FlexOS™ Programmer's Guide

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Foreword

FlexOS™ is a real-time, multitasking operating system designed for single-user and multiuser microcomputer systems. The programming interface to FlexOS is CPU- and peripheral-independent so you can develop programs that are portable between machines with different components and processors.

FlexOS Features

FlexOS provides comprehensive facilities for process, file, console, and device management. The following list summarizes these facilities:

- Process Management
  - FlexOS process execution
  - Independent, modifiable process environments
  - Asynchronous events and software interrupt handling
  - Interprocess communication and synchronization
- Disk System
  - PC DOS compatible, with hierarchical file directories
  - Shared file system with file and record locking
  - File system protection based on file and directory ownership
  - User and group file ownership
  - Removable media support
- Real-time processing
  - Support for real-time data acquisition and communications
  - Primitives for real-time process control and other real-time applications

- Console
  - Escape sequence decoding
  - Standard character and bit mapped screen interface
  - Standard 16 and 8 bit keyboard interfaces including function keys, numerical keypad and multikeyed characters
  - Virtual console management primitives that include window support
- International considerations
  - Support for 16-bit foreign languages
  - Customization of console messages including country codes
- Memory mapping and protection
- Dynamically loadable device drivers
- CPU-independent programming

Disk File System

The FlexOS disk file system is designed for multiuser and networked microcomputer systems. Hierarchical, shared disk files allow for the large, shared data bases commonly used with professional work stations. The record and file locking mechanisms, along with security through ownership, allow integrity and protection of data.

FlexOS's disk file system is designed to protect against file destruction from power interruptions or accidental system resets. A utility is provided that reconstructs file directory entries and allocation tables from the data area of the disk.

The FlexOS file system distinguishes removable from permanent media and recognizes removable media that have open door interrupts.

Real-time Kernel

The kernel provides multiuser and multitasking environments that allow both real-time control applications and integrated office environments on the same CPU.

The kernel is based on an event driven dispatcher that does priority driven scheduling. Time slicing is done by a timer event that occurs once per TICK, typically every 16 to 20 milliseconds (implementation dependent). Scheduling of equal priority processes is done in a round robin fashion.

Pipe File System

FlexOS performs process communication and synchronization through named pipes. These in-memory files are available to pass data from one process to another or to synchronize activities when acting as semaphores.

Console File System

The FlexOS console system provides dedicated functions designed specifically for the fast manipulation of bit-mapped and character-oriented displays. A single call can copy or modify a screen region ranging in size from a single character cell to the entire screen. These functions give you a consistent, hardware-independent interface to the computer's interactive devices without sacrificing program portability

The console system also provides window management facilities that allow applications to create and manage multiple virtual consoles.

Intended Audience and Manual Organization

This manual (hereinafter referred to as the Programmer's Guide) is written for the programmer whose goal is to write applications and utilities to run under the FlexOS operating system. The Programmer's Guide anticipates, but does not require, a working knowledge of the C programming language.

The Programmer's Guide is organized as follows:

Section 1	Terms and conventions used in this manual; file system characteristics; summary of Supervisor calls and tables.
Section 2	Disk Resource Manager
Section 3	Console Resource Manager
Section 4	Pipe Manager
Section 5	Process Management
Section 6	Miscellaneous Device Management
Section 7	Supervisor call reference
Section 8	system table reference
Appendix A	FlexOS character codes
Appendix B	System return and error codes
Appendix C	FlexOS country codes

The FlexOS Documentation Set

The Programmer's Guide is one of several manuals in the FlexOS documentation set. The other documents are

- FlexOS User's Guide: The user's reference for FlexOS operation. The User's Guide describes the command shell, advanced FlexOS concepts, and command files. It also provides an overview of system manager functions.
- FlexOS System Guide: The guide to FlexOS system implementation for an original equipment manufacturer or driver writer. Information presented in this guide includes driver and supervisor interfaces, FlexOS's driver services, and how to construct a boot loader.
- FlexOS Supplements: Microprocessor-dependent supplements to the Programmer's Guide and the FlexOS System Guide.
- FlexOS Programmer's Utilities Guides: The reference to FlexOS assembly language programming tools. There is a separate utilities guide for each microprocessor supported by FlexOS.

The Programmer's Guide, User's Guide, and System Guide are generic in that they are appropriate for FlexOS systems based on any supported microprocessor. Before developing programs, you should become familiar with the sections of the FlexOS supplements that describe microprocessor-dependent distinctions and differences of operation. In most cases, the points of difference are noted in the appropriate sections of this manual. However, not all information is cross-referenced.

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Terms, Concepts, and Conventions

This section defines the terms, concepts, and conventions used in this manual and describes the file system characteristics and FlexOS architecture.

1.1 C Language Conventions

Table 1-1 lists the data-type definitions used to promote C portability and reduce compiler differences.

Table 1-1. Standard Data-type Definitions

Data Type	Definition
BYTE	Signed 8-bit value
BOOLEAN	Byte with one of two values: true/false
WORD	Signed, 16-bit value
UWORD	Unsigned 16-bit value
LONG	Signed 32-bit value
STRUCT	Named sequence (structure) of variables

1.2 Supervisor Calls

The functions performed by FlexOS are referred to as Supervisor calls (SVCs). SVCs provide file, console, event, process control, and device I/O and management services. Table 1-2 lists the SVCs according to their purpose (asterisks indicate those SVCs that can be called asynchronously).

Table 1-2. Supervisor Call Summary

Purpose	Call	Action
File Management		
	DEFINE	Define logical name for a path
	CREATE	Create a file
	DELETE	Delete a file
	OPEN	Open a disk file
	CLOSE	Close a disk file
	READ*	Read from a file
	WRITE*	Write to a file
	SEEK	Modify or obtain current file pointer
	LOCK*	Lock/Unlock an area of a disk file
	RENAME	Rename or move a file
Console Management		
	KCTRL	Obtain keyboard and mouse ownership
	ORDER	Order windows on parent screen
	XLAT	Specify keystroke translation
	GIVE	Give keyboard and mouse to child process
	COPY	Copy one screen rectangle to another
	ALTER	Alter a screen rectangle
	RWAIT*	Wait for mouse to enter/leave a rectangle
	BWAIT	Wait for mouse button state change
Event Management		
	CANCEL	Cancel asynchronous events
	WAIT	Wait for multiple events
	STATUS	Get status of asynchronous events
	RETURN	Get return code of completed event

Table 1-2. (Continued)

Purpose	Call	Action
Real Time and Process Management		
	TIMER*	Set and wait for timer interrupt
	ABORT*	Abort specified process
	COMMAND*	Perform command
	EXCEPTION	Set software interrupts on exceptions
	MALLOC	Allocate memory to heap
	MFREE	Free memory from heap
	EXIT	Terminate with return code
	ENABLE	Enable software interrupts
	DISABLE	Disable software interrupts
	SWIRET	Return from software interrupt
	CONTROL*	Control a process for debugging
	OVERLAY	Load overlay from command file
Device Management		
	SPECIAL*	Perform special device function
	DEVLOCK	Lock or unlock device for user/group
	INSTALL	Install, replace and associate drivers
Table Management		
	GET	Get a table
	SET	Set table values
	LOOKUP	Scan and retrieve tables

* Your program can call these SVCs asynchronously.

Table 1-3 lists the SVCs by their number.

Table 1-3. Supervisor Calls by Number

Number	Call	Number	Call
0	F_GET	21	Reserved
1	F_SET	22	F_GIVE
2	F_LOOKUP	23	Reserved
3	F_CREATE	24	F_TIMER
4	F_DELETE	25	F_EXIT
5	F_OPEN	26	F_ABORT
6	F_CLOSE	27	F_CANCEL
7	F_READ	28	F_WAIT
8	F_WRITE	29	F_STATUS
9	F_SPECIAL	30	F_RETURN
10	F_RENAME	31	F_EXCEPTION
11	F_DEFINE	32	F_ENABLE
12	F_DEVLOCK	33	F_DISABLE
13	F_INSTALL	34	F_SWIRET
14	F_LOCK	35	F_MALLOC
15	F_COPY	36	F_MFREE
16	F_ALTER	37	F_OVERLAY
17	F_XLAT	38	F_COMMAND
18	Reserved	39	F_CONTROL
19	F_KCTRL	40	Reserved
20	F_ORDER	41	F_SEEK

1.2.1 Calling Conventions

FlexOS Supervisor calls are made by invoking the FlexOS entry point. The entry point takes two arguments and returns a value, as follows:

Arguments: a SVC 16-bit number
a parameter block pointer or value, 32-bit

Return: a 32-bit value

See the processor-specific supplement for the actual entry mechanism and registers used.

You can call FlexOS independent of a processor by calling the _osif function supplied with the operating system. The _osif function has two arguments: the SVC number (16 bits) and, depending on the SVC, a 32-bit parameter block address or parameter value. The C language definition of the _osif function is:

```
WORD    SVCno;
LONG    parm;
LONG    ret;

ret = _ _osif(SVCno,parm);
```

The _osif function returns the return code in registers, according to the convention of the language processor used to create the program.

