes preferred parts.

TO-52 (CASE 07)	TO-92 (CASE 92)
U308	J308
*U309	*J309
*U310	*J310

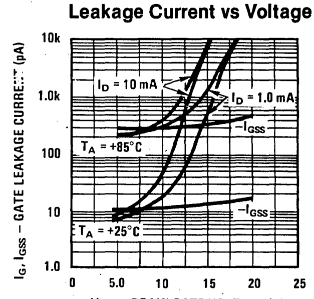
Parameter Interactions



Transconductance vs Drain Current

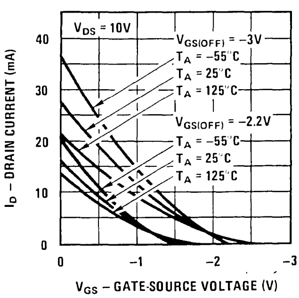


Leakage Current vs Voltage

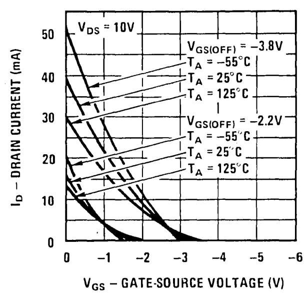


Process 92

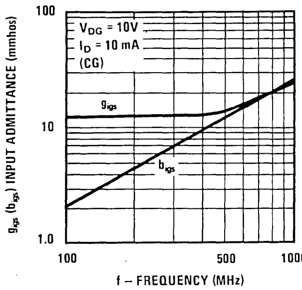
Transfer Characteristics



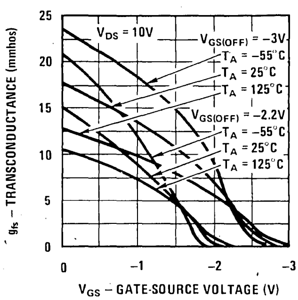
Transfer Characteristics



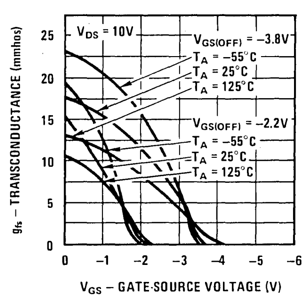
Input Admittance



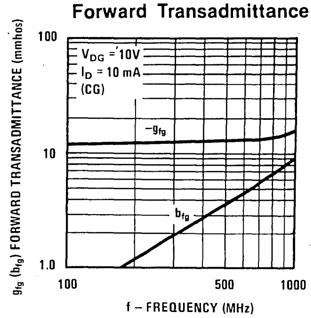
Transfer Characteristics



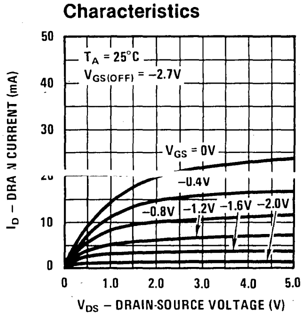
Transfer Characteristics



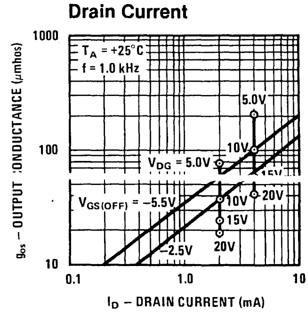
Forward Transadmittance



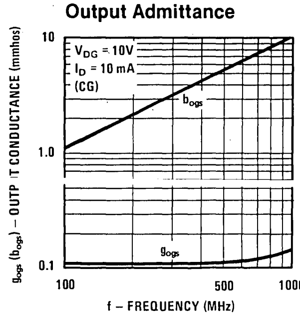
Common Drain-Source Characteristics



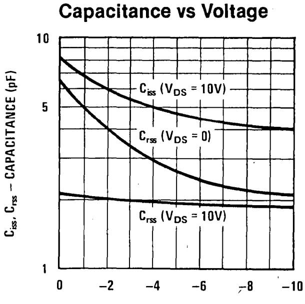
Output Conductance vs Drain Current



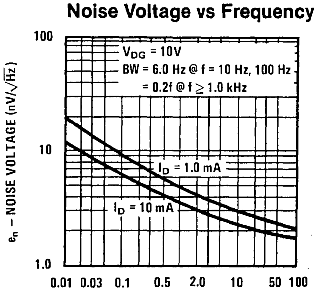
Output Admittance



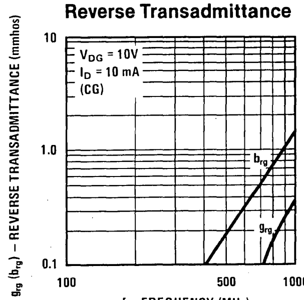
Capacitance vs Voltage



Noise Voltage vs Frequency

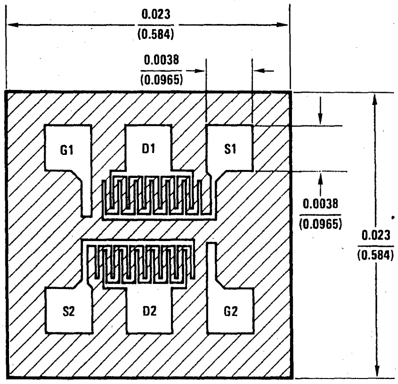


Reverse Transadmittance



National Semiconductor

Process 93 N-Channel Monolithic Dual JFET



DESCRIPTION

Process 93 is a monolithic dual JFET with a diode isolated substrate. It is intended for wide band, low noise, single ended video amplifier input stages, and high slew rate op amps. Monolithic structure eliminates thermal transient errors, and provides freedom to pick operating current and voltage.

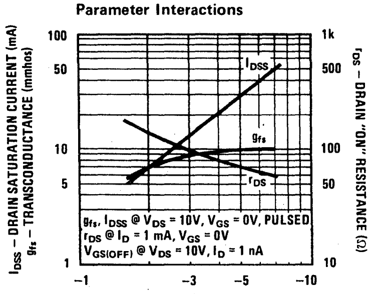
CHARACTERISTIC	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Gate-Source Breakdown Voltage	BV_{GSS}	V_{DS} = 0V, I_G = −1 μA	−25	−30		V
Zero Gate Voltage Drain Current	I_{DSS}	V_{DS} = 10V, V_{GS} = 0, Pulsed	3.0	18	40	mA
Forward Trans-conductance	g_{fs}	V_{DS} = 10V, V_{GS} = 0, Pulsed		8.0		mmhos
Forward Trans-conductance	g_{fs}	V_{DG} = 10V, I_D = 5 mA	5.0	6.0	10	mmhos
Output Conductance	g_{os}	V_{DG} = 10V, I_D = 5 mA		50	100	μmhos
Pinch Off Voltage	$V_{GS(OFF)}$	V_{DS} = 10V, I_D = 1 nA	−1.5	−3.5	−6.0	V
"ON" Resistance	r_{DS}	V_{DS} = 100 mV, V_{GS} = 0		100		Ω
Gate Current	I_G	V_{DG} = 10V, I_D = 5 mA		10	100	pA
Noise Voltage	e_n	V_{DG} = 10V, I_D = 5 mA, f = 100 Hz		9.0	30	nV/√Hz
Differential Match	$\|V_{GS1}-V_{GS2}\|$	V_{DG} = 10V, I_D = 5 mA		9.0	30	mV
Differential Match	ΔV_{GS1-2}	V_{DG} = 10V, I_D = 5 mA		15	40	μV/°C
Common Mode Rejection	CMRR	V_{DG} = 10V, I_D = 5 mA		90		dB
Feedback Capacitance	C_{rs}	V_{DG} = 10V, I_D = 5 mA, f = 1 MHz		1.0	1.2	pF
Input Capacitance	C_{is}	V_{DG} = 10V, I_D = 5 mA, f = 1 MHz		4.2	5.0	pF

This process is available in the following device types. *Denotes preferred parts.

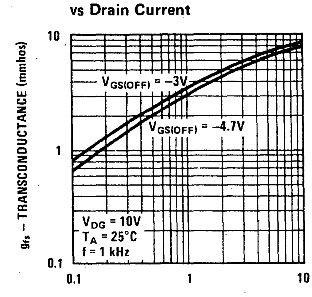
TO-78 (CASE 24)

*2N5911
*2N5912
U257

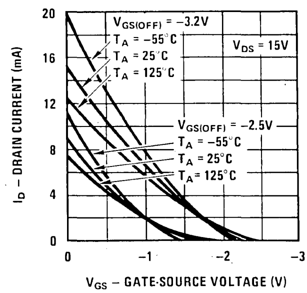
Parameter Interactions



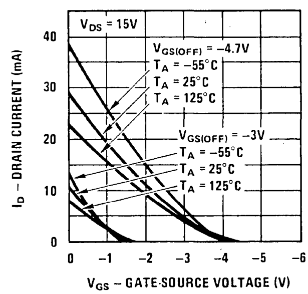
Transconductance vs Drain Current



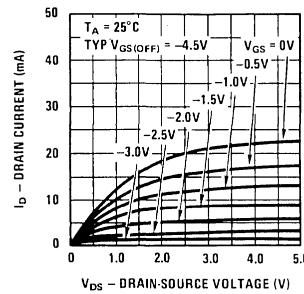
Transfer Characteristics



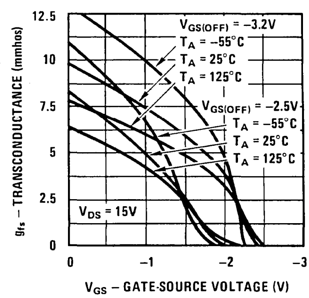
Transfer Characteristics



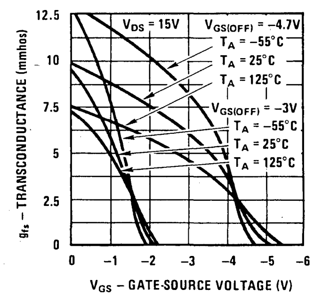
Common Drain-Source Characteristics



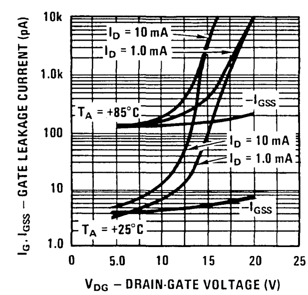
Transfer Characteristics



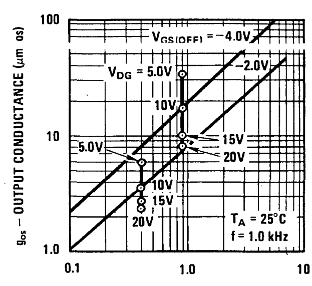
Transfer Characteristics



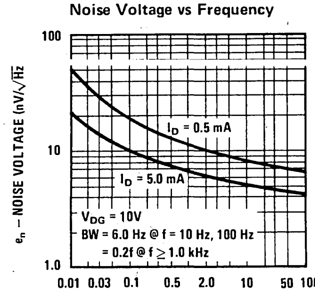
Leakage Current vs Voltage



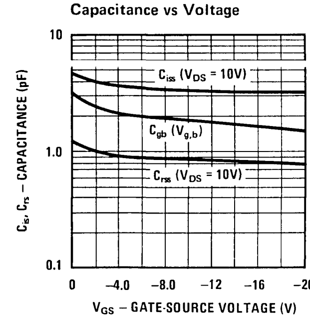
Output Conductance vs Drain Current



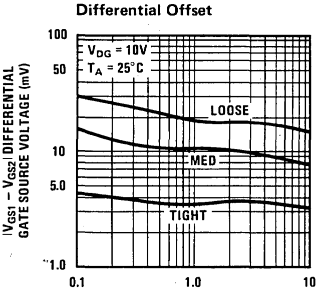
Noise Voltage vs Frequency



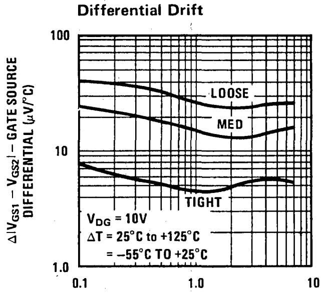
Capacitance vs Voltage



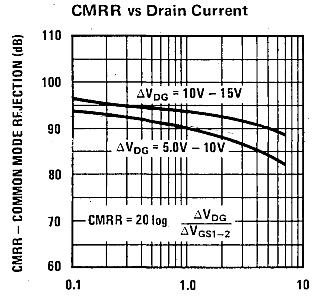
Differential Offset



Differential Drift

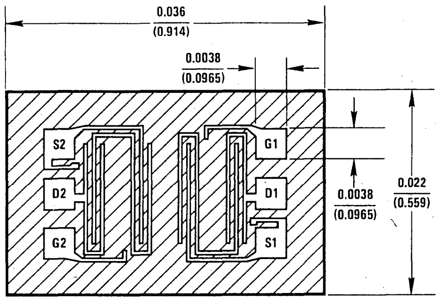


CMRR vs Drain Current



National Semiconductor

Process 94 N-Channel Monolithic Dual JFET



DESCRIPTION

Process 94 is a monolithic dual JFET. It is strictly intended for operational amplifier input buffer applications. Special processing results in extremely low input bias current and virtually unmeasureable offset current. It is important to note that the <5 pico ampere bias current is measured at 35 volts. Typical CMRR is 125 dB. Performance superior to electrometer tubes can be readily achieved with low offset voltage and almost zero long term drift.

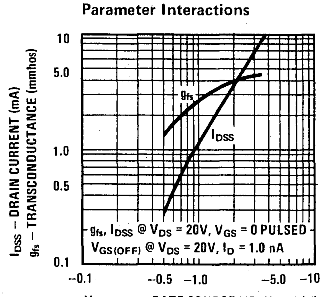
CHARACTERISTIC	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Gate-Source Breakdown Voltage	BV_{GSS}	V_{DS} = 0V, I_G = −1 μA	−40	−70		V
Zero Gate Voltage Drain Current	I_{DSS}	V_{DS} = 15V, V_{GS} = 0	0.5	3.0	10	mA
Forward Trans-conductance	g_{fs}	V_{DS} = 15V, V_{GS} = 0	1.5	3.5	7.0	mmho
Forward Trans-conductance	g_{fs}	V_{DG} = 15V, I_D = 0.2 mA	0.7	1.2	1.8	mmhos
Pinch Off Voltage	$V_{GS(OFF)}$	V_{DS} = 15V, I_D = 1 nA	−0.5	−2.0	−6.0	V
Gate Current	I_G	V_{DG} = 35V, I_D = 0.20 mA		2.0	15	pA
Feedback Capacitance	C_{rss}	V_{DS} = 15V, V_{GS} = 0, f = 1 MHz		0.01	0.02	pF
Input Capacitance	C_{iss}	V_{DS} = 15V, V_{GS} = 0, f = 1 MHz		4.0	5.0	pF
Noise Voltage	e_n	V_{DG} = 15V, I_D = 0.2 mA, f = 10 Hz		12	50	$nV/\sqrt{Hz}$
Output Conductance	g_{os}	V_{DG} = 15V, I_D = 0.2 mA		<0.1		μmhos
Differential Match	$\|V_{GS1}-V_{GS2}\|$	V_{DG} = 15V, I_D = 0.2 mA		5.0	25	mV
Differential Match	ΔV_{GS1-2}	V_{DG} = 15V, I_D = 0.2 mA		6.0	50	μV/°C
Common Mode Rejection	CMRR	V_{DG} = 15V, I_D = 0.2 mA		125		dB

This process is available in the following device types.
*Denotes preferred parts.

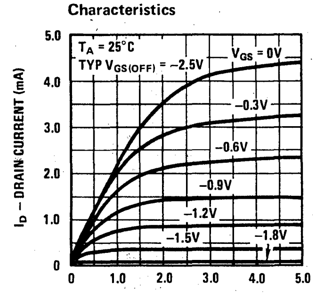
TO-71 (CASE 12)

*NDF9406
*NDF9407
*NDF9408
*NDF9409
*NDF9410

Parameter Interactions

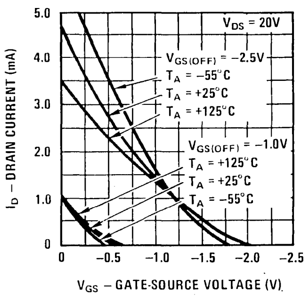


Common Drain-Source Characteristics

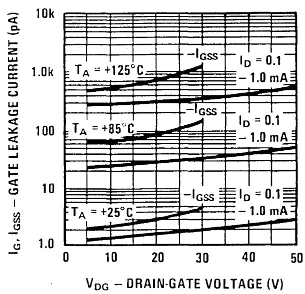


Process 94

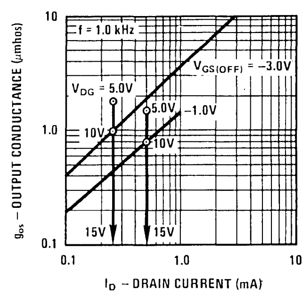
Transfer Characteristics



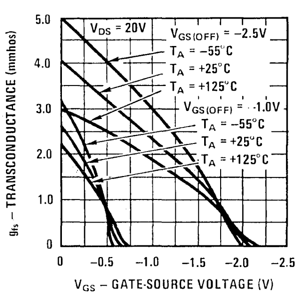
Leakage Current vs Voltage



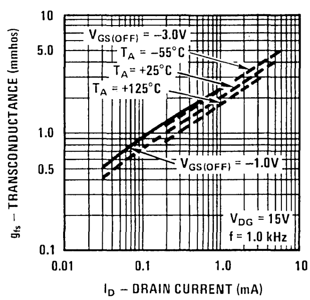
Output Conductance vs Drain Current



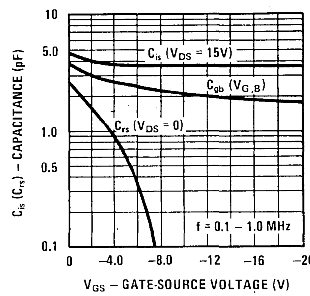
Transfer Characteristics



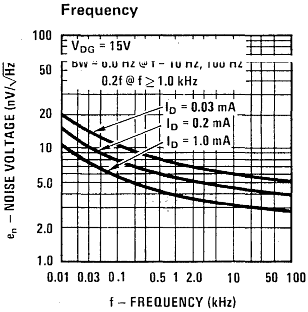
Transconductance vs Drain Current



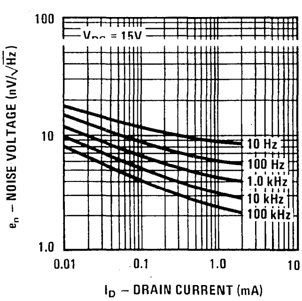
Capacitance vs Voltage



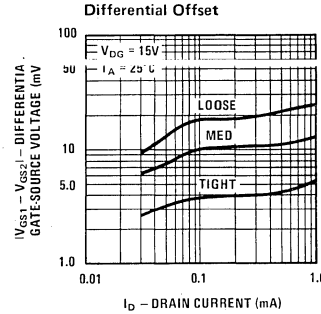
Noise Voltage vs Frequency



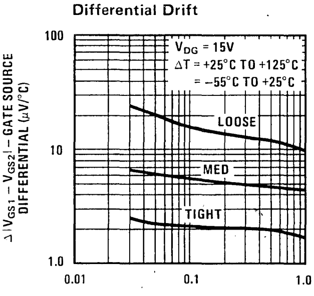
Noise Voltage vs Current



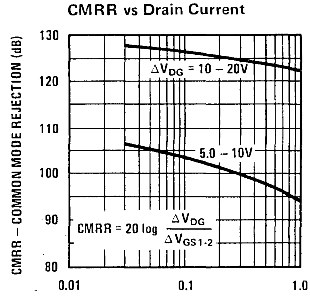
Differential Offset



Differential Drift

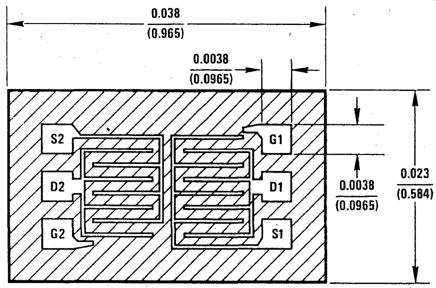


CMRR vs Drain Current



National Semiconductor

Process 95 N-Channel Monolithic Dual JFET



DESCRIPTION

Process 95 is a monolithic dual JFET with a diode isolated substrate. It is intended for operational amplifier input buffer applications. Processing results in low input bias current and virtually unmeasureable offset current. Low noise voltage and high CMRR for critical 1/f applications.

CHARACTERISTIC	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Gate-Source Breakdown Voltage	BV_{GSS}	V_{DS} = 0V, I_G = −1 μA	−40	−70		V
Zero Gate Voltage Drain Current	I_{DSS}	V_{DS} = 15V, V_{GS} = 0	0.5	3.0	8.0	mA
Forward Trans-conductance	g_{fs}	V_{DS} = 15V, V_{GS} = 0	1.0	2.5	4.0	mmhos
Forward Trans-conductance	g_{fs}	V_{DG} = 15V, I_D = 0.2 mA	0.5	0.7		mmhos
Gate Leakage	I_{GSS}	V_{GS} = −20V, V_{DS} = 0		−5.0	−100	pA
Pinch Off Voltage	$V_{GS(OFF)}$	V_{DS} = 15V, I_D = 1 nA	−0.5	−2.5	−4.0	V
Input Capacitance	C_{iss}	V_{DS} = 15V, V_{GS} = 0, f = 1 MHz		10	14	pF
Noise Voltage	e_n	V_{DS} = 15V, I_D = 0.2 mA, f = 10 Hz		8.0	30	$nV/\sqrt{Hz}$
Noise Voltage	e_n	V_{DS} = 15V, I_D = 0.2 mA, f = 100 Hz		6.0	10	$nV/\sqrt{Hz}$
Output Conductance	g_{os}	V_{DG} = 15V, I_D = 0.2 mA		0.3	1.0	μmhos
Feedback Capacitance	C_{rss}	V_{DS} = 15V, V_{GS} = 0, f = 1 MHz		3.5	5.0	pF
Differential Match	$\lvert V_{GS1}-V_{GS2} \rvert$	V_{DG} = 20V, I_D = 0.2 mA		6.0	25	mV
Differential Match	ΔV_{GS1-2}	V_{DG} = 20V, I_D = 0.2 mA		9.0	60	μV/°C
Common Mode Rejection	CMRR	V_{DG} = 20V, I_D = 0.2 mA	86	115		dB

This process is available in the following device types. *Denotes preferred parts.

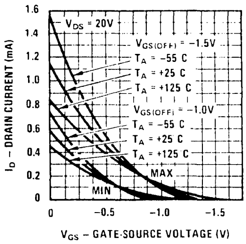
TO-71 (CASE 12)

2N5515	*2N5522
2N5516	*2N5523
2N5517	*2N5524
2N5518	*2N6483
2N5519	*2N6484
*2N5520	*2N6485
*2N5521	

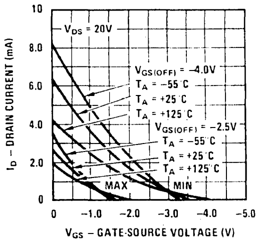
Process 95

Process 95

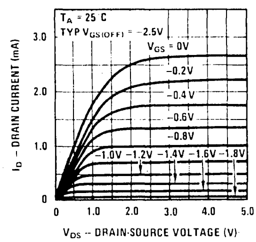
Transfer Characteristics



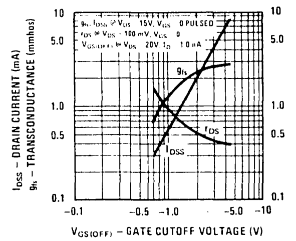
Transfer Characteristics



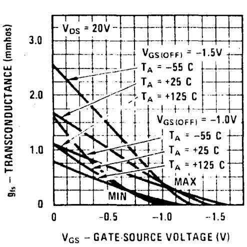
Common Drain-Source Characteristics



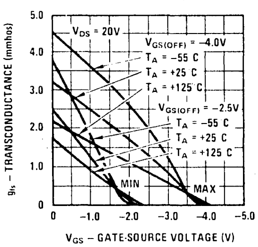
Parameter Interactions



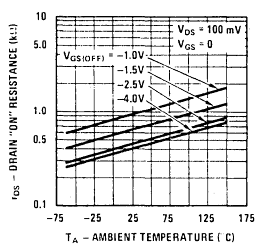
Transconductance Characteristics



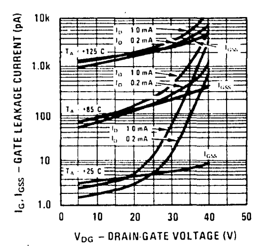
Transconductance Characteristics



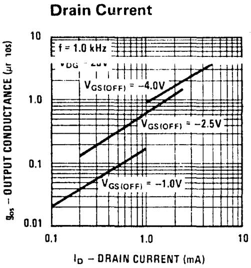
Channel Resistance vs Temperature



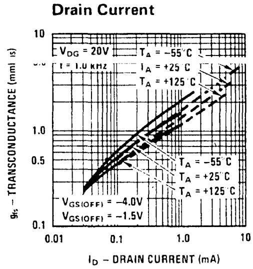
Leakage Current vs Voltage



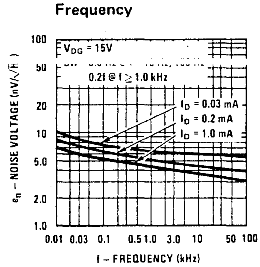
Output Conductance vs Drain Current



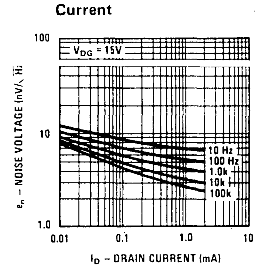
Transconductance vs Drain Current



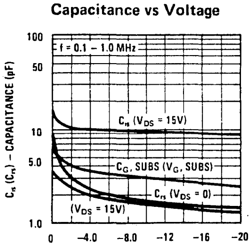
Noise Voltage vs Frequency



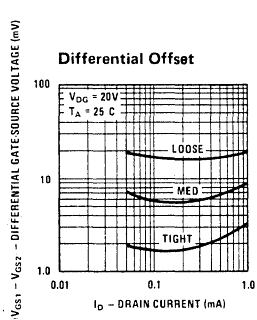
Noise Voltage vs Current



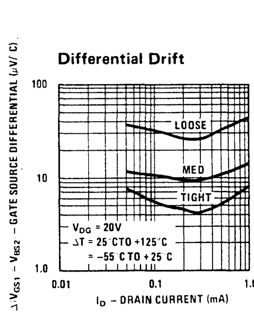
Capacitance vs Voltage



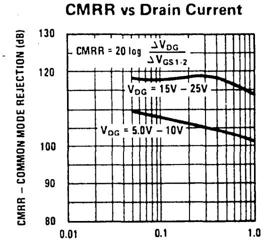
Differential Offset



Differential Drift

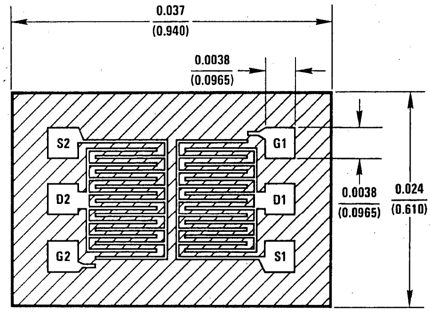


CMRR vs Drain Current



National Semiconductor

Process 96 N-Channel Monolithic Dual JFET



DESCRIPTION

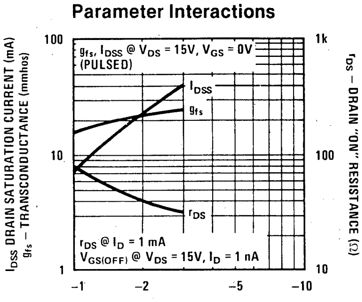
Process 96 is a monolithic dual JFET with a diode isolated substrate. It is intended for wide band, low noise, single ended video amplifier input stages. Also ideal for matched voltage variable resistor applications over 60 dB tracking range.

Characteristic	Parameter	Test Conditions	Min	Typ	Max	Units
Gate-Source Breakdown Voltage	BV_{GSS}	$V_{DS} = 0V$, $I_G = -1\ \mu A$	−40	−55		V
Zero Gate Voltage Drain Current	I_{DSS}	$V_{DS} = 15V$, $V_{GS} = 0$	5.0	15	30	mA
Forward Transconductance	g_{fs}	$V_{DS} = 15V$, $V_{GS} = 0$	9.0	18	30	mmhos
Forward Transconductance	g_{fs}	$V_{DG} = 15V$, $I_D = 2$ mA	7.5	9.0		mmhos
Output Conductance	g_{os}	$V_{DG} = 15V$, $I_D = 2$ mA		15	45	μmhos
Pinch Off Voltage	$V_{GS(OFF)}$	$V_{DS} = 15V$, $I_D = 1$ nA	−0.5	−1.8	−3.0	V
ON Resistance	r_{DS}	$V_{DS} = 100$ mV, $V_{GS} = 0$	35	70	120	Ω
Gate Current	I_{GSS}	$V_{GS} = -20V$, $V_{DS} = 0$		−8.0	−100	pA
Gate Current	I_G	$V_{DG} = 15V$, $I_D = 2$ mA		15	200	pA
Noise Voltage	e_n	$V_{DG} = 15V$, $I_D = 2$ mA, f = 100 Hz		4.5	10	$nV/\sqrt{Hz}$
Feedback Capacitance	C_{rs}	$V_{DG} = 15V$, $I_D = 2$ mA, f = 1 MHz		2.5	3.0	pF
Input Capacitance	C_{is}	$V_{DG} = 15V$, $I_D = 2$ mA, f = 1 MHz		10	12	pF
Differential Voltage	$\lvert V_{GS1} - V_{GS2} \rvert$	$V_{DG} = 15V$, $I_D = 2$ mA		8.0	25	mV
Differential Voltage	ΔV_{GS}	$V_{DG} = 15V$, $I_D = 2$ mA		9.0	50	μV/°C
Common-Mode Rejection	CMRR	$V_{DG} = 15V$, $I_D = 2$ mA	76	95		dB

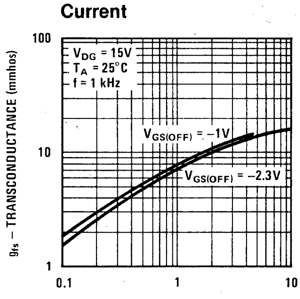
This process is available in the following device types. *Denotes preferred parts.

TO-71 (CASE 12)	8-Pin DIP (CASE 67)
*2N5564	*NPD5564
*2N5565	*NPD5565
*2N5566	*NPD5566

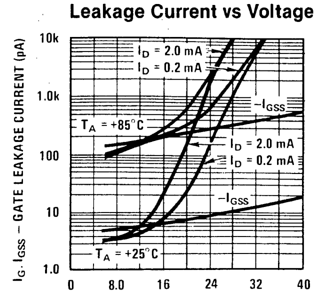
Parameter Interactions



Transconductance vs Drain Current

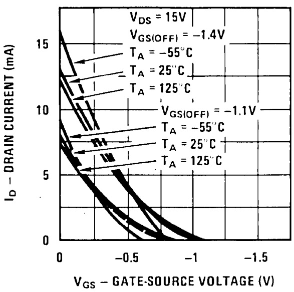


Leakage Current vs Voltage

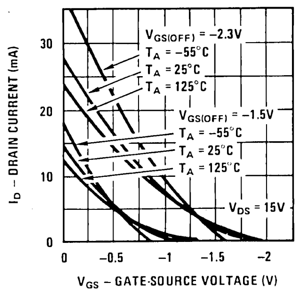


Process 96

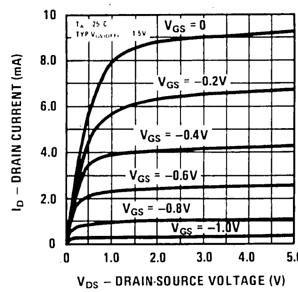
Transfer Characteristics



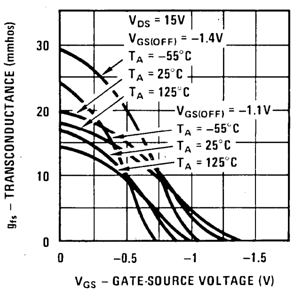
Transfer Characteristics



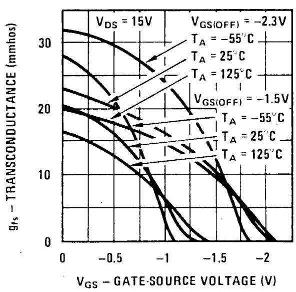
Common Drain-Source Characteristics



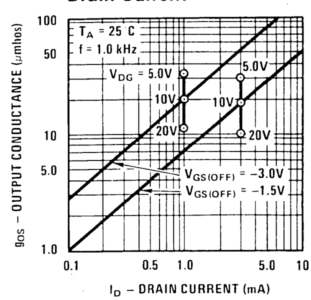
Transfer Characteristics



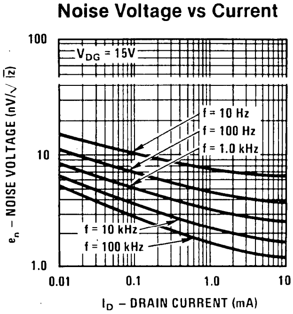
Transfer Characteristics



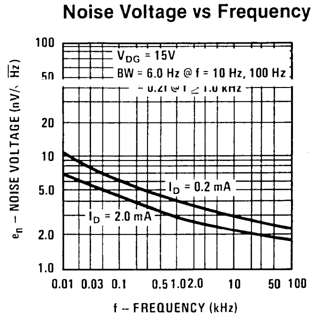
Output Conductance vs Drain Current



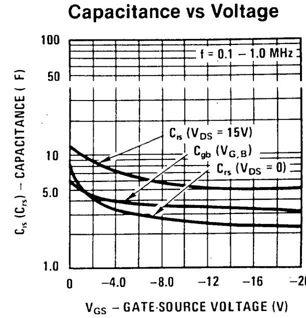
Noise Voltage vs Current



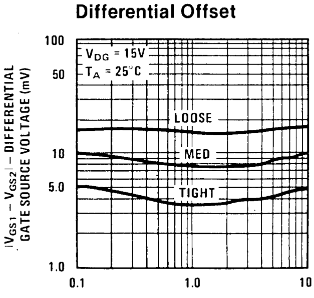
Noise Voltage vs Frequency



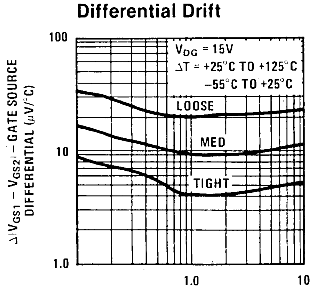
Capacitance vs Voltage



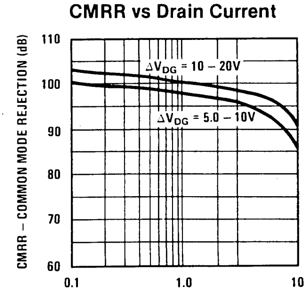
Differential Offset



Differential Drift

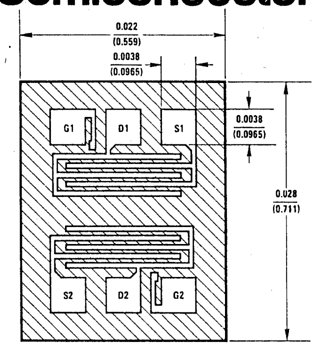


CMRR vs Drain Current



National Semiconductor

Process 98 N-Channel JFET



DESCRIPTION

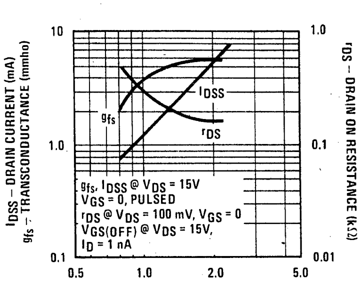
Process 98 is a high gain, general purpose, monolithic dual JFET with a diode isolated substrate. It is intended for amplifier input stages requiring high gain, low noise and low offset drift over temperature. Strict processing controls result in low input bias currents and virtually immeasurable offset currents. Matching characteristics are essentially independent of operating current and voltage.

