Table C-2. Operator Execution Times. (Continued)

Mnemonic	Opcode	Parameters	Time	Remarks
			Reals	
FLT [int] : [real]	204		10.8 | 14.8 to 46.8	TOS = Ø | TOS <> Ø : 44.8 - 2.Ø(trunc(lg(abs(TOS)))) + C C = 2.Ø if TOS < Ø C = Ø.Ø otherwise.
TNC [real] : [int]	19Ø		12.4 | 15.6 | 5Ø.Ø to 5Ø.8 | 24.Ø to 48.8	TOS = Ø.Ø | Ø.Ø < abs(TOS) < Ø.5 | Ø.5 <= abs(TOS) < 1.Ø : 5Ø.Ø + C | abs(TOS) >= 1.Ø : 48.Ø - Ø.8(trunc(lg(abs(TOS)))) + C C = Ø.8 if TOS < Ø.Ø, C = Ø.Ø otherwise.
RND [real] : [int]	191		12.4 | 15.6 | 52.4 to 53.2 | 24.8 to 49.6	TOS = Ø.Ø | Ø.Ø < abs(TOS) < Ø.5 | Ø.5 <= abs(tos) < 1.Ø : 52.4 + C | 48.8 - Ø.8(trunc(lg(abs(TOS)))) + C C = Ø.8 if TOS < Ø.Ø, C = Ø.Ø otherwise.
ABR [real] : [real]	227		5.2	
NGR [real] : [real]	228		5.2	
DUP2 [word,word] : [word,word,word,word]	198		12.Ø	
ADR [real,real] : [real]	192		18.8 | 6Ø.8 to 152.8	TOS-1 = Ø.Ø | Range of times represents difference in exponents of TOS and TOS-1. As the difference increases, the time increases until the difference exceeds the width of the mantissa.

Table C-2. Operator Execution Times. (Continued)

Mnemonic	Opcode	Parameters	Time	Remarks
			Reals Continued	
SBR	193		19.2 |	TOS-1 = Ø.Ø |
[real,real]	: [real]		64.4 to 152.Ø	Times vary for same reasons as ADR.
MPR	194		26.4 |	TOS-1 = Ø.Ø |
[real,real]	: [real]		159.4 to 177.8	Time is a function of the operands.
DVR	195		32.4 |	TOS = Ø.Ø |
eal,real]	: [real]		14Ø.6 to 293.8	Time is a function of the operands.
[rea				
EQUREAL	2Ø5		16.4 |	TRUE result |
[real,real]	: [bool]		14.8 |	FALSE in 1st word |
			18.4	FALSE in 2nd word.
LEQREAL	2Ø6		16.4 |	TRUE (TOS = TOS-1) |
[real,real]	: [bool]		16.Ø to 2Ø.4 |	TRUE (TOS < TOS-1) : 16.Ø + B + C, B = Ø.8 if "pos < pos", B = Ø.Ø otherwise, C = 3.6 if equal in 1st word, Ø.Ø otherwise |
			16.8 to 22.Ø	FALSE (TOS > TOS-1) : 16.8 + B + C, B = 1.6 if "pos < pos", B = Ø.Ø otherwise, C = 3.6 if equal in 1st word, Ø.Ø otherwise.
GEQREAL	2Ø7		16.4 |	TRUE (TOS = TOS-1) |
[real,real]	: [bool]		16.Ø to 2Ø.4 |	TRUE (TOS > TOS-1) : 16.Ø + B + C, B = Ø.8 if "pos > pos", B = Ø.Ø otherwise, C = 3.6 if equal in 1st word, Ø.Ø otherwise.
			16.Ø to 2Ø.4	FALSE (TOS < TOS-1) : 16.Ø + B + C, B = Ø.8 if "pos > pos", B = Ø.Ø otherwise, C = 3.6 if equal in 1st word, Ø.Ø otherwise.

Table C-2. Operator Execution Times. (Continued)

Mnemonic	Opcode	Parameters	Time	Remarks
			Sets	
ADJ [set] : [word-block]	199	UB	14.4 | 13.6 to 1747.6 | 16.4 to 1431.6	words(TOS) = UB | set expansion : 13.6 + 6.8(UB) | set compression : 16.4 + 5.6(words(TOS)) + 2.8(UB - words(TOS))
SRS [int,int] : [set]	188		18.Ø | 5Ø.4 to 11Ø.4 | 52.4 to 114.Ø | 56.4 to 1Ø23.6	null set (TOS-1 < TOS) | 1 word set : 5Ø.4 + 2.Ø(TOS-1) + 2.Ø(TOS) | 2 word set : 52.4 + 2.Ø(TOS mod 16) + 2.Ø(TOS-1 mod 16) + C, C = 1.6 if TOS > 15, C = Ø.Ø otherwise | all others : 45.6 + 3.6((TOS div 16) + 1) + 2.Ø(TOS mod 16) + 2.Ø(TOS-1 mod 16) - B, B = Ø.4 if ((TOS div 16) - (TOS-1 div 16)) < 2, B = Ø.Ø otherwise.
INN [int,set] : [bool]	218		18.4 | 22.8 to 52.8	TOS-1 outside bounds of set TOS | 22.8 + 2.Ø(TOS-1 mod 16)
UNI [set,set] : [set]	219		6.6 | 29.2 to 1756.4 | 19.6 to 1848.4 | 58.8 to 3475.2	TOS is null set | TOS-1 is null set : 22.4 + 6.8(words(TOS)) | words(TOS) <= words(TOS-1): 12.4 + 7.2(words(TOS)) | words(TOS) > words(TOS-1) : 24.Ø + 14.Ø(words(TOS)) + 6.8(words(TOS) - words(TOS-1))