You can also call FlexOS independent of the processor by using the standard FlexOS SVC library supplied with the language processor available for FlexOS. Each of these library functions builds a parameter block for the corresponding SVC and calls FlexOS. This high-level interface allows the description of FlexOS supervisor calls in processor-independent and register convention independent methods.

1.2.2 Data Structure Representation

Throughout this manual, data structures are represented as shown in Figure 1-1. Listing 1-1 contains the corresponding code representation. Byte and word order are critical when using these structures.

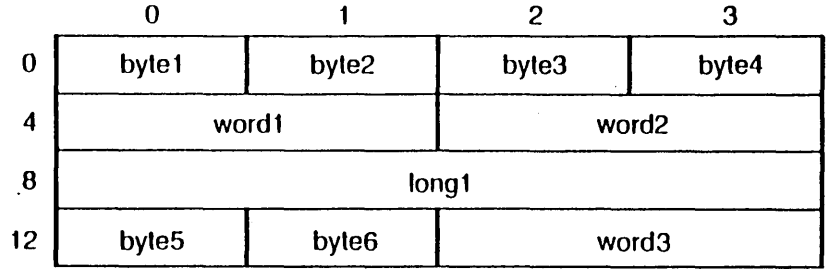


Figure 1-1. Data Structure Diagram

Listing 1-1. Data Structure Representation

```
STRUCT thisstruct
(
        BYTE        byte1;        /* byte offset = 0              */
        BYTE        byte2;        /* byte offset = 1              */
        BYTE        byte3;        /* byte offset = 2              */
        BYTE        byte4;        /* byte offset = 3              */
        WORD        word1;        /* byte offset = 4              */
        WORD        word2;        /* byte offset = 6              */
        LONG        long1;        /* byte offset = 8              */
        BYTE        byte5;        /* byte offset = 12             */
        BYTE        byte6;        /* byte offset = 13             */
        WORD        word3;        /* byte offset = 14             */
);                          /*          length = 16               */
```

1.2.3 Synchronous and Asynchronous SVCs

All SVCs have a synchronous form. This means the call does not return until the operating system completes the event--for example, reads a record from the disk, writes a string to the console, or opens a file. Some SVCs also have an asynchronous form. These calls return a value immediately which uniquely identifies the event requested. Program operation can then proceed independently of the event.

Synchronous and asynchronous SVCs take the following forms:

```
ret = s_funcname(parm1,parm2,...,parmN);
emask = e_funcname(swi,parm1,parm2,...,parmN);
```

SVC names starting with "s_" are synchronous SVCs. The ret value is the completion code for the event.

SVC names starting with "e_" are asynchronous. The emask value is the event mask which uniquely identifies the event. The completion code for asynchronous calls is acquired with the RETURN SVC.

The contents of the parameter block block built from an SVC call are different, depending on the SVC.

The individual parameters are always provided in the form shown in Figure 1-2. The largest parameter block is 28 bytes long.

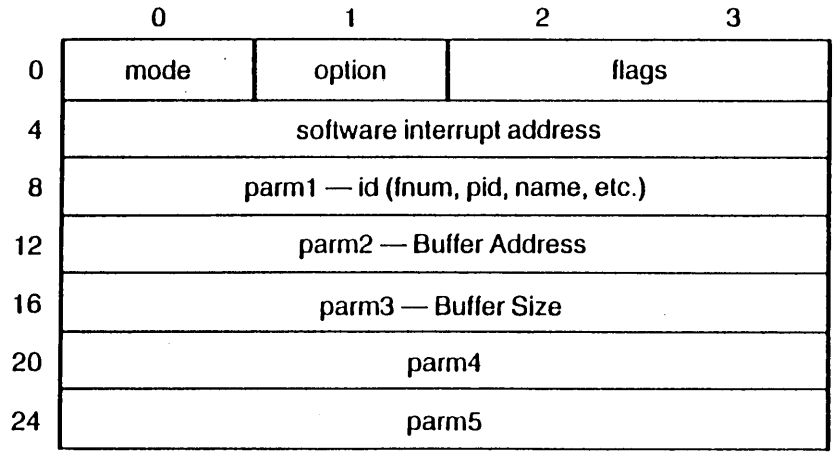


Figure 1-2. SVC Parameter Block

The Supervisor checks the mode to determine if the SVC is synchronous or asynchronous. A mode value of 0 indicates a synchronous SVC; a mode value of 1 indicates an asynchronous SVC. A parameter error is returned if the mode specified is not 0 or 1. The option and flags values select options unique to each SVC.

The software interrupt address is a pointer to an optional software interrupt routine available with asynchronous SVCs. FlexOS forces the calling process to jump to this routine when the asynchronous event completes.

The ID parameter uniquely identifies the object of the call. For example, for a WRITE call the object is a disk file, console, printer, or other peripheral device. The ID value in this case is a 32-bit file number.

The buffer is used to store data for transfer to or from the object. FlexOS checks the address and size values to ensure there are no memory boundary violations.

Many fields are marked with a 0 (zero) in the individual SVC calls. These fields must be set to zero to be compatible with future releases of FlexOS. An error is returned if they are not zero.

1.2.4 Return Codes

The return code for synchronous and asynchronous SVCs is always a LONG value (32 bits). A zero or positive value (high order bit is off) indicates a successful operation. SVCs not returning any particular value, such as a file number or a process ID, return a NULL (0) value to indicate success. For synchronous SVCs, the return value is the completion code. For asynchronous SVCs, the return value is the event mask, not the results of the operation.

A negative return code (high order bit is on) for synchronous and asynchronous SVCs indicates that an error occurred. The high order word contains the module or device code and the low order word contains the error type code. See Appendix B for the error code descriptions. These codes also apply to the asynchronous call's completion code.

1.2.5 Asynchronous Supervisor Calls

Asynchronous Supervisor calls allow a program to process multiple events simultaneously. Table 1-4 lists the Supervisor calls with asynchronous forms.

Table 1-4. Asynchronous SVCs

SVC	Purpose
READ*	Read from a file.
WRITE*	Write to a file.
LOCK	Lock/unlock an area of a disk file.
TIMER	Wait for a time period to expire.
COMMAND	Create a process.
SPECIAL	Perform a special device function.
CONTROL	Control a process with another process.
ABORT	Wait for a process to terminate.
BWAIT	Wait for a mouse button state to occur.
RWAIT	Wait for the mouse to enter or exit a region.

* You cannot read or write a disk file asynchronously. You can only use asynchronous READ and WRITE on console files, pipes, printers, and designated special devices.

Each process can have up to 31 on-going events; each identified by a single bit set in the event mask. The event mask is relevant to the following SVCs:

- WAIT to synchronize on one or more asynchronous events
- RETURN to acquire an event's completion code
- STATUS to indicate completed events
- CANCEL to cancel an event

FlexOS provides two mechanisms sensitive to event completion. You can suspend program execution until an event or one of several events completes or you can execute the software interrupt routine (swi) when the event completes.

Waiting on Events

Use the WAIT SVC to synchronize program operation on the completion of an event.

The event or events to wait on are specified in the WAIT argument and the call returns when any of the specified events completes. The event completed is indicated in the return code. While the process is waiting, it is removed from the dispatcher's ready list and minimizes the CPU load.

To get the completion code for an asynchronous event, use the RETURN SVC. RETURN use is limited to asynchronous events that do not have a software interrupt (swi). (The completion code is passed to the software interrupt and hence is not available to the process.) For asynchronous events without a swi, use the WAIT return code as RETURN's event mask. The event mask bit is not reset until RETURN has been called.

The STATUS SVC is also useful to determine completed events. STATUS places a heavy burden on the CPU and excessive use impacts program performance. You specify the events you want considered in STATUS's argument, and the call returns with the bit of all completed events set.

Interrupting upon Event Completion

Each asynchronous SVC allows a pointer to a swi so program code can be executed asynchronously when an event occurs. When the event completes, FlexOS preserves the stack pointers and proceeds with the swi.

Two values are passed to the swi, the completed event's mask and its completion code. Both are LONG values. A swi has the following C form:

```
swi_routine(emask,compcode);
    LONG emask;/*mask of completed event*/
    LONG compcode;/*event's completion code*/
{
/*interrupt routine*/

    s_swiret(0L);/*swi exit call--return to main program*/
}
```

FlexOS clears the event mask when the swi is called; do not call RETURN to reset the bit.

You must use the SWIRET SVC to exit the swi. It gives you two options: return to the program at the point of interruption or assume the process identity from the main program. For both options the stack pointer is restored to its condition when the program was interrupted.

When you have the swi assume the process identity, you can force a return to the main program or not return at all. If you force the return to the main program, the stack condition is unknown. Consider the use of a routine that returns the stack to a known place and jump to this routine from the swi.