Characteristic	Parameter	Test Conditions	Min	Typ	Max	Units
Gate-Source Breakdown Voltage	BV_{GSS}	$V_{DS} = 0V$, $I_G = -1\ \mu A$	50	75		V
Gate Leakage Current	I_{GSS}	$V_{GS} = -30V$, $V_{DS} = 0V$		2.0	100	pA
Pinch-off Voltage	$V_{GS(OFF)}$	$V_{DS} = 15V$, $I_D = 1$ nA	0.5	1.3	3.0	V
Zero Gate Voltage Drain Current	I_{DSS}	$V_{DS} = 10V$, $V_{GS} = 0$	0.5	1.8	10	mA
Forward Transconductance	g_{fs}	$V_{DS} = 10V$, $V_{GS} = 0$	2.0	4.5	7.0	mmhos
Output Conductance	g_{os}	$V_{DS} = 10V$, $V_{GS} = 0$		8.0	20	μmhos
Forward Transconductance	g_{fs}	$V_{DG} = 15V$, $I_D = 200\ \mu A$	1.0	1.4	1.8	mmhos
Output Conductance	g_{os}	$V_{DG} = 15V$, $I_D = 200\ \mu A$		1.3	2.0	μmhos
Differential Offset Voltage	V_{OS}	$V_{DG} = 10V$, $I_D = 200\ \mu A$		10	40	mV
Feedback Capacitance	C_{rss}	$V_{DG} = 15V$, $I_D = 200\ \mu A$, f = 1 MHz		1.7	3.0	pF
Input Capacitance	C_{iss}	$V_{DG} = 15V$, $I_D = 200\ \mu A$, f = 1 MHz		6.0	8.0	pF
Noise Voltage	e_n	$V_{DS} = 15V$, $I_D = 200\ \mu A$, f = 10 Hz		8.0	50	$nV/\sqrt{Hz}$
Common Mode Rejection Ratio	CMRR	$V_{DG} = 5V - 10V$, $I_D = 200\ \mu A$	90	108		dB

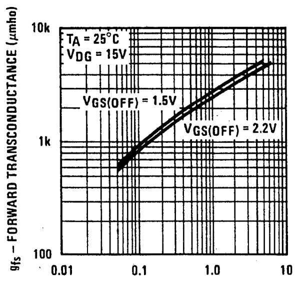
This process is available in the following device types.

TO-71 (CASE 12)			8-PIN DIP (CASE 60)	
2N5561	U401	U404	J401	J404
2N5562	U402	U405	J402	J405
2N5563	U403	U406	J403	J406

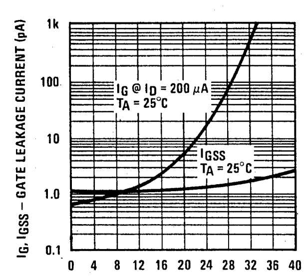
Parameter Interactions



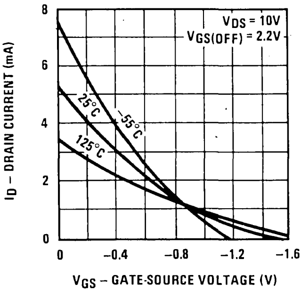
Forward Transconductance vs Drain Current



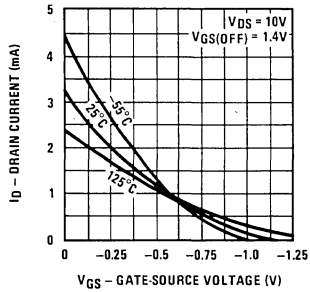
Gate Leakage Current vs Voltage



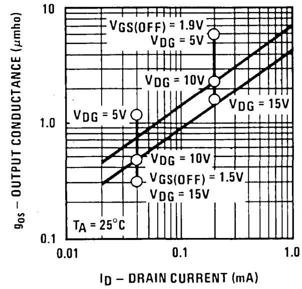
Transfer Characteristics



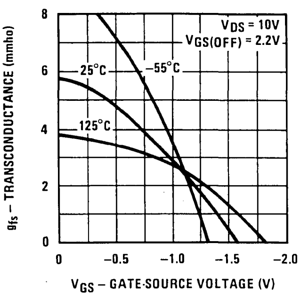
Transfer Characteristics



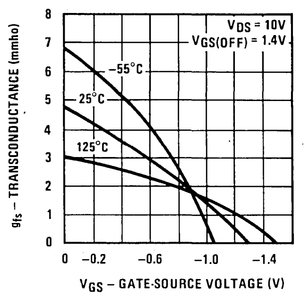
Output Conductance vs Drain Current



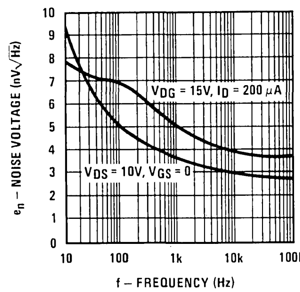
Transconductance vs Gate Source Voltage



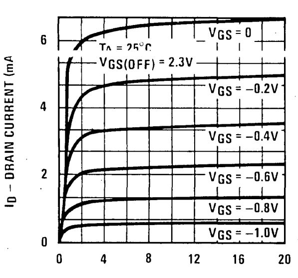
Transconductance vs Gate Source Voltage



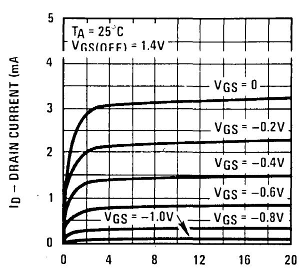
Noise Voltage vs Frequency



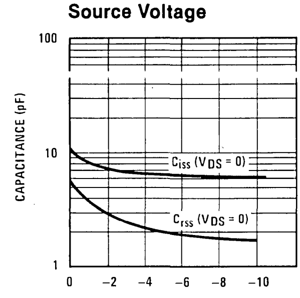
Common Drain Source Characteristics



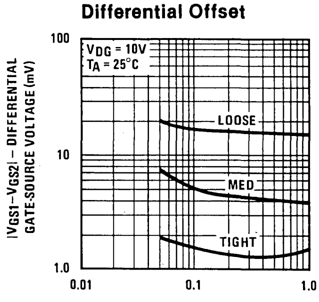
Common Drain Source Characteristics



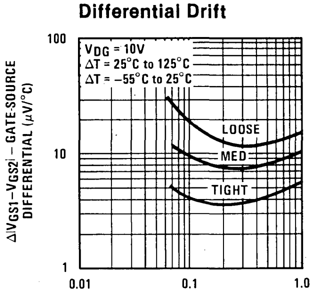
Capacitance vs Gate Source Voltage



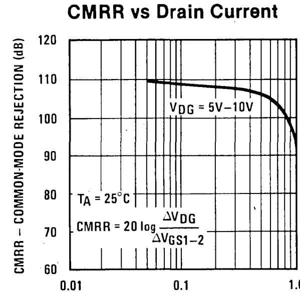
Differential Offset



Differential Drift



CMRR vs Drain Current



Section 11

JFET Applications Notes

11

FET Application Guide

National Semiconductor manufactures a broad line of silicon Junction Field Effect Transistors (JFETs). National's JFETs provide excellent performance in many areas such as RF amplifiers, analog switching, low input current amplifiers, ultra low noise amplifiers and outstanding matched duals for operational amplifiers input applications.

The following chart is a guide to enable the user to determine what parameters are important in each application.

APPLICATIONS AND THEIR PARAMETERS LISTED IN APPROXIMATE ORDER OF IMPORTANCE

LOW FREQUENCY AMPLIFIER	SOURCE FOLLOWER	ELECTROMETER AMPLIFIERS	LOW DRIFT AMPLIFIER	LOW NOISE AMPLIFIER	HIGH FREQUENCY AMPLIFIER	OSCILLATOR	DIFFERENTIAL AMPLIFIER	ANALOG AND DIGITAL SWITCHING
Y_{fs}	Y_{fs}	I_G	I_{DZ}	e_n	$Re(Y_{fs})$	Y_{fs}	$\|V_{GS1}-V_{GS2}\|$	$r_{DS(ON)}$
I_{DSS}	I_G	Y_{fs}	Y_{fs} @ I_{DZ}	I_G, i_n	$Re(Y_{is})$	I_{DSS}	$\frac{\Delta\|V_{GS1}-V_{GS2}\|}{\Delta T}$	$I_{D(OFF)}$
$V_{GS(OFF)}$	C_{rss}	I_{DZ}	V_{GS} @ I_{DZ}	Y_{fs}	NF	C_{rss}		C_{iss}
C_{iss}	C_{iss}	e_n	I_G	I_{DSS}	C_{rss}	C_{iss}	$\|I_{G1}-I_{G2}\|$	C_{rss}
C_{rss}	I_{DSS}	g_{os}	BV_{GSS}	$V_{GS(OFF)}$	$Re(Y_{os})$	$V_{GS(OFF)}$	I_G	$V_{GS(OFF)}$
e_n	$V_{GS(OFF)}$				I_{DSS}	BV_{GSS}	Y_{fs}	BV_{GSS}
BV_{GSS}	BV_{GSS}				$V_{GS(OFF)}$		Y_{fs1}/Y_{fs2}	
							$\|Y_{os1}-Y_{os2}\|$	
							CMRR	
							$V_{GS(OFF)}$	

JFET Parameter Relationships

$$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_{GS(OFF)}}\right)^2$$

Variation of drain current with gate bias. Square low transfer characteristic.

$$V_{GS(OFF)} = \frac{2\,I_{DSS}}{g_{fso}}$$

Gate-source cutoff voltage in terms of I_{DSS} and g_{fso}.

$$V_{GS} = V_{GS(OFF)}\left(1-\left(\frac{I_D}{I_{DSS}}\right)^{1/2}\right)$$

Gate-source voltage in terms of operating current I_D, I_{DSS}, and $V_{GS(OFF)}$.

$$g_{fso} = K\,\frac{I_{DSS}}{V_{GS(OFF)}}$$

Transconductance at zero gate voltage in terms of I_{DSS} and $V_{GS(off)}$. K = 1.1 to 2.5. Typically 2 for N-channel JFETs.

$$g_{fs} = g_{fso}\left(1 - \frac{V_{GS}}{V_{GS(OFF)}}\right)$$

Variation in transconductance with gate bias.

$$g_{fs} = g_{fso}\sqrt{I_D/I_{DSS}}$$

Variation in transconductance with drain current.

$$r_{DS} \approx \frac{1}{g_{fs}}$$

Relationship between r_{DS} and g_{fs} in the triode region (i.e., $V_{DS} < V_{GS(OFF)}$).

$$r_{DS} \approx \frac{r_{DS(0)}}{1 - \frac{V_{GS}}{V_{GS(OFF)}}}$$

Variation of drain resistance with gate bias in terms zero bias resistance (r_{DSO}) and $V_{GS(OFF)}$.

$$r_{DS} \approx \frac{K\,V_{GS(OFF)}^2}{I_{DSS}(V_{GS(OFF)} - V_{GS})}$$

$K = 0.5 - 0.9$

Variation of drain resistance in terms of V_{GS}, and $V_{GS(OFF)}$ I_{DSS}.

$$r_{DST} \approx r_{DS} @ 25^\circ C\,(1 + 0.007\,(\Delta T))$$

Variation of ON resistance as a function of temperature.

Monolithic Dual FETs vs 2-Chip Dual FETs

National Semiconductor
February 1977

INTRODUCTION

Recent development of a monolithic dual field effect transistor offers distinct cost and design advantages to the dual FET user. In this article, we have pointed out these advantages on the basis of a comparison that was made between this monolithic structure and the 2-chip dual. Finally, a typical application for this FET is presented and evaluated.

GENERAL

Most dual junction field effect transistors that are available today are the 2-chip variety. These devices are costly to manufacture since 2 FET dice must be found whose electrical characteristics match under a certain set of bias conditions. Finding the matched pair is accomplished by collecting data on a large number of dice and, with the help of a computer, selecting 2 devices with identical characteristics. The result is a device that exhibits excellent end point temperature characteristics as long as the device is operated at the manufacturer specified bias conditions. If the device is operated at bias levels that deviate too much from the specified conditions, the user runs the risk of poor temperature performance. In addition, even if the device is biased at the specific drain current operating point, there still is no guarantee that the device will be well behaved between the temperature end points.

The dual FET manufacturer and user alike would like to have a device that exhibits none of the above shortcomings. They are:

1. High price because of the device selection process.
2. Poor temperature tracking characteristics at currents other than those specified by the manufacturer.
3. Non-linear temperature tracking performance between the manufacturer specified end point temperatures.

Recent development by National of a complete family of dual monolithic junction FETs has virtually eliminated these shortcomings. National's family of duals include general purpose dual process 83 (2N3954 family, etc.), ultra low leakage dual process 84 (2N5902 family), wideband RF dual process 93 (2N5911 family) instrumentation dual cascode process 94 (NDF9400 family), low noise dual process 95 (2N5515 family), and wideband chopper switch dual process 96 (2N5564 family). While some other companies now manufacture a monolithic dual g.p. FET similar to process 83, National is the only "all monolithic" dual manufacturer. These devices (illustrated in *Figures 1a and 1b*) consist of 2 diffused isolated junction FETs.

Since these devices are a monolithic structure, no dice matching is required. The FETs that make up the chip either match or they don't. Units that do not match are eliminated at the wafer sorting stage. Units that do match and exhibit good temperature tracking characteristics at a specified drain current also exhibit good temperature tracking characteristics at other current levels. These devices display a linear differential gate-source voltage relationship to temperature. This is very important to the operational amplifier manufacturer since it allows him to temperature compensate the dual FET or his entire amplifier circuit for that matter, such that temperature coefficient approaching 0 $\mu V/^{\circ}C$ can be achieved. Since the 2 FETs that constitute the monolithic structure are isolated by a diffusion, they can be operated at different potentials without device interaction.

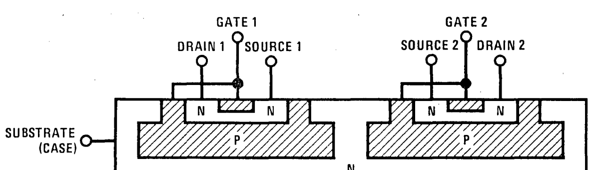


FIGURE 1a. Typical National Monolithic Dual FET Cross-Section (Processes 83, 84, 93, 94, 95 and 96)

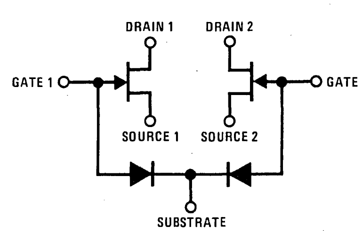


FIGURE 1b. Process 83 Equivalent Schematic

FET TEMPERATURE CHARACTERISTICS

Figure 2 illustrates the gate-source voltage temperature dependence of the 2N3954 (process 83) monolithic FET for various values of drain current. All junction FETs, whether they are monolithic or single unit construction, display similar characteristics. It becomes evident, upon examination of this curve, that a very slight change in drain current results in a substantial change in the gate to source voltage (V_{GS}) temperature coefficient.

Figure 3 illustrates just exactly how dependent V_{GS} is to an I_D change. For example, suppose a device is biased at a 200 μA drain current level. The curve in *Figure 4*, tells us that a drain current change of 1 μA will change the V_{GS} temperature coefficient 4.8 μV/°C. The fact the V_{GS} temperature coefficient can be predictably changed by slight variation in the drain current implies that the differential gate-source voltage temperature coefficient can be adjusted to 0 μV/°C by a change in drain current. A 2-chip dual FET can also be temperature compensated in this same manner provided the differential V_{GS} temperature coefficient is constant at all temperatures. The temperature coefficient of the 2-chip system, however, is generally not constant over the specified operating temperature range, therefore making this type compensation difficult. To illustrate the difference in temperature tracking characteristics of the 2-chip FET and the monolithic structure, a 2-chip 10 μV/°C device was compared to a monolithic 10 μV/°C unit.

Figure 4 illustrates how the differential gate-source voltage of the monolithic 2N3954 varies as a function temperature. When both sides of the dual FET are biased at the specified 200 μA ±0.01% level, the temperature coefficient is constant and equal to 6 μV/°C. Also, note that the ΔV_{GS} temperature coefficient can be adjusted to about 0 μV/°C by increasing the drain current in Q2 to 201 μA. The ΔV_{GS} temperature characteristics for the 2-chip 2N3954 dual FET are shown in *Figure 5*. Note that if one employs the definition of temperature coefficient set forth in Note 1, the ΔV_{GS} temperature coefficient of the 2-chip dual is about 8 μV/°C. It would be impossible, however, to achieve a temperature coefficient much better than 8 μV/°C (by adjusting the drain current), because the ΔV_{GS} temperature curve is non-linear.

The ΔV_{GS} temperature characteristics of the 2-chip dual and the monolithic dual were then measured at 500 μA of drain current. The results are illustrated in *Figures 6 and 7*.

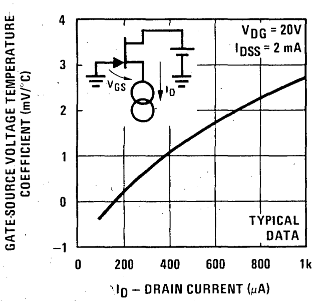


FIGURE 2. Gate-Source Voltage Temperature Coefficient vs Drain Current (Single Device)

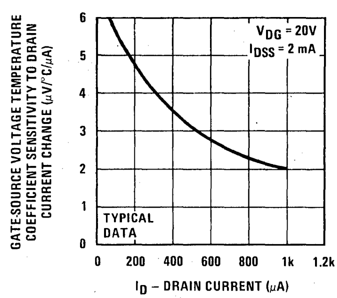


FIGURE 3. Gate-Source Voltage Temperature Coefficient Sensitivity to Drain Current Change vs Drain Current (Single Device)

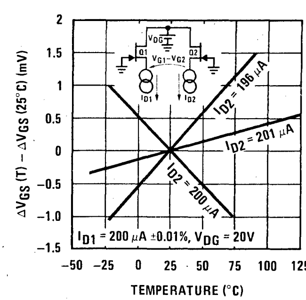


FIGURE 4. Differential Gate-Source Voltage vs Temperature for a Typical Monolithic Dual JFET

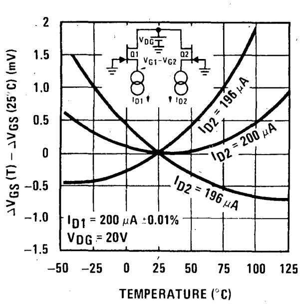


FIGURE 5. Differential Gate-Source Voltage vs Temperature for a Typical 2-Chip Dual JFET (10 μV/°C Unit)

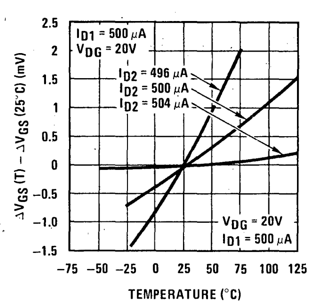


FIGURE 6. Differential Gate-Source Voltage vs Temperature for the Same Monolithic JFET in *Figure 4*, Only the Drain Current has been Changed to 500 μA.

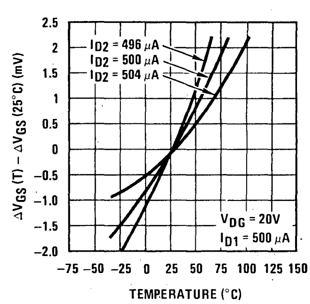


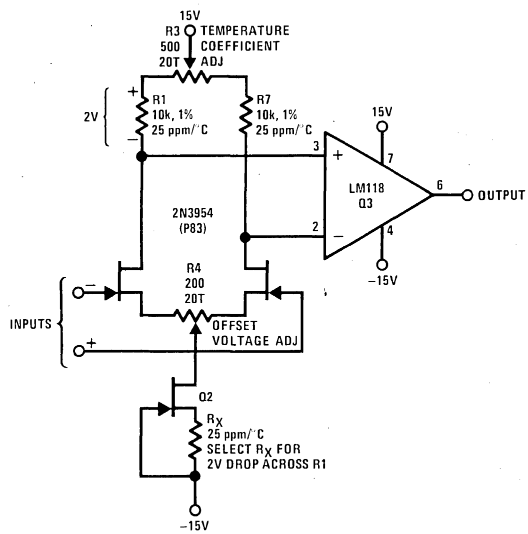
FIGURE 7. Differential Gate-Source Voltage vs Temperature for the Same 2-Chip Dual FET in *Figure 5*, Only the Drain Current is 500 μA

Note that the monolithic dual exhibits good ΔV_{GS} temperature characteristics (TC $\simeq$ 15 μV/°C) while the 2-chip dual has a temperature coefficient greater than 50 μV/°C. The data displayed in *Figures 4–7* is for 2 specific devices; however, it is representative of the data accumulated on a number of process 83 and 2-chip dual FETs.

Another point that warrants discussion is the fast thermal transient response of the monolithic dual FET. This type device is generally employed as the input stage for an operational amplifier; therefore, it may be subjected to electrical overload such as input voltage transients. This condition causes 1 side of the dual FET to dissipate more power than the other, which in turn results in a temperature differential between the 2 sides of the device. The ΔV_{GS} error will disappear once the devices are again in thermal equilibrium. The time for the 2-chip dual FET to reach thermal equilibrium, after a thermal transient, is considerable since the FET chips making up the 2-chip dual are located some distance apart. On the other hand, the monolithic structure recovers from thermal transients very rapidly because the 2 FETs, constituting the chip, are in intimate contact.

APPLICATIONS

A typical operational amplifier application is illustrated in *Figure 8*. This circuit employs the 2N3954 monolithic dual FET as the input device. The drain current level is set by FET Q2 and resistor R_X. FET Q2 is a 2N5457. This device exhibits a 0 TC drain current operating point



Note 1: The temperature coefficient can typically be adjusted (by R3 and R4) to less than 5 μV/°C from −25°C to +85°C.

Note 2: The common-mode rejection ratio is typically greater than 100 dB for input voltage swings of 5V.

FIGURE 8. Low Temperature Coefficient Operational Amplifier

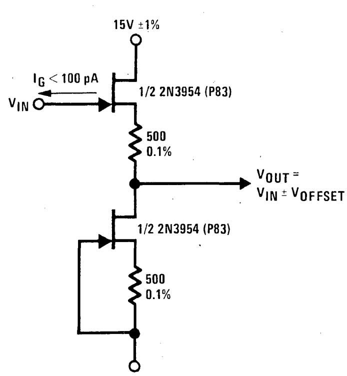


FIGURE 9

at about 400 μA. In addition, the Q2–R_X combination exhibits an output impedance typically greater than 10 MΩ. This characteristic, coupled with the high output impedance of the 2N3954, contribute to a CMRR of greater than 100 dB for this amplifier. Input offset voltage can be adjusted to 0 with R4. This control exhibits sensitivity of 2 mV/turn. The temperature coefficient can be compensated by R3 with an approximate sensitivity of 5 μV/°C/turn. The temperature performance of a typical amplifier of this type is illustrated in *Figure 10*.

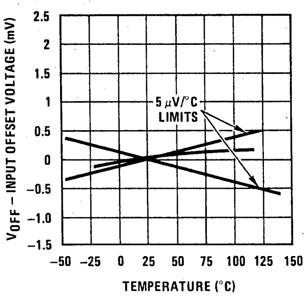


FIGURE 10. Input Offset Voltage vs Temperature

CONCLUSION

The junction isolated dual monolithic junction FET does exhibit a more linear ΔV_{GS} temperature relationship than does the 2-chip dual FET. In addition, the monolithic structure exhibits good temperature tracking characteristics at drain currents other than the specified I_D. This is generally not the case for the 2-chip system. Since all National duals are monolithic structures, the cumbersome process of matching individual dice is not required.

This, of course, makes the monolithic dual less expensive then its 2-chip counterpart. And finally, the monolithic dual FET maintains excellent tracking characteristics when the device is subjected to thermal transients or momentary voltage overloads. This is not the case with the 2-chip dual since these devices are thermally isolated from one another.

Note 1:

Definition of temperature coefficient:

$$(TC)_L = \frac{|\Delta V_{GS}(T_O) - \Delta V_{GS}(T_L)|}{T_O - T_L} \times 10^6 \ \mu V/°C$$

$$(TC)_H = \frac{|\Delta V_{GS}(T_H) - \Delta V_{GS}(T_O)|}{T_H - T_O} \times 10^6 \ \mu V/°C$$

Where T_O = 25°C
T_H — High temperature limit (T_H = 85 or 125°C)
T_L — Low temperature limit
$\Delta V_{GS}(T_O)$ in the differential gate-source offset voltage at T_O (volts)
$\Delta V_{GS}(T_H)$ — Differential gate-source offset voltage at T_H
$\Delta V_{GS}(T_L)$ — Differential gate-source offset voltage at T_L

Why Use Cascode Dual FETs?

National Semiconductor
FET Brief 2
Mike Turner
March 1977

National Semiconductor's cascode dual JFET is a unique structure in which each half of a monolithic dual is actually 2 FETs connected in cascode. *Figure 1a and 1b* show the comparison. The advantages of a cascode structure are low dynamic leakage (I_G) and greatly improved common-mode rejection ratio. National's processes 84 and 94 use the cascode configuration.

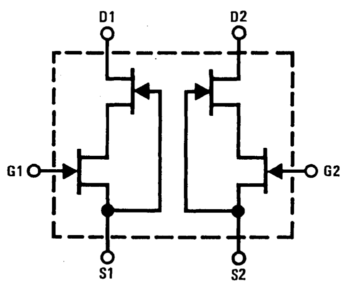


FIGURE 1a. Cascode Configuration

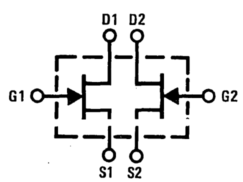


FIGURE 1b. Triode Configuration

The cascode FET device offers a significant improvement in gain/input current ratio when compared to standard FET triodes. Specifically, the NDF9406 series devices are specified at $I_G < 5$ pA under operating conditions, and they exhibit operating g_{fs} of 1200 μmho typical. This compares favorably with non-cascode duals exhibiting 3–10 times the I_G.

Furthermore, the NDF9406 series will maintain this low input current over a common-mode input range of up to ±15V, while triode devices are limited to approximately ±5V for the same performance.

Table I compares popular junction dual devices available in the marketplace.

It is important to remember that I_G is a dynamic characteristic. The data supplied by major FET suppliers clearly shows the effect of operating voltage and current on I_G and the considerable difference between I_G and the static parameter I_{GSS}.

Figure 2 explores the differences between cascode devices such as NDF9406–NDF9409 and a triode configured 2N5196. It is easily seen that severe gate current modulation will result in triode devices with even relatively small change in V_{DG}. Gate current variations will cause variations in offset bias currents, offset voltage and common-mode rejection. This is especially true in high impedance circuits where gate impedances are not matched.

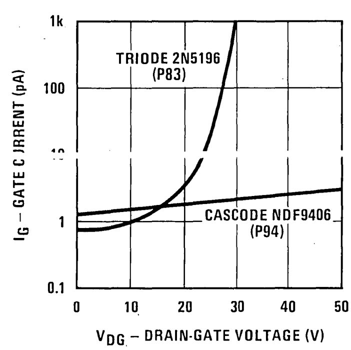


FIGURE 2. Typical Gate Current vs Drain-Gate Voltage @ I_D = 200 μA

The second major advantage of the cascode configuration is improved common-mode rejection ratio. The input FETs are effectively shielded from large changes in operating point by the drain load FETs.

TABLE I

DEVICE SERIES	BV	I_G V_{DG}/I_D	g_{fs} I_D
2N3954–2N3958	>50V	<50 pA @ 20V/200 μA	1000 @ 200 μA*
2N5196–2N5199	>50V	<15 pA @ 20V/200 μA	>700 @ 200 μA
NDF9406–NDF9409	>50V	<5 pA @ 35V/200 μA	>950 @ 200 μA

*Limits not specified on the published data sheet.

The inherent matching of all devices because of monolithic construction further reduces the effects of common-mode signals.

Figure 3 compares CMRR of a monolithic triode dual FET (National P83) with a cascode structure (National P94).

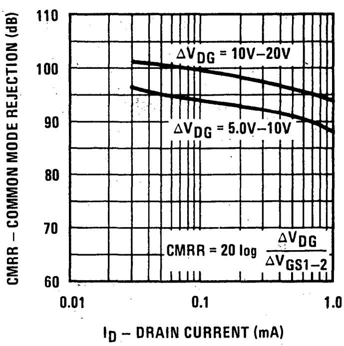


FIGURE 3a. Triode Construction

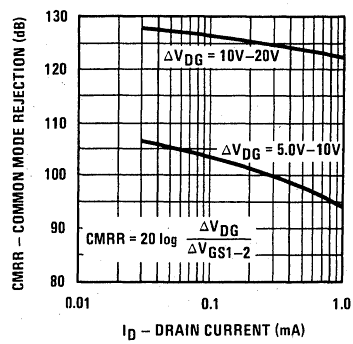
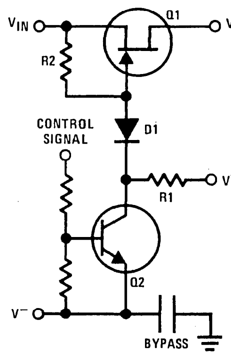


FIGURE 3b. Cascode Construction

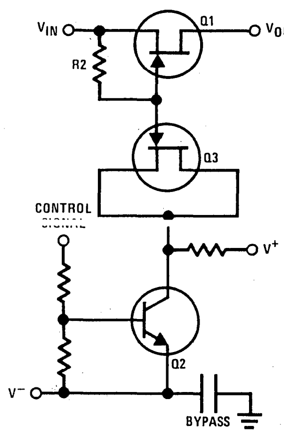
Simple VHF Analog Switches

National Semiconductor
FET Brief 1
Mike Turner
February 1977

Simple JFET switches like those in *Figure 1* will toggle at rates to about 10 MHz and switch analog signals with frequencies to above 100 MHz. They accomplish this by resolving in the gate-driver design the contradictory performance goals that even the best switching transistors cannot meet.



a. Series-Pass Switch



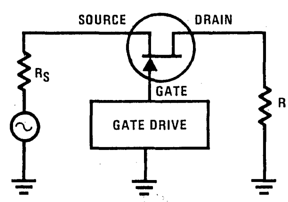
b. With JFET Gate Diode

FIGURE 1. High-Frequency JFET Switching Circuits

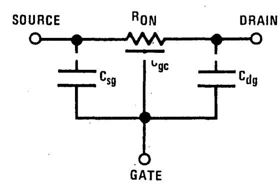
To switch high-frequency signals, the JFET should have low ON impedance, $r_{ds(on)}$ or R_{ON}, and low input capacitance, C_{iss}. The switch's RC time constant is established by these 2 parameters, and they also indicate the bandwidth capability. JFETs have been developed that come close to being ideal, but unfortunately the real-world nature of semiconductor devices makes it impossible to achieve optimum values of both parameters in the same device. Low R_{ON} calls for a physically large JFET. On the other hand, the very low capacitance needed for fast toggle rates implies small size.

At a casual glance, gate drive impedance does not appear very important. However, the JFET device conflict between R_{ON} and C_{iss} may be overcome by using the proper gate driver. The drive circuit should have a low impedance when the JFET is turned OFF and a high impedance when the JFET is turned ON. The low-impedance path is needed to prevent analog-signal feedthrough and the high impedance to minimize signal attenuation through the driver while the JFET is conducting. A well-designed driver can do both.

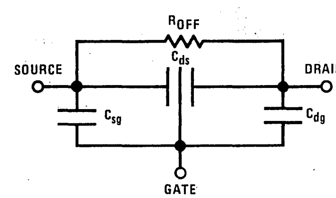
The relationships among JFET and driver characteristics can be sorted out with the help of *Figure 2*, which shows a typical series-pass switch and the equivalent circuits of the JFET in its ON and OFF conditions. A JFET operates best as a series-pass switch when the ON condition allows R_{ON} and shunt capacitance to be low, and series-pass capacitance to be high. But in the OFF condition, it should exhibit low series-pass capacitance and high series-pass resistance (R_{OFF}). The JFET will have these characteristics when properly matched to the driver.



a. Series-Pass JFET Switch



b. JFET On



c. JFET Off

C_{dg} = drain-gate capacitance
C_{gc} = gate-channel distributed capacitance
C_{sg} = source-gate capacitance
C_{ds} = drain-source capacitance
R_{ON} = ON impedance
R_{OFF} = OFF impedance

FIGURE 2. Series-Pass Switch and JFET Equivalent Circuits

Getting down to a low R_{ON} when the gate is turned ON is no problem. A JFET such as the 2N4391 has a maximum R_{ON} of 30Ω (see $r_{ds(on)}$ in Table I). However, the parallel capacitance in the signal path can become fairly high—about 15 pF when drain, source and gate have the same potential ($V_{DS} = V_{GS} = 0$). The simple answer to this dilemma is to drive the gate with a high AC impedance when the switch is closed. The shunt capacitance will be in series with a high impedance. Virtually all of the signal will then go through the JFET, the path of least resistance, rather than through the gate-to-ground connection.

Next problem. When the switch is OFF, high-frequency attenuation is the name of the game. It is depended upon to prevent the signal at the input from reaching the output. The JFET channel is, for all practical purposes, an open circuit because R_{OFF} of a quality JFET is over $10^{12}\Omega$ although this decreases as frequency goes up. However, capacitive feedthrough is the most significant route across the switch. From *Figure 2c*,

$$C_{FEEDTHROUGH} = C_{ds} + \frac{C_{sg}C_{dg}}{C_{sg} + C_{dg}}$$

Feedthrough capacitance can be significant if the gate is not operated at AC ground. Minimizing the right-hand term by operating the gate at AC ground allows C_{ds} to become the pacing factor. If the gate is grounded, C_{ds} will be approximately 0.2 pF. In other words, the effective R_{OFF} of the switch depends directly on circuit design, not the JFET.

Now to put these principles to work. The best high-frequency switch is an N-channel JFET. Its gate should be biased positive from a high-impedance source for turn-on and biased negative through a low-impedance path for turn-off. Driving the switch ON through an RF choke sounds tempting, but it would be difficult to avoid resonances and oscillation bursts during some switching conditions. DC resistances could be increased to equal or exceed R_S in parallel with R_L, but then the toggle rate would be kept down by the very high drive impedance.

We prefer the circuits in *Figure 1*, which are fairly fast and not tricky. When NPN transistor Q2 is in saturation, Q1 is biased OFF through a low-impedance path. The diode is slightly forward-biased and exhibits high capacitance. When Q2 turns OFF, D1's cathode is driven positive by R1. Now the diode is reverse-biased and exhibits high impedance and low capacitance. The charge that was stored on D1 discharges into the gate of Q1, allowing the JFET to be turned ON. Because there is no good discharge path available to the charge stored on Q1's gate, the gate will "follow" any signal swing in the analog input voltage. Adding R2 will ensure that the gate follows the signal even during DC conditions. Remember, however, that the $R2/C_{sg}$ time constant will effect switching time and gate-source signal tracking.

Don't expect just any diode to work well; D1's capacitance is critical and should match that of the JFET ($C_{D1} = C_{Q1}$). One good way of making sure that the JFET and the diode are well mated is to use the same type of JFET for both. The gate lead is 1 electrode of the diode and the drain and source leads are simply tied together to form the other electrode. The circuit in *Figure 1b* was optimized in this way.

Excellent high-frequency series switches can be made with 2N4091, 2N4092 and 2N4093 JFETs. RC time constants are short because of their low $r_{ds(on)}$ and capacitance, and leakage is low. The 2N4391, 2N4392 and 2N4393 series is even better, having only 100 pA leakage and lower C_{iss}. Even though the 2N4416 is classed as an RF amplifier, it is also listed in Table I to illustrate that many of our other JFETs can solve special switching problems. This one does well in circuits requiring very low capacitance and leakage. Although the R_{ON} of an RF transistor is not specified, it can be estimated as $r_{ds(on)} \cong 0.85/Y_{fs}$, which is typically 170Ω for the 2N4416.