Table C-2. Operator Execution Times. (Continued)

Mnemonic	Opcode	Parameters	Time	Remarks
		Sets Continued		
INT [set,set] : [set]	22Ø		11.6 | 12.Ø | 22.4 to 1851.2 | 26.6 to 1848.2	both sets null | only TOS null | words(TOS) >= words(TOS-1) : 15.2 + 7.2(words(TOS)) | words(TOS) < words(TOS-1) : 16.6 + 7.2(words(TOS) + 2.8(words(TOS-1) - words(TOS))
DIF [set,set] : [set]	221		6.Ø | 12.Ø | 21.2 to 185Ø.Ø | 2Ø.8 to 1842.4	TOS is null set | TOS-1 is null set | words(TOS) <= words(TOS-1) : 14.Ø + 7.2(words(TOS)) | words(TOS) > words(TOS-1) : 13.6 + 7.2(words(TOS-1))
EQUPWR [set,set] : [bool]	182		23.6 to 1954.Ø	16.Ø + 7.6(N) + 4.Ø(D) + C + B. N = # words compared to assert FALSE. Ø < N < words in smaller set D = # words examined in larger set (beyond size of smaller set) to assert FALSE. Ø <= D <= (size of larger set) - N C = 2.Ø if D <> Ø and result is TRUE, Ø.Ø otherwise. B = Ø.Ø if words(TOS) >= words(TOS-1), else 1.2 if result TRUE else Ø.8 if result FALSE

Table C-2. Operator Execution Times. (Continued)

Mnemonic	Opcode	Parameters	Time	Remarks
			Sets Continued	
LEQPWR [set,set] : [bool]	183		24.4 to 2158.Ø	words(TOS) >= words(TOS-1) : 16.Ø + 8.4(N)
			3Ø.Ø to 2175.2	words(TOS-1) > words(TOS) : 17.2 + 8.4(N) + 4.Ø(D) + C N = same as EQUPWR D = same as EQUPWR C = Ø.4 if D <> Ø and result is TRUE, Ø.Ø otherwise
GEQPWR [set,set] : [bool]	184		31.2 to 218Ø.8	words(TOS-1) >= words(TOS) : 21.6 + 8.4(N) + C + B C = 1.2 if result is TRUE, else Ø.Ø B = Ø.Ø if sets same size, else Ø.4 if result TRUE, else 1.2 if result FALSE
			29.2 to 2176.4	words(TOS) > words(TOS-1) : 2Ø.8 + 8.4(N) + 4.Ø(D) + C N = same as EQUPWR D = same as EQUPWR C = 2.Ø if D <> Ø and result is TRUE, Ø.Ø otherwise

Table C-2. Operator Execution Times. (Continued)

Mnemonic	Opcode	Parameters	Time	Remarks
			Byte Arrays	
EQUBYT [addr,addr] : [bool]	185	B	29.6 to 170404.8 |	TRUE result : 19.2 + 10.4((B+1) div 2) + 2.8((B+1) mod 2) |
			21.8 to 170397.0	FALSE result : 11.4 + 10.4((D+1) div 2) + 2.8((D+1) mod 2) D = # bytes compared to assert FALSE.
LEQBYT [addr,addr] : [bool]	186	B	28.8 to 170404.0 |	EQUAL (TRUE) result : 18.4 + 10.4((B+1) div 2) + 2.8((B+1) mod 2) |
			27.2 to 170402.4 |	LESS (TRUE) result : 16.8 + 10.4((L+1) div 2) + 2.8((L+1) mod 2) L = # bytes compared to assert LESS |
			28.0 to 170403.2	GREATER (FALSE) result : 17.6 + 10.4((G+1) div 2) + 2.8((G+1) mod 2) G = # bytes compared to assert GREATER.
GEQBYT EQBYT [addr,addr] : [bool]	187	B	28.8 to 170404.0 |	EQUAL (TRUE) result : 18.4 + 10.4((B+1) div 2) + 2.8((B+1) mod 2) |
			31.6 to 170406.8 |	GREATER (TRUE) result : 21.2 + 10.4((G+1) div 2) + 2.8((G+1) mod 2) G = # bytes compared to assert GREATER |
			32.4 to 170407.6	LESS (FALSE) result : 22.0 + 10.4((L+1) div 2) + 2.8((L+1) mod 2) L = # bytes compared to assert LESS.