When you have the swi assume the process identity, use EXIT to terminate the process. Do not call EXIT until after you have called SWIRET, however.

Note: The asynchronous form of ABORT is typically used as a mechanism to preserve a process when it is user-aborted. For example, consider a menu-driven program where the user enters a control-C to abort a menu-selection. To trap the control-C and return to a menu within the program rather than the operating system, you would use the asynchronous ABORT and a swi to force the return to the program. To abort the menu program entirely, the user would have to enter two control-Cs.

To establish critical regions where a swi cannot interrupt program execution, use the DISABLE SVC. No swi is executed while DISABLE is active, however, FlexOS does log the completion of asynchronous events during this time. Use the ENABLE SVC to end the DISABLE mode. All event swis impeded while DISABLE was active are executed after ENABLE is called.

1.3 File Specifications

A file is a logical construct applicable to the range of devices and functional units managed by FlexOS. FlexOS uses files to store or display information (disk files, pipes, console files, device files), get data input (keyboard and device files), and control access (zero length pipes).

Every file is specified by a path. A path consists of the following elements:

node::	network node name
device:	logical device name
\	root directory
directory\	subdirectory name
filename	file name and extension

These elements are always entered in the following sequence:

node::device:\directory\...directory\filename

If you do not specify a node, device, or directory, the current disk directory is assumed.

The node and device names can be one to eight alphanumeric characters. A directory name can have one to eight alphanumeric characters and always has the DIR extension. File names consist of a one to eight alphanumeric character name and an optional one to three alphanumeric character extension. You cannot have a NULL file name. The complete specification cannot exceed 127 characters.

Directories are distinguished from files in a path specification by either backslash (\) or slash (/). FlexOS recognizes the following abbreviations:

./ means the current directory
../ means the parent directory
// means the root directory of the specified device

Although ./, ../, and // are most useful at the user interface level, the FlexOS logical name substitution means these abbreviations can also be useful at the programmatic level as well. Note that // ignores whatever directory specification preceded the // and specifies the root directory on the specified device or, if no device was specified, the default device.

Paths are also used to identify pipe files, console files, and devices. The following are examples of path specifications.

remote disk file	svr::hd:\dir\FILE.EXT	full path
disk file	hd1:/mydir/file.typ	device, directory, and file
pipe	pi:mypipe	
virtual console	con1:vc002/console	screen and keyboard for virtual console #2
device	mydevice:	
abbreviations	m:a/b\./../x	means m:a/x
	m:a/b//c/d	means m:c/d

1.3.1 Uppercase Versus Lowercase Names

File names can consist of uppercase and/or lowercase characters. Name matching is conducted according to the following rules. The rules are summarized in Table 1-5.

- The Disk Resource Manager accepts two types of disk media, uppercase media (default) and case sensitive media. You make the selection in the disk label. All file names on uppercase media are converted to uppercase. On case sensitive media, the Disk Resource Manager either converts names to lowercase or leaves them as is, depending on the force case flag in the SVC.
- Device names are always lowercase and are searched in force lowercase mode. This way, an uppercase or lowercase name will match a device name.
- The DEFINE SVC forces logical names to lowercase but leaves the substitution string as is. All logical names are forced to lowercase when the define tables are searched, but left as is if no substitution occurs.
- Programs using FlexOS's SVCs can choose between force case or not.

Table 1-5. Rules for Forcing Name Case

Device	Default Case	Cases Supported	Forced Case
Disk	Upper-only	Upper-only Mixed	Upper Lower
Pipe	Mixed	Mixed	Lower
Console	Lower-only	Lower-only	Lower
Miscellaneous	Lower-only	Lower-only	Lower

1.3.2 Wildcards

Wildcard characters are available for use with the FlexOS LOOKUP SVC. This supervisor call is a scanning tool that searches tables by type and extracts items matching the name specification in the LOOKUP call. Where there is a match, LOOKUP puts all or part of the table into a buffer. The Table 1-6 lists the wildcard characters.

Table 1-6. Wildcards

Wildcard	Meaning
*	Matches any number of characters, 0 or more
?	Matches any single character
^	Finds names that do not match the wildcard name

The * and ? characters can be freely intermixed with characters that must be in the item names. The ^ must be the first character of the wildcard name. The following examples illustrate the use of wildcard characters.

Suppose the following set of names exists for a table type:

a ab abc bac bb bc c

The following wildcard names would specify the indicated set:

*	a,ab,abc,bac,bb,bc,c (all files)
*c	abc,bac,bc,c (all files ending with c)
^*c	a,ab,bb (all files not ending with c)
?b	ab,bb (all files with a 2 character name ending with b)
a*	a,ab,abc (all files starting with a)
b	ab,abc,bac,bb,bc (all files with b anywhere)
?	a,c (all files with a 1 character name)
?*b*	ab,abc,bb (all files with b anywhere after 1 character)
*b?	abc,bb,bc (all files with b as next-to-last character)

You can have logical name translation with LOOKUP and use paths in your LOOKUP name specification. In path specifications, wildcards can only be used in the last element of path. The following examples demonstrate valid and invalid uses of wildcards in LOOKUP name specifications.

Specification	Explanation
hd:/B1/GL*.*	Valid: Returns the table for all files in directory B1 on device hd: that begin with GL.
pi:^mx\input	Invalid: The wildcard cannot be used if the file is not at the end of the specification.
hd?:/	Invalid: The wildcard cannot be in the device name if there are subsequent directory or file references.
hd?:	Valid: Returns the table for all devices beginning with hd.

1.3.3 Reserved Names

Table 1-7 lists file names reserved by FlexOS. The BOOTINIT script initially defines default: in the process logical name table and defines system: and boot: in the system logical name table.

Table 1-7. Reserved File Names

Name	Definition
stdin	The standard input file.
stdout	The standard output file.
stderr	The standard error file.
stdcmd	Reserved for system use.
prn:	The system list (print spooler) device.
default:	The process's current directory: FlexOS expands a NULL path to the path associated with default:. A path consisting of filename alone is expanded to begin with default:.
system:	The process's system directory: The system directory is intended as the location to store shared program and data files. FlexOS searches it after any unsuccessful attempt to find a match in the default: directory when the path specification consists of a file name alone. Files in the system: directory must have the system attribute set to be loaded in this manner.
boot:	The system boot directory: Device drivers are typically located in the boot directory.

1.3.4 Logical Name Substitution

FlexOS contains a logical name preprocessor which allows paths to be represented by a single logical name. FlexOS checks the first item in a path specification against a logical name table and substitutes the

replacement string when a match is found. An item is defined as a character string delimited by a NULL, space, tab, or colon. For example, if you define home: to be the string

```
floppy1:dir1/dir2/
```

then the path specification home:datafile is expanded to:

```
floppy1:dir1/dir2/datafile
```

After the replacement string has been inserted into the original path specification, FlexOS checks the first item again for a replacement string. This loop continues until no replacement is found. The complete file specification after all substitution has been performed cannot exceed 127 characters.

If the file datafile in this example is a logical name, FlexOS does not search for the replacement string because it is not the first item in the path specification.

FlexOS maintains a single, system-wide logical name table--the SYSDEF table--and separate logical name tables for each process--the PROCDEF tables. FlexOS cross-references the logical names in the PROCDEF table first and then the SYSDEF table. You make changes to both tables with the DEFINE SVC; however, only privileged users can make changes to the SYSDEF table. You can assign logical names for complete or partial paths.

When a process creates another process, the new process, called the child, inherits a copy of its parent's local process logical name table. Any changes the child process makes affect its table only. The parent's table is not modified. This is how the logical names replacements for the standard files are passed from parent to child processes.

1.4 File Access

FlexOS monitors file access for four types of privileges--read, write, delete/set, and execute--and three types of users--owner, group, and world. For disk files, access is monitored only when disk security is enabled. (See the description of the disk label in Section 2.4.1 for the description of disk security.) Before you can read from or write to a

file, you must open it. In your open call, you select which privileges (read and/or write) you require and specify an access mode. The access privileges available to you depend upon your user and group ID numbers.

When the open is successful, FlexOS returns a 32-bit file number. You subsequently access the file by its number. FlexOS keeps all file numbers in a global table of open files and uses them to dispatch requests to the proper resource manager. The number is disassociated from the file when you close it.

1.4.1 Standard File Numbers

FlexOS reserves four file numbers for reference to the standard files. Table 1-8 lists these file numbers by their reserved names.

Table 1-8. Standard File Numbers and Names

File Number	Name	Description
0	stdin	standard input file
1	stdout	standard output file
2	stderr	standard error file
3	overlay	overlay file

Note: The overlay file is the command file from which the program was loaded. This file is left open when an indication of overlays exists.

These numbers are not the actual file numbers of your standard input, output, error, and overlay files. FlexOS translates these numbers into the actual file numbers. The definition of the standard to actual file numbers is made by the shell or window manager program. Should you need the actual file number, you can get them from the ENVIRON table.