TABLE I. JFETs for High-Frequency Analog Signal Switching

TYPE NO.	BV_{GSS} OR BV_{DGO} (MAX)	I_{GSS} (MAX)	C_{iss} (MAX)	C_{rss} OR C_{DGO} (MAX)	$r_{ds(on)}$ (MAX)	t_{on} (MAX)	t_{off} (MAX)
2N4091	40V	0.2 nA	16 pF	5 pF	30Ω	25 ns	40 ns
2N4092	40V	0.2 nA	16 pF	5 pF	50Ω	35 ns	60 ns
2N4093	40V	0.2 nA	16 pF	5 pF	80Ω	60 ns	80 ns
2N4391	40V	0.1 nA	14 pF	3.5 pF	30Ω	15 ns	20 ns
2N4392	40V	0.1 nA	14 pF	3.5 pF	60Ω	15 ns	35 ns
2N4393	40V	0.1 nA	14 pF	3.5 pF	100Ω	15 ns	50 ns
2N4416	30V	0.1 nA	4 pF	0.8 pF	170Ω*		
2N4416A	35V	0.1 nA	4 pF	0.8 pF	170Ω*		

*This value is not specified in RF amplifier JFETs; 170Ω is typical

Noise of Sources

National Semiconductor
John Maxwell
February 1977

INTRODUCTION

The elimination or minimization of noise is one of the most perplexing problems facing engineers today. Many preamplifiers and components come with outstanding noise specifications, only to disappoint the user. The problem is the difference between specification and application, as the amplifiers are specified under ideal conditions not the real conditions, (i.e., a transducer connected to the input). Many times the transducer noise is as large or even greater than the amplifier noise, degrading the signal to noise ratio. Before amplifier or component noise can be considered, familiarity with the source noise is essential.

REVIEW OF NOISE BASICS

There are 3 types of transducers: resistive, capacitive and inductive. The noise of a passive network is thermal noise, generated by the real part of the complex impedance, as given by Nyquist's relation:

$$\overline{V_n^2} = 4kTRe(Z)\,\Delta f \qquad (1)$$

$\overline{V_n^2}$ = Mean square noise voltage (V^2)

k = Boltzmann's constant (1.38×10^{-23} VAS/°K)
T = Absolute temperature (°K)
Re(Z) = Real part of complex impedance (Ω)
Δf = Noise bandwidth (Hz)

The noise may be represented as a spectral density (V^2/Hz) or more commonly in $\mu V/\sqrt{Hz}$ or $nV/\sqrt{Hz}$ and is given by:

$$e_n^2 = \frac{\overline{V_n^2}}{\Delta f} \qquad (2)$$

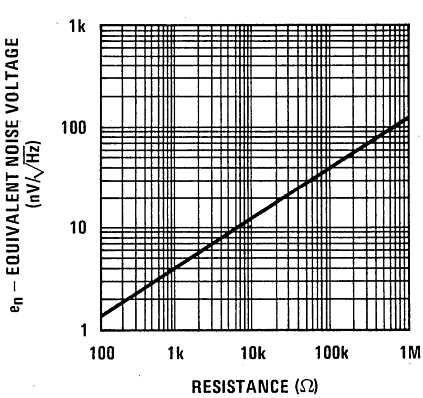


FIGURE 1. Thermal Noise Voltage vs Resistance

The total noise voltage in a frequency band can be readily calculated if it is white noise (i.e., Re(Z) is frequency independent). This is not the case for capacitive or inductive sources or most real world noise problems.

Rapidly changing network impedance and amplifier gain equalization combine to complicate the issue. The total source noise in a non-ideal case can be calculated by breaking the noise spectrum into several small bands where the noise (Re(Z)) is nearly white and calculating the noise of each band. The total source noise is the RMS sum of the noise in each of the bands N_1–N_n.

$$V_{NOISE} = \left(V_{N_1}^2 + V_{N_2}^2 + --- + V_{N_n}^2\right)^{1/2} \qquad (3)$$

The expression does not take amplifier gain equalization (like RIAA) into account, which will change the character of the noise at the amplifier output. By reflecting the gain equalization to the amplifier input and normalizing the gain to 0 dB at 1 kHz, the equalized source noise may then be calculated.

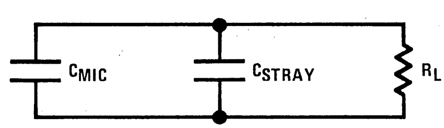
$$V_{EQ} = \left(|A_1|^2 V_{N_1}^2 + |A_2|^2 V_{N_2}^2 + --- + |A_n|^2 V_{N_n}^2\right)^{1/2} \qquad (4)$$

Where V_{EQ} = equalized source noise (μV) and
$|A_n|$ = magnitude of the equalized gain at the center of each noise band (V/V).

SOURCE NOISE

Models are needed for capacitive and inductive systems such that noise calculations can be made. Namely, the real part of the impedance needs to be determined.

A lumped model of a capacitive source, such as condenser or electret microphone, consists of the microphone and stray capacitance shunted by a load resistance.



$$Z = Re(Z) + jIM(Z) \qquad (5)$$

$$Re(Z) = \frac{R}{1 + \omega^2R^2C^2}$$

$$|Z| = \left(\frac{R^2}{1 + \omega^2R^2C^2}\right)^{1/2}$$

FIGURE 2. Lumped Model of a Capacitive Microphone

It should be noted that for any particular microphone, the noise of the network $((C_m + C_s)//R_L)$ is reduced by increasing R_L because Re(Z) (the real part of the impedance) is inversely proportional to R_L (see equation 5).

The inductive source (phono cartridges and tape heads) is more complex to analyze because it has a much more complex model. The simplified lumped model of a phono cartridge or tape head consists of a series inductance and resistance shunted by a small capacitor. Each phono cartridge or tape head has a recommended load consisting of a specified shunt resistance and capacitance. A model for the inductive source and preamp input network is shown in *Figure 3*.

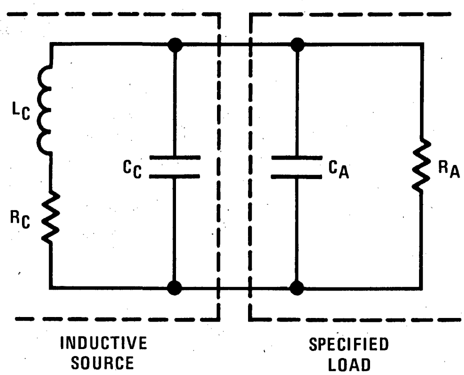
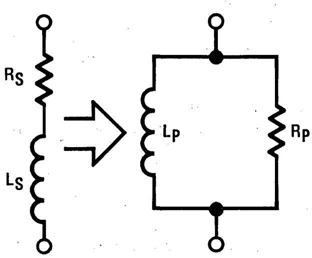


FIGURE 3. Phono Cartridge or Tape Head and Preamp Input Network

This circuit is quite formidable to analyze and needs further simplication. Through the use of Q equations, a series L-R is transformed to a parallel L-R.

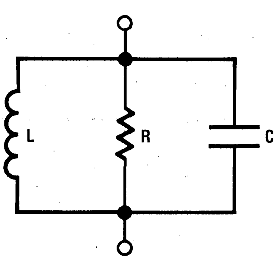


$$Q = \frac{\omega L_s}{R_s} \qquad (6)$$

$$R_p = R_s\,(1 + Q^2)$$

$$L_p = L_s\left(\frac{1 + Q^2}{Q^2}\right)$$

Simplifying the input network to:



$$R = R_A // R_p$$
$$L = L_p$$
$$C = C_s + C_c$$

FIGURE 4. Simplified Inductive Source Network

$$\mathrm{Re}(Z) = \frac{RX_L^2X_C^2}{(RX_L - RX_C)^2 + X_L^2\,X_C^2} \qquad (7)$$

$$Z = \frac{RX_LX_C}{((RX_L - RX_C)^2 + X_L^2\,X_C^2)^{1/2}}$$

$$X_L = \omega L$$
$$X_C = 1/\omega C$$

The tools are now available to calculate the noise of a variety of transducers and see how this unspecified noise affects amplifier (S/N) performance.

EXAMPLES

Calculations of electret microphone noise with various loads and RIAA equalized phono cartridge noise is done using equations (1)–(7). Center frequencies and frequency bands must be chosen first. Values of the lumped circuit components calculated and noise calculated for each band, then summed for the total noise. Octave bandwidths starting at 25 Hz will be adequate for approximating the noise.

In this example, the microphone capacitance is 10 pF loaded with 5 pF of amplifier and stray capacitance. Two resistive loads will be used to illustrate the effect R_L has on the microphone noise. R_{L1} = 1GΩ (10^9), R_{L2} = 10GΩ (10^{10}). It is assumed that there is no gain equalization in the amplifiers that follow. The noise calculations are summarized in Table I.

The electret or condenser microphone noise (Re(Z)) is reduced when the load resistance is increased. This is one of the cases when a larger resistance means lower noise, not more noise.

The second example is the calculation of the RIAA equalized noise of an ADC 27 phono cartridge loaded with C_A = 250 pF and R_A = 47k. The cartridge constants are R_s = 1.13k and L_s = 0.75H (C_c may be neglected). The noise calculations are summarized in Table II for this example.

The RIAA equalized noise of the ADC 27 phono cartridge and preamp input network was 0.73 μV for the audio band. Typical high quality preamps have noise voltages less than 1 μV, resulting in a 3 dB or more loss in system S/N ratio when the cartridge noise is added to the preamp noise (in an RMS fashion).

CONCLUSIONS

Zero noise sources and amplifiers do not exist. Specifying amplifier noise under ideal conditions will only lead to ideal specifications, not a measure of actual performance. Methods of S/N ratio measurement should be used that reflect the true performance instead of hollow specifications.

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TABLE I Summary of Electret Microphone Calculations

f Range (Hz)	25–50	50–100	100–200	200–400	400–800	800–1600	1600–3200	3200–6400	9600–12.8k	12.8k–20k
f Center (Hz)	37.5	75	150	300	600	1200	2400	4800	9600	16,400
f_{BW} (Hz)	25	50	100	200	400	800	1600	3200	6400	7,200
for $R_L = 1G\Omega$										
Re(Z) (Ω)	74.2M	19.6M	4.98M	1.25M	0.31M	78k	19k	4.9k	1.22k	420
|Z| (Ω)	272M	140M	70.6M	35.4M	17.7M	8.8M	4.4M	2.2M	1.1M	650
e_{nz} (nV/$\sqrt{Hz}$)	1100	560	280	140	71	36	18	9	4.5	2.8
V_{nz} (μV)	5.5	3.96	2.8	1.98	1.42	1.02	0.72	0.51	0.36	0.24
V_{nz}^2 (μV^2)	30.2	15.7	7.84	3.92	2.0	1.04	0.52	0.26	0.13	0.06
$(\Sigma V_{nz}^2)^{1/2} \simeq 7.9\ \mu V$										
$R_L = 10G\Omega$										
Re(Z) (Ω)	8M	2M	0.5M	125k	31.3k	7.8k	2k	500	122	42
|Z| (Ω)	283M	141M	70.8M	35.4M	17.7M	8.8M	4.4M	2.2M	1.1M	650k
e_{nz} (nV/$\sqrt{Hz}$)	320	180	90	45	23	11.4	5.8	2.9	1.4	0.84
V_{nz} (μV)	1.6	1.3	0.9	0.64	0.46	0.32	0.232	0.16	0.112	0.07
V_{nz}^2 (μV^2)	2.56	1.62	0.81	0.41	0.21	0.103	0.054	0.025	0.013	0.005
$(\Sigma V_{nz}^2)^{1/2} \simeq 2.4\ \mu V$										

TABLE II. Summary of Phono Cartridge Calculations

f Range (Hz)	25–50	50–100	100–200	200–400	400–800	800–1.6k	1.6k–3.2k	3.2k–6.4k	6.4k–12.8k	12.8k–20k
f Center (Hz)	37.5	75	150	300	600	1200	2400	4800	9600	16.4k
f_{BW} (Hz)	25	50	100	200	400	800	1600	3200	6400	7.2k
$Q = (\omega L_s/R_s)$	0.156	0.313	0.625	1.25	2.5	5	10	20	40	68.4
Q^2	0.0244	0.098	0.391	1.56	6.25	25	100	400	1600	4678.6
$1 + Q^2$	1.0244	1.098	1.391	2.56	7.25	26	101	401	1601	4679.6
$1 + Q^2/Q^2$	42	11.24	3.56	1.64	1.16	1.04	1.01	1.0	1.0	1.0
R_p (Ω)	1.16k	1.24k	1.57k	2.9k	8.2k	29.4k	114k	454k	1.8M	5.29M
L_p (H)	31.5	8.43	2.67	1.23	0.87	0.78	0.76	0.75	0.75	0.75
R_p//R (Ω)	1.13k	1.21k	1.52k	2.74k	7k	18.1k	32.9k	42.6k	45.8k	46.6k
X_L (Ω)	7.42k	3.97k	2.52k	2.32k	3.28k	5.88k	11.45k	22.6k	45.2k	77.2k
X_c (Ω)	17M	8.48M	4.24M	2.12M	1.06M	0.53M	0.265M	0.133M	66.3k	38.8k
Re(Z) (Ω)	1.11k	1.11k	1.11k	1.15k	1.26k	1.73k	3.86k	12.4k	41.5k	34k
|Z| (Ω)	1.12k	1.15k	1.3k	1.77k	2.97k	5.59k	11.7k	24.4k	43.6k	40.1k
e_{nz} (nV/$\sqrt{Hz}$)	4.24	4.24	4.24	4.31	4.51	5.29	7.9	14.2	26	23.5
V_N (nV)	21.2	30	42.4	61	90.2	149.6	316	803	2080	1994
V_n^2 (nV^2)	449.4	900	1798	3721	8136	22.4k	99.9k	645k	4.33M	3.98M
A^2	63.0	29.5	10.7	3.85	1.66	0.85	0.49	0.154	0.043	0.019
$A^2V_n^2$ (nV^2)	28.3k	26.6k	19.2k	13.2k	13.5k	19k	48.9k	99.3k	186k	76k

$(\Sigma V_n^2)^{1/2} = 3\ \mu V$ unequalized noise

$(\Sigma 1An\ 1^2 V_n^2)^{1/2} = 0.73\ \mu V$ RIAA equalized noise

The Noise Figure Fallacy

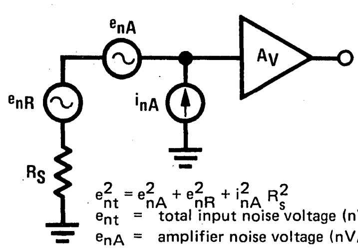
National Semiconductor
John Maxwell
February 1977

Noise Figure (NF) can be one of the most misleading specifications confronting the engineer today. Noise Figure is defined as the ratio of total output noise power to the output noise power of the source.

$$NF = 10 \text{ Log } \frac{\text{Total output noise power}}{\text{Output noise power of the source}} \quad (1)$$

A minimum NF exists for any amplifier, but is usually far removed from the actual operating conditions. This is where the problem begins. Lowering the NF doesn't always lower the noise which is what the engineer is really interested in. NF only gives the designer insight into the ratio of the amplifier noise to the source noise, not the input noise of the amplifier or the signal to noise ratio.

Amplifier noise performance is adequately described by modeling the noise sources as a series voltage generator and a shunt current generator with a series voltage generator for the source resistance noise.



$e_{nt}^2 = e_{nA}^2 + e_{nR}^2 + i_{nA}^2 R_s^2$

e_{nt} = total input noise voltage ($nV/\sqrt{Hz}$)

e_{nA} = amplifier noise voltage ($nV/\sqrt{Hz}$)

i_{nA} = amplifier noise current ($pA/\sqrt{Hz}$)

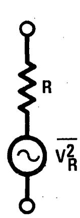
e_{nR} = source resistance thermal noise ($nV/\sqrt{Hz}$)

FIGURE 1. Simiplified Amplifier Noise Model

The amplifier noise data is found on vendor data sheets in the form of e_n and i_n vs frequency for bipolar transistors and e_n vs frequency for FETs and FET amplifiers.

Current noise depends on amplifier input bias current which is only a few picoamps for FETs and is therefore negligible. However, bipolar transistor amplifiers have bias currents into the microamp range where current noise is significant.

The thermal noise of the source resistance is given by Nyquist's relation.



$$\overline{V_R^2} = 4kTR\Delta f \quad (2)$$

$\overline{V_R^2}$ = mean square noise voltage (V^2)

k = Boltzmann constant (1.38×10^{-23} VAS/°K)

T = absolute temperature (°K)

R = resistance (Ω)

Δf = noise bandwidth (Hz)

with the spectral density given by e_n^2

$$e_{nR} = (\overline{V_R^2}/\Delta f)^{1/2} \quad (3)$$

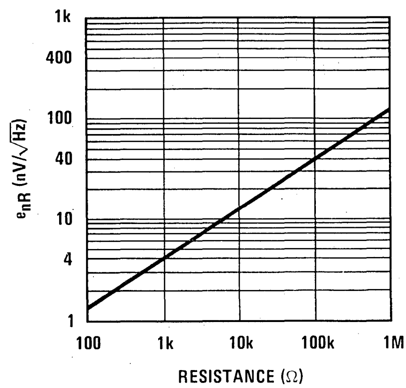


FIGURE 2. Thermal Noise vs Resistance

Using the model of *Figure 1*, an expression of noise figure in terms of the noise generators can be developed.

The noise power of the source can be found by using Nyquist's relation.

$$\text{Source Noise Power} = \frac{\overline{V_R^2}}{R^2} = \frac{e_{nR}^2 \Delta f}{R^2} \quad (4)$$

with the total output noise power at the input of the amplifier of:

$$\text{Total noise power} = \frac{e_{nR}^2 \Delta f}{R^2} + \frac{e_{nA}^2 \Delta f}{R^2} + i_{nA}^2 R^2 \Delta f \quad (5)$$

Yielding

$$NF = 10 \text{ Log} \left[1 + \frac{e_{nA}^2 + i_{nR}^2 R^2}{e_{nR}^2} \right] \quad (6)$$

Noise figure has a minimum that occurs at an optimum source resistance R_{opt}.

$$R_{opt} = \frac{e_{nA}}{i_{nA}} \quad (7)$$

Artifically changing the source resistance for minimum NF will generally increase the circuit noise as demonstrated by the following example.

Example:

An amplifier is needed to boost the signal from a resistive transducer.

Amplifier requirements

$A_v = 100$
$f = 10$ Hz to 10 kHz
Transducer = 10 kΩ

Amplifier—LF356
Noise data, $e_n = 12\ nV/\sqrt{Hz}$ @ 1 kHz
$i_n = 0.01\ pA/\sqrt{Hz}$ @ 1 kHz

The optimum source resistance for the amplifier is found to be 12M (using equation (7)). Using *Figure 2*, the noise of the transducer is $12\ nV/\sqrt{Hz}$ and the noise of the optimum source resistance is $140\ nV/\sqrt{Hz}$.

Using the non-inverting amplifier configuration, we'll view the effect of R_{opt}. In one case, resistance will be added to the source to equal the amplifier optimum source resistance (not affecting gain). The other case will only have the transducer connected to the input.

We will neglect the noise of the feedback resistors and determine the input noise and NF for both configurations using equations (1)–(6).

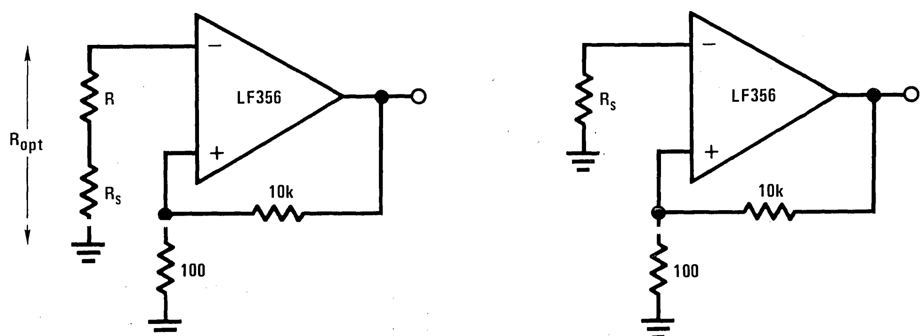
Case A, minimum NF

Total input noise $V_n = e_{nt}\,(\Delta f)^{1/2} = 14\ \mu V$
$NF = 0.06$ dB

Case B, minimum noise

$V_n = 1.7\ \mu V$
$NF = 3$ dB

Noise figure is only a measurement of the amplifier noise relative to the source noise. The example used was radical, but it illustrated a very important point. Resistance should never be added in series with the source to improve the NF. The NF will improve but the input noise will suffer, degrading performance. Total input noise should always be considered allowing problem sources to be identified and minimized to meet the system's specific noise requirements.



a. Minimum NF

b. Minimum Noise

FIGURE 3. 2 Amplifier Solutions

Low Noise FET Amplifiers

National Semiconductor
John Maxwell
March 1977

INTRODUCTION

Discrete JFETs reign supreme as low noise amplifiers. JFETs are virtually free from the problems of current noise, popcorn noise and limited bandwidth which plague bipolar transistors and bipolar input op amps.

Unfortunately, JFETs are cumbersome to use because of low gain and the need of extensive biasing networks. However, monolithic op amps are cheap and easy to use but suffer from poor noise performance. By combining JFETs with an op amp yields single and differential input amplifiers that have the best of both worlds; low noise, high gain and ease of use.

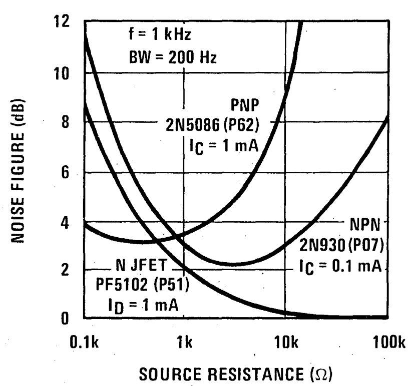


FIGURE 1. Bipolar and JFET Transistor Noise Comparison

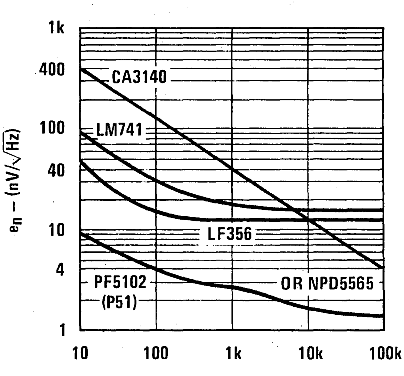
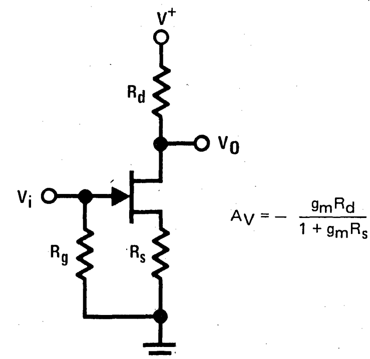
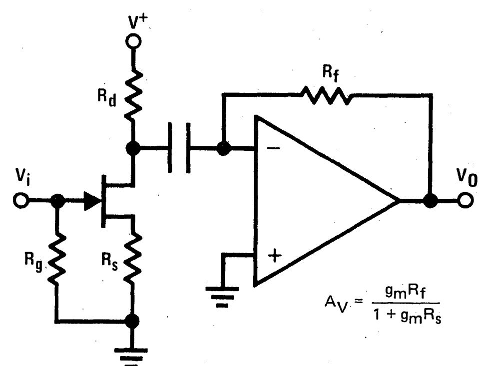


FIGURE 2. Discrete JFET and Op Amp Noise Comparison

The main problem with JFETs is that the voltage gain is limited by the size of the load resistance which is limited by the power supply voltage and the FET operating current. The voltage gain can be increased by combining the JFET (a transconductance amplifier) with an op amp current to voltage (I/V) amplifier, circumventing the limited load resistor.



a. Single FET Stage



b. FET with I/V Amplifier

FIGURE 3. FET Gain Stages

In the FET/op amp configuration, the FET AC drain current is shunted to the op amp virtual ground and through its feedback resistor, bypassing the FET drain resistor, R_d. The drain resistor is used to bias the FET in a linear region with the feedback resistor, R_f, used to set the gain.

Biasing problems associated with lot and device to device parameter variations are minimized by biasing the source through a large resistor to the negative supply of the op amp. A portion of the source resistor should be unbypassed to minimize gain variations between FETs.

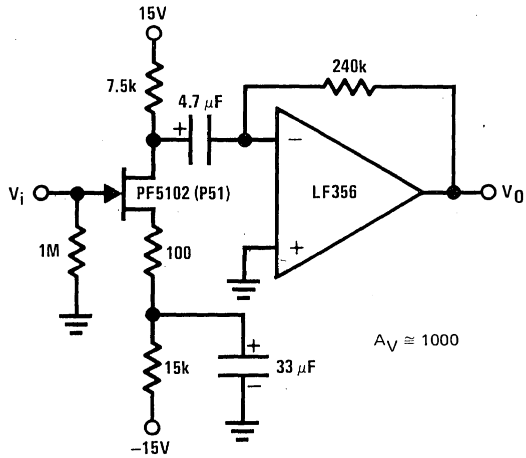
From a design standpoint, the maximum AC drain current should be 1/10 of the FET quiescent current for low distortion. The unbypassed portion of the source resistor should be limited to 220Ω for minimum noise and to increase the op amp feedback resistor (decreased AC current).

Expressions for the single and differential amplifier configurations are needed for optimizing the noise to meet system noise requirements.

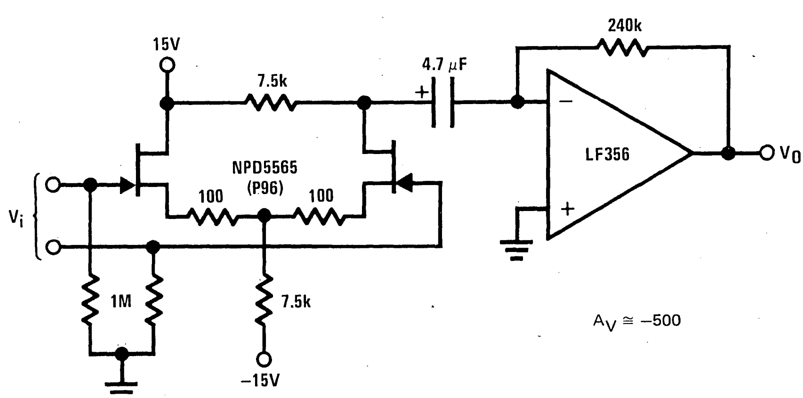
Amplifier noise performance is adequately described by modeling the noise sources as a series voltage generator and a shunt current generator with a series voltage generator for the source resistance thermal noise. The thermal noise of a resistor is given by Nyquist's relation and has a spectral density given by e^2_{nR}.

$$e^2_{nR} = 4kTR \quad (1)$$

e^2_{nR} = mean square noise voltage per unit bandwidth (nV^2/Hz)
k = Boltzmann constant (1.38×10^{-23}VAS/°K)
T = absolute temperature (°K)
R = resistance (Ω)



a. Single-Ended



b. Differential Input

FIGURE 4. High Gain FET/Op Amp AC Amplifiers

The single ended and differential input amplifier input noise (FET noise current is negligible) is given by the RMS sum of the noise generators.

Single-Ended:

$$e_{nt}^2 = e_{nf}^2 + e_{ns}^2 + \left(\frac{1 + g_m R_s}{g_m R_d}\right)^2 (e_{nA}^2 + e_{nR}^2 + i_{nA}^2 R^2)$$

Differential Input:

$$e_{nt}^2 = 2\,(e_{nf}^2 + e_{ns}^2) + 4\left(\frac{1 + g_m R_s}{g_m R_d}\right)^2 (e_{nA}^2 + e_{nR}^2 + i_{nA}^2 R^2)$$

with

- e_{nt} = total input noise voltage ($nV/\sqrt{Hz}$)
- e_{nf} = FET noise voltage ($nV/\sqrt{Hz}$)
- e_{nA} = op amp noise voltage ($nV/\sqrt{Hz}$)
- i_{nA} = op amp noise current ($pA/\sqrt{Hz}$)
- e_{ns} = source resistor thermal noise ($nV/\sqrt{Hz}$)
- e_{nR} = drain and feedback ($R_d//R_f$) resistor thermal noise ($nV/\sqrt{Hz}$)
- g_m = FET transconductance at the FET operating current (mmho)
- R = parallel resistance of R_d and R_f (Ω)

The differential configuration has higher noise and lower gain than the single-ended version, but is useful when low distortion or balanced inputs are of paramount importance.

The noise of the op amp and the FET drain resistor is reduced by the gain of the FET portion of the amplifier $\frac{g_m R_d}{1 + g_m R_s}$. The noise of the feedback resistor has little effect on the noise but in conjunction with the drain resistor, it can have a dramatic effect on the total circuit noise. The drain resistor is the input leg of an inverting amplifier with the op amp and the feedback resistor. This amplifier has a gain of $-R_f/R_d$ which boosts the op amp noise, limiting the size of R_f to about 390k.

Practical low noise, high gain AC amplifiers can be built using a low noise JFET and just about any op amp. The op amp needs to meet the slew rate and bandwidth requirements of the circuit, eliminating selected low noise op amps or complex discrete amplifiers.

A note of caution is in order for the op amp noise. Virtually any JFET input or bipolar input op amp can be used without trouble, but MOSFET input op amps should be avoided. MOSFET 1/f noise is one or more orders of magnitude greater than discrete JFETs, JFET op amps or bipolar input op amps. MOSFETs have 1/f corner frequencies (where the noise power rises as 1/f) starting as high as 100 kHz. The other forms of amplifiers have 1/f corner frequencies of 1 kHz and less. Quite a difference.

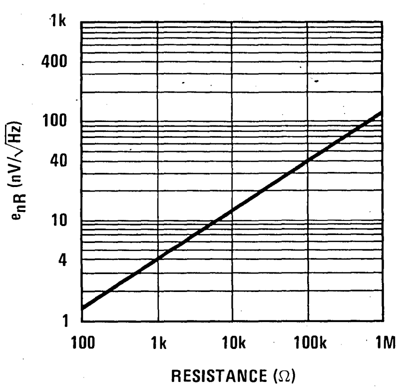


FIGURE 5. Thermal Noise vs Resistance

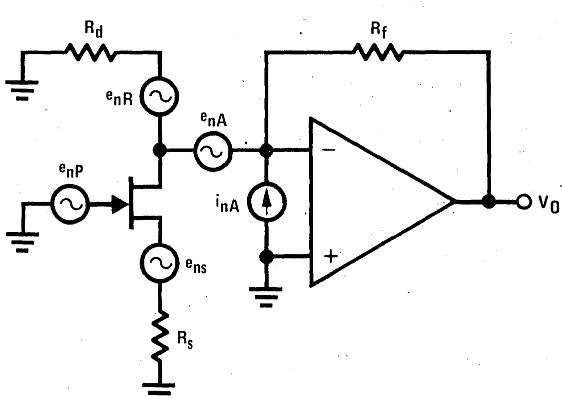


FIGURE 6. Single-Ended Noise Model

The Low Noise JFET— The Noise Problem Solver

National Semiconductor
Application Note 151
John Maxwell
January 1976

The most versatile low noise active device available to the designer today is the Junction Field-Effect Transistor (JFET). JFETs are virtually free of the problems which have plagued bipolar transistors—limited bandwidth, popcorn noise, a complex design procedure to optimize noise performance. In addition, JFETs offer low distortion and very high dynamic range.

Most designers think of JFETs for very high source impedances. However, modern devices offer the designer performance improvements over bipolar transistors in NF for all but lowest impedance ($<500\Omega$) sources and even then may provide improved performance if popcorn noise, bandwidth or circuit component noise is a consideration (see *Figure 1).*

Therefore, the purpose of this article is to review low noise design procedures and indicate the simplicity of designing high performance low noise amplifiers with low cost JFETs.

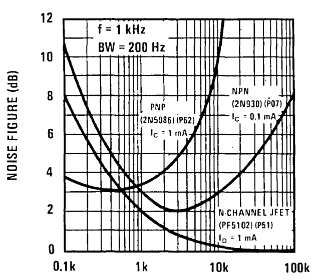
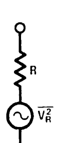


FIGURE 1. Bipolar and JFET Transistor Noise Comparison

REVIEW OF BASICS

Before guidelines are established for designing low noise JFET amplifiers, a method of noise characterization must be chosen. Designers are confronted with a multitude of different noise parameters such as Noise Figure (NF), noise voltage and current densities, noise temperature, noise resistance, etc. Designers are primarily concerned with signal to noise (S/N) ratios preferring noise voltage, (e_n) and current (i_n) density.

Noise generally manifests itself in three forms: thermal noise, shot noise and flicker or "1/f" noise. Thermal noise arises from thermal agitation of electrons in a conductor and is given by Nyquist's relation:



$$\overline{V_R^2} = 4k\,TR\,\Delta f \tag{1}$$

$\overline{V_R^2}$ = mean square noise voltage
k = Boltzmann constant (1.38×10^{-23} VAS/°K)
T = Absolute temperature (°K)
R = Resistance in ohms
Δf = Noise bandwidth (Hz)

The noise of a resistor may be represented as a spectral density (V^2/Hz) or more commonly in $\mu V/\sqrt{Hz}$ or $nV/\sqrt{Hz}$ and is given by:

$$e_{nR} = (\overline{V_R^2}/\Delta f)^{1/2} \tag{2}$$

It is sometimes more convenient to represent thermal noise as noise current instead of a noise voltage. One needs only to consider the Norton equivalent yielding a noise current density.

$$i_{nR} = \frac{e_{nR}}{R} = \left(\frac{4\,kT}{R}\right)^{1/2} \tag{3}$$

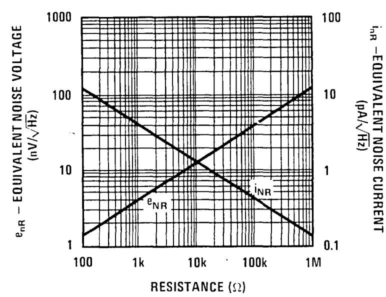


FIGURE 2. Thermal Noise Voltage and Current Densities vs Resistance.

The second basic form of noise, shot noise, is due to the randomness of current flow (discrete charge particles) in semiconductor P-N junctions.

$$\overline{i^2} = 2\,q\,I_{DC}\,\Delta f \tag{4}$$

$\overline{i^2}$ = Mean square noise current
q = Charge of an electron (1.6×10^{-19} AS)
I_{DC} = dc current flowing through the junction (A)
Δf = Noise bandwidth (Hz)

As with thermal noise, shot noise may be represented as a current density (A^2/Hz) or $pA/\sqrt{Hz}$.

$$i_n = (\overline{i^2}/\Delta f)^{1/2} \tag{5}$$

It should be noted that both thermal noise and shot noise are "white" noise sources, i.e., frequency independent.

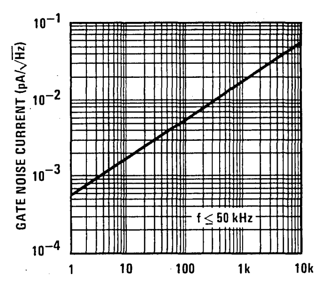


FIGURE 3. Current Noise vs Gate Leakage Current

The third basic noise source confronting designers is flicker or "1/f" noise whose density is roughly inversely proportional to frequency starting at about 1 kHz in both JFETs and bipolar transistors and increasing as frequency is decreased. Through careful processing, flicker noise in JFETs has been reduced to levels nearly insignificant to the designer. Flicker noise in JFETs is primarily a noise voltage and is source independent. Flicker noise in bipolar transistors is a function of base and leakage currents increasing with increased source impedance or operating currents.

A simple noise model of a JFET or any amplifying device may be constructed using a thermal and shot noise source which would adequately describe its noise performance allowing signal to noise ratios to be calculated directly.

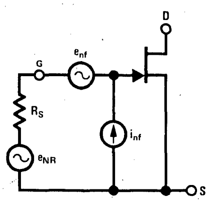


FIGURE 4. Simple JFET Noise Model

The input noise per unit bandwidth at some frequency may be calculated from the mean square sum of the noise sources (assuming the JFET noise sources are uncorrelated or independent of one another).

$$e_{nt}^2 = e_{nR}^2 + e_{nf}^2 + i_{nf}^2 \ R_s^2 \quad (6)$$

The total noise in the same bandwidth Δf, where the noise sources are independent of frequency, is simply:

$$V_{NOISE} = (e_{nt}^2 \ \Delta f)^{1/2} \quad (7)$$

Practically, noise sources are not frequency independent except resistor noise with no dc bias. The total input noise for the nonideal case may be calculated by breaking the spectrum up into several small bands and calculating the noise in each band where the noise sources are nearly frequency independent. The total input noise would then be the RMS sum of the noise in each of the bands N1 . . . Nn.

$$V_{NOISE} = (V_{N1}^2 + V_{N2}^2 + \ldots V_{Nn}^2)^{1/2} \quad (8)$$

THE DESIGN PROCESS

The final circuit configuration and suitable JFET will be determined by the external circuit constraints.