Table C-2. Operator Execution Times. (Continued)

Mnemonic	Opcode	Parameters	Time		Remarks
			Jumps		
UJP [] : []	138	SB	12.4		
FJP [bool] : []	212	SB	16.8	1Ø.8	jump | no jump
EFJ [int,int] : []	21Ø	SB	19.2	11.8	jump | no jump
NFJ [int,int] : []	211	SB	19.2	12.Ø	jump | no jump
UJPL [] : []	139	W	12.8		
FJPL [bool] : []	213	W	18.8	1Ø.Ø	jump | no jump
XJP [int] : []	214	B	32.Ø 29.2 34.Ø		jump | TOS < min index | TOS > max index

Table C-2. Operator Execution Times. (Continued)

Mnemonic	Opcode	Parameters	Time	Remarks
		Procedure and Function Calls and Returns		
CPL [param] : [activation]	144	UB	45.6	
CPG [param] : [activation]	145	UB	44.8	
CPI [param] : [activation]	146	DB, UB	56.8 to 450.0	53.6 + 3.2(DB)
CXL [param] : [activation]	147	UB1, UB2	64.4	
CXG [param] : [activation]	148	UB1, UB2	63.2	
CXI [param] : [activation]	149	UB1, DB, UB2	76.4 to 469.6	73.2 + 3.2(DB)
CPF [param,addr,seg#/proc#] : [activation]	151		75.6	
RPU [activation] : [func-result]	150	B	26.0	
LSL [] : [addr]	153	DB	15.6 to 408.8	12.4 + 3.2(DB)

Table C-2. Operator Execution Times. (Continued)

Mnemonic	Opcode	Parameters	Time	Remarks
			System Control	
SIGNAL	222		14.8 |	waitq nil, count > Ø |
[addr] : []			18.Ø |	waitq nil, count = Ø |
			52.Ø |	waitq non-nil, no taskswitch |
			134.8	waitq non-nil, taskswitch performed
WAIT	223		11.6 |	count > Ø, no wait |
[addr] : []			9Ø.8	count = Ø, 9Ø.8 is time to taskswitch to another task.
LPR	157		8.4 |	TOS < Ø |
[int] : [word]			55.2	TOS >= Ø
SPR	2Ø9		8.4 |	TOS - 1 = -2, -3 |
[int,word] : []			53.2 |	TOS - 1 = -1 |
			54.8	TOS - 1 >= Ø
			Debugger	
BPT	158		- - -	time for this operator is comparable to the time for CXG. BPT unconditionally calls execution error procedure, resulting in a halt of execution.
[] : [activation]				
			Miscellaneous	
NOP	156		3.6	
[] : []				
SWAP	189		12.4	
[word,word] : [word,word]				

C-3. P-MACHINE DESCRIPTION METALANGUAGE

This appendix presents the III.Ø P-code operators in a Pascal-like notation. Pointer expressions are allowed. For example sp^.i is the contents of the memory location the top of stack register is pointing at taken as an integer. The expression (sp+1)^.i is one memory cell above the the sp register taken as an integer. The notation i<x:y> means take the field starting from bit position x for y bits. Table C-3 shows the P-code operators in a Pascal-like metalanguage.

The record declarations used are close to those used by the Western Digital MicroEngine operating system. The declarations follow.

```
const
    version     = 'BØ';  { Version of this document }
    mscw_sz     = 4;     { Size of mark stack control word in words}
    real_sz     = 2;     { Size of reals in words}
    bset_sz     = 4Ø8Ø;  { Max size of sets in bits}
    iset_sz     = 255;   { Max size of sets in words}
    word_sz     = 16;    { Size of word in bits}
    NIL         = -1Ø24; { Representation for nil pointer}
type
   object_type     = (int_obj, real_obj, byte_obj, bool_obj, set_obj,
                      ptr_obj, sv_obj, sem_obj, mscw_obj, tib_obj);
   byte            = Ø..255;
   sibp            = ^sib;
   sibvec          = array [Ø..127] of sibp;
   sib             = record { segment info block }
                       segbase: memp;    { memory address of seg }
                       segleng: integer; { # words in segment }
                       segrefs: integer; { active calls }
                       segaddr: integer; { absolute disk address }
                       segunit: integer; { physical disk unit }
                       prevsp : memp;    { SP saved by getseg for relseg }
                     end { sib } ;
   mscwp           = ^mscw;
   mscw            = packed record  { mark stack control word }
                       msstat: mscwp;   { lexical parent pointer }
                       msdynl: mscwp;   { ptr to caller's mscw }
                       msipc:  integer; { byte index in return code seg }
                       msseg:  byte;    { seg # of caller code }
                       msflag: byte
                     end { mscw } ;
```