The COMMAND SVC opens stdin, stdout, and stderr. These names are inherited from the parent process which called the COMMAND SVC. The standard input file is opened for read access in shared file pointer mode; the standard output and the standard error files are opened for write access in shared file pointer mode.

1.4.2 Access Privileges

There are four access privileges: read (R) allows the process to read from the file; write (W) allows the process to write to the file; execute (E) allows the process to run the program; and delete (D) allows the process to delete the file and set values in the file's table.

Access privileges are assigned on a owner, group, and world basis when the file is created. Which access privileges are available to a given process is determined by comparing its user and group identification numbers against the file creator's. At log in, FlexOS reads the user's ID numbers from the USER.TAB file. The comparison is made when the user attempts to open, execute, or delete the file. If both numbers match (indicating the user is the file owner), FlexOS allows the user the access privileges established for the owner. If there is a match on the group ID only, FlexOS allows only the group-level access privileges. If neither match or the user IDs match but the group IDs do not, only world-level privileges are available.

User, group, and world categories are independent and do not have to provide diminishing levels of access. For example, you can set the world level to have complete rights over a file, while the group level can only write to the file and the owner can only read the file. The file owner and superuser can always change the attributes of the file, regardless of the security word.

The privileges available for owner, group, or world access are kept in the file's File Security Word. The File Security Word is a 2-byte bit-map of the access privileges by level as shown in Figure 1-3. The values are set in the CREATE call. Only disk and pipe files and directories have a File Security Word. Console file access privileges are determined by the mode.

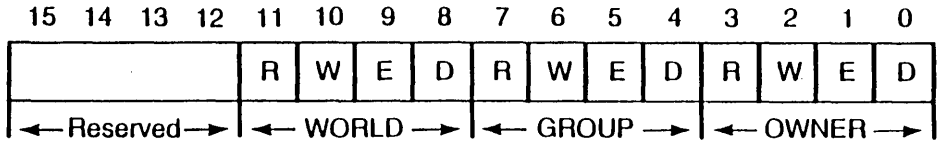


Figure 1-3. File Security Word

The execute and delete privileges are determined when the process attempts to run or erase the file. You do not need to open the file for either operation. You can, however, delete a file once it is open. The delete is not performed until the last close is performed on the file.

You select the process's read and/or privileges in bits 2 and 3 in the OPEN SVC's flags. If the privileges requested are available in the File Security Word, the resource manager checks them against the file's current access modes (see below). If the privilege is available given existing modes, the file is opened and the file number returned.

When a requested privilege is not available, the OPEN succeeds or fails depending on the value of the Reduced Access flag in the OPEN call. The access level granted is derived by ANDing the privileges requested with those in the File Security Word. For example, if the requested OPEN access rights are RW and the File Security Word access rights are RDE, then the reduced access right is R--the only common access privilege. The resource manager determines if that privilege is available given any current access modes before opening the file and returning the file number. If none of the requested rights match, then an access violation error code is returned and the file is not opened.

1.4.3 Access Modes

FlexOS provides a set of access modes which determine whether or not and, if so, how open files are shared. These modes are selected in the OPEN flags word and consist of the following:

- EX: exclusive access by calling process
- AR: allow reads by other processes
- ARW: allow reads and writes by other processes

The default mode is exclusive access, where the calling process prevents any other process from sharing the file. Exclusive access to a file is denied if another process has the file open.

If a process tries to open a file with write privilege and another file has the file open in (AR) mode, then the new open is denied and an error is returned.

ARW mode has two options: shared or unique file pointer. The shared file pointer mode is only available to processes with the same family ID, and all processes in the family must specify this mode.

For processes outside of the family, the file appears in exclusive mode. There are no such restrictions when the unique file pointer option is selected.

1.4.4 File Pointers

FlexOS supports both sequential and random access to pipes and disk files. Sequential file access is supported by a file pointer. File reads and writes increment the pointer so you need not constantly calculate your position within the file. Random file access is supported through the use of offsets in the READ and WRITE supervisor calls. The offset can be specified relative to the file pointer, the beginning of the file, or the end of the file.

The file pointer is initialized to 0 when you create or open the file. Subsequent reads and writes move the file pointer to the byte position of the next sequential location. For example, if a new file is created and then 12 bytes are written, the file pointer would be pointing at the 13th byte (essentially the EOF marker).

Separate processes sharing access to the same file can share the same file pointer or can have separate ones. File pointer sharing is limited to processes with the same family identification number (FID). When the pointer is shared, READ or WRITES by any process update the file pointer. Use the SEEK SVC to determine the file pointer's location. SEEK can also be used to set the pointer's location.

Random access on printer, console, and other serial files produces results that are device dependent. Consequently, file pointers are not maintained on these types of devices but rather assume an offset of 0 independent of the actual request.

1.5 Deleting Files

Files are deleted by name with the DELETE SVC. Unless the disk security has been enabled or the file has the read-only attribute, there is nothing to prevent the calling process from erasing the file. A file cannot be erased when it is set read-only. When file security is enabled and the file has not been opened, the calling process must have the delete privilege. If the process has the file opened, it must have either write or delete privilege.

FlexOS does not immediately erase an open file when you try to delete it. Instead, FlexOS returns success to the DELETE call but marks the file as temporary. FlexOS leaves files marked temporary available until the last close is performed. At this point, the file is deleted.

You can automatically delete files by setting one of two flags when you create the file. One CREATE flag designates the file as temporary or permanent. Temporary means the file is deleted after the last open is closed; permanent means the file remains after the last close. The other CREATE flag deletes a file if it has the same name as the file you are creating. (Alternatively, you can have CREATE return an error if it finds a file with the same name.)

1.6 Basic Terms

Table 1-9 defines the special terms used in this manual.

Table 1-9. FlexOS Operating System Terms

Term	Meaning
Buffer	Address of buffer: Many SVCs require buffers for either I/O or information. Buffers must be within the logical address range of the calling process. FlexOS checks the buffer address and size to ensure legal buffers.
Bufsiz	Size of buffer (in bytes): The size of the buffer sets the SVC's limit. For instance, the buffer size indicates the number of bytes to transfer in the WRITE SVC. The buffer size is also used with the buffer address to catch illegal buffer specifications.
Completion code	The return code of an asynchronous event.

Table 1-9. (Continued)

Term	Meaning
Event	Asynchronous operation: When a process issues an asynchronous SVC, the requested activity is called an event. For example, in an asynchronous write call to a printer, the event is the output of the character or string. Events can be successful or unsuccessful, the latter indicating that the resource manager's or driver's error recovery mechanism determined that the action could not be completed. A process can have up to 31 ongoing events.
Event Mask	Asynchronous SVC return value: When you call an asynchronous SVC, a 32-bit value is returned immediately. If it is positive (the most significant bit is 0), the value is the event mask for that event. If the value is negative, the SVC could not be performed. The event mask is a unique value in which one of bits 0 to 30 is set to designate the event started. You use this value in subsequent calls to check event status and to retrieve the event's completion code.
Flags	The flags word in many SVCs offers options that are enabled by setting a bit. Not all SVCs have flags. Bit 0 in the SVC descriptions corresponds to the lowest order bit and bit 15 the highest. All unused bits must be set to 0.
Fnum	File number: SVCs that do I/O require a file number. You get the file number from the OPEN and CREATE SVCs.
Name	File specification address: File specifications are not typically entered in an SVC. Instead, you enter the address of a NULL terminated string containing the complete specification. For all SVCs, the maximum length string is 128 bytes limiting you to a 127-byte file specification.

Table 1-9. (Continued)

Term	Meaning
OEM	Original Equipment Manufacturer: In the context of this manual, the OEM is the person or company who integrates FlexOS with the computer or develops the interface to a supplemental piece of hardware such as a plotter or communications card.
Option	SVC options: Several SVCs have, besides the flags, options numbered from 1 to 255. Where options are available they are shown in the SVC descriptions in Section 7. OEM-supplied SPECIAL calls may also have options not documented in this manual. Select the option by entering the corresponding value in your call or parameter block.
Privileged user	A process with group and user numbers of 0. Group and user numbers are established when FlexOS is loaded from information in the USER.TAB file
Process	Program entity: FlexOS provides a multitasking environment in which multiple processes can execute program instructions independently of each other. Processes are uniquely identified by a process identification number and are related to other processes through a family idenfication number. A process is always in one of three states: • **running** when it has the CPU • **ready** when it could use the CPU if it had it • **blocked** when it is waiting for an event to complete

Table 1-9. (Continued)

Term	Meaning
Return code	LONG value returned by a Supervisor call (SVC).
Superuser	Synonymous term for a privileged user.
swi	Software Interrupt Routine: Each asynchronous SVC allows the optional use of a software interrupt routine (swi) that functions similarly to a hardware interrupt routine. When the asynchronous SVC completes its operation, the calling process is interrupted and control passes to the swi. When the swi is finished, it either returns control back to the main process where the main process was interrupted or becomes the main process. It is not necessary to have a swi specified to execute an SVC asynchronously.
Table	FlexOS data structure: FlexOS provides information about itself in structures known as Tables. You can examine these tables and in many cases control process environments by setting values in the tables. FlexOS also provides an SVC for scanning and retrieving portions of tables. Table 1-10 lists the FlexOS tables.