1) Minimum signal to noise ratio (maximum amplifier noise)
2) Type and magnitude of source impedance (resistive or reactive)
3) Amplifier input impedance requirements
4) Bandwidth and maximum frequency of interest
5) Maximum operating temperature
6) Stage gain
7) Power supply voltage and current limitations
8) Circuit configuration, single or dual device

The design procedure is dependent on the type of source and each case must be considered separately. Resistive sources will be considered first because they are the least restrictive for the preamplifier.

Resistive Sources

Preamplifiers for resistive sources are typically voltage amplifiers requiring a fixed input resistance and capacitance consistent with the maximum frequency of interest and source resistance. In most cases a resistor of the desired value connected between the gate and ground will satisfy the input resistance requirement leaving the maximum input capacitance as the major concern.

The maximum amplifier input capacitance is a function of the JFET source resistor, input resistance, source capacitance and maximum frequency. The maximum allowable input capacitance will be used in eliminating unsuitable JFET geometrics and optimizing the circuit configuration. Sometimes the JFET geometry (or type) with the lowest noise may also have an input capacitance that makes it unsuitable. The JFET input capacitance should be considered before noise in high source resistance, wideband amplifier designs.

$$C_{in} \cong C_{rs}\left(1 + \frac{gm\ R_D}{1 + gm\ R_s}\right) + \frac{C_{gs}^*}{1 + gm\ R_s} \quad (9)$$

$^*C_{gs} = C_{is} - C_{rs}$

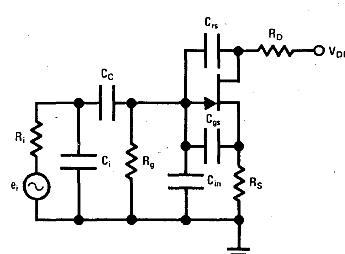


FIGURE 5. A Typical Resistive Source JFET Amplifier

If low input capacitance is required, a cascode configuration minimizes input capacitance and still allows high gain within a device type. The cascode configuration can also be used to reduce the voltage across a device, reducing device heating (for high current operation) and gate leakage currents when source impedances are very high.

Once the basic circuit configuration has been decided upon or dictated by gain, bandwidth and power supply limitations, the final JFET selection will be on noise. Redrawing the amplifier in *Figure 4* with all of the noise sources, the total amplifier noise per unit bandwidth can be found.

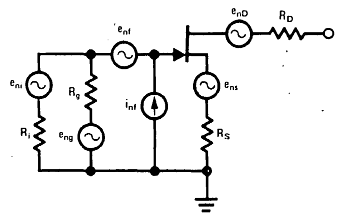


FIGURE 6. A Typical Resistive Source JFET Amplifier with Noise Sources

$$e_{nt} = \left[e_{nig}^2 + e_{nf}^2 + e_{ns}^2 + \frac{e_{nD}^2}{A_V^2} + i_n^2 \, (R_i//R_g)^2 \right]^{1/2} \quad (10)$$

where:
- e_{nig}^2 = The noise of the parallel connection of R_i and R_g
- e_{nf}^2 = The noise voltage of the JFET
- e_{ns}^2 = The noise of the source resistor R_s
- $\frac{e_{nD}^2}{A_V^2}$ = The noise at the drain (thermal noise of the load plus the second stage noise)
- $i_n^2(R_i//R_g)^2$ = The current noise contribution of the JFET

When the amplifier is operated at room temperature and moderate drain voltages, the current noise term is usually negligible with source resistances as high as 10 MΩ. Depending on the voltage gain of the stage, the drain circuit noise may be negligible, simplifying the input noise expression.

$$e_{nt} = (e_{nig}^2 + e_{nf}^2 + e_{ns}^2)^{1/2} \quad (11)$$

The final JFET selection will be based on the noise requirements from the maximum allowable noise V_{MAX}.

$$V_{MAX} = (e_{nf}^2 + e_{ns}^2)^{1/2} \quad (12)$$

Depending on V_{MAX} and e_{nf}^2 the source resistor may have to be bypassed to ground to eliminate noise of the bias resistor.

Capacitive Sources

Preamplifiers for capacitive sources are primarily current amplifiers requiring very high input resistance and controlled input capacitance to match the source capacitance.

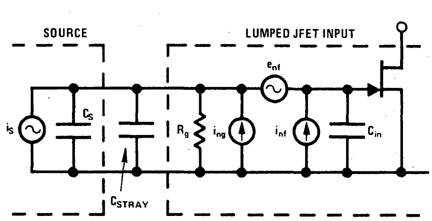


FIGURE 7. JFET Preamplifier with a Capacitive Source

The source capacitance should equal the sum of the preamplifier input capacitance and the stray capacitance for maximum frequency response and power transfer from the signal source. Assuming the gate resistor, R_g, is so large as to not load the capacitive source, the input noise voltage is:

$$e_{nt} \cong \left[e_{nf}^2 + (i_{nf}^2 + i_{ng}^2) \left(\frac{R_g^2}{(1 + \omega^2 R_g^2 C^2)} \right) \right]^{1/2} \quad (13)$$

where $C = C_S + C_{in}$

with an input signal of

$$e_s \cong i_s \left(\frac{R_g^2}{1 + \omega^2 R_g^2 C^2} \right)^{1/2} \quad (14)$$

When the source and input capacitance are matched, the final JFET geometry will be selected on two criteria: the noise voltage, e_n, and the current noise from the gate leakage, $I_{G(ON)}$, to optimize the signal to noise ratio. As in the resistive source case, the circuit configuration and JFET selection is an iterative process using all of the external circuit constraints and device parameters and limitations.

Inductive Sources

Amplifiers designed for inductive sources (including transformers) require fixed input resistances (as in the resistive source case) and controlled input capacitance (as in the capacitive source case). The input noise per unit bandwidth will rise with increasing frequency to a maximum value at resonance of the inductive source and the input capacitance or when the shunt resistance of the inductor is larger than the input resistance of the amplifier.

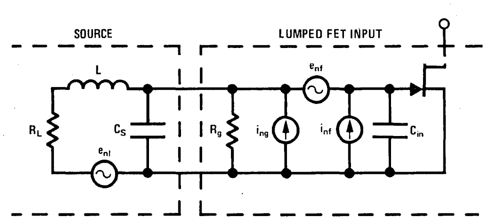


FIGURE 8. JFET Amplifier with an Inductive Source

The inductive source amplifier is the most difficult to analyze due to the complex input impedance. The input noise per unit bandwidth is given by:

$$e_{nt}^2 = e_{nf}^2 + (i_{nf}^2)(|Z_{in}|^2) + 4\,kT\,(\mathrm{Re}\,(Z_{in})) \quad (15)$$

where $Z = X_{CIN}//R_g$

and $Z_{in} = Z//(Z_L + R_L)$

Usually the current noise of the JFET is negligible, simplifying the expression a little, but not much. The optimization process for inductive sources is very complex and it will require the spectrum to be broken up into several small bands to arrive at a final design. Generally, a JFET with a minimum noise voltage will be the proper choice.

Transformers may be used with JFET amplifiers to minimize noise with very low source impedances. Transformers have both drawbacks and advantages and both must be examined before a transformer design is chosen. Poor frequency response, susceptibility to mechanical and magnetic pickup and thermal noise head the list of disadvantages to be weighed against two very important advantages. First, the noise voltage is transformed by the turns ratio N; second, the resistance is transformed by N^2. These can be used to advantage by matching very low values of source resistance to a relatively noisy amplifier and still maintaining a good signal to noise ratio, i.e., the total noise at the source assuming an ideal transformer is

$$e_{nt}^2 = e_{nRs}^2 + \frac{e_{nAmp}^2}{N^2} \quad (16)$$

SUMMARY

Low noise amplifier design concepts have been introduced for the three basic types of sources. Basic parameters (C_{in}, e_n, gm) were discussed that affect both circuit configuration and JFET type. There is no universal low noise JFET or circuit configuration that solves all problems. Each low noise amplifier design is different and must be considered within its own framework of performance requirements.

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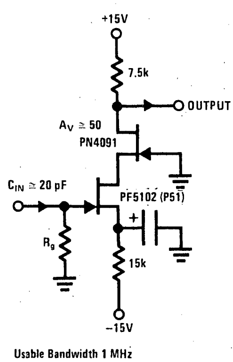
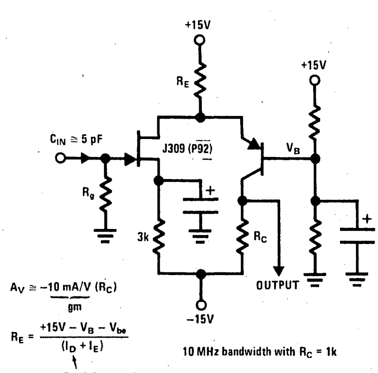
Richard S.C. Cobbold, "Theory and Applications of Field-Effect Transistors," John Wiley & Sons, 1970.

C.D. Motchenbacher and F.C. Fitchen, "Low Noise Electronic Design," John Wiley & Sons, 1973.

SOME PRACTICAL LOW NOISE JFET INPUT CIRCUITS



a) Wide Band, Low Input Capacitance, Very Low Noise Preamplifier



b) Low Noise, Very Low Input Capacitance Video Amplifier

APPENDIX A

Important National JFET Process Parameter Guide

Test Conditions V_{DS} = 15V, I_D = 1 mA (V_{GS} = 0V)*

PROCESS	e_n @ 10 Hz ($nV/\sqrt{Hz}$)	e_n @ 1 kHz ($nV/\sqrt{Hz}$)	e_n @ 100 kHz ($nV/\sqrt{Hz}$)	g_{fs} (mmho)	$I_{G(ON)}$ (pA)	C_{GD} (pF)	C_{GS} (pF)
50	15	5	2.5	3	5V 2 pA 10V 10 pA 15V 1 nA	0.7	2.5
51	5	3	1.3	7	30	3	9
55	10	4	2.5	2.4	5	2	4
92	10	4	1.5	4.5	10V 20 pA 15V 1 nA	2	4
83	10	5	2.5	2	5	1	2.5
84*	50	15	9	0.2	0.1	0.01	2
94	10	5	2.5	2	1–2	0.01	4
95	10	4	2.5	1.5	15	3.5	15
96	5	3	1.3	7	30	3	9
93	15	7	2	3.5	10V 20 pA 15V 1 nA	1	3.2

National JFET Process Low Noise Amplifier Guide

PROCESS	50	51	55	92	83	84	93	94	95	96
Low Noise Application	Single JFET				Dual JFET					
Resistive Ultra-Low $e_n < 5\ nV/\sqrt{Hz}$ @ 10 Hz		X								X
Resistive Low Freq < 20 kHz		X	X		X			X	X	X
Resistive Wideband < 10 MHz	X	X		X	X		X	X	X	X
Resistive Wide Band > 10 MHz	X			X			X			
Resistive Very High R_S > 10 MΩ	X					X		X		
Capacitive Low C < 10 pF	X		X	X	X	X	X	X		
Capacitive High C > 20 pF		X	X						X	X
Inductive	X	X	X	X	X	X	X	X	X	X

APPENDIX B

NOISE PARAMETER CONVERSION

Noise Figure (NF) to an Effective e_n

It is more convenient to present noise data for bipolar transistors in the form of contours of constant noise figure at a fixed frequency or plots of noise figure versus frequency at a fixed source resistance due to large values of noise current (i_n). Noise figure must be converted to an effective noise voltage (e_{nE}) for comparisions to be made between a BJT and a JFET or for signal to raise ratio calculations.

By definition:

$$NF = 10 \log \frac{\text{Total Output Noise Power}}{\text{Output Noise Power of the Source}} \qquad (B1)$$

From equations 1 and 2, one finds the source noise power to be

$$\text{Source Noise Power} = \frac{e_{nR}^2 \, \Delta f}{R_S} \qquad (B2)$$

for some source resistance R_S.

Referring to *Figure 4*, the total output noise power at the input of the amplifier would be:

$$\text{Total Output Noise Power} = \frac{e_{nR}^2 \, \Delta f}{R_S} + \frac{e_{nf}^2 \, \Delta f}{R_S} + i_{nf}^2 \, R_S^2 \, \Delta f \qquad (B3)$$

The noise figure (NF) can now be expressed in terms of the noise source generators, e_{nR}, e_{nf} and i_{nf} allowing an expression to convert noise figure (NF) to an effective noise voltage (e_{nE}).

$$NF = 10 \log \left(1 + \frac{e_{nf}^2 + i_{nf}^2 R_S^2}{e_{nR}^2}\right) \qquad (B4)$$

yielding

$$e_{nf}^2 + i_{nf}^2 R_S^2 = e_{nE}^2 = (10^{NF/10} - 1) \; e_{nR}^2 \qquad (B5)$$

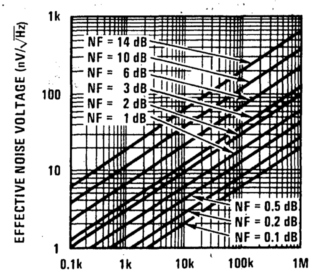


FIGURE B1. Effective Noise Voltage (e_{nE}) vs Noise Figure and Source Resistance (R_S)

Noise Resistance

The effective noise voltage density (e_n) and noise current density (i_n) are found directly by referring to *Figure 1,* and reading the values for the corresponding resistances.

$$e_{nR} = (4\,KTR)^{1/2} \qquad (1)$$

$$i_{nR} = \left(\frac{4\,KT}{R}\right)^{1/2} \qquad (3)$$

APPENDIX C

JFET Current Noise

At low frequencies the current noise and voltage noise sources are uncorrelated in JFETs with the current noise being pure shot noise due to gate leakage currents. As frequency is increased, the current noise also increases starting at frequencies as low as 50 kHz in some high capacitance device types.

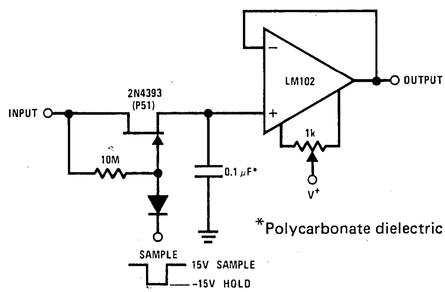
It has been suggested and experimentally verified that the noise current at high frequencies is due to increased gate input conductance.

$$i_n^2 = 4\,KT\left[\text{Re}\,(Y_{11})\right]^{-1} \qquad (C1)$$

Re (Y_{11}) is available on high frequency JFET data sheet as the real portion of the common source input admittance parameters. In effect the channel noise is coupling to the gate circuit through the source-gate and drain gate capacitances. Hence low capacitance devices exhibit lower values of noise current at high frequencies than do high capacitance devices.

FET Circuit Applications

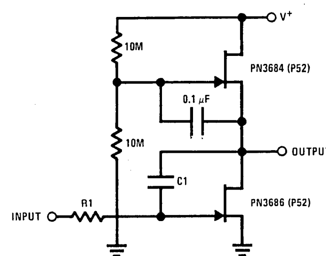
National Semiconductor
Application Note 32
April 1977



*Polycarbonate dielectric

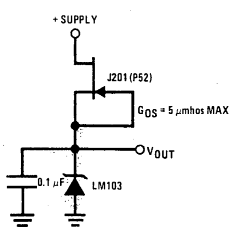
Sample and Hold With Offset Adjustment

The 2N4393 JFET was selected because of its low I_{GSS} (<100 pA), very low $I_{D(OFF)}$ (<100 pA) and low pinchoff voltage. Leakages of this level put the burden of circuit performance on clean, solder-resin free, low leakage circuit layout.



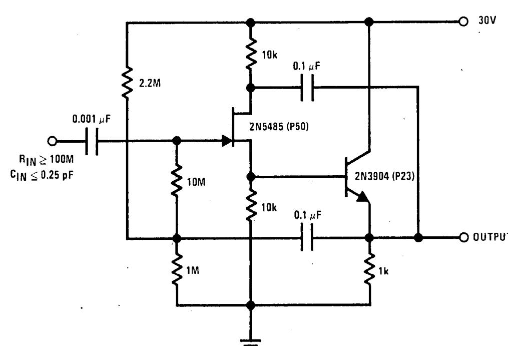
JFET AC Coupled Integrator

This circuit utilizes the "μ-amp" technique to achieve very high voltage gain. Using C1 in the circuit as a Miller integrator, or capacitance multiplier, allows this simple circuit to handle very long time constants.



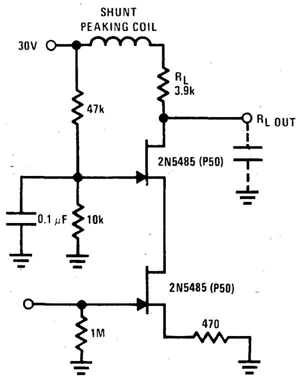
Low Power Regulator Reference

This simple reference circuit provides a stable voltage reference almost totally free of supply voltage hash. Typical power supply rejection exceeds 100 dB.

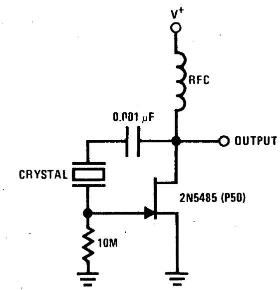


Ultra-High Z_{IN} AC Unity Gain Amplifier

Nothing is left to chance in reducing input capacitance. The 2N5485, which has low capacitance in the first place, is operated as a source follower with bootstrapped gate bias resistor and drain.



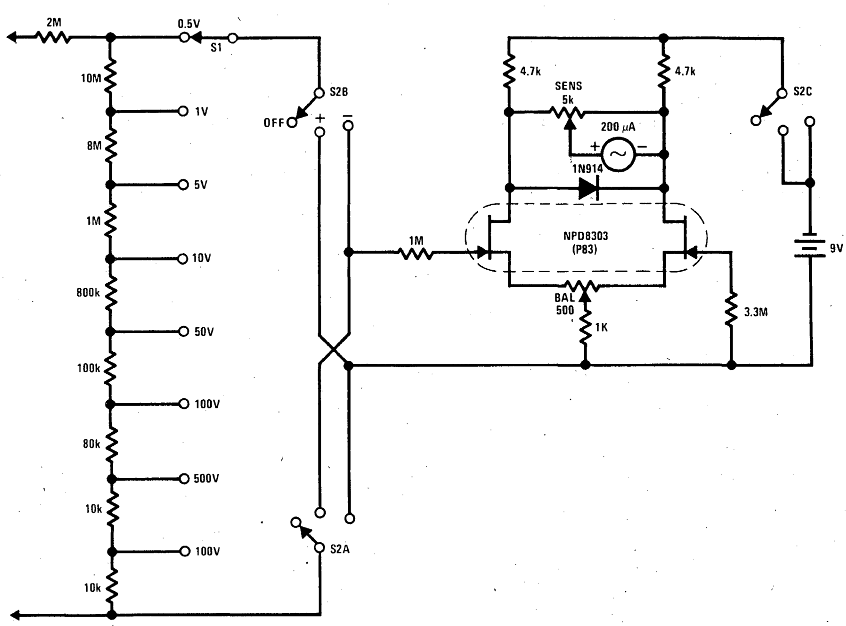
FET Cascode Video Amplifier



JFET Pierce Crystal Oscillator

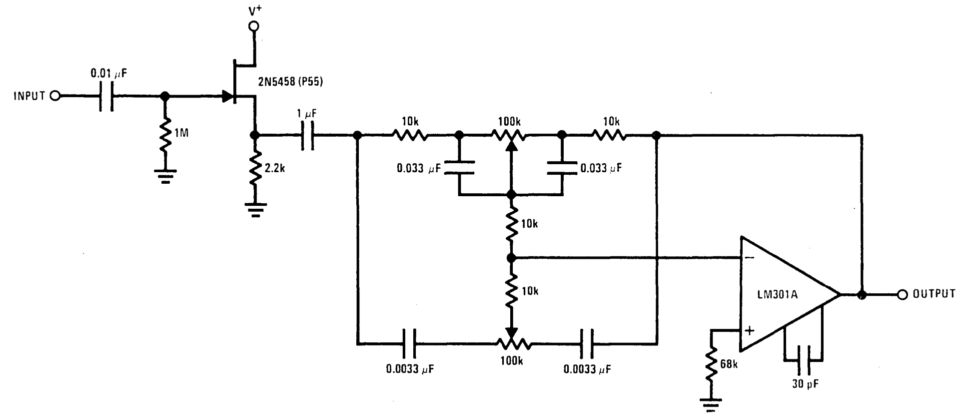
The FET cascode video amplifier features very low input loading and reduction of feedback to almost zero. The 2N5485 is used because of its low capacitance and high Y_{fs}. Bandwidth of this amplifier is limited by R_L and load capacitance.

The JFET Pierce crystal oscillator allows a wide frequency range of crystals to be used without circuit modification. Since the JFET gate does not load the crystal, good Q is maintained, thus insuring good frequency stability.



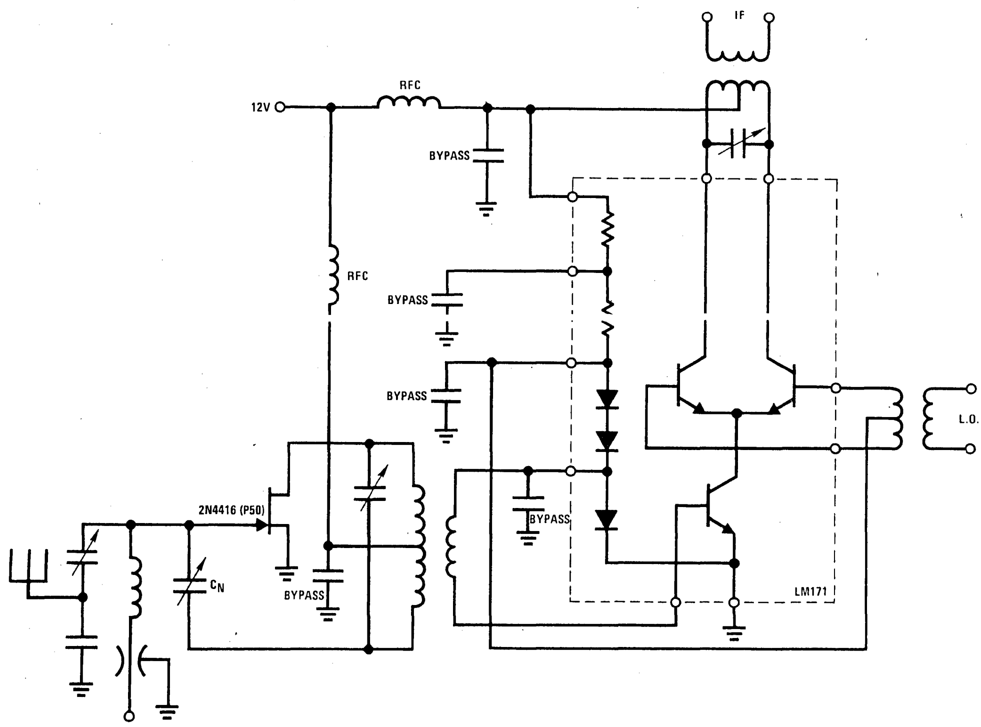
FETVM—FET Voltmeter

This FETVM replaces the function of the VTVM while at the same time ridding the instrument of the usual line cord. In addition, drift rates are far superior to vacuum tube circuits allowing a 0.5V full-scale range which is impractical with most vacuum tubes. The low leakage, low noise NPD8303 is an ideal device for this application.



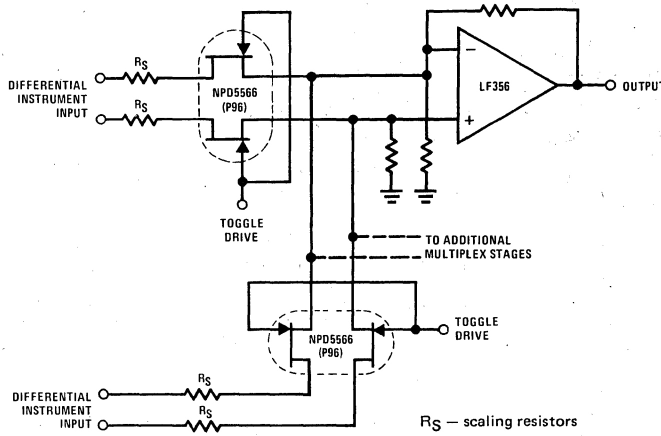
HI-FI Tone Control Circuit (High Z Input)

The 2N5458 JFET provides the function of a high input impedance and low noise characteristics to buffer an op amp-operated feedback type tone control circuit.



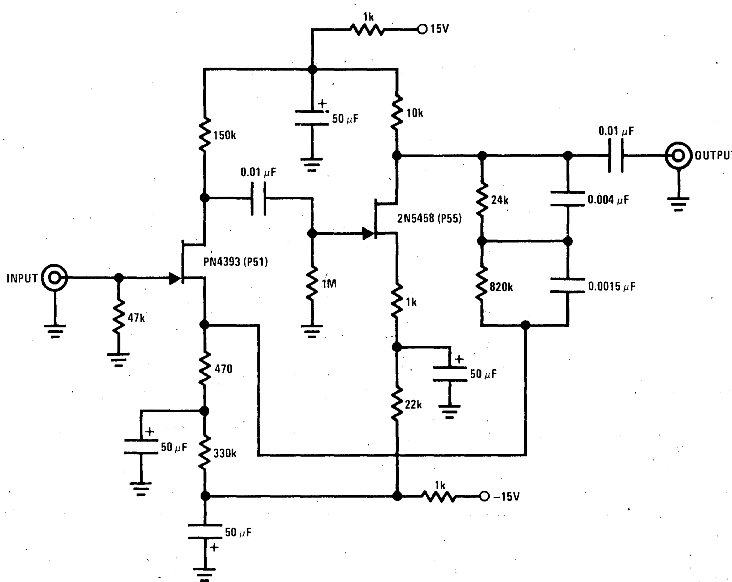
100 MHz Converter

The 2N4416 JFET will provide noise figures of less than 3 dB and power gain of greater than 20 dB. The JFET's outstanding low crossmodulation and low intermodulation distortion provides an ideal characteristic for an input stage. The output feeds into an LM171 used as a balanced mixer. This configuration greatly reduces L.O. radiation both into the antenna and into the IF strip and also reduces RF signal feedthrough.



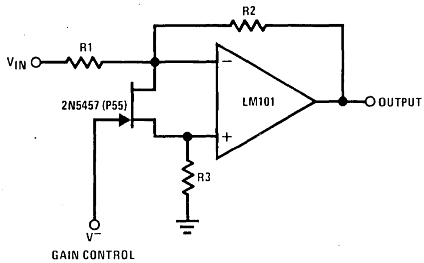
Differential Analog Switch

The NPD5566 monolithic dual is used in a differential multiplexer application where $R_{DS(ON)}$ should be closely matched. Since $R_{DS(ON)}$ for the monolithic dual tracks at better than ±1% over wide temperature ranges (−25°C to +125°C), this makes it an unusual but ideal choice for an accurate multiplexer. This close tracking greatly reduces errors due to common-mode signals.



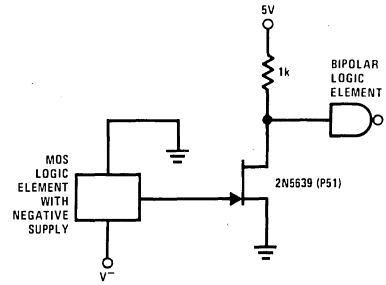
Magnetic Pickup Phono Preamplifier

This preamplifier provides proper loading to a reluctance phono cartridge. It provides approximately 35 dB of gain at 1 kHz (2.2 mV input for 100 mV output), it features S + N/N ratio of better than −70 dB (referenced to 10 mV input at 1 kHz) and has a dynamic range of 84 dB (referenced to 1 kHz). The feedback provides for RIAA equalization.



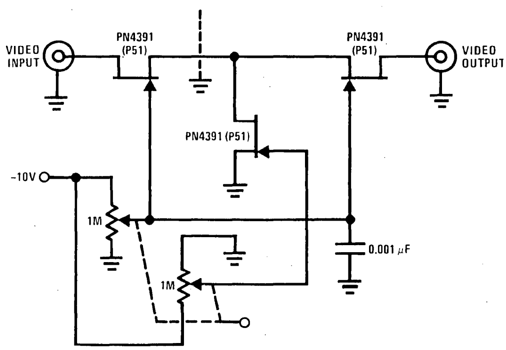
Voltage Controlled Variable Gain Amplifier

The 2N5457 acts as a voltage variable resistor with an $R_{DS(ON)}$ of 800Ω max. Since the differential voltage on the LM101 is in the low mV range, the 2N5457 JFET will have linear resistance over several decades of resistance providing an excellent electronic gain control.



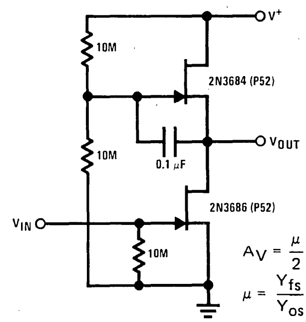
Negative to Positive Supply Logic Level Shifter

This simple circuit provides for level shifting from any logic function (such as MOS) operating from minus to ground supply to any logic level (such as TTL) operating from a plus to ground supply. The 2N5639 provides a low $r_{ds(ON)}$ and fast switching times.



Variable Attenuator

The PN4391 provides a low $R_{DS(ON)}$ (less than 30Ω). The tee attenuator provides for optimum dynamic linear range for attenuation and if complete turn-off is desired, attenuation of greater than 100 dB can be obtained at 10 MHz providing proper RF construction techniques are employed.

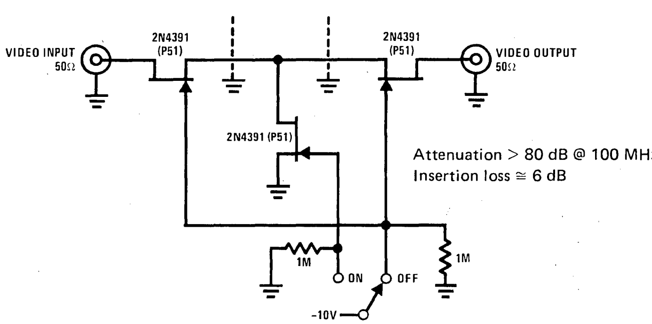


$$A_V = \frac{\mu}{2} = 500 \text{ typical}$$

$$\mu = \frac{Y_{fs}}{Y_{os}}$$

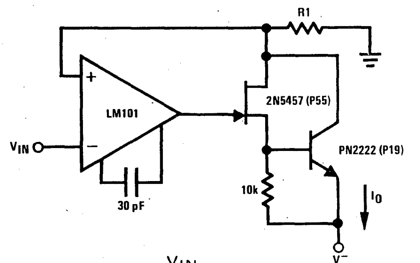
Ultra-High Gain Audio Amplifier

Sometimes called the "JFET μ-amp", this circuit provides a very low power, high gain amplifying function. Since μ of a JFET increases as drain current decreases, the lower drain current is, the more gain you get. You do sacrifice input dynamic range with increasing gain, however.



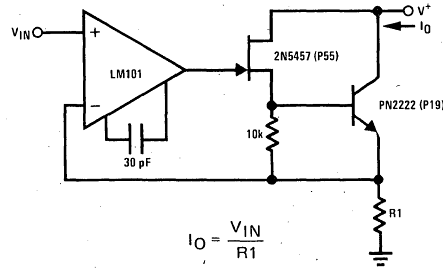
High Frequency Switch

The 2N4391 provides a low ON resistance of 30Ω and a high OFF impedance (<0.2 pF) when OFF. With proper layout and an "ideal" switch, the performance stated above can be readily achieved.



$I_O = \frac{V_{IN}}{R1} \quad V_{IN} \leq 0V$

Precision Current Source



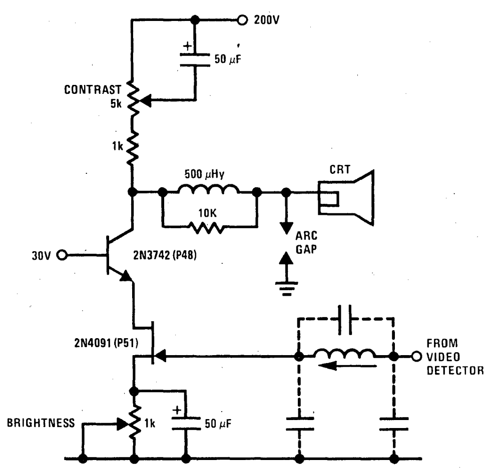
$I_O = \frac{V_{IN}}{R1}$

$V_{IN} > 0V$

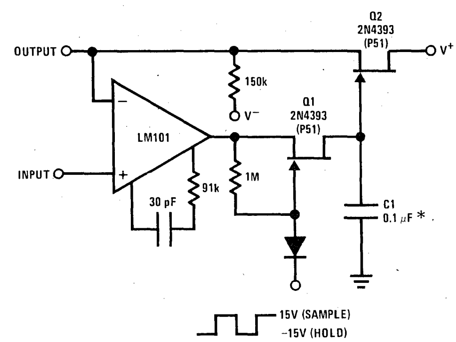
Precision Current Sink

The 2N5457 and PN2222 bipolar serve as voltage isolation devices between the output and the current sensing resistor, R1. The LM101 provides a large amount of loop gain to assure that the circuit acts as a current source. For small values of current (<1 mA), the PN2222 and 10k resistor may be eliminated with the output appearing at the source of the 2N5457.

The 2N5457 JFET and PN2222 bipolar have inherently high output impedance. Using R1 as a current sensing resistor to provide feedback to the LM101 op amp provides a large amount of loop gain for negative feedback to enhance the true current sink nature of this circuit. For small current values, the 10k resistor and PN2222 may be eliminated if the source of the JFET is connected to R1.



JFET–Bipolar Cascode Circuit

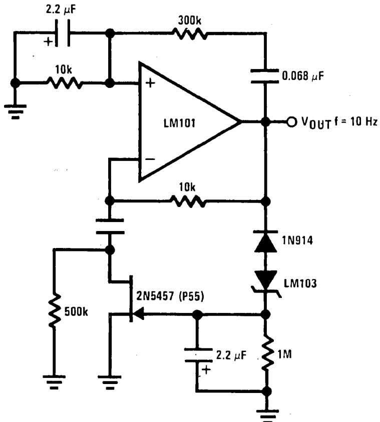


*Polycarbonate dielectric capacitor

Low Drift Sample and Hold

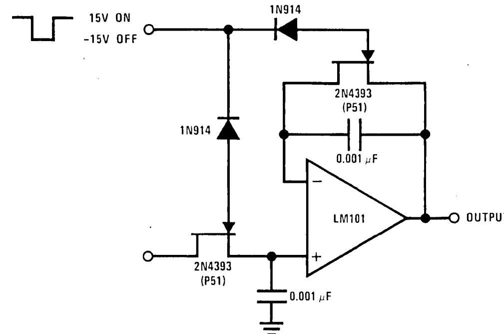
The JFET-bipolar cascode circuit will provide full video output for the CRT cathode drive. Gain is about 90. The cascode configuration eliminates Miller capacitance problems with the 2N4091 JFET, thus allowing direct drive from the video detector. An m derived filter using stray capacitance and a variable inductor prevents 4.5 MHz sound frequency from being amplified by the video amplifier.

The JFETs, Q1 and Q2, provide complete buffering to C1, the sample and hold capacitor. During sample, Q1 is turned ON and provides a path, $r_{ds(ON)}$, for charging C1. During hold, Q1 is turned OFF, thus leaving Q1 $I_{D(OFF)}$ (<100 pA) and Q2 I_{GSS} (<100 pA) as the only discharge paths. Q2 serves a buffering function so feedback to the LM101 and output current are supplied from its source.