1.7 Tables

You can monitor most aspects of FlexOS operation through its tables. Use the GET and LOOKUP SVCs to retrieve the information and the SET SVC to modify those table fields that are read/write. Tables are assembled by the supervisor when you make the call; they are not maintained in system memory. Section 8 contains detailed information about FlexOS tables. Table 1-10 lists the tables.

Table 1-10. FlexOS Tables

Table Name	Contents
Supervisor/Kernel	
PROCESS	Process information
ENVIRON	Process environment information
TIMEDATE	System time and date
MEMORY	System memory information
SYSTEM	Global system information
FILNUM	Table information for a given file number
SYSDEF	System level defined names
PROCDEF	Process level defined names
CMDENV	Command line entry
DEVICE	Information on devices
PATHNAME	Fully-expanded path for given logical name
Pipe	
PIPE	Pipe information
Disk	
DISK	Disk device information
DISKFILE	Disk file information
Console	
PCONSOLE	Physical console information
VCONSOLE	Virtual console information
CONSOLE	Screen and keyboard information
MOUSE	Mouse information
Miscellaneous Device	
PRINTER	Printer device information
PORT	Port device information
SPECIAL	Special device information

1.8 FlexOS Functional Components

The computer system software can be grouped into three categories. Figure 1-4 illustrates the three categories and their relationship to each other.

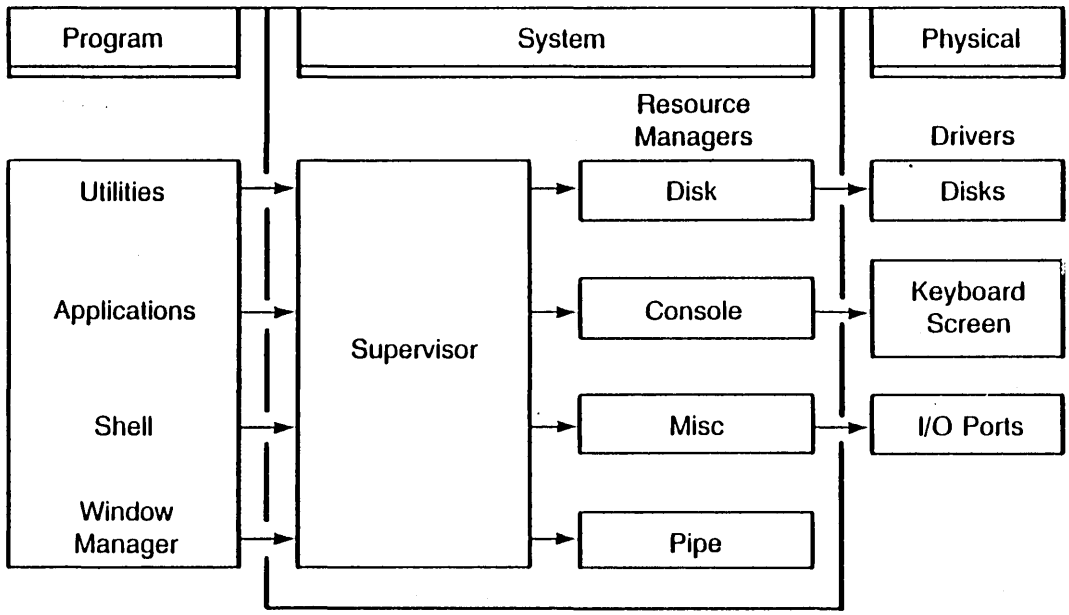


Figure 1-4. Computer System Software Categories

The categories are defined as follows:

- Program: This group includes the applications run by users to perform tasks and various system management utilities. Background programs which control the user interface such as the shell and window manager also fall into this category.

- System: This group provides the file system services, process scheduling, and data flow mediation. Programs use these services on a system call basis. The supervisor receives the functions and sends them to the appropriate resource manager for servicing.

- Physical: The physical functional unit contains the device-specific code, called device drivers. The physical functional unit varies for each computer system. This unit translates the generic SVCs from the resource managers into the device-specific routine for execution.

These divisions illustrate FlexOS's two interfaces: the program-to-system interface and the system-to-physical interface. This manual describes how to call the Supervisor and what you get in return. Refer to the FlexOS System Guide for detailed information on how the system functional unit relates to the physical functional unit.

1.8.1 The Supervisor and Resource Managers

The Supervisor receives SVCs from the program units and sends them to the appropriate resource manager. File numbering is another of the Supervisor's duties. Every time you open a file or device or create a file, the Supervisor returns the file number. You use this number to access the file, and the Supervisor uses it to send the call to the proper resource manager.

The resource managers control the access to the physical devices and pipes. Table 1-11 lists the resource managers and summarizes their tasks.

Table 1-11. Resource Managers

Resource Manager	Task
Disk	Manages the disk file system for disk drives.
Console	Manages physical and virtual consoles.
Pipe	Manages interprocess communications through FIFO (first-in-first-out) memory files called pipes.
Misc	Manages all devices not managed by the other resource managers.

1.8.2 Kernel

Not shown in Figure 1-4 is the FlexOS kernel. This proprietary module is responsible for all process management tasks. This includes process creation, state maintenance, and dispatching. The kernel also manages process context switching and scheduling and memory allocation.

Process scheduling is performed on a priority basis. Priority is established at program invocation by a number in the range of 0 to 255 (see the COMMAND description in Section 7). 200 is the recommended priority for user processes. Higher numbers have a lower priority; lower numbers have a higher priority. Processes with the same priority are scheduled on a round-robin basis.

End of Section 1

Disk File Management

This section describes FlexOS's disk file management tools and the fundamental concepts involved in dealing with files. Table 2-1 lists the SVCs available for disk device, directory, and file management.

Table 2-1. Disk Resource Manager

SVC	Disk Device	Disk Directory	Disk File
CLOSE	Y	Y*	Y
CREATE	Y	Y	Y
DELETE	Y	Y	Y
DEVLOCK	Y	N	N
GET	Y	Y	Y
LOCK	N	N	Y
LOOKUP	Y	Y	Y
OPEN	Y	Y*	Y
READ	Y	N	Y
RENAME	N	Y	Y
SET	Y	Y	Y
SEEK	N	N	Y
SPECIAL	Y	N	N
WRITE	Y	N	Y

* You open and close a directory file to get and set its DISKFILE table only; you do not open it to read from or write to it.

2.1 File Access

Access to files is initiated using the OPEN or CREATE SVC. Use OPEN to open an existing file; use CREATE to make and open a new file. Both calls require you to specify a file name; both return a 32-bit file number. You use the file number for all subsequent file operations. The CLOSE SVC disassociates the file number from the file. Use the DELETE SVC to remove files.

Files can be accessed in a byte-oriented manner. Any record in a disk file can be accessed at random. The file system maintains a byte level end-of-file on disk files.

2.2 Disk File Attributes

Each file in FlexOS has attributes that control access and define characteristics. The attributes are initially established by setting the ATTRIB word in the DISKFILE tables. Any user with the delete/set access privilege can change the ATTRIB word. The Disk Resource Manager records this value in the file's directory entry. Table 2-2 lists the attributes.

Table 2-2. FlexOS Disk File Attributes

Attribute	Meaning
Read-only	The Read-only attribute overrides the access rights that are User/Group based. A process cannot delete or write to a Read Only file even if it has write and delete privileges for the file.
Hidden	Files with the Hidden Attribute ON are not shown in a directory listing unless you use a special option.

Table 2-2. (Continued)

Attribute	Meaning
System	Files in the system: directory can be opened indirectly when the System attribute is ON. Indirectly means, "from another directory." On each open, if a filename is given without device or directory specification, the Disk Resource Manager first searches the default: directory. If the file is not found, the system: directory is searched. If the file is found and the System attribute is ON, the file is opened. Files with the System Attribute ON are not included in a directory listing unless you explicitly ask to see them (see LOOKUP in Section 7).
Archive	If the Archive Attribute is OFF, the file has been archived since it was created or last modified. It is automatically turned ON if the file is modified. Programs performing backup functions can turn this attribute OFF to perform incremental backups.

2.3 Disk Media

FlexOS disk media have the following characteristics:

Disk label A root directory entry containing the label name, user and group number of the label's creator, and mode flags. The mode flags determine if disk security is enabled and whether uppercase and lowercase or just uppercase file names are supported.

File security A four-byte field in the file's directory entry containing the creator's user and group number and the two-byte File Security Word. Both are set when the file is created.

File record size A two-byte field in the file's directory entry indicating its record size. A record size of zero is equivalent to a record size of one byte.