Peak output voltage
$V_p \cong V_Z + 1V$

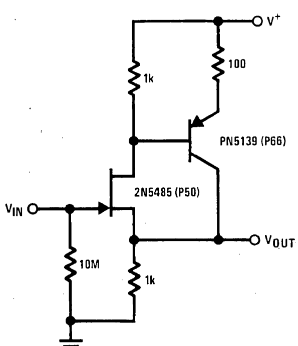
Wien Bridge Sine Wave Oscillator



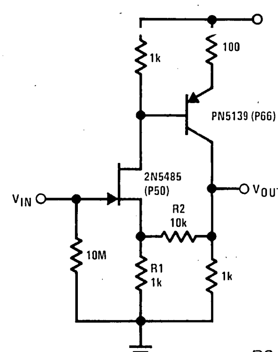
JFET Sample and Hold Circuit

The major problem in producing a low distortion, constant amplitude sine wave is getting the amplifier loop gain just right. By using the 2N5457 JFET as a voltage variable resistor in the amplifier feedback loop, this can be easily achieved. The LM103 zener diode provides the voltage reference for the peak sine wave amplitude; this is rectified and fed to the gate of the 2N5457, thus varying its channel resistance and, hence, loop gain.

The logic voltage is applied simultaneously to the sample and hold JFETs. By matching input impedance and feedback resistance and capacitance, errors due to $r_{ds(ON)}$ of the JFETs is minimized.



High Impedance Low Capacitance Wideband Buffer

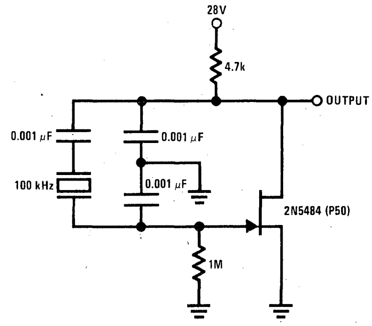


$$V_{OUT} \cong \frac{R2}{R1} V_{IN}$$

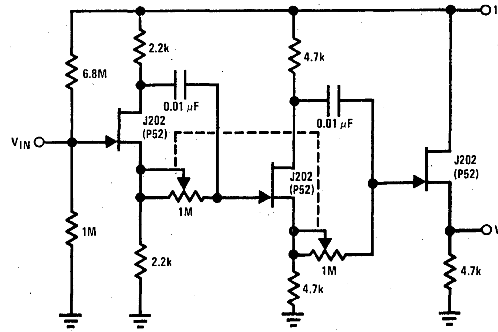
High Impedance Low Capacitance Amplifier

The 2N5485 features low input capacitance which makes this compound series-feedback buffer a wide-band unity gain amplifier.

This compound series-feedback circuit provides high input impedance and stable, wide-band gain for general purpose video amplifier applications.



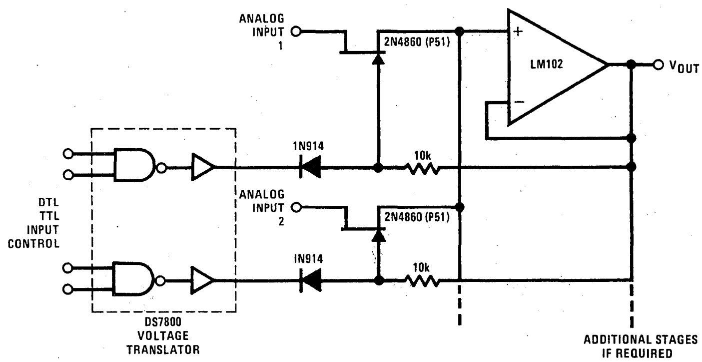
Stable Low Frequency Crystal Oscillator



0 to 360° Phase Shifter

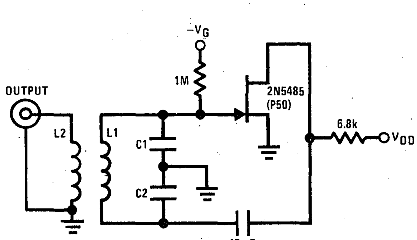
This Colpitts-Crystal oscillator is ideal for low frequency crystal oscillator circuits. Excellent stability is assured because the 2N5484 JFET circuit loading does not vary with temperature.

Each stage provides 0° to 180° phase shift. By ganging the 2 stages, 0° to 360° phase shift is achieved. The J202 JFETs are ideal since they do not load the phase shift networks.



DTL-TTL Controlled Buffered Analog Switch

This analog switch uses the 2N4860 JFET for its 25Ω r_{ON} and low leakage. The LM102 serves as a voltage buffer. This circuit can be adapted to a dual trace oscilloscope chopper. The DS7800 monolithic IC provides adequate switch drive controlled by DTL/TTL logic levels.



20 MHz oscillator values

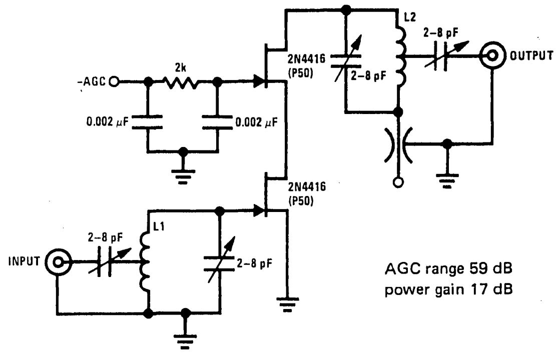
C1 ≅ 700 pF	L1 = 1.3 μH
C2 = 75 pF	L2 = 10T 3/8" dia 3/4" long
V_{DD} = 16V	I_D = 1 mA

20 MHz oscillator performance

Low distortion 20 MHz osc
2nd harmonic — 60 dB
3rd harmonic > −70 dB

Low Distortion Oscillator

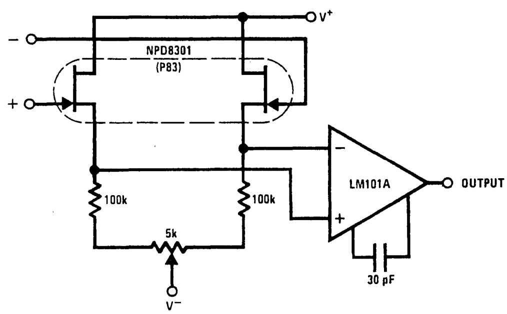
The 2N5485 JFET is capable of oscillating in a circuit where harmonic distortion is very low. The JFET local oscillator is excellent when a low harmonic content is required for a good mixer circuit.



L1 = 0.07 μHy center tap
L2 = 0.07 μHy tap 1/4 up from ground

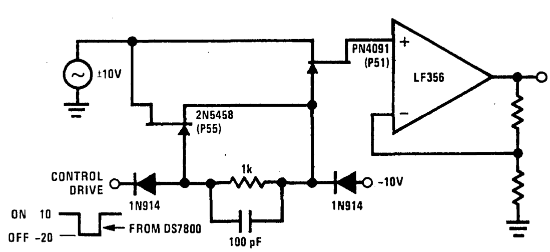
200 MHz Cascode Amplifier

This 200 MHz JFET cascode circuit features low cross-modulation, large signal handling ability, no neutralization, and AGC controlled by biasing the upper cascode JFET. The only special requirement of this circuit is that I_{DSS} of the upper unit must be greater than that of the lower unit.



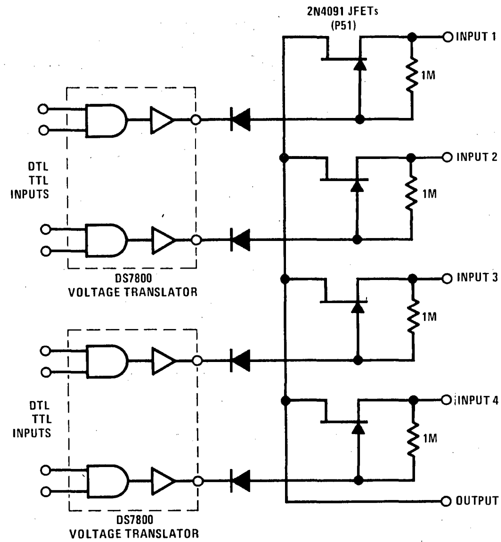
FET Op Amp

The NPD8301 monolithic-dual provides an ideal low offset, low drift buffer function for the LM101A op amp. The excellent matching characteristics of the NPD8301 track well over its bias current range, thus improving common-mode rejection.



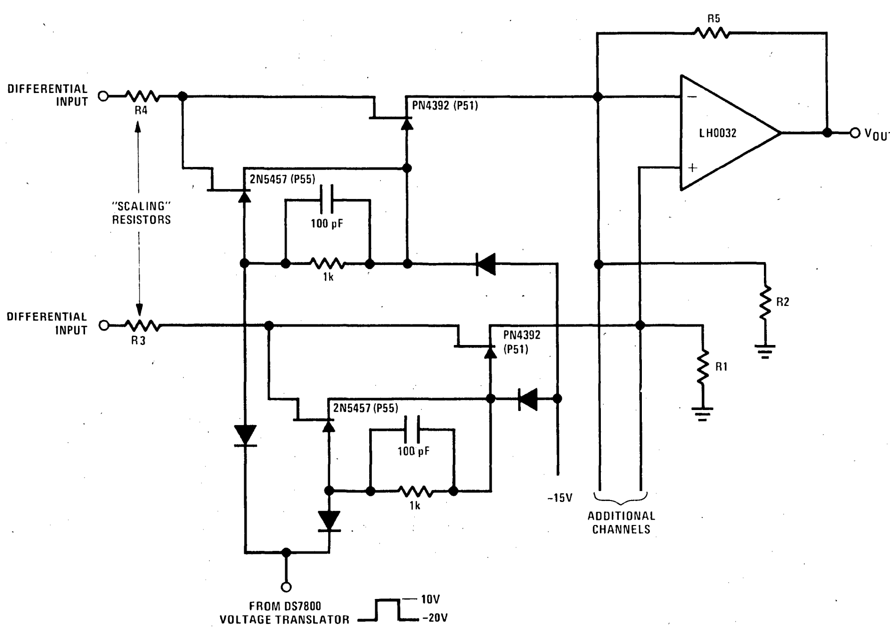
High Toggle Rate High Frequency Analog Switch

This commutator circuit provides low impedance gate drive to the PN4091 analog switch for both ON and OFF drive conditions. This circuit also approaches the ideal gate drive conditions for high frequency signal handling by providing a low AC impedance for OFF drive and high AC impedance for ON drive to the PN4091.



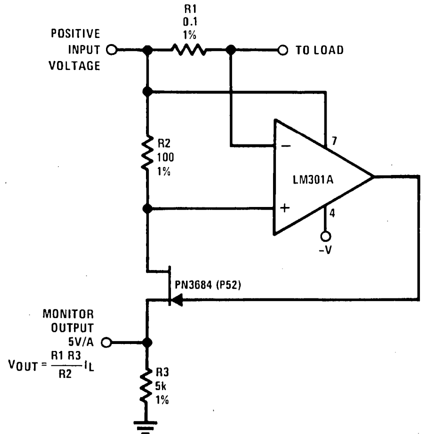
4-Channel Commutator

This 4-channel commutator uses the 2N4091 to achieve low channel ON resistance (<30Ω) and low OFF current leakage. The DS7800 voltage translator is a monolithic device which provides from 10V to −20V gate drive to the JFETs while at the same time providing DTL/TTL logic compatability.



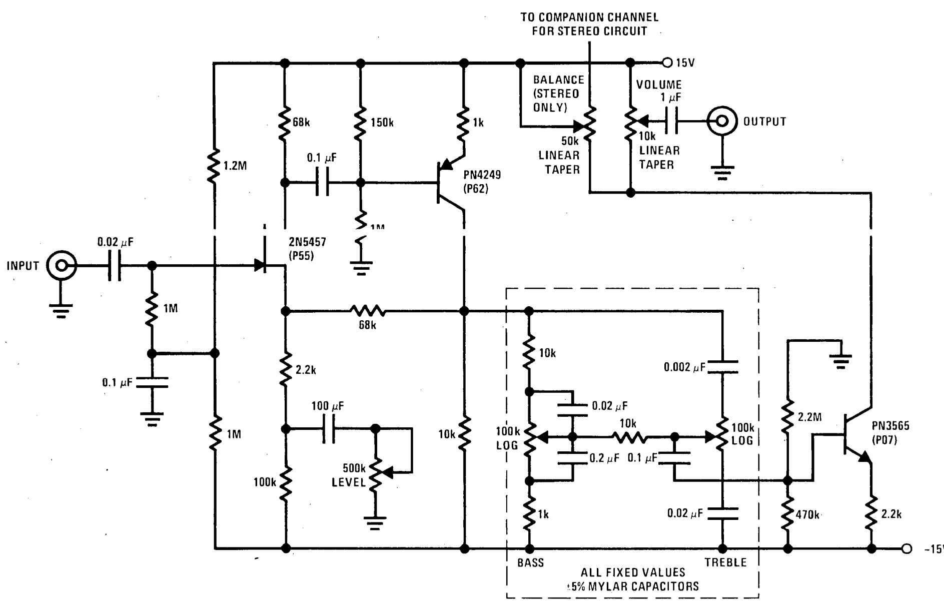
Wide Band Differential Multiplexer

This design allows high frequency signal handling and high toggle rates simultaneously. Toggle rates up to 1 MHz and MHz signals are possible with this circuit.



Current Monitor

R1 senses current flow of a power supply. The JFET is used as a buffer because $I_D = I_S$, therefore the output monitor voltage accurately reflects the power supply current flow.



Low Cost High Level Preamp and Tone Control Circuit

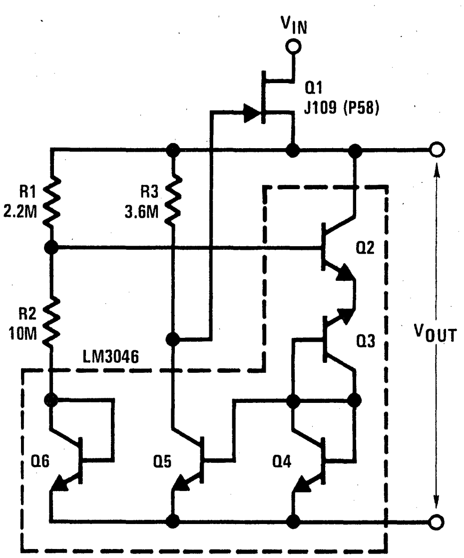
This preamp and tone control uses the JFET to its best advantage; as a low noise high input impedance device. All device parameters are non-critical, yet the circuit achieves harmonic distortion levels of less than 0.05% with an S/N ratio of over 85 dB. The tone controls allow 18 dB of cut and boost; the amplifier has a 1V output for 100 mV input at maximum level.

A Novel FET Micropower Voltage Regulator

National Semiconductor
John Maxwell
February 1977

Many systems require a stable voltage supply to maintain constant performance. When these systems are battery-operated, a regulator is needed to stabilize the system voltage as the battery decays with time. Unfortunately, IC voltage regulators require several milliamps of quiescent current, making them impractical for micropower applications. Zener diodes may also be impractical because of short term peak current requirements of the system. This could require additional buffering or high standby currents, but both increase the battery drain. An inexpensive micropower voltage regulator is needed to fill the gap between IC regulators (high quiescent current) and zener diodes (high standby current).

Instead of the tranditional bipolar approach, the regulator shown in *Figure 1* uses a JFET as the series pass element. This offers several advantages: first, no pre-regulation is needed for the pass element as with an NPN because the drive comes from the regulated output. Next, the gate-source is isolated from the line via the drain, thus offering excellent line regulation. This is not the case with PNP pass elements, where the emitter is the input. Finally, and possibly the most important feature for micropower regulators, is FETs require no current drive.



Output Voltage

$$V_{OUT} = V_{BE}\left(2 + \frac{R1}{R2}\right) + BV_{EB}\left(1 + \frac{R1}{R2}\right)$$

Drift

$$\frac{\partial V_{OUT}}{\partial T} = \frac{\partial V_{BE}}{\partial T}\left(2 + \frac{R1}{R2}\right) + \frac{\partial BV_{EB}}{\partial T}\left(1 + \frac{R1}{R2}\right)$$

Quiescent Current $\simeq 4\ \mu A$

FIGURE 1. Micropower Regulator

The emitter-base breakdown voltage of Q3 is used as a reference (~7.2V) in conjunction with Q2 to form a shunt regulator. The shunt current drives a current mirror, Q4–Q5, which creates the gate drive voltage of the pass FET. The value of the shunt current is determined by R3 and the V_{GS} of the pass FET ($I_{R3} \simeq I_{SHUNT}$). High load currents will reduce the shunt current because the FET V_{GS} is lower. Temperature stability is achieved by cancelling the drift of Q2 and Q3's V_{BE} (~ −2 mV/°C/transistor) with the BV_{EB} drift of Q3 (~3 mV/°C) resulting in a negative drift at the base of Q2, and the output, of 1 mV/°C.

Selection of the FET requires some care. Ideally, the FET I_{DSS} needs to be greater than the load current at all temperatures (I_{DSS} has a temperature coefficient of ~ −0.7%/°C) and the breakdown voltage should be greater than the maximum input voltage. Practically, the FET I_{DSS} needs to be much larger than the maximum load current. Linear operation requires the FET's drain to gate voltage (V_{DG}) to be greater than the pinchoff voltage V_P. By operating the FET at currents much less than I_{DSS}, the gate to source voltage (V_{GS}) will be close to V_P ($V_{GS} = V_P\,(1-I_D/I_{DSS})^{1/2}$) allowing small drain to source voltages (V_{DS}). For linear operation:

$$|V_{DG}| > |V_P|$$

$$V_{DG} = V_{DS} - V_{GS}$$

It should be noted that N FET's can be paralleled for higher load current requirements without matching the devices.

Actual performance of the regulator is quite good. With a 10V typical output, the line regulation is within ±0.05% for a range of $V_{IN}-V_{OUT}$ of 0.3V to 10V. The load regulation is 0.2% with a load range of 10 μA to 10 mA ($Z_O \simeq 10\Omega$) and the temperature stability is −0.01%/°C (−1 mV/°C). The output voltage can be easily trimmed by adding a pot at the $R1R2Q2_{BASE}$ junction to eliminate BV_{EB} variations or to make the output adjustable over a limited range. Also, the temperature stability can be improved by replacing Q3 with an 8.2V zener diode, because its temperature drift (~ 4 mV/°C) would nearly match the combined V_{BE} drift of Q2 and Q4. The regulator is good enough to be used as a reference in low accuracy (6–7-bit) or limited temperature range applications if current drain is important.

REFERENCES

1. "Voltage Regulator Handbook", National Semiconductor Corporation, May 1975.
2. "Zener Diode Handbook", Motorola, Inc., May 1967.
3. Williams, P., "D.C. Voltage-Reference Circuits with Minimum Input-Output Differentials", Proc. IEEE pp. 1280–1281, December, 1969.

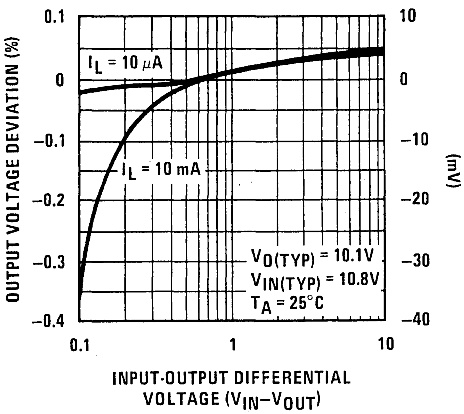


FIGURE 2. Line Regulation vs Input-Output Differential

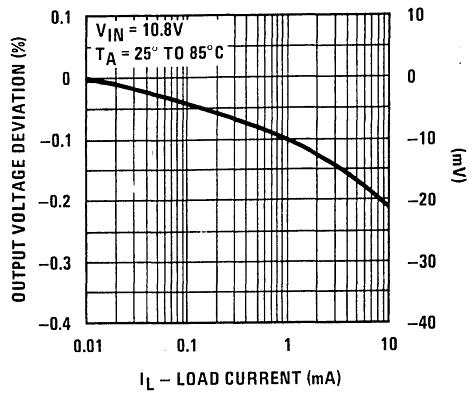


FIGURE 3. Load Regulation

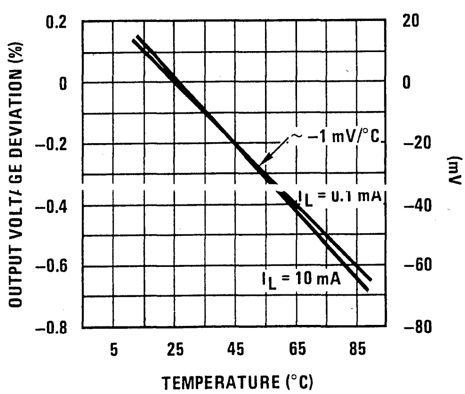


FIGURE 4. Temperature Stability

A Linear Multiple Gain-Controlled Amplifier

National Semiconductor
Application Note 129
Jim Sherwin
August 1975

INTRODUCTION

A linear control function over three decades of gain can be achieved with a FET in the feedback path of a non-inverting amplifier. Besides the ultimate simplicity of the circuit, multiple tracking gain control circuits can be constructed with dual op amps and monolithic dual FET's or quad op amps and monolithic quad FET's. Such circuits could even be integrated with ion-implanted FET's on single or multiple monolithic op amp chips. The gain control range may be designed for less than 2 to 1 or higher than 1000:1, but input voltage levels are limited by acceptable levels of distortion. Bandwidth is dependent on maximum gain and unity gain bandwidth of the op amp used. The gain control circuit is especially suitable for volume expansion applications.

GAIN CONTROL WITH FETS

The FET has long been used as a voltage controlled resistor (VCR), often as the shunt arm in the series-shunt attenuator of *Figure 1.* Advantages of the FET as a VCR are that:

1. The control signal is almost perfectly isolated from the controlled signal path, and
2. The resistance can be made to vary over an almost infinite max/min ratio.

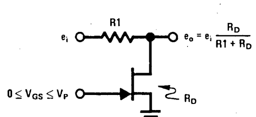


FIGURE 1. Voltage Controlled FET Attenuator

Disadvantages are that:

1. The FET behaves as a linear resistance only for small values of source-drain voltage V_{DS},
2. Non-linearity (of resistance) increases as the control voltage V_{GS} approaches cut-off voltage V_P when the resistance is maximum,
3. The relationship of resistance r_d to V_{GS} is reciprocal rather than direct linear,
4. VCR multiples with matched resistance characteristics over their full control range have been extremely difficult to obtain at any kind of reasonable price, and
5. Production spread in V_P requires separate bias set and gain set on each circuit.

Examination of the FET drain characteristics in *Figure 2* will reveal the essential non-linearity of r_d at high signal levels, especially as V_{GS} approaches V_P. This non-linear region must be avoided in order to achieve tolerable distortion levels. One obvious way is to limit V_{DS} to small values when r_d is high as suggested by *Figures 2c and 2d,* another is to utilize FET's with high V_P as suggested by reference to *Figures 2b and 2d.*

The reciprocal relationship of r_d and V_{GS} is an advantage, as it is precisely that which allows the linear control of gain in the circuit to be described. The availability of matched monolithic dual FET's such as the NSC 2N3958 (watch out for the matched pairs as their resistance match close to V_P may not be as good as that of the monolithic versions) make available low cost duals with very closely matched resistance characteristics over the full control range. There are even some monolithic quads available (such as the AM9709 series). The final problem of the production range of V_P can be much improved with ion-implant diffusion techniques whereby lot variation in V_P may be held to within a few tenths of one volt.

The gain control circuit is that of an ordinary non-inverting op amp with feedback. The usual circuit is modified in *Figure 3a* to include a FET as controlled resistor. The gain function is normal except that r_d replaces R2 in the usual form.

$$A_V = 1 + \frac{R1}{r_d} \qquad (1)$$

Now r_d can be equated to a control voltage V_C as follows:

$$r_d = r_o \frac{V_P}{V_P - V_{GS}} \qquad (2)$$

Where:

$$r_o = r_d \Big|_{V_{GS} = 0}$$

$$r_d = r_o \frac{V_P}{V_C} \qquad (3)$$

Where:

$$V_C = V_P - V_{GS}$$

The gain function is thus seen to be linear with V_C.

$$A_V = 1 + \frac{R1}{r_o} \frac{V_C}{V_P} \qquad (4)$$

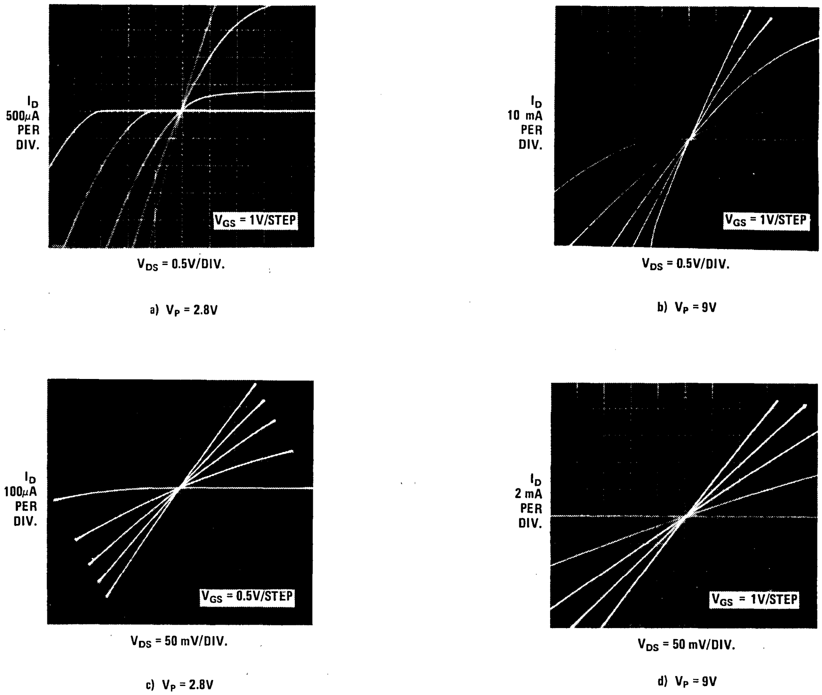


FIGURE 2. AC Output Characteristics of FET

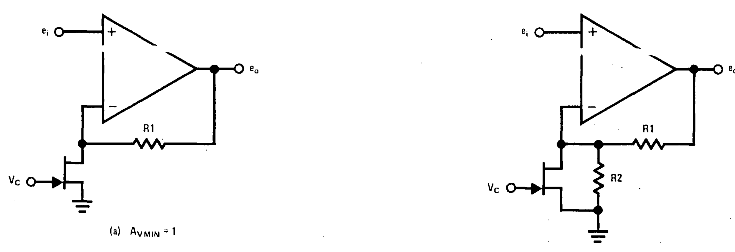


FIGURE 3. FET/Op Amp Gain Control Circuit

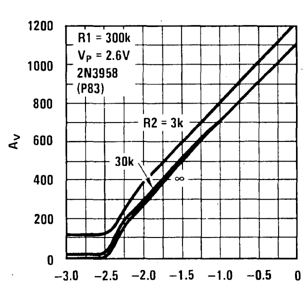


FIGURE 4. Gain vs Control Voltage For Short Channel FET

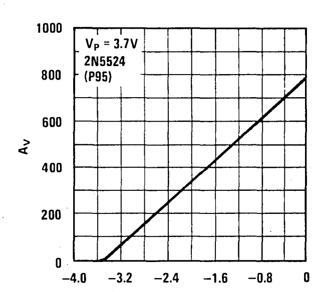


FIGURE 5. Gain vs Control Voltage For Long Channel FET

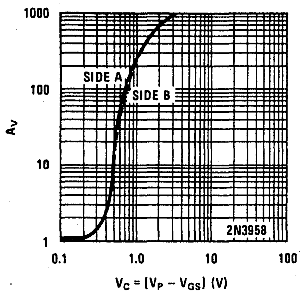


FIGURE 6. Control-Gain Match For Dual FET

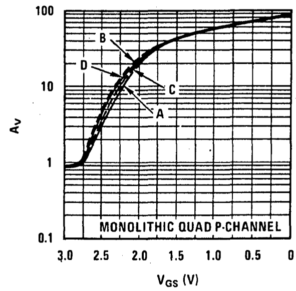


FIGURE 7. Monolithic Quad Gain Control Tracking

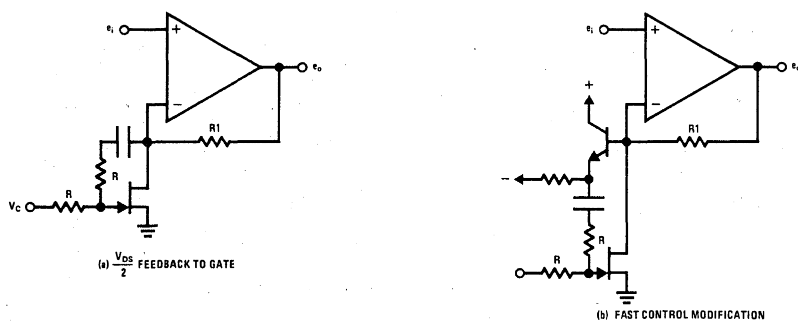


FIGURE 8. Circuit to Reduce Distortion

At $V_C = 0$, the gain reduces to unity; and at $V_C = V_P$, the gain increases to $1 + R1/r_o$ which may be as high as 1000 or so. If it is desired to limit the minimum gain to some value greater than unity, another resistor R2 may be added as in *Figure 3b.* Then the gain equation becomes:

$$A_V = 1 + \frac{R1}{\dfrac{R2\, r_o\, (V_P/V_C)}{R2 + r_o\, (V_P/V_C)}}$$

$$= 1 + \frac{R1\, [R2 + r_o\, (V_P/V_C)]}{R2\, r_o (V_P/V_C)}$$

$$A_V = 1 + \frac{R1}{R2} + \frac{R1\, V_C}{r_o\, V_P} \qquad (5)$$

In either case, the gain function is linear with V_C.

The circuits of *Figure 3* do indeed show a linear gain versus control voltage as plotted in *Figure 4* for several values of minimum gain. There is some non-linearity near minimum gain which appears in all curves. This is certainly due to a non-ideal characteristic of the FET caused by finite contact and bulk resistance at source and drain. *Figure 5* shows a similar control curve for a FET with longer channel in which the controlled channel resistance is a greater part of the total resistance than that of the short channel device of *Figure 4*. For those applications requiring a more precisely linear control of gain, the long channel devices will be preferable.

Several variable-gain circuits can be made to track when monolithic multiple FET's are used as the control elements with matched feedback resistors. A monolithic FET dual (NSC 2N3958) used in two identical control circuits shows remarkable tracking over the entire control range, even when V_{GS} is near V_P where variations would be expected to be most apparent. The plots appear in *Figure 6.* Similar performance for a quad gain control using a monolithic P-channel quad FET (AH5009) is shown in *Figure 7*.

DISTORTION

Reference to *Figure 2* will show that the FET acts as a linear resistance only for relatively small values of drain-source voltage, in either polarity. This is particularly apparent for positive V_{DS} (for N-channel FET) and V_{GS} approaching V_P. The difference between *Figures 2c and 2d* indicates that the maximum allowed applied signal will be greater for high V_P as compared with low V_P.

It is possible to improve the linearity characteristics somewhat by applying a part of the V_{DS} in series with the control voltage applied as V_{GS}. The circuit to accomplish this is that shown in *Figure 8.* It happens that about half of V_{DS} applied to the gate provides the greatest improvement for small signals. The addition of two resistors and one capacitor as in *Figure 8a* is all that is required. The capacitor simply blocks the control voltage from the FET drain and the op amp input. *Figure 8b* shows the addition of an emitter follower to

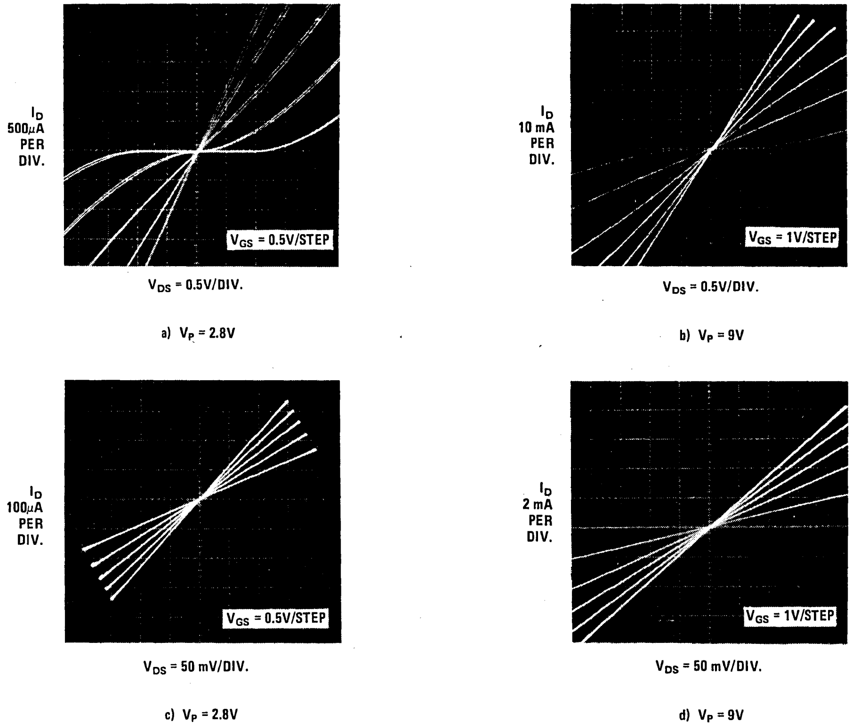


FIGURE 9. AC Output Characteristics of FET with Feedback Linearization

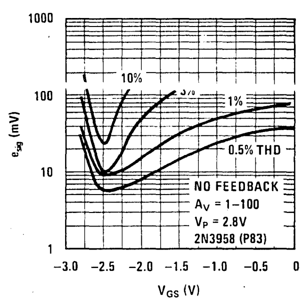


FIGURE 10. Distortion With V_P = 2.8V

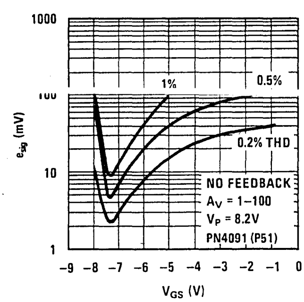


FIGURE 11. Distortion With V_P = 8.2V

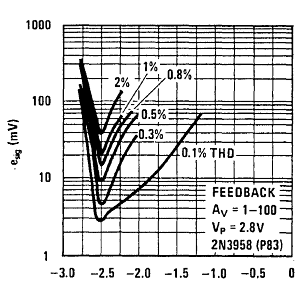


FIGURE 12. Distortion With V_P = 2.8V, With Linearization

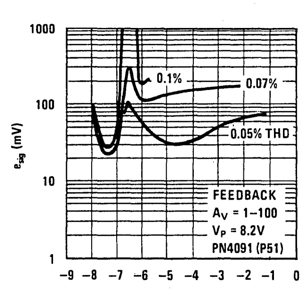


FIGURE 13. Distortion With V_P = 8.2V, With Linearization

prevent abrupt changes in V_C from coupling to the op amp. *Figure 9* shows the improved linearity of the drain characteristics as compared to *Figure 2*. The improvement is also seen in the distortion versus input signal plots of *Figures 10–13*. Note particularly that the distortion at any value of V_C is primarily a function of input signal (which equals the feedback signal applied to the FET drain at the inverting input). Some modification is made to this direct relationship if an R2 is shunted across the FET as in *Figure 3b*. Measured distortion at low signal level is the result of noise rather than of signal distortion. Maximum gain is limited to about 100 in these plots so as to avoid the region of lower S/N. The noise is that of the op amp input stage and the signal source resistance plus the contribution of the FET which is essentially the thermal noise of r_d.

BANDWIDTH AND CONTROL TIME CONSTANT

The circuit bandwidth is the closed loop bandwidth of the op amp used at the (instantaneous) set gain. The gain control time constant is that of the input circuit to the FET (dependent on the value of R in *Figure 8*) limited by the slew rate of the op amp. The FET itself reacts practically instantly, producing a step change in feedback ratio. Control time constant is thus a few microseconds at most.

APPLICATIONS

Three obvious applications present themselves; they are:

1. Remote or multichannel gain control

2. Volume expansion

3. Volume compression/limiting

To this short list might be added a number of others, including applications in noise reduction and quad sound techniques.