The File Security Word and record size are set when the file is created and the disk label is initialized to 0. The label and its options are set in the DISK table.

2.4 Disk File and Directory Security

File and directory access is controlled by four factors:

- The security enable flag value in the disk label.
- The user and group ID of the calling process.
- The owner, group, and world access privileges available.
- The access privileges requested in the OPEN call.

The read-only attribute supersedes the access privileges. An error will be returned if you attempt to write to, set DISKFILE values of, or delete a file with the read-only attribute return.

2.4.1 Disk Label

The disk label is created when you set the LAMODE and LABEL fields in the DISK table for the first time. The Disk Resource Manager completes the remainder of the DISK table's label fields by adding the label maker's user and group IDs and setting the LAFLAG. Subsequently, only that user or a superuser can change the label. You cannot remove a label after it is created. You can set all fields to NULL.

File security is not enabled on a disk without a label. Once the label is established, you enable and disable disk security by setting and resetting LAMODE bit 0. When file security is disabled, all processes have full (R,W,E,D) access to all files on the disk. When file security is enabled, all users except the superuser are monitored for read, write, execute, and delete privilege according to their user and group ID. The superuser always has full (R,W,E,D) access to files; regardless of the File Security Word contents.

The disk label also determines if the drive supports uppercase only or uppercase and/or lowercase file names.

2.4.2 User/group IDs and Available Access Privileges

Before a file is opened, FlexOS grants all processes the minimum access privileges. This lets the process lookup the file's DISKFILE table. To execute, read from, write to, or set the file's attributes, a process must have the corresponding privilege. FlexOS qualifies a process for read or write privilege when the process attempts to open the file. Execute and delete privilege are determined when the process attempts to run and delete the file, respectively.

To determine the access privileges available to a process, FlexOS compares the process's user and group ID against the file creator's user and group ID. This indicates whether the process falls into the owner, group, or world category. The privileges set in the file's File Security Word for that category are the only ones available to the calling process.

The privileges given to the calling process are dependent on three other factors: the comparison of the privileges requested to those available, whether or not the file has the read-only attribute, and any current access modes. FlexOS compares the privilege requested against those specified in the File Security Word. If there is a match, FlexOS then determines if the file is read-only. Finally, FlexOS checks the file to see if it is open and, if so, the access mode is set. Some access modes--for example, write exclusive mode--prevent all other processes from using the file. Other access modes--for example, read exclusive--let other processes open the file but only for the purpose of reading.

FlexOS opens the file and returns the file number, executes the program, or deletes the file when the requested privileges are available. The function is not performed if the privileges requested do not match those available or are not available given the current access mode. Processes can acquire reduced access by setting the corresponding flag bit in the OPEN call.

2.4.3 Directory Versus File Access Privileges

The user and group mechanisms used to qualify users for access to files are also used for directory security. However, access privileges to directories have a slightly different meaning than they do for files. Table 2-3 compares the two meanings Directory security, like file security, is only enabled when the corresponding LAMODE bit is set.

Table 2-3. Privilege Definitions for Files and Directories

Security Privilege	File	Directory
Read (R)	Allows reading from a file	Allows LOOKUP operations on files in the directory
Write (W)	Allows writing to a file plus the privileges listed for delete/set	Allows file creation and deletion
Execute (E)	Allows a file to be executed	Allows opening of files in the directory
Delete/Set (D)	Allows renaming, changing file attributes, or deleting files	Allows changing attributes of files in directory

2.4.4 Access Rules and Restrictions

Read-only file attribute overrides file access privileges set in the File Security Word. The following list describes other access restrictions for files and directories. Recall that the rules only apply when disk security is enabled.

- To access any file you need execute access in each directory specified in the pathname of the file.
- To LOOKUP files you must have read access to the last named directory in the path. No access is needed of the files themselves.
- The GET SVC requires only a file number; you do not need any access privilege to a file's DISKFILE table.

- The SET SVC requires write access to the directory the file is in, as well as delete or write access to the file itself. The file must be successfully opened with delete access before SET can be called. A file owner cannot use SET to change file attributes without write access to the directory. After obtaining write access to a file's directory, the owner can always obtain delete access to a file, even if is set to R/O.
- The DELETE and RENAME SVCs require write access in the directory as well as delete or write access for the file. No exception is made for the owner of the file.
- The COMMAND and OVERLAY SVCs require execute access to the file being loaded. Read access in not required.
- The CONTROL SVC requires both execute and read access to load a file for debugging.
- The READ SVC requires read access to the file.
- The WRITE SVC requires write access to the file.

2.5 Disk File Access Modes

The FlexOS disk file system divides open modes and the privileges allowed with each mode into three categories.

1. All exclusive opens, with the exception of read/exclusive (R/EX) reserve the file for the exclusive use of the calling process.
2. (R/EX) opens are treated as read/allowed shared read (R/AR) opens in order to allow the shared open of read/only files by multiple processes.
3. Shared read/write opens do not restrict file access by other processes. You can restrict record access with the LOCK SVC.

The first category applies to other processes only. Previous open modes set by a process do not delimit its subsequent open modes options. Thus, a process with a file opened in read/write exclusive mode can open the file again and in any other mode. However, the exclusive mode is in force until that open is closed.

2.6 Direct Disk Access

There are two ways to access the disk directly:

- with the READ and WRITE SVCs
- with the SPECIAL SVC disk functions

Both methods require you to open the disk drive before access is provided. Use the OPEN SVC for this purpose using the device name to select the drive and the OPEN flags to select the access privileges and access mode. FlexOS returns the file number number you use in your READ, WRITE and SPECIAL calls. Disk security measures are provided to restrict access.

2.6.1 Disk Device READ and WRITE

Using the READ and WRITE SVCs requires the process to have read and write privilege and the drive to be installed to allow raw reads and writes. In your calls, the Disk Resource Manager translates the offset specified into a logical record number. (The disk is treated as a serial sequence of records starting with the first head, cylinder, and sector and ending at the last sector, cylinder, and head.) The buffer size you specify must be a multiple of the sector size and all operations must be performed on sector boundaries. The information transferred is the data portion of the sector only; the sector header is not included.

2.6.2 SPECIAL Disk Functions

The SPECIAL disk functions provide the disk format capabilility and direct access to any sector of the disk, including the system area, using the file system's head, cylinder, and sector identification scheme. Table 2-4 summarizes the SPECIAL functions and the access modes required to use them.

Note: We cannot guarantee the compatibility of the SPECIAL disk functions with future releases of Digital Research® operating systems.

Table 2-4. SPECIAL Disk Functions

Function	Description
0[1]	Read the system area of the disk
1[2]	Write to the system area of a disk
2[2]	Format the system area of a disk
3[2]	Format a track of the disk
4	Check the media for change or errors
5	Flush buffer contents to the disk
6[1]	Read physical record by head, sector, track
7[2]	Write physical record by head, sector, track
8[2]	Set drive's Media Descriptor Block (MDB)

1 Must open in at least shared read-only mode
2 Must open in exclusive mode

2.6.3 Disk Drive Open Modes

Disk device access is subject to the current access modes. You specify the mode you require along with the READ and/or WRITE privilege in your device OPEN call. FlexOS compares the request against the privileges available, any modes in affect, and, when write/exclusive mode is requested, the presence of open files by other processes. Three open modes are supported for direct disk access:

- GET-only
- Shared read-only (AR)
- Exclusive (EX)

The GET-only mode starts when you open the drive without requesting any access privileges or modes. Use this mode to make a connection to the device. This connection allows you to use GET to retrieve the drive's DISK table and DEVLOCK to lock the device. This type of open has no effect on disk usage by other processes until DEVLOCK is initiated.

The shared read-only mode allows the calling process to have read, write, and set access. Other processes are limited to read access with the SPECIAL read functions, with the READ SVC, and through the disk file system. Use DEVLOCK to restrict disk access further.

The exclusive mode precludes all access attempts by other processes. The calling process can declare read, write, and/or set access. FlexOS does not grant exclusive mode while there are open files or existing DEVLOCKs on the drive. While the disk is open, no file system operations can be performed. All the SPECIAL disk functions supported by a device driver can be accessed in this mode if the calling process has obtained the required access level. This is the only mode that lets you set the disk label.

NOTE: Superusers get full read, write, and delete access to a disk for any mode, DEVLOCK status, or INSTALL option.

2.6.4 Disk Security INSTALL Options

Disk security is established in two places: Options selected when the disk driver is installed and the options set in the disk label. See 2.4.1 above for the description of the disk label.

The installation options offered in the INSTALL SVC follow:

- Removable or Permanent Device
- Device raw reads allowed
- Device raw writes allowed
- Device set allowed
- DEVLOCKs allowed

The device read, write, and set options control the level of direct access to the disk supported by the device driver. Disk security cannot be guaranteed if the disk driver allows raw reads and/or writes. When a disk is opened as a device, the read, write, and set options determine the allowed access level.

The DEVLOCK option determines whether processes can use the DEVLOCK SVC to lock the drive. The DEVLOCK SVC allows a process to lock a disk for its exclusive use or the exclusive use of processes in the same family. Superusers can use the DEVLOCK SVC regardless of this option.

End of Section 2

Console Management

This section describes how to perform console I/O under FlexOS. The presentation has four parts:

- The first part describes general characteristics of the console system and introduces the supervisor calls and tables used to manage it. Also described are the FRAME and RECT data structures and the console file naming conventions.
- The second part describes how to use the WRITE, ALTER, COPY, and READ SVCs to control the screen and keyboard.
- The third part describes how to monitor console input from the keyboard and pointing device with the READ, XLAT, RWAIT, and BWAIT SVCs.
- The fourth part describes use of the CREATE, OPEN, KCTRL, GIVE, ORDER, SET, and GET SVCs to create and manage virtual consoles and windows.

The 8-bit and 16-bit character sets referenced in this section are described in Appendix A. For the list of the country codes mentioned below, see Appendix C.

3.1 Console File System

A console under FlexOS consists of a keyboard and screen and optionally a pointing device. For convenience, the term **mouse** is used to refer to all kinds of pointing devices.

The Console Resource Manager controls console I/O on a file-oriented basis. A single file can represent the keyboard and screen or you can have separate files. With a single file, read and write access are independent so that keyboard and screen access privileges and modes can be different. Separate files are used to monitor mouse input and to represent window borders.

Other Console Resource Manager features are: 8-bit and 16-bit character modes (individually selectable for keyboard and screen), escape sequence decoding, keystroke translation, and multiple international character sets. All features are turned on or off with the SET SVC.

FLexOS maintains each physical console independently of other consoles on the system, so different features and options can be selected for each console. The same independence applies to virtual consoles.

The COMMAND or CREATE SVCs open the standard files stdin (file number 0), stdout (file number 1), and stderr (file number 2). The files are opened in shared file pointer mode so all processes in the family have console access. (See Section 5 for the explanation of process families.) The definitions for these logical names are inherited from the parent process. The Supervisor always translates file numbers 0, 1, and 2 to the actual file numbers.

For applications invoked from the shell, the standard files should represent the keyboard and screen. However, these files might be defined to be other than console files through redirection. Get the FILNUM table for files 0, 1, and 2 to determine the type of device each references.

3.1.1 Console-Related SVCs

The console-related SVCs provide two types of services: console file I/O and virtual console management. The first type are the SVCs you use in applications and utilities to control the screen and gather user input. Use the second type in window management programs and applications to create and control virtual console displays. Table 3-1 lists the console-related SVCs by type.

Table 3-1. Console-Related Supervisor Calls

SVC	Purpose
Console File I/O	
ALTER	Modify a RECT (rectangle)
COPY	Copy a RECT from one FRAME to another
READ	Read from a console file
WRITE	Write to a console file
XLAT	Translate keyboard input
BWAIT	Wait for mouse button state change
RWAIT	Wait for mouse to enter or exit a RECT
Virtual Console Management	
CLOSE	Close a console file
CREATE	Create a virtual console file
DELETE	Delete a virtual console file
DEFINE	Set process's stdin, stdout, and stderr files
GET	Get a table
GIVE	Transfer physical keyboard and mouse ownership
KCTRL	Obtain physical keyboard and mouse ownership
LOOKUP	Scan virtual console tables
OPEN	Open a virtual console file
ORDER	Change order of virtual consoles
SET	Change table contents

3.1.2 Console-Related Tables

The Console Resource Manager also maintains tables for each physical, logical, and virtual console and mouse so applications can determine their console environment and, to the extent allowed, change it. Table 3-2 lists the tables associated with console management and indicates the console characteristics maintained in that table. Complete descriptions of the tables and their contents are provided in Section 8.

Table 3-2. Console-Related Tables

Table Name	Information
CONSOLE	Number of characters in keyboard's type-ahead buffer Screen and keyboard modes Cursor position Number of character rows and columns Virtual console number Console type Physical console name
ENVIRON	Current stdin, stdout, and stderr file numbers
PROCESS	Process's DEFINEd physical console number Process's virtual console number
VCONSOLE	Window mode Virtual console number Console type View origin reference point on virtual console Total character rows and columns in window Window position reference point on parent console Total rows and columns in virtual console Top, bottom, left, and right border sizes
PCONSOLE	Physical device name and identification number Current number of virtual consoles Number of pixel and/or character rows and columns Console type FRAME planes supported Attribute and extension plane bit maps Country code Number of function keys Number of mouse buttons Mouse serial number

Table 3-2. (Continued)

Table Name	Information
	Current mouse form position Keystate of Alt, Control and Shift keys Current state of mouse button Mickeys/pixel sensitivity of rows and columns Click interval time period Height and width of mouse form Position of mouse form hotspot Mask to mask effect of DATA rectangle DATA rectangle to "BLT" to screen

3.1.3 Console Screen Model and Data Structures

The screen is represented by a three-dimensional data structure called a FRAME. The FRAME's height and width are defined in terms of character columns and rows. Each intersection of a row and column defines a FRAME character cell. A cell is always one byte. Figure 3-1 illustrates the FRAME model.

The FRAME's depth is defined in terms of planes, each with the same dimensions as the FRAME. There are three planes: character, attribute, and extension. Each plane consists of either a two-dimensional byte array or a single byte used by the Console Resource Manager to set all plane bytes.

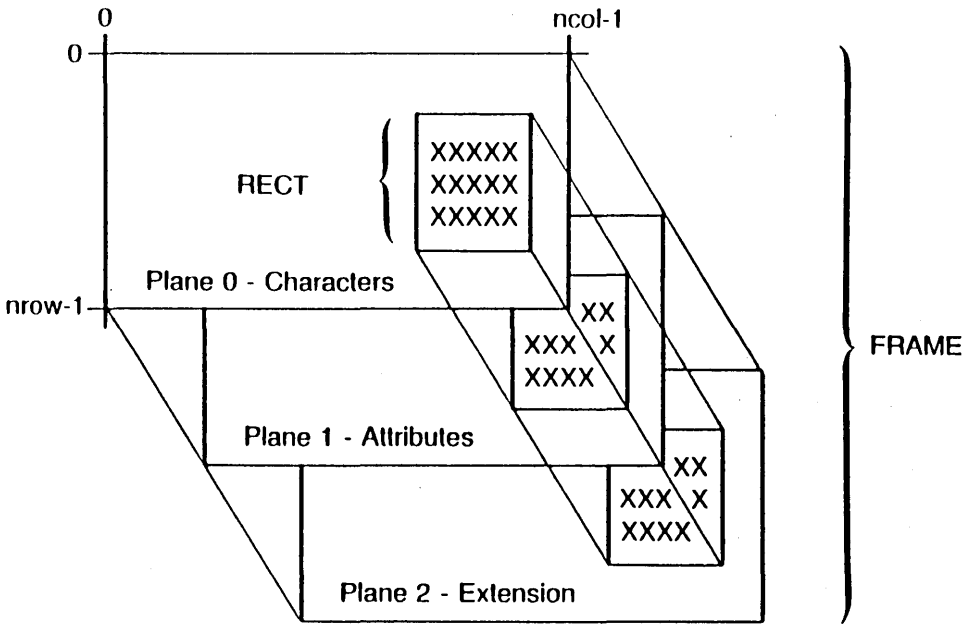


Figure 3-1. FRAME Planes with RECT

Plane Descriptions

The FRAME planes are defined as follows:

- Character Plane (plane 0): Each byte corresponds to a text character space on the screen. The 8-bit character set used in this plane is defined on a per country basis.
- Attribute Plane (plane 1): Each byte defines the foreground color, background color, and color intensity and contains a blink flag for the corresponding character cell. The attribute plane byte is used as shown in Figure 3-2.

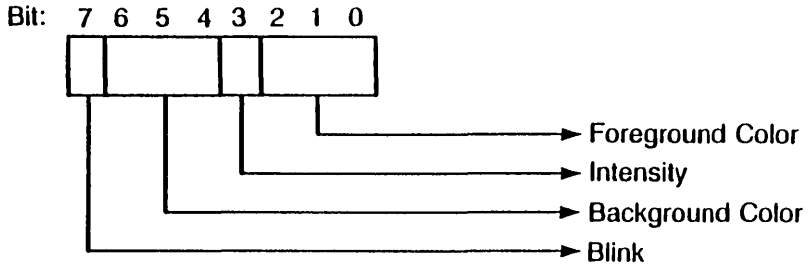


Figure 3-2. Attribute Plane Byte Format

- The three bits in the foreground and background color fields are assigned as follows:

  low bit: blue
  middle bit: green
  high bit: red

  Table 3-3 lists the colors corresponding to each 3-bit value in the lefthand column. The righthand column shows the foreground color resulting when the intensity bit is set.