The gain-controlled amplifier of *Figure 14* has a gain range of 1–1000, a maximum output level of 8.5 Vrms, and a bandwidth of better than 20 kHz at maximum gain. The FET used has high V_P for maximum freedom from distortion. *Figures 15 and 16* show the gain function and constant distortion contour lines. Note that the gain control curve is non-linear near unity gain because the PN4091 is a short channel FET. Distortion is quite low except as limited by maximum output voltage. Note that the maximum e_{in} is restricted by output saturation. The LM318 is used in the example only to achieve wideband response at maximum gain. The amplifier input voltage must be restricted to about 8 mVrms at maximum gain when the S/N will be about 60 dB over a 10 kHz bandwidth.

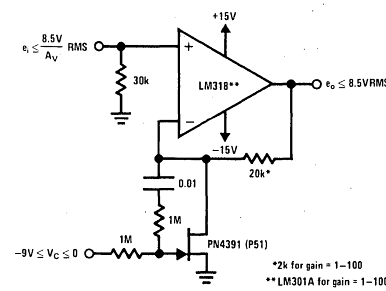


FIGURE 14. Amplifier With Gain Range = 1–1000

A more practical circuit might employ a gain range of 1–100. Then the amplifier could be a LM301A and still achieve a 10 kHz bandpass at maximum gain. The input signal could, accordingly, be increased to 80 mVrms for a S/N of 80 dB. This performance can be extended to dual and quad control circuits with tracking gain functions, but watch the bandwidth as required at maximum gain. Any of the several dual op amps could be used with the 2N3958 (monolithic dual from NSC), or the LM324 quad op amp can be used in limited gain times bandwidth applications with a quad monolithic FET. *Figure 17* shows all details of an ac coupled tracking quad gain control with 40 dB range. Gain varies over 1–100 range, bandwidth is 10 kHz minimum, S/N is better than 70 dB with 4.3 Vrms maximum output. *Figure 7* shows the gain curve and matching characteristics.

Noise considerations could be important in this method of gain control, as the signal is amplified rather than attenuated. To realize the function of a 40 dB variable attenuator, it is necessary to install a fixed attenuator at the amplifier input and perhaps also at the output. This will reduce the minimum signal level to millivolts, thus a low noise amplifier is desirable. The LM381 dual low-noise ac coupled amplifier could be used in a 40 dB

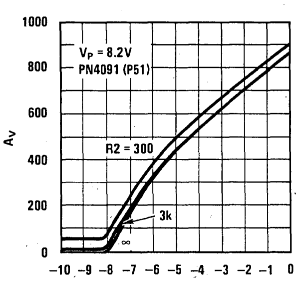


FIGURE 15. Gain For Circuit of Figure 14

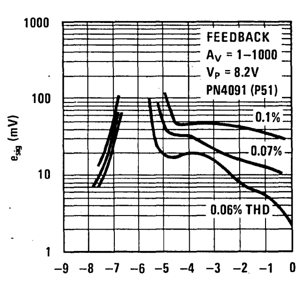


FIGURE 16. Distortion For Circuit of Figure 14

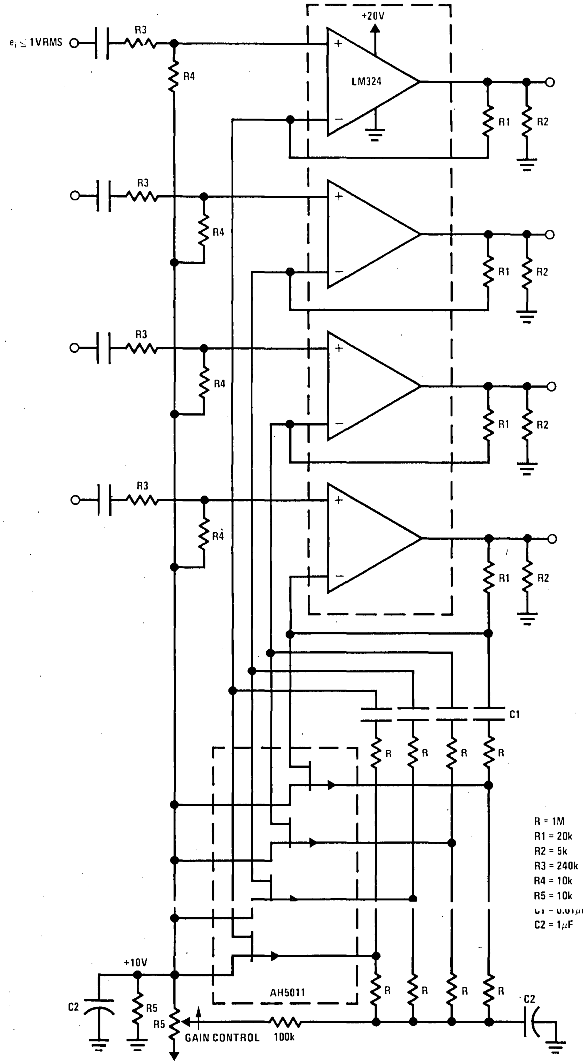


FIGURE 17. Quad Gain Control

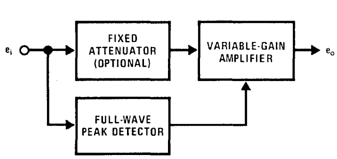


FIGURE 18. Volume Expander/Compressor Block Diagram

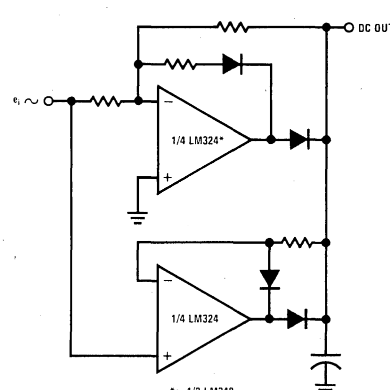


FIGURE 19. Full Wave Linear Precision Peak Detector

audio attenuator to realize S/N about 100 dB or in a 60 dB attenuator to realize 80 dB S/N. Improvements in S/N can be made by reducing system bandwidth in fixed or low frequency operation. Minimum noise is also achieved by using the minimum practical amplifier source resistance. Values as low as 1 kΩ are advantageous.

The effect of temperature will be to change the gain according to the temperature sensitivity of the FET. This effect can be reduced by using a silicon resistor for the feedback resistor, R1. If the FET were to be integrated onto the op amp chip, an attempt should be made to include R1 on the chip as well.

The application to a volume expander circuit is of interest as the control is linear, the required control range is only about 1:4, and the input signal is small for the low gain condition when distortion would otherwise be most apparent. The elements of a volume expander are indicated in *Figure 18.* The gain controlled amplifier need only exhibit a 12 dB variation in gain, being lowest for small signals. The slope of gain versus control should be linear, more specifically the slope of (log) gain in dB versus (log) signal in dB should be linear. A practical range is 12 dB gain change over a 30 dB input signal range. The peak detector should be linear down to very small signals, exhibit a fast attack or charge time of a millisecond or less, a discharge time constant of about 2 seconds, and operate on the first half cycle (full-wave detector). The detector should, therefore, be a full-wave precision linear peak detector with low internal impedance; the requirements can be met with the circuit of *Figure 19.*

The expander circuit shown in *Figure 20* will perform as desired. The gain control function is plotted in *Figure 21;* distortion is below 0.1% at all levels. Resistors R3 and R4 are added in order to modify the linear control curve to the desired log curve. Note that the input signal is attenuated prior to amplification in order to reduce distortion and maintain an overall gain of approximately 0 dB at midrange of expansion. The noise with the LM124 over a 20 kHz bandwidth is, of course, a function of signal; but the maximum signal to noise ratio is 80 dB. The circuit could be adapted to stereo or quad sound as in *Figures 22–23.* Questions for individual design concern the method of control. Whether to expand all channels together, and whether to derive the control signals individually from each channel, a summation from 2 to 4 channels, or from a single channel (assuming that high level from any channel indicates high levels from all channels). Note that the FET is biased OFF (minimum gain) for low signals, and increasing signals progressively bias the FET ON (maximum gain).

The volume compression circuit is a logical mate to the expander. The only difference would be that the FET is initially biased ON (maximum gain) for low signals, and

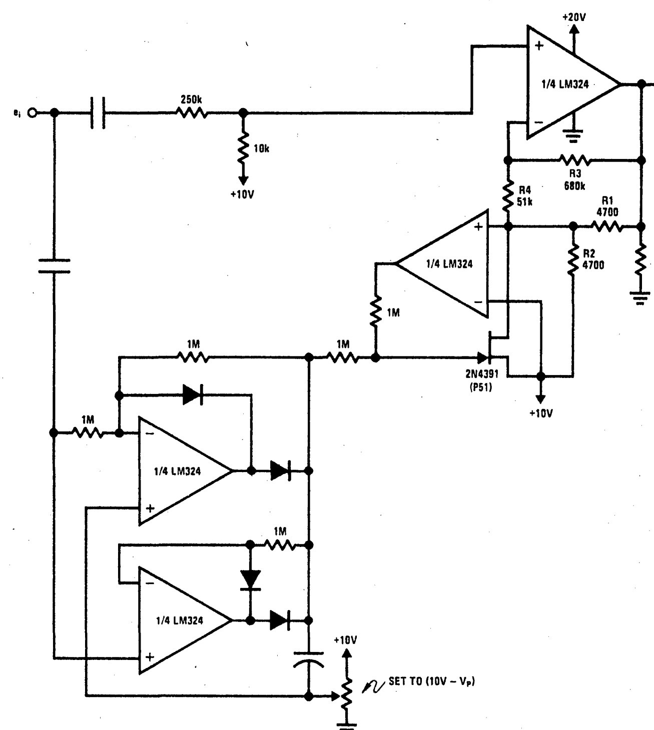


FIGURE 20. Volume Expander Circuit

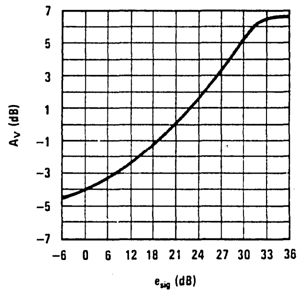


FIGURE 21. Expander Gain Characteristic

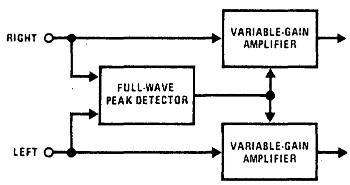


FIGURE 22. Stereo Expander Block

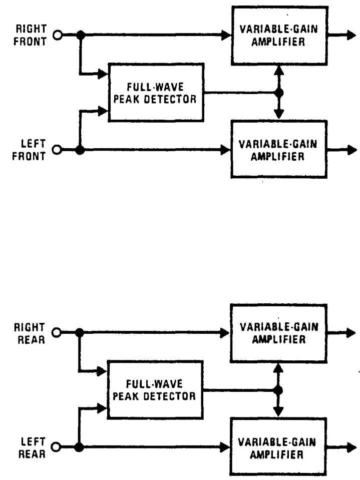


FIGURE 23. Four-Channel Expander Block

increasing signals progressively bias the FET OFF (minimum gain). A disadvantage is that the circuit produces greatest distortion in the low gain condition when signals are highest. Maximum S/N is degraded by 24 dB over that of the expander, minimum S/N is the same.

CONCLUSION

The combination of FET and op amp provides a linear dc (voltage) control of gain over a range to 60 dB. As the circuit realizes positive gain, rather than being a controlled attenuator, the input signal is limited. Input signal is further limited to several hundred millivolts by the non-linearity of the FET (which sees the full input signal). Because input signals will generally be in the 10–300 mV range, noise performance of the selected op amp will be important. Even so, S/N of 60–100 dB is obtainable with standard amplifiers. Tracking pair or quad gain-control amplifiers are realizable with existing monolithic dual or quad FET's, and the combination of FET and op amp lends itself to simple integration. The circuit is well-suited to remote and multiple linear gain control and to volume expander/compressors. The volume expander is especially interesting as the signal level and gain conditions result in extremely low distortion and more than adequate signal-to-noise ratio.

Binary/BCD Gain Programmed Amplifiers

National Semiconductor
John Maxwell
February 1977

Many systems require logic controlled gain programmable amplifiers (GPA) for signal preconditioning, level control and dynamic range expansion. The system sets GPA requirements for accuracy, speed and signal handling capability, limiting the type used. Conventional CMOS analog switches limit signal handling to ±7.5V and accuracy to 1%. High voltage CMOS or JFET analog switches increase both accuracy and signal handling (±10V to ±15V) but at a greater cost. Programmable amplifiers using current mode analog switches have the highest signal handling capability (±25V) with high accuracy, speed and low cost.

In reality, the logic controlled GPA is a multiplying digital-to-analog converter (multiplying D/A). The D/A input is the reference node which is multiplied by the digital input. Multiplying D/A converters have been available for some time in module, hybrid and monolithic form but suffer from high cost and poor signal handling capability (±10V maximum).

Large signal handling (±25V), moderate cost multiplying D/A converters can be built using monolithic current mode analog switches, an op amp and a few resistors.

Unlike conventional analog switches, only signal current is switched at the virtual ground of an op amp with current mode analog switches. Limiting the voltage across the switch to a few hundred millivolts, power supplies, logic interface and level translator circuits are eliminated allowing the JFET switches to be driven directly by standard logic.

A logic "0" turns the switch ON with a logic "1" shutting the switch OFF by pinching the FET OFF. The diode is used to clamp the source to drain voltage to about 0.7V in the switch OFF state. The series FET in the feedback path is used to compensate for the ON resistance of the switch FET.

Current through the switch is determined by the input resistor, R1, the switch ON resistance and the input voltage, V_{IN}. Scaling of the output voltage is accomplished with the feedback resistor, setting the gain of the amplifier.

$$A_V = -\frac{R2 + R_{ON2}}{R1 + R_{ON1}} \qquad (1)$$

A 4-bit multiplying D/A converter can be built using a quad current mode switch, 4 binary weighted resistors (R, 2R, 4R, 8R) and an op amp. The output voltage will be a function of the feedback resistor, input resistors and the logic state of the FET gates, G_N.

The number of bits is expanded by cascading another quad current switch and resistor array to the first. Instead of continuing the binary progression of the input resistors, (16R, 32R, etc), current splitting resistors are used such that the same resistor array (R, 2R, 4R, 8R) is used for the additional bits, minimizing the number of resistor values required for higher order converters.

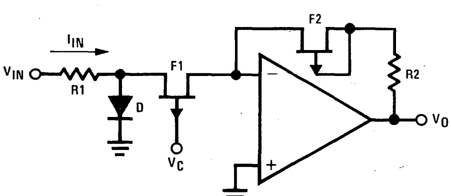
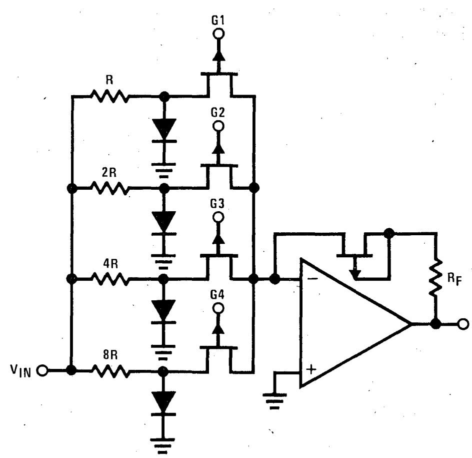
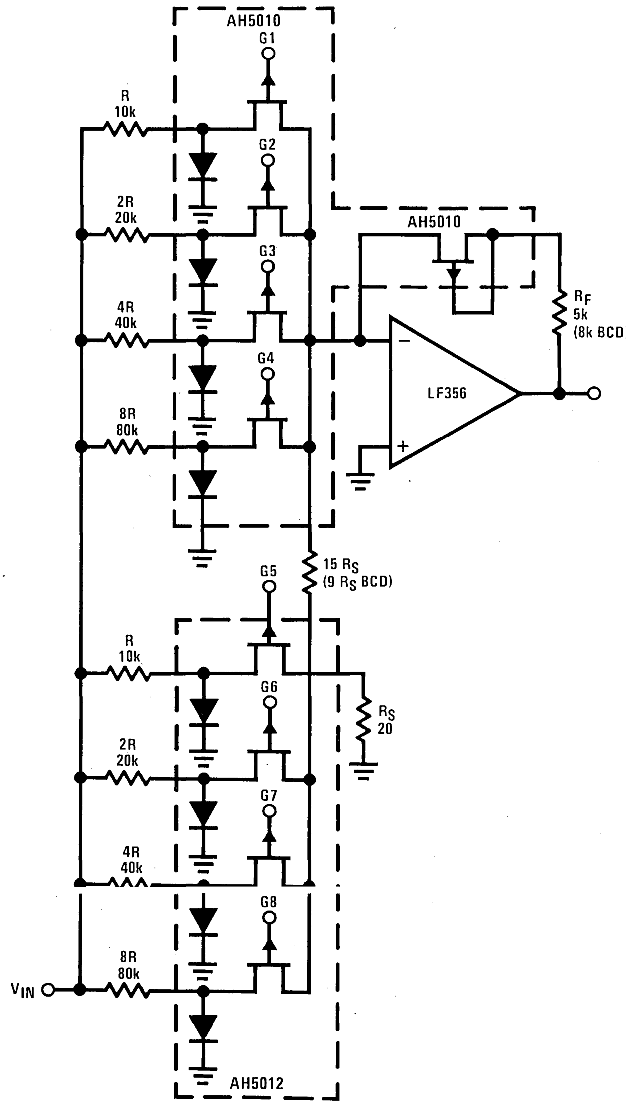


FIGURE 1. Current Mode Analog Switch



$$V_O = -V_{IN}\frac{R_F}{R}(\overline{G1}\,2^0 + \overline{G2}\,2^{-1} + \overline{G3}\,2^{-2} + \overline{G4}\,2^{-3})$$

FIGURE 2. 4-Bit Multiplying D/A Converter



$$V_O = -V_{IN}\frac{R_F}{R}\left[\overline{G1}\,2^0 + \overline{G2}\,2^{-1} + \overline{G3}\,2^{-2} + \overline{G4}\,2^{-3} + 1/16\left(\overline{G5}\,2^0 + \overline{G6}\,2^{-1} + \overline{G7}\,2^{-2} + \overline{G8}\,2^{-3}\right)\right]$$

(1/10 for BCD)

FIGURE 3. 8-Bit Multiplying D/A Using Cascaded 4-Bit Sections

Binary weighting requires a 1/16 current split for the second switch quad while BCD weighting requires a 1/10 split.

There are 2 basic switch configurations available that are optimized for a variety of logic drives: TTL or CMOS Multiple independent switches (4 by SPST) and a 4-channel multiplex version with a series compensation FET.

Practical limitations in using monolithic current mode analog switches need consideration. Resistor values and tolerance impacted by switch resistance is minimized by increasing resistor values without regard, but limits bandwidth and creates leakage errors at elevated temperatures. Using resistors that are too small, increase switch resistance errors. Current saturation (increased switch resistance) occurs when the switch current approaches the FET saturation current, I_{DSS}. High currents also cause $I_{G(ON)}$, current lost through the gate, as the diode and FET source to gate diode become forward biased. An input resistor value of 10k limits the switch current to less than 2 mA minimizing both leakage and switch resistance problems. For example, the gain accuracy at unity gain using the compensation FET is less than 0.05% with $R = R_F = 10k$.

The current shunt resistor used in cascading switches should be kept small to minimize the voltage drop, keeping the FET drains near ground. Values of R_S should be less than 100Ω (20 typ).

Resistor tolerance will be determined by converter resolution, i.e., the number if bits (N). For example, an 8-bit binary D/A converter will have $2^N - 1$ or 255 steps (99 for BCD) or different gains. The resolution or smallest step is (least significant bit) $1/2^N$ of the full-scale value (0.0039). Typical accuracy specifications for D/A converters are stated as 1 LSB or ±1/2 LSB.

This works out to be ±0.2% for the 8-bit binary unit. Errors in the feedback resistor directly affect the output of the converter. The most significant resistor, R, contributes 1/2 full-sca'e, reducing its error contribution by a factor of 2. The same is true for the rest of the resistors with contributions of 1/4, 1/8, etc. Using a resistor tolerance of 0.1% for the feedback resistor, 0.2% for the 2 most significant resistors (R, 2R), 0.5% for the 3rd and 1% for the 4th and 5th switches allows 5% resistors to be used in the 6th, 7th and 8th switch positions.

Using the above information, 4-bit or more binary/BCD gain programmable amplifiers can be built with large signal handling capability, few parts and easily adjustable gain or attenuation. *Figure 3* shows a practical 8-bit binary/BCD GPA with gains of 0.996 (binary) with $R_F = 5k$ and 0.99 (BCD) with $R_F = 8k$. For other gains, only the feedback resistor need be changed.

$$\% \text{ error} = \left[\epsilon_f^2 + \left(\frac{\epsilon_R}{2}\right)^2 + \left(\frac{\epsilon_{2R}}{2^2}\right)^2 + --- + \left(\frac{\epsilon_{nR}}{2^n}\right)^2\right]^{1/2} \tag{2}$$

or

$$\% \text{ error} = \left[(0.1)^2 + \left(\frac{0.2}{2}\right)^2 + \left(\frac{0.2}{4}\right)^2 + --- + \left(\frac{5}{256}\right)^2\right]^{1/2} = \pm 0.198\%$$

ϵ_f = tolerance of feedback resistor
ϵ_R = tolerance of most significant resistor
ϵ_{nR} = tolerance of Nth resistor

FET Curve Tracer

National Semiconductor
John Maxwell
February 1977

Junction field-effect transistors (JFETs), unlike bipolar transistors, do not easily lend themselves to analytic solutions of bias networks. By their very nature, JFETs are voltage controlled devices. Gate to source voltage (control voltage V_{GS}) variations of several volts can exist within a given part type at the same operating conditions, causing the problem. Multiple suppliers and inadequate or non-existent data sheet curves compound the problem further, requiring data from the suppliers or the use of a curve tracer.

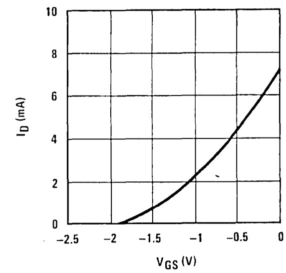


FIGURE 1. Typical N-Channel FET Transfer Curve

A simple curve tracer, used with any oscilloscope, can be built using a quad op amp and a handful of parts. The circuit displays drain current versus gate voltage for both P and N-channel JFETs at a constant drain voltage.

The circuit consists of an op amp current to voltage (I/V) amplifier with a positive or negative gate sweep

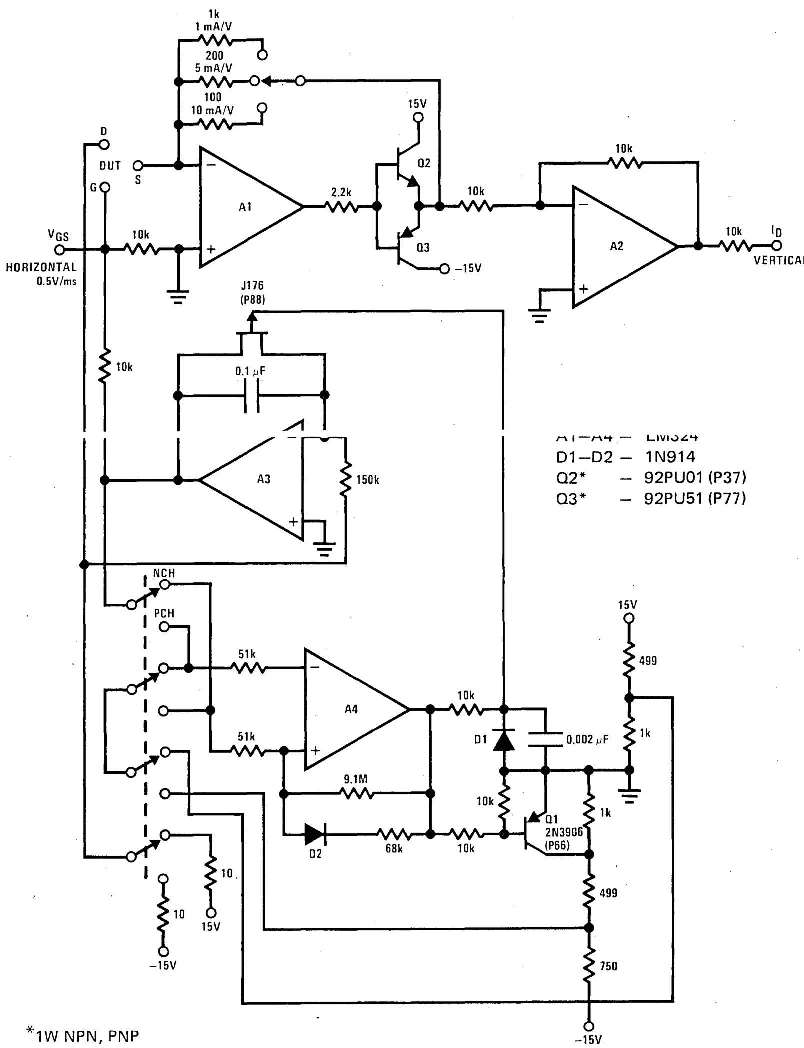


FIGURE 2. FET Curve Tracer

voltage. The I/V amplifier uses 1/4 of the quad op amp and 3 switchable feedback resistors for drain current scaling: 1k for 1 mA/V, 200Ω for 5 mA/V and 100Ω for 10 mA/V. An NPN-PNP emitter-follower buffer is used with the I/V amplifier to handle high FET currents (to 100 mA). A unity gain inverting amplifier is used for proper drain current polarity.

The gate sweep generator consists of 2 parts, a linear ramp generator with a reset and a window comparator. The ramp generator is an op amp with a capacitor in its feedback loop. The sweep rate is set by a constant current supplied to the capacitor through a resistor tied to either the plus or minus voltage supply.

The positive (P-channel) ramp mode uses the positive reference on the plus input of the comparator with the ramp connected to the minus input. The comparator output stays high (15V) pinching the FET OFF until the input exceeds the reference (10V). At that point, the output snaps to the negative supply, turning the FET switch ON, discharging the capacitor. The reference voltage at the plus input is set near ground using the 51k input resistor, D2 and 68k feedback resistor when the comparator output is in the low state. When the capacitor is discharged, the comparator resets, restarting the ramp.

A negative sweep is more difficult to generate using the same comparator. The reference (−10V) is on the minus input with the ramp connected to the plus input. As with the positive sweep, the comparator output is high until the negative sweep exceeds the reference. The difference is that the reference cannot be set to ground for the reset sweep but to a negative voltage such that when the ramp is at 0V the comparator resets. The function of Q2 is to short R1, changing the reference voltage from −10V to −6V.

In both cases, the sweep time is 10 ms. The resistor attenuator on the FET gate terminal divides the voltage in half, yielding a sweep rate of 0.5V/ms with a maximum gate voltage of ±5V. This should be adequate for most FETs used as amplifiers but if additional gate voltage is required, the attenuator can be switched out.

The circuit is limited to displaying only the FET transfer characteristic I_D vs V_{GS}, but this is the curve most needed by designers. It gives insight into parameter variations of bias circuits and it can be used to observe temperature effects on the FET. The oscilloscope vertical input is used for the drain current and the horizontal input is used for the gate voltage. The horizontal sweep can be used if no horizontal input is available where a sweep rate of 0.5 ms/cm corresponds to 0.5V/ms, allowing the curve tracer to be used with any oscilloscope.

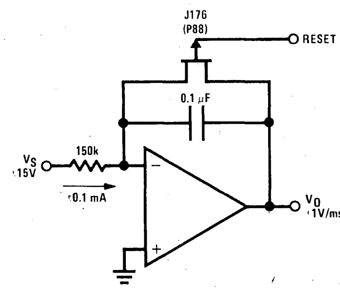


FIGURE 3. Linear Ramp Generator

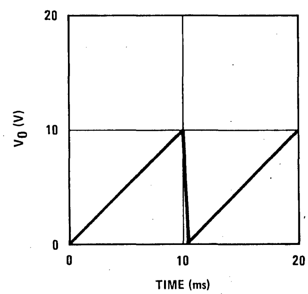


FIGURE 4. Positive Sweep

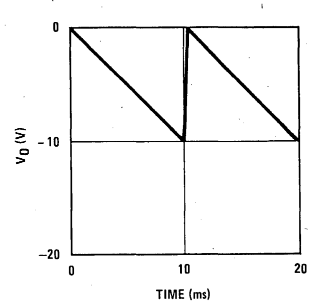


FIGURE 5. Negative Sweep

Section 12

Appendices

12

National Semiconductor

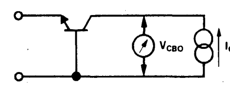
Transistor Glossary of Symbols

DC PARAMETERS

BV_{CBO}

Collector-Base Breakdown Voltage with Emitter Open-Circuited

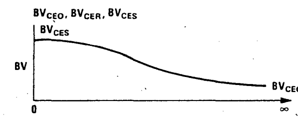
The breakdown voltage of the collector-base junction, measured at a specified current, with the emitter open-circuited.



BV_{CEO}

Collector-Emitter Breakdown Voltage with the Base Open-Circuited

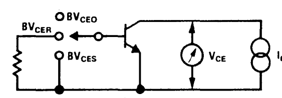
The collector-emitter breakdown voltage, measured at a specified collector current, with the base open-circuited.



BV_{CER}

Collector-Emitter Breakdown Voltage with Resistance between Emitter and Base

The collector-emitter breakdown voltage measured at a specified current with a specified resistance R connected between the base and the emitter.



BV_{CES}

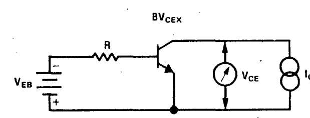
Collector-Emitter Breakdown Voltage with Base Shorted to Emitter

The collector-emitter breakdown, measured at a specified current, with the base shorted to the emitter.

BV_{CEX}

Collector-Emitter Breakdown Voltage at a Specified Condition

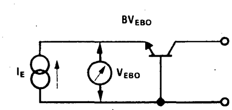
The collector-emitter breakdown voltage measured at a specified current with the base-emitter junction forward or reverse biased by a specified voltage or current.



BV_{EBO}

Emitter-Base Breakdown Voltage with Collector Open-Circuited

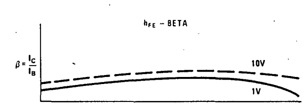
The emitter-base breakdown voltage, measured at a specified current, with the collector open-circuited.

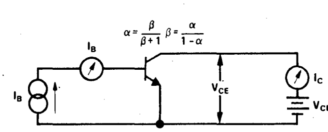


h_{FE}

Common-Emitter DC Current Gain

The ratio of DC collector current to DC base current measured at a specified collector-emitter voltage and a specified collector current.

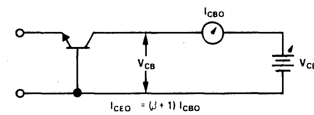




I_{CBO}

Inverse Collector-Base Current

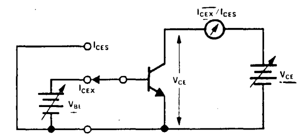
The collector-base current with the junction reverse biased by a specified voltage, with the emitter open-circuited.



I_{CEX}, I_{CES}

Inverse Collector-Emitter Current at a Specified Condition

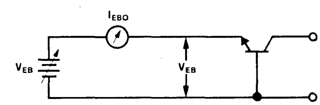
The collector-emitter current measured at a specified collector-emitter voltage with the base forward or reverse biased by a specified voltage or current, or with the base shorted to the emitter.



I_{EBO}

Inverse Emitter-Base Current

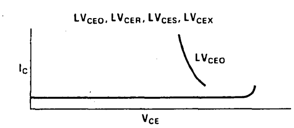
The emitter-base current with the junction reverse biased by a specified voltage with the collector open-circuited.

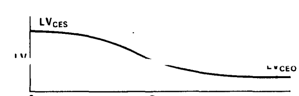


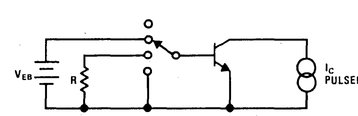
LV_{CEO}, LV_{CER}, LV_{CES}, LV_{CEX}, or, $V_{CEO}(sust)$, $V_{CER}(sust)$, $V_{CES}(sust)$, $V_{CEX}(sust)$

Pulsed Limiting Breakdown Voltages

These are similar to the corresponding, above defined, BV parameters but are measured at a specified high current point where collector-emitter voltage is lowest. The duration of the pulse and its duty cycle must be specified. The letter L indicates LIMITING Value and is measured outside the negative resistance zone of the reverse characteristic.



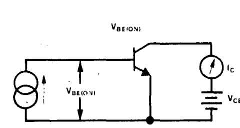


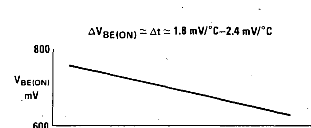


$V_{BE\ (ON)}$

Unsaturated Base-Emitter Voltage

The base-emitter voltage measured in the common-emitter connection at a specified collector to emitter voltage and specified collector current.



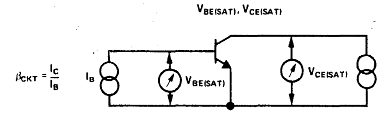


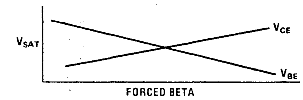
$V_{BE(SAT)}$ — **Base-Emitter Saturation Voltage**

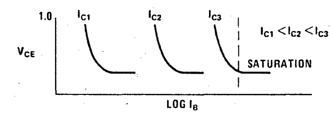
The base-emitter voltage measured in the common-emitter connection at a specified collector and base saturation currents.

$V_{CE(SAT)}$ — **Collector-Emitter Saturation Voltage**

The collector-emitter voltage measured in the common-emitter connection at specified collector and base saturation currents.







V_{RT} — **Reach Through Voltage**

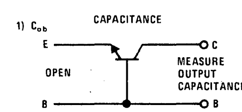
V_{PT} — **Punch Through Voltage**

The collector-base voltage above which an increase of applied voltage can be measured in the emitter-base open circuit.

SMALL SIGNAL PARAMETERS

C_{ob} — **Common-Base Output Capacitance**

The common-base output capacitance with input ac open.



C_{re} — **Common-Emitter Reverse Transfer Capacitance**

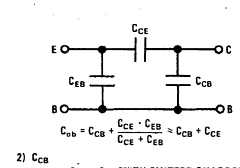
This parameter is the imaginary part of y_{re}. When $I_C = 0$, C_{re} is identical to C_{CB}.

C_{te}, C_{ib}, C_{EB} — **Base-Emitter Capacitance**

The capacity of the base-emitter junction at a specified inverse voltage with the collector open.

C_{CB} — **Collector-Base Capacitance**

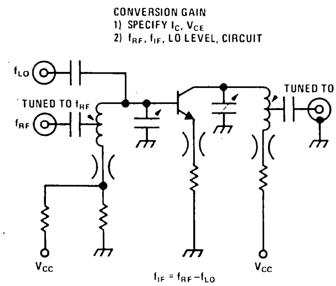
Collector-base capacitance measured at some specified collector-base voltage.



CG_e, CG_b

Conversion Gain, Common-Emitter or Common-Base

The ratio of the output power of a mixer, at one specified frequency, to its input power, at another specified frequency. This parameter is a function of oscillator injection voltage and the mixer operating point.



$f_{\alpha b}$, $f_{h_{fb}}$

Common-Base Cut Off Frequency

The frequency at which the h_{fb} (α) is reduced to 0.707 of its low frequency value.

f_β, $f_{h_{fe}}$

Common-Emitter Cut Off Frequency

The frequency at which the h_{fe} (β) is reduced to 0.707 of its low frequency value.

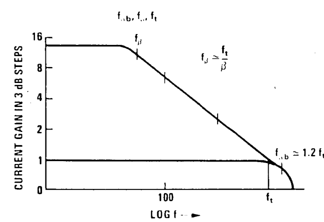
Gain Band-Width Product

The common-emitter current gain bandwidth product in the frequency range where the current gain is falling at approximately 6 db/octave.

f_t

Transition Frequency

The frequency at which the h_{fe} (β) is equal to 1.0. This is a device figure of merit that is often specified at a V_{CE} and I_C.



f_{MAX}

Maximum Frequency of Oscillation

This parameter is a device figure of merit that is calculated from ft and rb′Cc.

$$f_{MAX} = \frac{\text{MAX FREQUENCY OF OSCILLATION}}{\text{FREQUENCY AT WHICH MAG = 1}}$$

$$f_{MAX} = \sqrt{\frac{f_t}{8\pi\, rb\, Cc}} = f\sqrt{PG}$$

GP_e

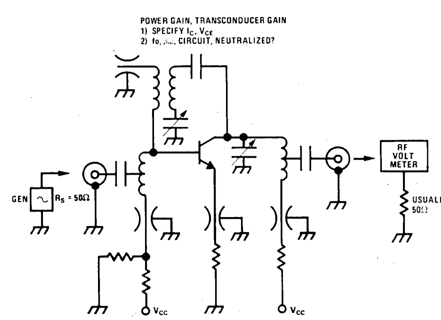
Common-Emitter Power Gain

PG

Power Gain

Can be common-emitter or common-base.

Usually stability-limited gains involved, thus are effectively a transducer gain measurement.



G_{TE}

Common-Emitter Transducer Gain

A test fixture must be specified.

$$G_{TE} = \frac{\text{POWER DELIVERED TO THE LOAD}}{\text{POWER AVAILABLE FROM THE SOURCE}}$$

GMA

Stability Limited Gain or Gain Maximum Available

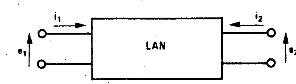
This parameter is a device figure of merit and must be calculated from the two port "y" parameters.

$$GMA = 10\ LOG\left[\frac{|Y_{fe}|}{|Y_{re}|}\left(K - \sqrt{K^2 - 1}\right)\right]$$

NOT DEFINED FOR K < 1

h Parameters

h – PARAMETERS



WHERE e_1, i_1, e_2, i_2 ARE SMALL SIGNAL VOLTAGES AND CURRENTS
THE h – (HYBRID) PARAMETERS ARE DEFINED BY

$e_1 = h_{11}\, i_1 + h_{12}\, e_2$
$i_2 = h_{21}\, i_1 + h_{22}\, e_2$

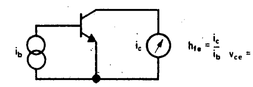
AND FOR COMMON EMITTER OPERATION THESE E Q BECOME

$e_1 = h_{ie}\, i_1 + h_{re}\, e_2$
$i_2 = h_{fe}\, i_1 + h_{oe}\, e_2$

h_{fe} — Common-Emitter Current Gain

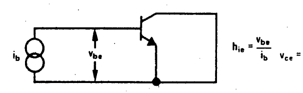
The common-emitter forward current transfer ratio with output ac shorted. This is a complex quantity.

h – PARAMETERS–COMMON EMITTER



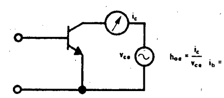
h_{ie} — Common-Emitter Input Impedance

The common-emitter input impedance with the output ac shorted. This is a complex quantity.



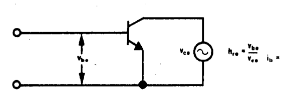
h_{oe} — Common-Emitter Output Admittance

The common-emitter output admittance with the input ac open. This is a complex quantity.



h_{re} — Common-Emitter Reverse Voltage Transfer Ratio

The common-emitter reverse voltage transfer ratio with input ac open. This is a complex quantity.



MAG — Maximum Available Gain

Device figure of merit that must be calculated from the two port "y" parameters.

$$\text{MAG} = 10\ \text{LOG}\ \frac{|Y_{21}|^2}{4\ \text{Re}\ (Y_{11})\ \text{Re}\ (Y_{22})}$$

MSG — Maximum Stable Gain

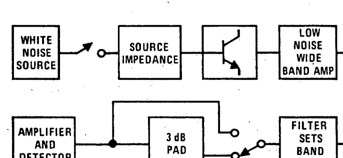
This parameter is a device figure of merit that is calculated from the two port "y" parameters.

$$\text{MSG} = 10\ \text{LOG}\ \frac{|Y_{fe}|}{|Y_{re}|}$$

NF — Noise Figure

Noise figure = 10 $\log_{10} F$, where F is the ratio of total output noise power to the output power due solely to the thermal noise of the source impedance.

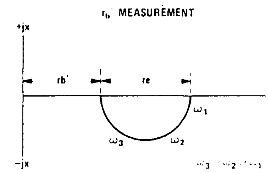
NOISE FIGURE MUST SPECIFY
1) V_{CE}, I_C
2) R_S, f_o, PBW



r_{bb}', r_b'

Base << Spreading >> Resistance

Equivalent to the real part of h_{ie} at some specified very high frequency.



rb'Cc

Collector Base Time Constant

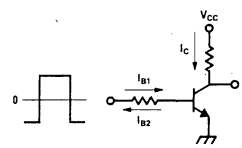
This parameter is a device figure of merit and is measured in a specified test circuit.

$r_b'\,C_c$ = COLLECTOR BASE TIME CONSTANT SPECIFY – I_C, V_{CE}, FREQUENCY

Common-Emitter Switching Parameters

In the following, drive circuit conditions and collector circuit conditions must be specified. The transition times of the input must be negligible compared to the measured times.

SWITCHING PARAMETERS



$T_{ON} = t_d + t_r$
$T_{OFF} = t_s + t_f$

t_d } t_{ON}

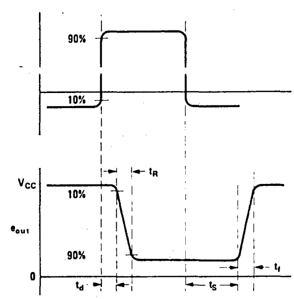
Delay Time

The time interval during turn-on from the point when the input pulse at the base reaches 10% of its full amplitude to the point when the collector pulse changes from 0 to 10% of its maximum amplitude.

t_r

Rise Time

The time interval during turn-on in which the collector pulse changes from 10% to 90% of its maximum amplitude.



t_s } t_{OFF}

Storage Time

The time interval during turn-off from the point when the turn-off pulse at the base changes from 100% to 90% of its full amplitude to the time when the collector current has changed from 100% to 90% of its maximum amplitude.

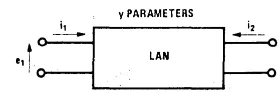
t_f

Fall Time

The time interval during turn-off in which the collector pulse decreases from 90% to 10% of its maximum amplitude.

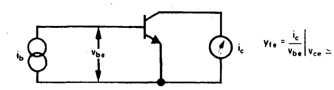
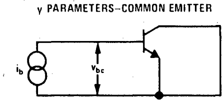
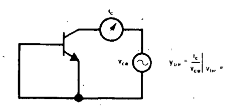
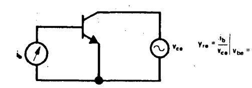
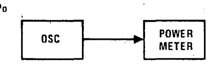
Y Parameters

y PARAMETERS



y PARAMETERS ARE DEFINED BY
$i_1 = y_{11} e_1 + y_{12} e_2$
$i_2 = y_{21} e_1 + y_{22} e_2$

OR IN COMMON EMITTER NOTATION
$i_1 = y_{ie} e_1 + y_{re} e_2$
$i_2 = y_{fe} e_1 + y_{oe} e_2$

Symbol	Term and Definition	Illustration
y_{fe}	**Common-Emitter Forward Transfer Admittance** The common-emitter forward transfer admittance with output ac shorted. This is a complex quantity (g_{fe} + jb_{fe}).	
y_{ie}	**Common-Emitter Input Admittance** The common-emitter input admittance with output ac shorted. This is a complex quantity (g_{ie} + jb_{ie}).	y PARAMETERS–COMMON EMITTER 
y_{oe}	**Common-Emitter Output Admittance** The common-emitter output admittance with input ac open. This is a complex quantity (g_{oe} + jb_{oe}).	
y_{re}	**Common-Emitter Reverse Transfer Admittance** The common-emitter reverse transfer admittance with input ac shorted. This is a complex quantity (g_{re} + jb_{re}).	
LARGE SIGNAL PARAMETERS		
η	**Collector Efficiency** This parameter applies to oscillators and class C amplifiers, predominantly. It is defined as the ratio of RF Power Out/DC Power In.	η – COLLECTOR EFFICIENCY $\eta = \frac{P_O\,(RF)}{P_{IN(DC)}} = \frac{vi}{I_C \times V_{CE}}$
P_o	**Power Out** This parameter applies to oscillators. The units are watts and a test circuit must be specified.	Po  SPECIFY – I_C, V_{CE} UNDER QUIESCENT CONDITIONS – f_o, R_{LOAD}
THERMAL PARAMETERS		
R_{TH}	**Internal Junction-to Case Thermal Resistance** The rated increase of junction temperature with respect to the case temperature per unit of dissipated power. It is also called Thermal Resistance with infinite heat sink.	
θ_{JC}	**Junction-to Case Thermal Rating**	
θ_{JA}	**Junction-to Ambient Thermal Rating**	

National Semiconductor

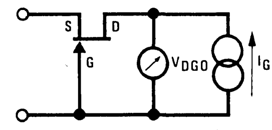
JFET Glossary of Symbols

DC PARAMETERS

BV_{DGO} (V) or BV_{GDO}

Drain-Gate Breakdown Voltage with Source Open-Circuited

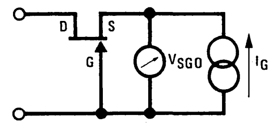
The breakdown voltage of the drain-gate junction, measured at a specified current with the source open-circuited.



BV_{SGO} (V) or BV_{GSO}

Source-Gate Breakdown Voltage with Drain Open-Circuited

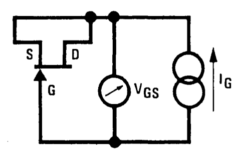
The breakdown voltage of the source-gate junction, measured at a specified current, with the drain open-circuited.



BV_{GSS} (V) or BV, $V_{(BR)GSS}$

Source-Gate Breakdown Voltage with Drain-Source Shorted

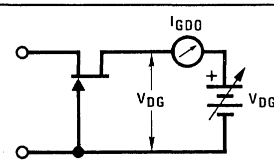
The breakdown voltage of the source-gate and drain-gate junctions, measured at a specified current with the drain-source shorted.



I_{DGO} (pA) or I_{GDO}

Drain-Gate Leakage Current, Source Open-Circuited

The leakage current of the drain-gate junction, measured at a specified voltage, with the source open-circuited.



I_D (μA) or $I_{D(ON)}$

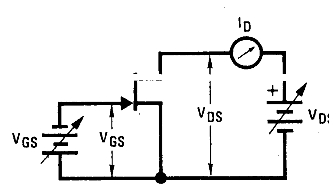
Drain ON Current

The drain current, measured at a specified drain-source voltage and gate-source voltage.

$I_{D(OFF)}$ (pA)

Drain Cutoff Current

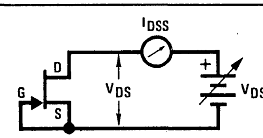
The drain cutoff current, measured at a specified drain-source voltage and gate-source voltage.



I_{DSS} (mA)

Drain Saturation Current

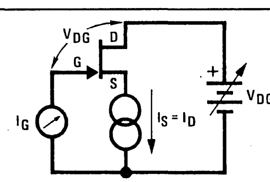
The drain current, measured at a specified drain-source voltage with the source shorted to the gate ($V_{GS} = 0$)



I_G (pA) or $I_{G(ON)}$

Gate Leakage Current with Drain Current Flowing

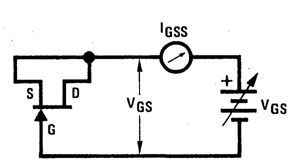
The gate leakage current, measured at a specified drain current and drain-gate voltage.



I_{GSS} (pA)

Gate-Source Reverse Leakage Current with Drain-Source Shorted

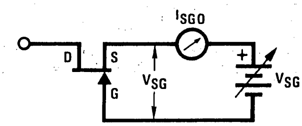
The gate-source reverse leakage current measured at a specified gate-source voltage.



I_{SGO} (pA) or I_{GSO}

Source-Gate Reverse Leakage Current with Drain Open-Circuited

The leakage current of the source-gate junction, measured at a specified voltage, with the drain open-circuited.



r_{DS} (Ω) or r_{ds}, R_{DS}, $r_{DS(ON)}$

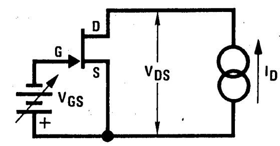
Drain-Source ON Resistance

The drain-source ON resistance, measured at a specified gate-source voltage and drain current.

$V_{DS(ON)}$ (mV)

Drain-Source ON Voltage

The drain-source ON voltage, measured at a specified gate-source voltage and drain current.

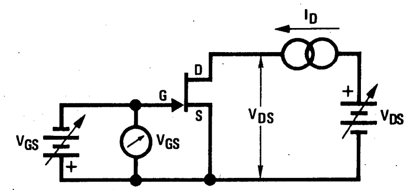


$$r_{DS} = \frac{V_{DS}}{I_D}$$

V_{GS} (V) or $V_{GS(ON)}$, V_G

Operating Gate-Source Voltage

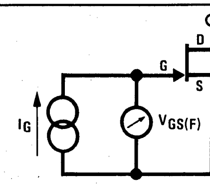
The gate-source voltage, measured at a specified drain current and drain-source voltage.



$V_{GS(F)}$ (V)

Forward Gate-Source Voltage

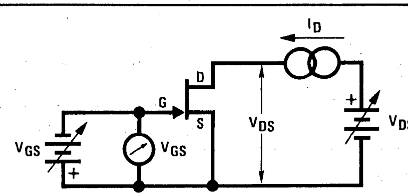
The forward gate-source voltage, measured at specified current.



$V_{GS(OFF)}$ (V) or V_P

Gate-Source Cutoff (Pinch-Off) Voltage

The gate-source cutoff voltage, measured at a specified drain current and drain-source voltage.

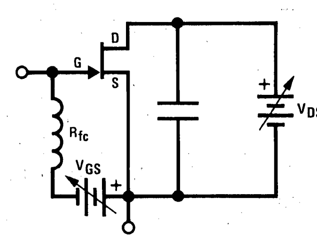


SMALL SIGNAL PARAMETERS

C_{iss} (pF) or C_{iss}, C_{gss}

Common-Source Input Capacitance

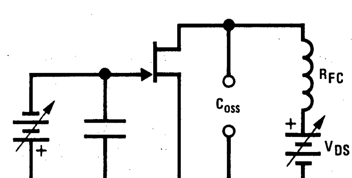
The common-source input capacitance measured between the gate and source with the drain A–C shorted to the source at specified drain-source and gate-source voltages.



C_{oss} (pF) or C_{os}, C_{dss}

Common-Source Output Capacitance

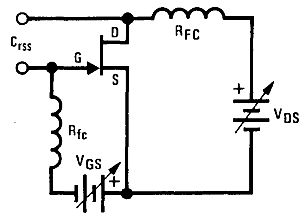
The common-source output capacitance, measured between the drain and source with the source A–C shorted to the gate at specified drain-source and gate-source voltages.



C_{rss} (pF)
or C_{rs}, C_{dg}

Common-Source Reverse Transfer Capacitance

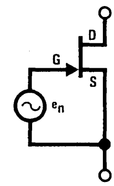
The common-source reverse transfer capacitance, measured between the drain and gate at specified drain-source and gate source voltages.



e_n (nV/$\sqrt{\text{Hz}}$)
or e_n, V_n, E_n

Equivalent Input Noise Voltage

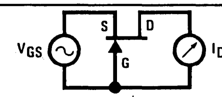
The equivalent input noise voltage per unit bandwidth, measured with the input A–C shorted to the source at a specified operating condition.



g_{fg} (mV) (m℧)
or y_{fg}

Common-Gate Forward Transconductance

The common-gate forward transconductance with the output A–C shorted. This is a complex quantity ($g_{fg} + jb_{fg}$).



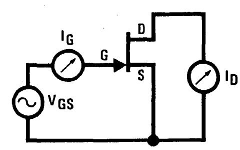
$$Y_{fg} = \left.\frac{I_D}{V_{GS}}\right|_{V_{DS}=0}$$

g_{fs} (mV) (m℧)
or g_m, Y_{fs},
Re|Y_{fs}|

Common-Source Forward Transconductance

The common source forward transconductance with the output A–C shorted. This is a complex quantity ($g_{fs} + jb_{fs}$).

$$Y_{fs} = \left.\frac{I_D}{V_{GS}}\right|_{V_{DS}=0}$$



g_{iss} (μV) (μ℧)
or Y_{is}

Common-Source Input Conductance

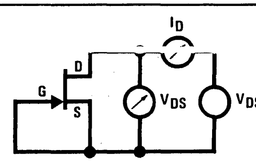
The common-source input conductance with the output A–C shorted. This is a complex quantity ($g_{is} + jb_{is}$).

$$Y_{is} = \left.\frac{I_G}{V_{GS}}\right|_{V_{DS}=0}$$

g_{oss} (μV) (μ℧)
or Y_{os}

Common-Source Output Conductance

The common source output conductance with the input A–C shorted. This is a complex quantity ($g_{os} + jb_{os}$).



$$Y_{os} = \left.\frac{I_D}{V_{DS}}\right|_{V_{GS}=0}$$

G_{pg} (dB)

Common-Gate Power Gain

The common-gate power gain is the ratio of output power to input power.

G_{PS} (dB)

Common-Source Power Gain

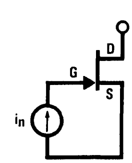
The common-source power gain is the ratio of output power to input power.

$$G_p = 10 \log_{10} \frac{P_O}{P_I},$$

i_n (pA/$\sqrt{\text{Hz}}$)

Equivalent Input Noise Current

The equivalent input noise current measured with the input open-circuited under specified operating conditions.



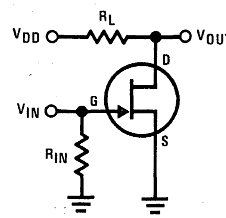
NF (dB) — **Spot Noise Figure**

Noise figure = 10 $\log_{10}$ F were F is noise factor which is the ratio of the total output noise power to the output noise power of the source. Measured at specified operating conditions and source resistance.

$$F = \frac{\text{Total Output Noise Power}}{\text{Source Output Noise Power}}$$

COMMON-SOURCE SWITCHING PARAMETERS

In the following, drive circuit conditions and drain circuit conditions must be specified. The transition times of the input must be negligible compared to the measured times.



$t_{d(ON)}$ — **Turn-On Delay Time**

The time interval during turn-on from the point when the input pulse at the gate reaches 10% of its full amplitude to the point when the drain pulse changes from 0 to 10% of its maximum amplitude.

t_r — **Rise Time**

The time interval during turn-on in which the drain current pulse changes from 10% to 90% of its maximum amplitude.

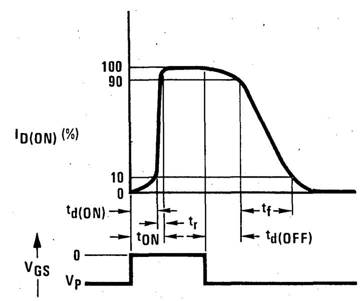
$$I_{D(ON)} = \frac{V_{DD} - V_{DS(ON)}}{R_L}$$

$t_{d(OFF)}$ — **Turn-Off Delay Time**

The time interval during turn-off from the point when the turn-off pulse at the gate changes from 100% to 90% of its full amplitude to the time when the drain current has changed from 100% to 90% of its maximum amplitude.

t_f — **Fall Time**

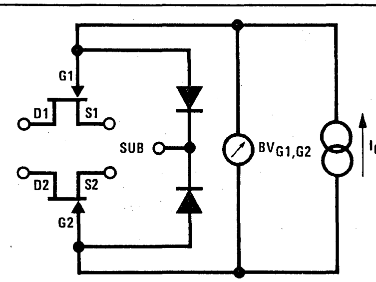
The time interval during turn-off in which the drain current pulse decreases from 90% to 10% of its maximum amplitude.



DUAL FET PARAMETERS

$BV_{G1, G2}$ (V) or BV_{G1-2} — **Gate to Gate Breakdown Voltage**

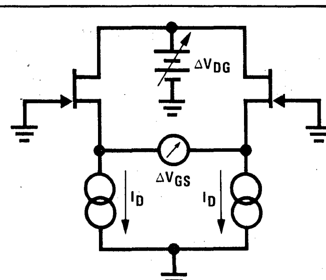
The breakdown voltage of the gate to gate junctions, measured at a specified current.



CMRR (dB) or CMR — **Common-Mode Rejection Ratio**

The common-mode rejection ratio is the ratio of the change in differential gate voltage with a change in the drain to gate voltage.

$$\text{CMRR} = 20 \log_{10} \frac{\Delta V_{DG}}{\Delta V_{os}}$$



g_{fs1-2} (%) or g_{fs1}/g_{fs2} — **Common-Source Forward Transconductance Ratio (Match)**

The transconductance ratio = g_{fs1}/g_{fs2} x 100 (%) measured at specified drain-gate voltage and drain current.

$g_{oss\,1\text{-}2}$ (μV) or g_{os1-2} — **Common-Source Output Conductance (Match)**

Output conductance match = $|g_{os1}-g_{os2}|$ measured at specified drain-gate voltage and drain current.

I_{DSS1-2} (%) or I_{DS1-2}, I_{DSS1}/I_{DSS2} — **Drain Saturation Current Ratio (Match)**

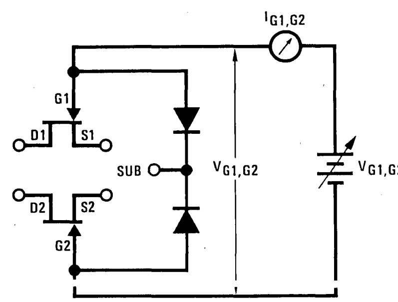
The drain saturation current ratio = I_{DSS1}/I_{DSS2} x 100% measured at specified drain-source voltages.

I_{G1-2} (pA) — **Differential Gate Leakage Current**

Differential gate leakage current = $||I_{G1}-I_{G2}|$ measured at specified drain-gate voltage and drain current.

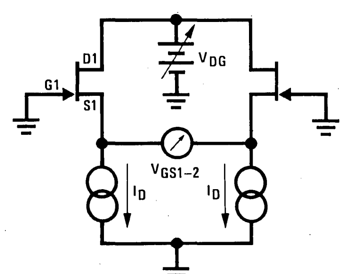
$I_{G1,\,G2}$ (pA) — **Gate to Gate Reverse Leakage Current**

The gate to gate reverse leakage measured at a specified voltage monolithic dual with diode isolation shown.



V_{GS1-2} (mV) or ΔV_{GS}, V_{os}, $|V_{GS1}-V_{GS2}|$ — **Differential Gate-Source Voltage**

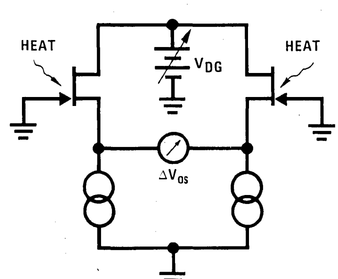
The differential gate-source voltage, measured at a specified drain-gate voltage and drain current.



ΔV_{GS1-2} (μV/°C) or $\Delta|V_{GS1}-V_{GS2}|/\Delta T$, $\Delta V_{os}/\Delta T$ — **Differential Gate-Source Voltage Drift**

The differential gate-source voltage drift is the change in the differential gate-source voltage with a change in device temperature at a specified operating condition.

$$\frac{\Delta V_{os}}{\Delta T} = \left| \frac{(V_{GS1}-V_{GS2})|T_1 - (V_{GS1}-V_{GS2})|T_2}{T_1-T_2} \right|$$



National Semiconductor

Package Outlines

Dimensions are in $\frac{\text{inches}}{\text{(millimeters)}}$.

Numbers in parentheses behind package titles are NS internal package codes.

PACKAGES

Dual-In-Line Packages

(N) Devices ordered with "N" suffix are supplied in plastic molded dual-in-line package. Molding material is a highly reliable compound suitable for military as well as commercial temperature range applications. Lead material is copper or alloy 42 with a hot solder dipped surface to allow ease of solderability.

(J) Devices ordered with the "J" suffix are supplied in a cer-dip package (ceramic lid and base sealed with high temperature vitreous glass). Lead material is solder dipped alloy 42.

(D) Devices ordered with the "D" suffix are supplied in side braze, multi-layer ceramic dual-in-line packages. The leads are Kovar or alloy 42 and either tin-plated, gold-plated, or solder-plated.

(Q) Devices ordered with the "Q" suffix are supplied in either a "D" or "J" package, but with a U.V. window.

Metal Can Packages

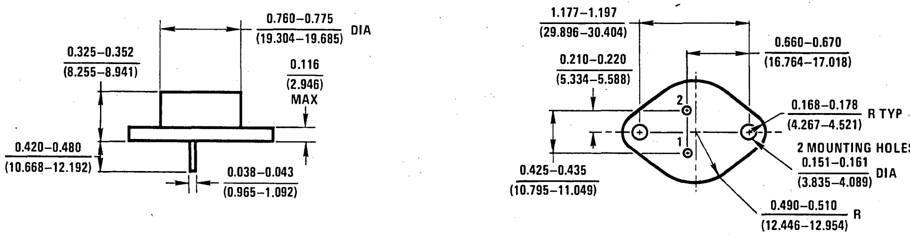
(H) Devices ordered with the "H" suffix are supplied in a metal can package. The cap is nickel finish and the leads are gold-plated Kovar. Gold free construction using epoxy D/A is also available, with a tin-plated finish.

Flat Packages

(F) Devices ordered with the "F" suffix are supplied in a multi-layer ceramic bottom brazed flat package. The lid is plated alloy 42, and leads are gold-plated, tin-plated, or solder-plated alloy 42 or Kovar.

NS PACKAGE CODE	JEDEC CODE	NS PACKAGE CODE	JEDEC CODE
02	TO-18 Glass	39	TO-116 14-Lead Molded DIP (CN)
04	TO-5 Glass	40	TO-116 14-Lead Ceramic DIP (CD)
05	TO-71 Glass Diff. Amp. TO-18	41	TO-116 14-Lead Molded Array
06	TO-46 Solid	42	TO-3
07	TO-52 Solid	51	TO-202
09	TO-39 Solid Kovar	55	TO-202
10	TO-39 Solid Steel	56	TO-202
11	TO-18 Glass	57	TO-220
12	TO-71 Glass TO-18 Diff. Amp.	58	TO-126
17	TO-39 Solid Steel Low Profile	60	8-Lead Molded DIP (CN)
18	TO-52 Glass	67	8-Lead Molded DIP (CN)
19	TO-18 Solid	92	TO-92
23	TO-72 Glass (4-Lead TO-18)	94	TO-92
24	TO-78 Glass TO-5 Diff. Amp.	96	TO-92 Faraday Shield
25	TO-72 Glass (4-Lead TO-18)	97	TO-92
27	TO-78 Diff. Amp. TO-5	98	TO-92 Faraday Shield
28	TO-72 Glass (4-Lead TO-18)	90	TO-237
29	TO-72 Glass (4-Lead TO-18)	91	TO-237
30	TO-78 Glass Diff. Amp. TO-5		

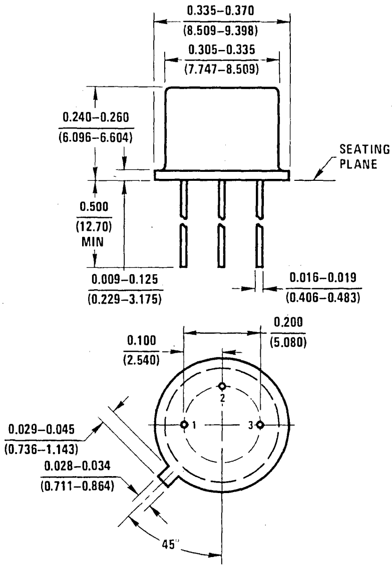
TO-3 (42)



Pin 1—Base
Pin 2—Emitter
Case—Collector

TO-5 (04)

PIN	T
1	E
2	B
3	C

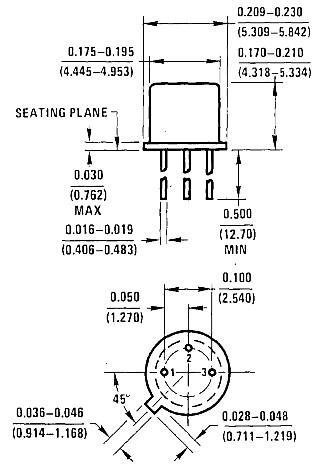


TO-18 (02, 11, 19)

PIN	T (02), (19)
1	E
2	B
3	C

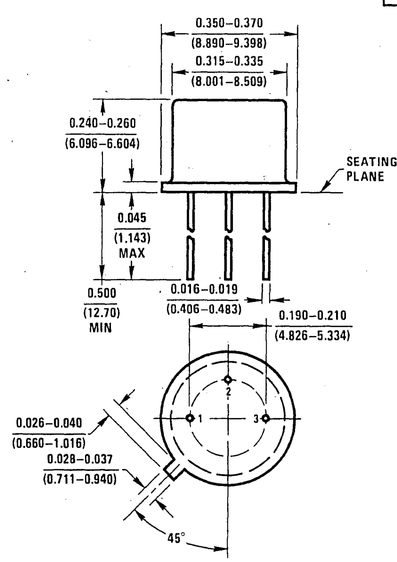
PIN	FET N (02)
1	S
2	D
3	G

PIN	FET P (11)
1	S
2	G
3	D



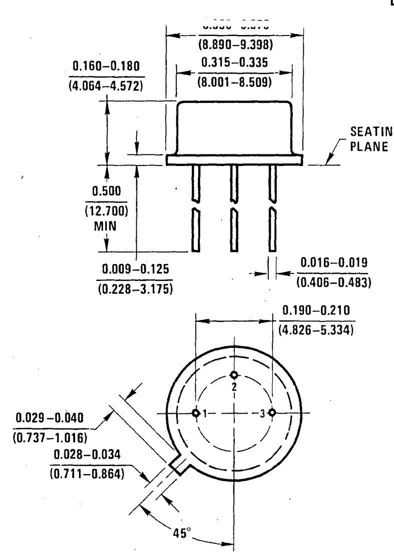
TO-39 (09, 10)

PIN	T
1	E
2	B
3	C



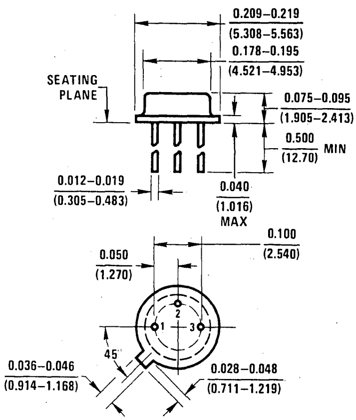
TO-39 (17) LO-PROFILE

PIN	T
1	E
2	B
3	C



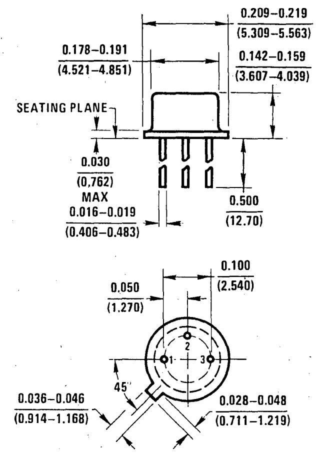
TO-46 (06)

PIN	T
1	E
2	B
3	C



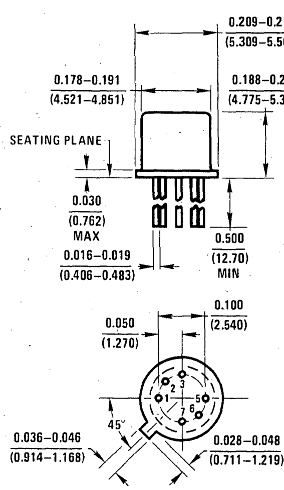
TO-52 (07, 18)

PIN	T (18)	FET (07)
1	E	S
2	B	D
3	C	G



TO-71 (08, 12)

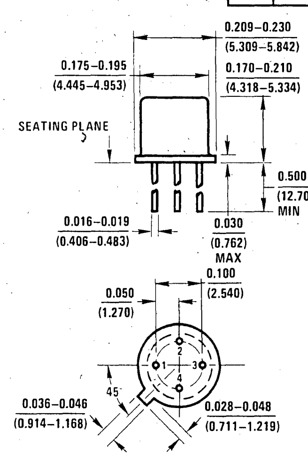
PIN	FET (12)
1	S1
2	D1
3	G1
5	S2
6	D2
7	G2



TO-72 (23, 25, 28, 29)

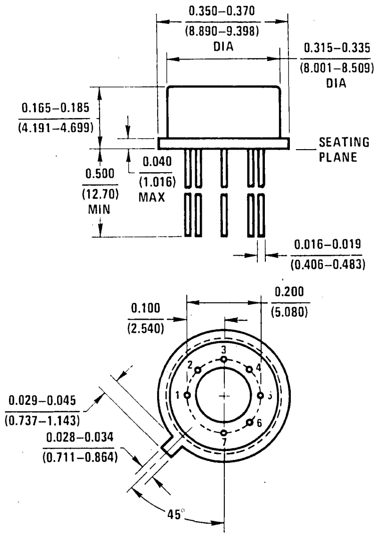
PIN	T (25)	FET N (25, 29)
1	E	S
2	B	D
3	C	G
4	GND	CASE

PIN	T (28)	FET P (23)
1	B	S
2	E	G
3	C	D
4	GND	CASE



TO-78 (24, 30)

PIN	T (30)	FET (24)
1	E1	S1
2	B1	D1
3	C1	G1
5	E2	S2
6	B2	D2
7	C2	G2



TO-92 (92, 94, 96, 97, 98)

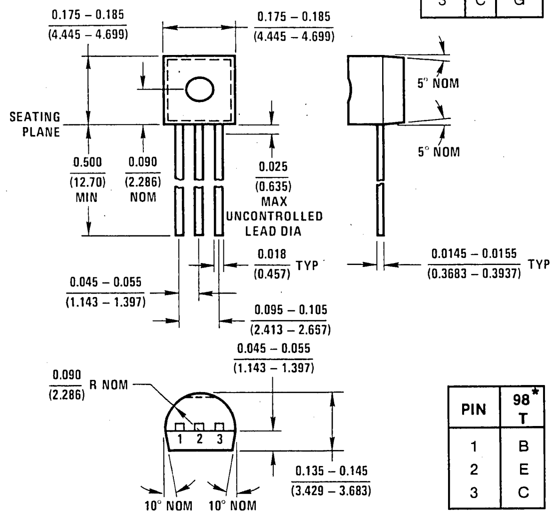
PIN	92 (STD)	
	T	FET
1	C	G
2	B	S
3	E	D

PIN	96	
	T	FET
1	C	G
2	E	D
3	B	S

PIN	94	
	T	FET
1	B	S
2	C	G
3	E	D

Drain-source interchangeable on most JFET devices

PIN	97*	
	T	FET
1	E	D
2	B	S
3	C	G

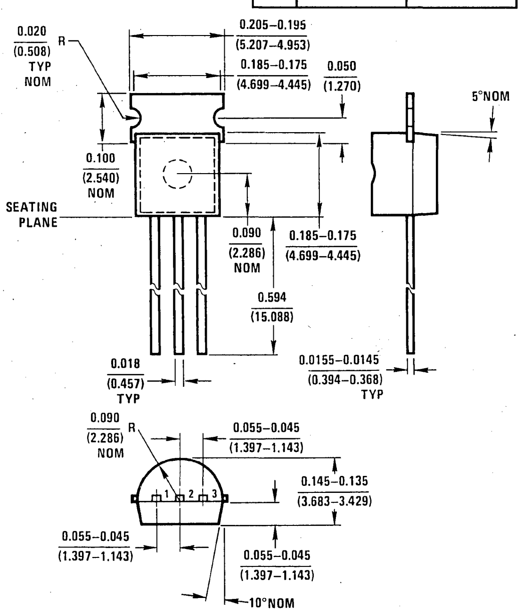


PIN	98*
	T
1	B
2	E
3	C

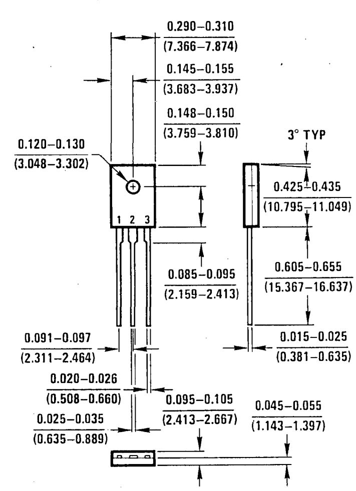
*See note regarding leadform on 12-19

TO-237 (90, 91)

PIN	PACKAGE 90	PACKAGE 91
1	Base	Collector
2	Collector	Base
3	Emitter	Emitter



TO-126 (58)

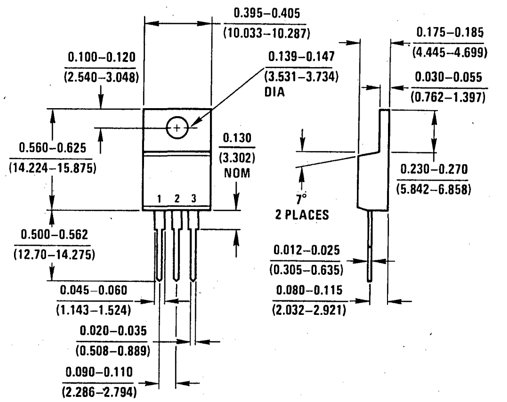


Pin 1— Emitter
Pin 2— Collector
Pin 3— Base

When mounting the device, torque not to exceed 6.0 in lb.

If lead bending is required, use suitable clamp or other supports between transistor case and point of bend.

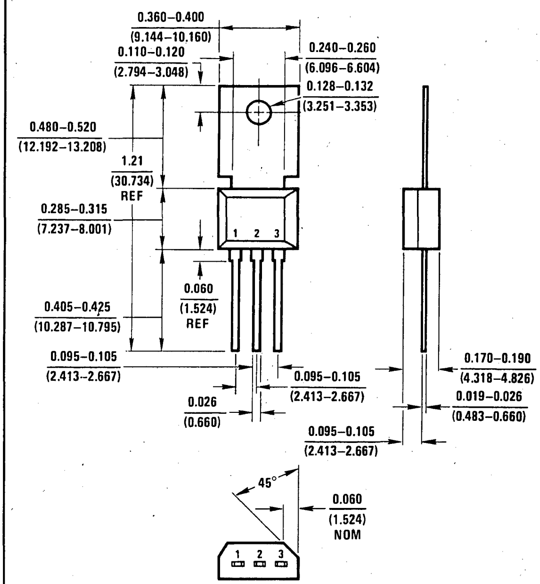
TO-220 (57)



Pin 1 — Base
Pin 2 — Collector
Pin 3 — Emitter

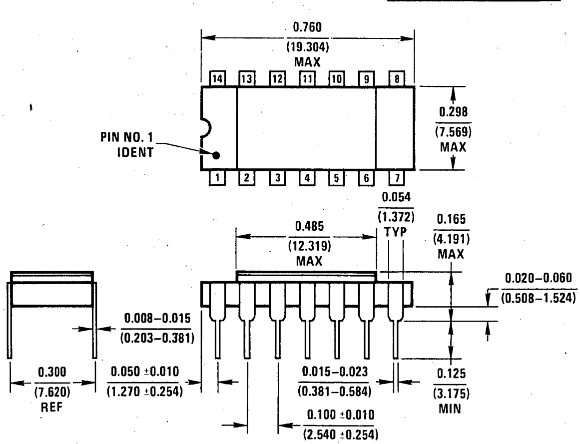
TO-202 (51, 55, 56)

PIN	PACKAGE 51 T	PACKAGE 55 T	PACKAGE 56 T
1	Emitter	Emitter	Base
2	Collector	Base	Collector
3	Base	Collector	Emitter



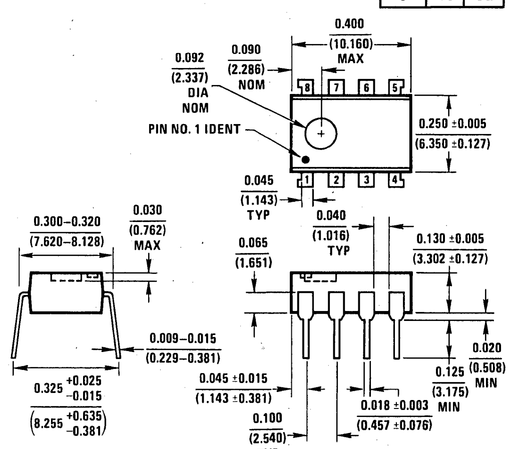
CAVITY DUAL-IN-LINE PACKAGE D (40)

PIN	T	PIN	T
1	C1	8	C3
2	B1	9	B3
3	E1	10	E3
4	NC	11	NC
5	E2	12	E4
6	B2	13	B4
7	C2	14	C4



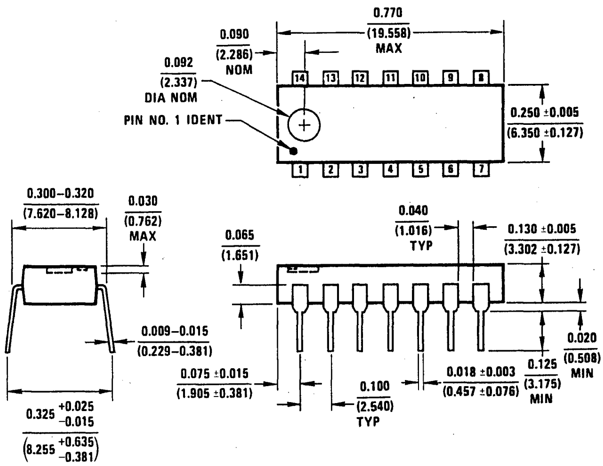
MOLDED MINI-DIP (60, 67)

PIN	60	67
1	NC	S1
2	S1	D1
3	D1	NC
4	G1	G1
5	S2	S2
6	D2	D2
7	G2	NC
8	NC	G2

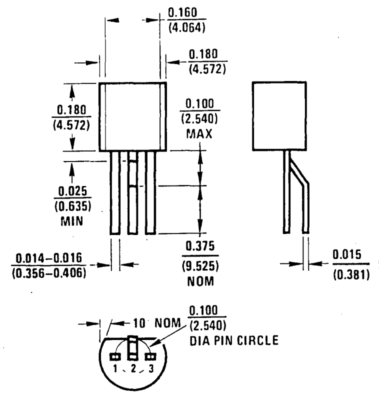


MOLDED DUAL-IN-LINE PACKAGE N (39)

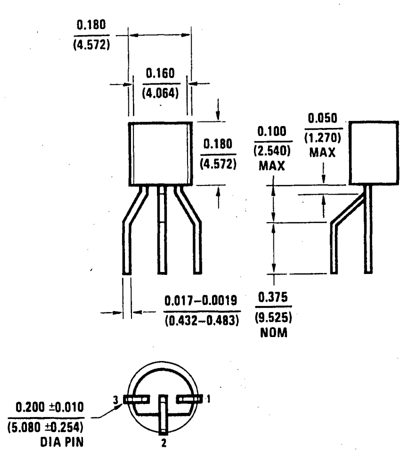
PIN	T	PIN	T
1	C1	8	C3
2	B1	9	B3
3	E1	10	E3
4	NC	11	NC
5	E2	12	E4
6	B2	13	B4
7	C2	14	C4



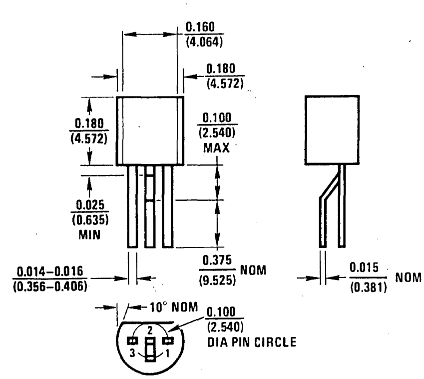
TO-92 (92, 94, 96) TO-18 LEAD FORM -18 OPTION



TO-92 (92, 94, 96) TO-5 LEAD FORM -5 OPTION

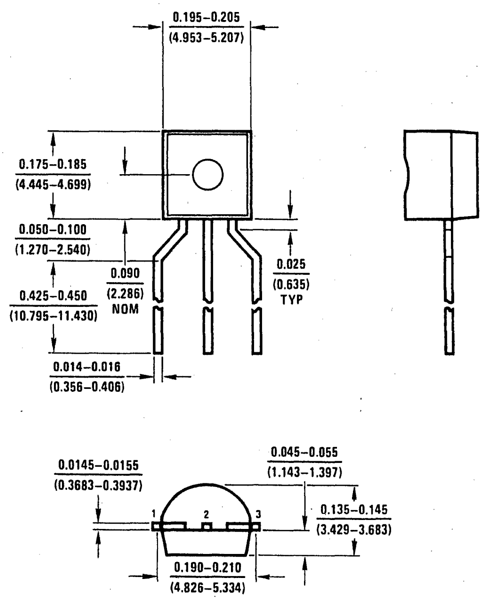


TO-92 (97, 98) TO-18 LEAD FORM STD FOR IN-LINE LEADS L34Z OPTION

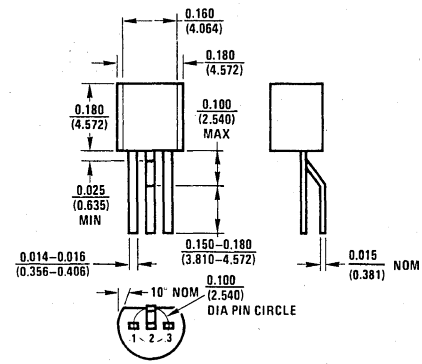


* Note: All package 97 or 98 transistors are leadformed to this configuration prior to shipment.

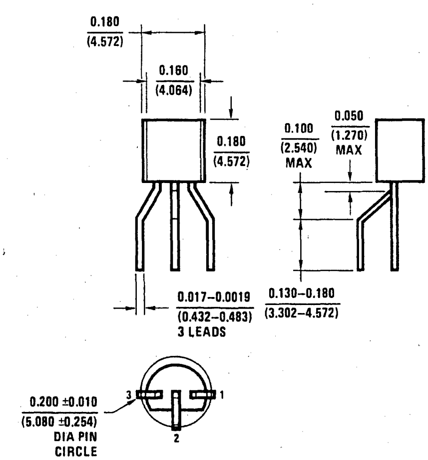
TO-92 (92, 94, 96)
0.100" SPACING LEAD FORM   J61Z OPTION



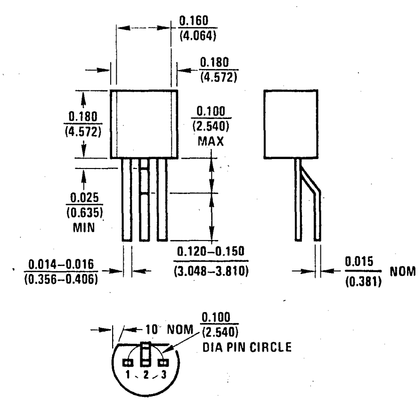
TO-92 (92, 94, 96)
TO-18 LEAD FORM AND CROP   J14Z OPTION



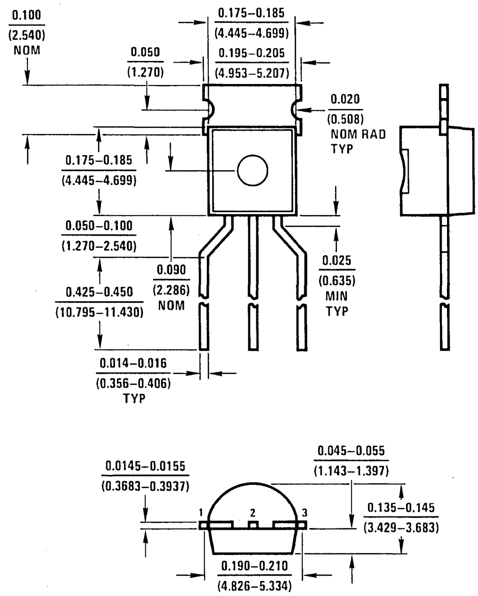
TO-92 (92, 94, 96)
TO-5 LEAD FORM AND CROP   J25Z OPTION



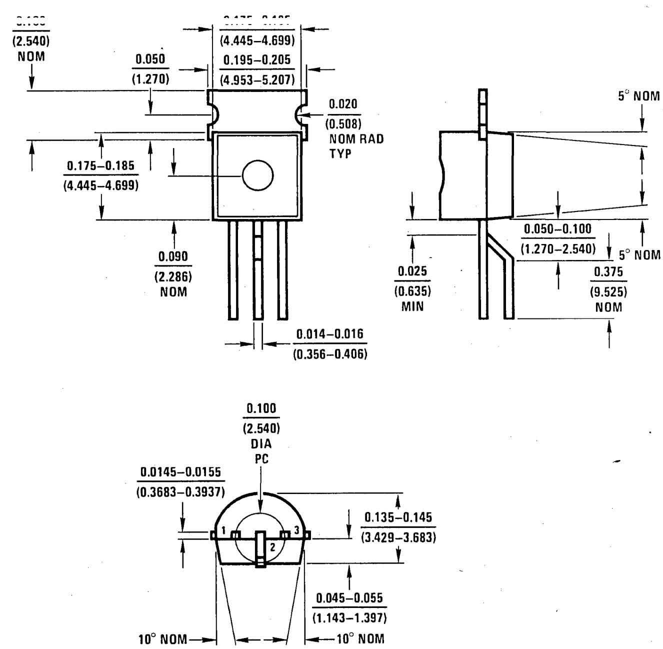
TO-92 (92, 94, 96)
TO-18 LEAD FORM AND CROP   J22Z OPTION



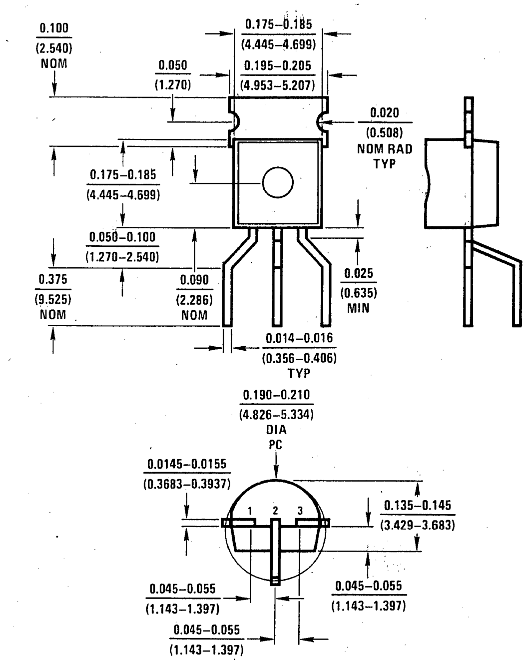
TO-237 (90, 91)
0.100" SPACING LEAD FORM J61Z OPTION



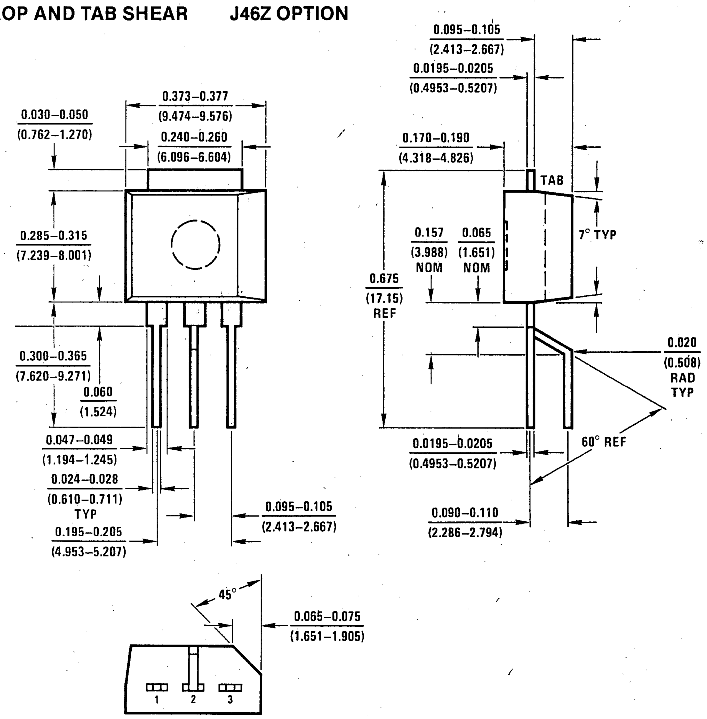
TO-237 (90, 91)
TO-18 LEAD FORM -18 OPTION



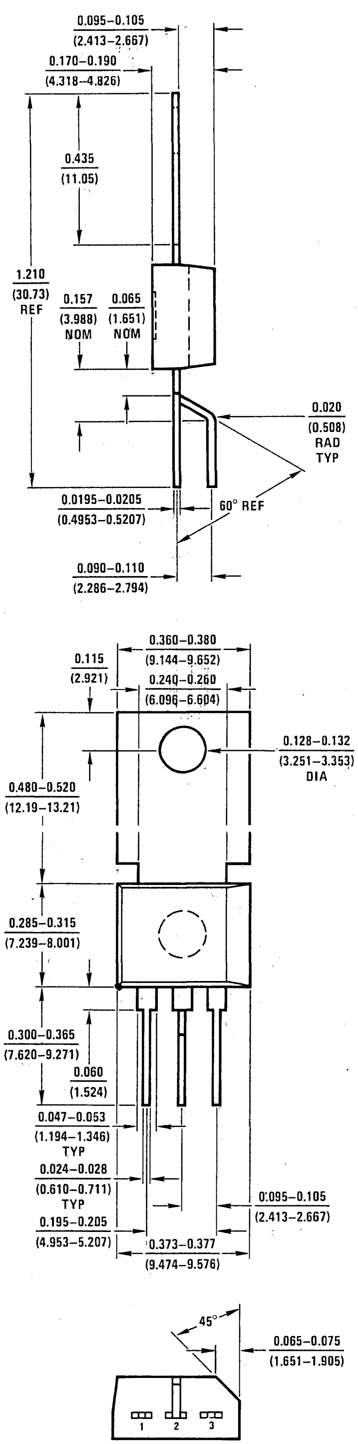
TO-237 (90, 91)
TO-5 LEAD FORM -5 OPTION



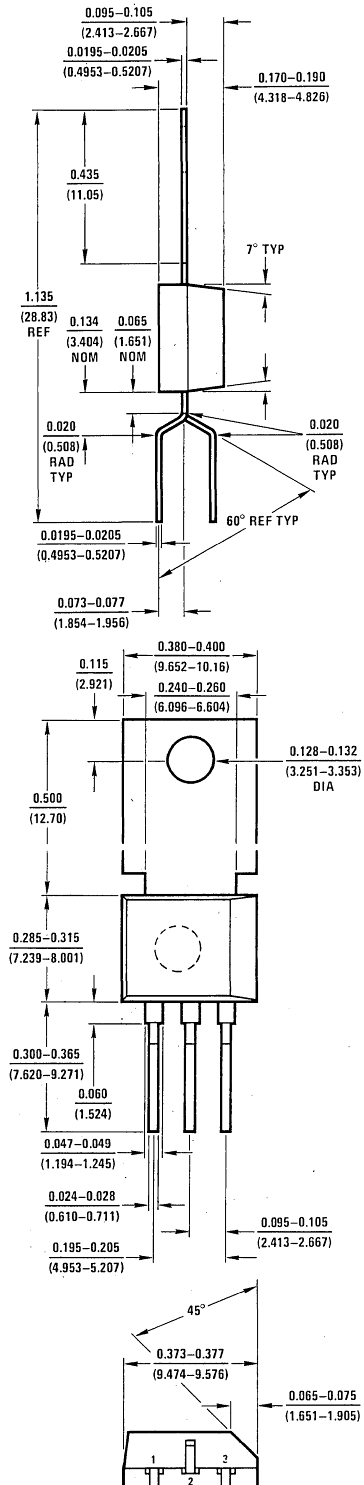
TO-202 (51, 55, 56)
TO-5 LEAD FORM, CROP AND TAB SHEAR J46Z OPTION



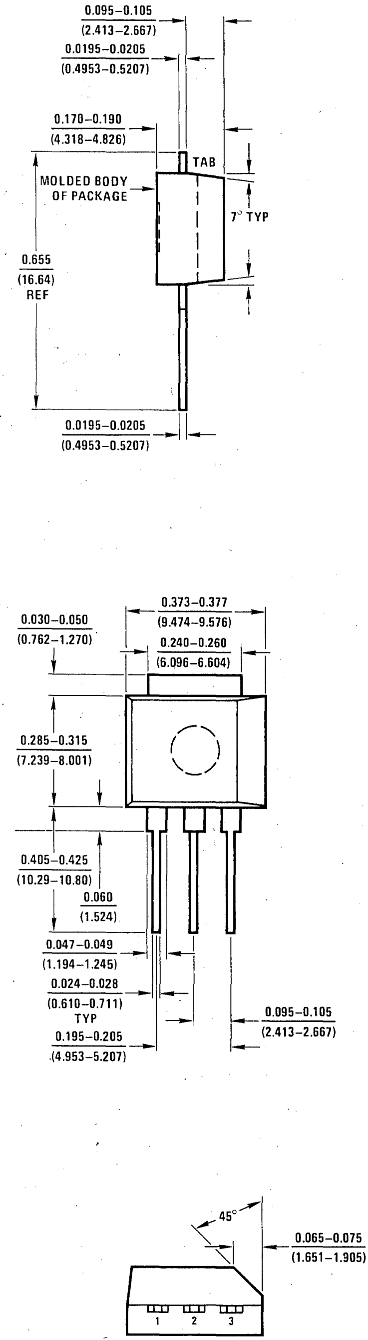
TO-202 (51, 55, 56)
TO-5 LEAD FORM AND CROP J41Z OPTION



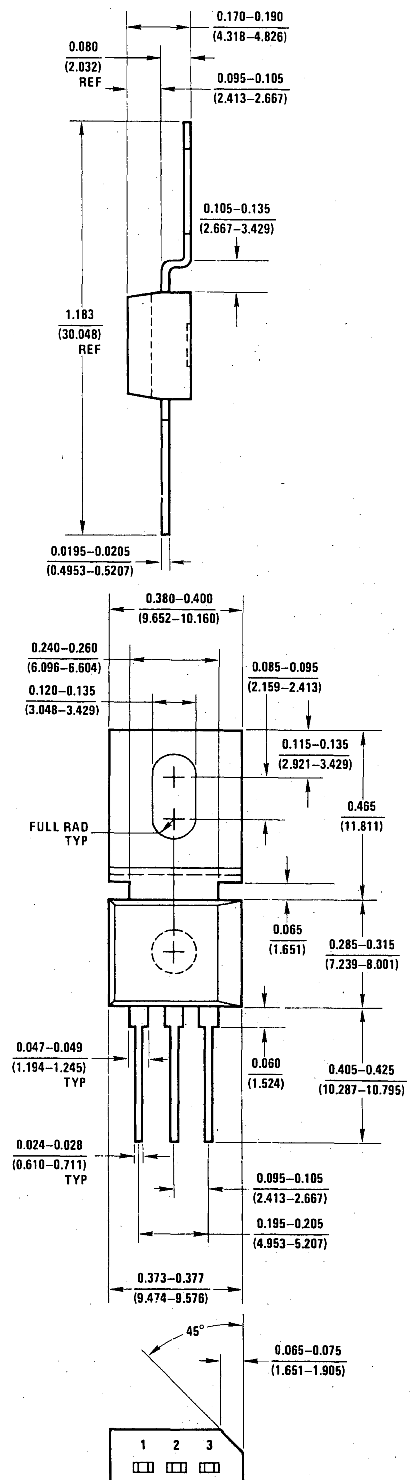
TO-202 (51, 55, 56)
LEAD FORM J52Z OPTION



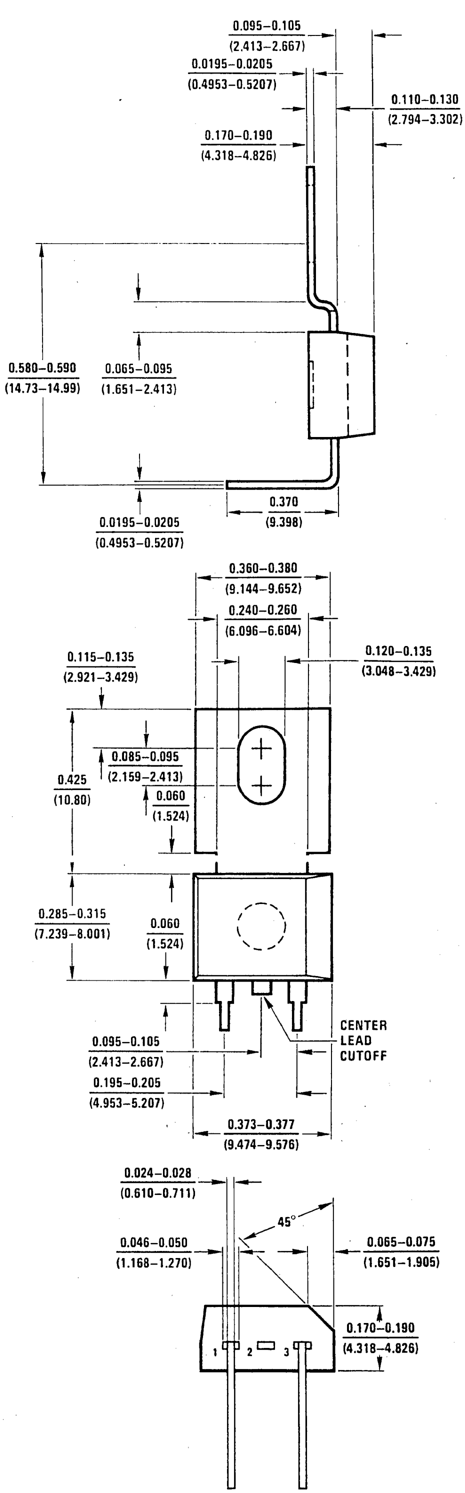
TO-202 (51, 55, 56)
TAB SHEAR L43Z OPTION



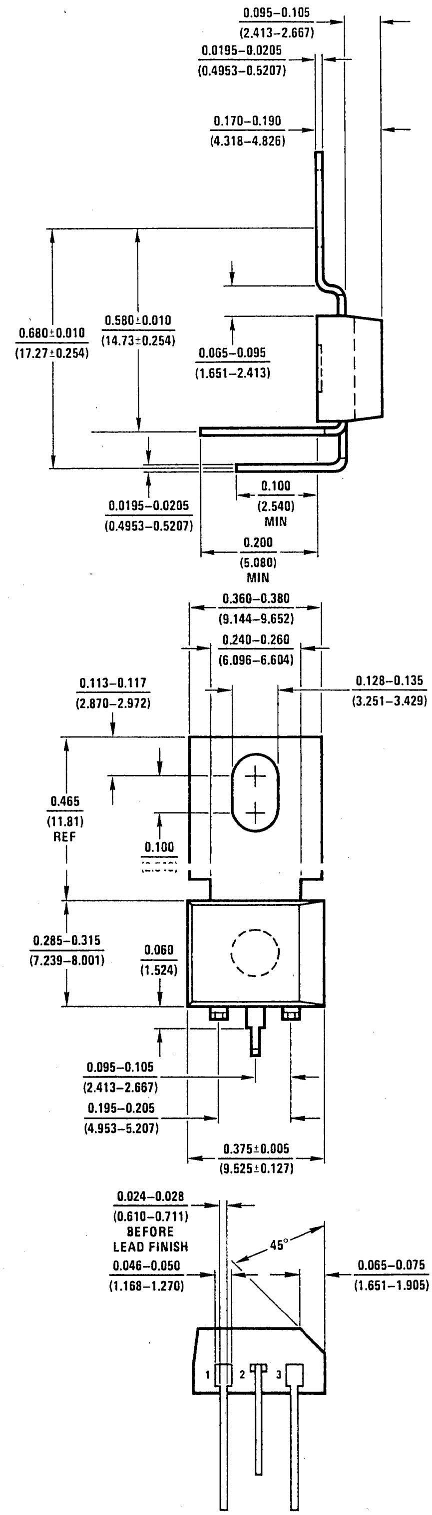
TO-202 (51, 55, 56)
TAB FORM L42Z OPTION



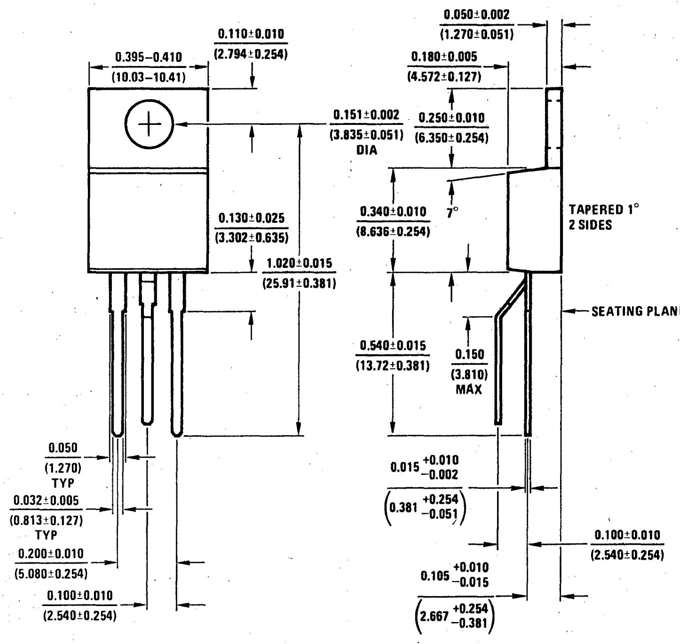
TO-202 (51, 55, 56)
TO-66 LEAD FORM, CROP AND TAB FORM
J45Z OPTION



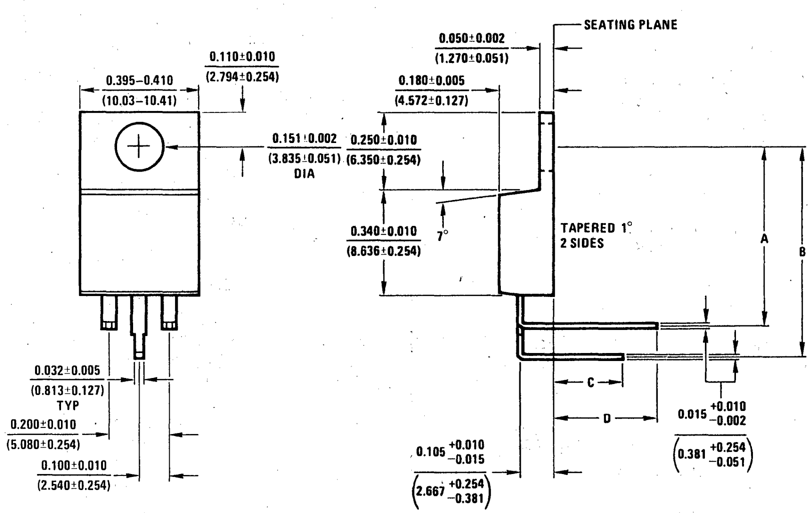
TO-202 (51, 55, 56)
TO-5 LEAD FORM FOR FLUSH MOUNT J68Z OPTION



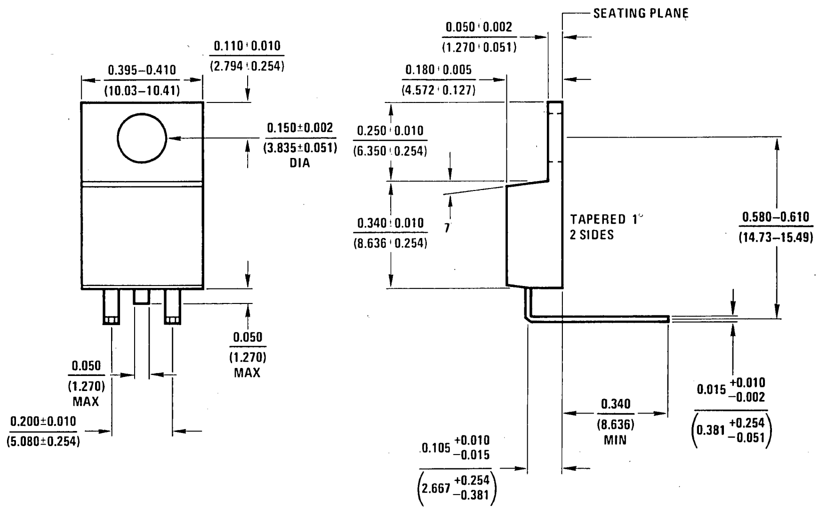
TO-220 (57)
TO-5 LEAD FORM J69Z OPTION



TO-220 (57)
TO-5 LEAD FORM FOR FLUSH MOUNT J672 OPTION



TO-220 (57)
TO-66 LEAD FORM AND CROP J48Z OPTION



National Semiconductor Corporation
2900 Semiconductor Drive
Santa Clara, California 95051
Tel: (408) 737-5000
TWX: (910) 339-9240

Electronica NSC de Mexico SA
Hegel No. 153-204
Mexico 5 D.F. Mexico
Tel: (905) 531-1689, 531-0569
Telex: 017-73559

National Semiconductores Do Brasil Ltda.
Avda Brigadeiro Faria Lima 830
8 ANDAR
01452 Sao Paulo, Brasil
Tel: 212-1181
Telex: 1131931 NSBR

National Semiconductor GmbH
Furstenriederstrasse Nr.5
8 Munchen 21
West Germany
Tel: (089) 58 30 81
Telex: 522772

National Semiconductor (UK) Ltd.
301 Harpur Centre
Horne Lane
Bedford MK40 1TR
United Kingdom
Tel: 0234-47147
Telex: 826 209

National Semiconductor Benelux
Ave. Charles Quint 545
1080 Brussels
Belgium
Tel: (02) 4661807
Telex: 61007

National Semiconductor (UK) Ltd.
1, Bianco Lunos Alle
DK-1868 Copenhagen V
Denmark
Tel: (01) 213211
Telex: 15179

National Semiconductor
Expansion 10000
28, Rue de la Redoute
92 260 Fontenay-aux-Roses
France
Tel: (01) 660-8140
Telex: 250956

National Semiconductor S.p.A.
Via Solferino 19
20121 Milano
Italy
Tel: (02) 345-2046/7/8/9
Telex: 332835

National Semiconductor AB
Box 2016
12702 Skaerholmen
Sweden
Tel: (08) 970190
Telex: 10731

National Semiconductor
Calle Nunez Morgado 9
Esc. Dcha. 1-A
Madrid 16
Spain
Tel: (01) 733-2954/733-2958
Telex: 46133

National Semiconductor Switzerland
Alte Winterhurerstrasse 53
Postfach 567
CH-8304 Wallisellen-Zurich
Tel: (01) 830-2727
Telex: 59000

National Semiconductor
Pasilanraitio 6C
00240 Helsinki 24
Finland
Tel: (0) 14 03 44
Telex: 124854

NS Japan K.K.
POB 4152 Shinjuku Center Building
1-25-1 Nishishinjuku, Shinjuku-ku
Tokyo 160, Japan
Tel: (03) 349-0811
Telex: 232-2015 NSCJ-J

National Semiconductor (Hong Kong) Ltd.
1st Floor
Cheung Kong Electronic Bldg.
4 Hing Yip Street
Kwun Tong
Kowloon, Hong Kong
Tel: 3-899235
Telex: 43866 NSEHK HX
Cable: NATSEMI HX

NS Electronics Pty. Ltd.
Cnr. Stud Rd. & Mtn. Highway
Bayswater, Victoria 3153
Australia
Tel: 03-729-6333
Telex: 32096

National Semiconductor (PTE) Ltd.
10th Floor
Pub Building, Devonshire Wing
Somerset Road
Singapore 0923
Tel: 652700047
Telex: NAT SEMI RS 21402

National Semiconductor (Far East) Ltd.
P.O. Box 68-332 Taipei
3rd Flr. Apollo Bldg. No. 281-7
Chung HSIAO E. Rd., Sec. 4
Taipei, Taiwan R.O.C.
Tel: 7310393-4, 7310465-6
Telex: 22837 NSTW
Cable: NSTW TAIPEI

National Semiconductor (Hong Kong) Ltd.
Korea Liaison Office
6th Floor, Kunwon Bldg.
2-1 GA Mookjung-Dong
Choong-Ku, Seoul
C.P.O. Box 7941 Seoul
Tel: 267-9473
Telex: K24942

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