Table 3-3. Foreground and Background Colors by Byte Value

Foreground and Background Colors	Foreground Color with Intensity Bit Set
0 - black	8 - dark gray
1 - blue	9 - light blue
2 - green	10 - light green
3 - cyan	11 - light cyan
4 - red	12 - light red
5 - magenta	13 - light magenta
6 - brown	14 - yellow
7 - light gray	15 - white

Set bit 7 to have the character blink. This feature is not available if the hardware does not support it.

- Extension Plane (plane 2): An OEM-implemented option that provides support for 2-byte characters. Each extension-plane byte is formatted as shown in Figure 3-3.

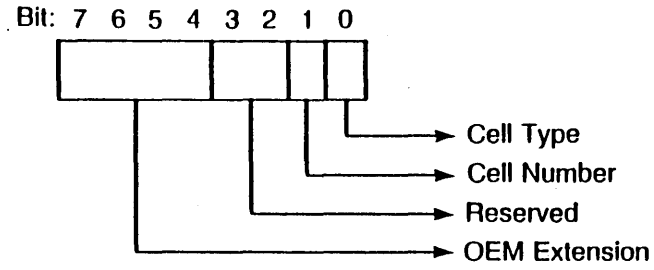


Figure 3-3. Extension Plane Byte Format

The Cell Type bit is 1 when characters are two cells long. Single cell characters are indicated by a 0 in this bit.

The Cell Number bit indicates if the corresponding character plane cell is the first or second cell of a two-cell character. If the value is 0, the cell is the first part of the character; if it's a 1, the cell is the second part. This bit is always 0 for single-cell characters.

The OEM Extension field is implementation-dependent and defines alternate character sets. The Console Resource Manager assumes the standard character set when this field is 0.

FRAME C Structure

The FRAME's C structure is as follows. Figure 3-4 illustrates this memory model.

```
struct FRAME
{
BYTE    *character,*attribute,*extension;
        /*Pointers to planes*/
WORD    nrow,ncol;
        /*Number of character rows and columns*/
WORD    use;
        /*Plane bit map*/
}
```

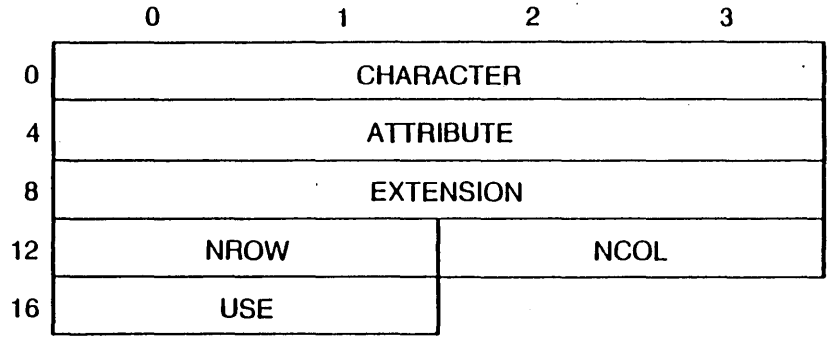


Figure 3-4. FRAME Data Structure Diagram

The FRAME fields are defined as follows:

- **character:** Address of FRAME's character plane
- **attribute:** Address of FRAME's attribute plane
- **extension:** Address of FRAME's extension plane
- **nrow:** Number of character rows in the FRAME
- **ncol:** Number of character columns in the FRAME
- **use:** A bit map indicating plane characteristics as follows:

  Bit 0: 1 - character pointer addresses a two-dimensional array
  0 - character pointer addresses a single byte

  Bit 1: 1 - attribute pointer addresses a two-dimensional array
  0 - attribute pointer addresses a single byte

  Bit 2: 1 - extension pointer addresses a two-dimensional array
  0 - extension pointer addresses a single byte

The FRAME's use field indicates if the plane consists of a complete two-dimensional array or a single byte. When the plane's bit value is 0, the Console Resource Manager applies the single byte's value to all bytes in the plane. Otherwise, the full array must be specified.

A FRAME is defined as either a **screen** FRAME or a **memory** FRAME. The screen FRAME is the console screen representation contained in the console file. You use the ALTER, COPY, or WRITE SVC to modify the screen FRAME, and modifications are immediately reflected on-screen. The memory FRAME is a data structure you create in the application's memory space and hence is not limited to modification by ALTER, COPY, and WRITE alone. Changes made to the memory FRAME are not reflected on-screen until they are COPYed to the screen FRAME.

Screen FRAME dimensions are indicated by the NROW and NCOL values in the CONSOLE table (see Figure 3-6). There are no restrictions except physical memory restraints limiting the size of a memory FRAME.

RECT C Structure

The RECT data structure defines a rectangular region of a FRAME. The point of reference is the FRAME coordinates of the region's upper lefthand corner. The region's width and height are specified within the data structure in terms of character rows and columns. The SVCs using the RECT structure specify which FRAME planes are included in the RECT. Figure 3-5 shows the RECT data structure diagram. The corresponding C structure is as follows:

```
struct RECT
{
        WORD    row,col,nrow,ncol;
/*              Top left corner FRAME coordinates
                and RECT width and height*/
}
```

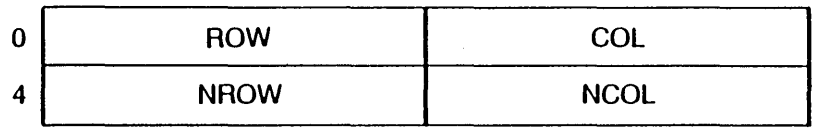


Figure 3-5. RECT Structure

The RECT fields are defined as follows:

- **row:** The row coordinate relative to the FRAME of the rectangle's upper lefthand corner
- **col:** The column coordinate relative to the FRAME of the rectangle's upper lefthand corner
- **nrow:** The number of rows (height) in the rectangle
- **ncol:** The number of columns (width) in the rectangle

3.2 Controlling the Console

Console attributes such as screen and keyboard modes, cursor location, and the number of character rows and columns are contained in the CONSOLE table. You manage the console screen on a FRAME basis with the ALTER and COPY SVCs and on a character basis with the WRITE SVC.

3.2.1 Console Attributes

The CONSOLE table is your reference source for information regarding console attributes and conditions. Figure 3-6 illustrates the CONSOLE table data structure. To get or set your process's CONSOLE table, use 0 or 1 or the stdin and stdout file numbers from the ENVIRON table as the GET or SET ID value

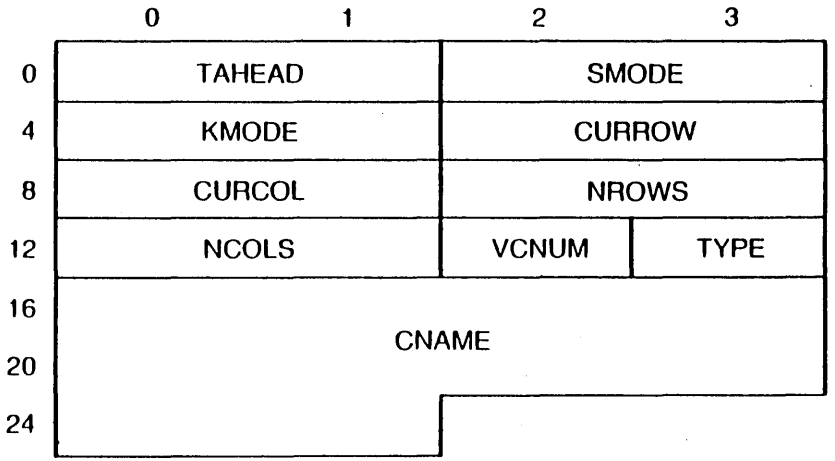


Figure 3-6. CONSOLE Table

SMODE and KMODE set the screen and keyboard modes, respectively. CURROW and CURCOL indicate the current cursor location. These values are initialized to 0 when the console is created. Set the mode options to select 8-bit or 16-bit characters, escape sequence decoding, and other features. Set CURROW and CURCOL to change the cursor position. The remainder of the parameters are read-only; their values determined by the physical console characteristics or established when the corresponding virtual console was created.

3.2.2 Manipulating the Screen

There are three ways to manipulate the console display: use ALTER to change a screen region, use COPY to copy one screen region to another, or WRITE to send a character, character string, or escape sequence. ALTER and COPY are also useful for character and string output, however, they cannot be used when console output is redirected to non-console devices.

Note: The window border files vcxxx/top, /bottom, /left, and /right are a special class of console file--only COPY and ALTER can be used to manipulate their contents. See 3.4 for the description of the border files.

Using ALTER and COPY

ALTER and COPY work on RECT structures to modify a FRAME. The FRAME can be a memory or a screen FRAME. The RECT can specify a FRAME region from single cell up to the entire FRAME itself. The ALTER form is as follows:

```
ret = s_alter(flags,fnum,dframe,drect,alterb);
```

Use ALTER's flags to select the character, attribute, and/or extension plane. To modify the screen FRAME, specify the console file number in the fnum field and set the dframe value to zero. To modify a memory frame, set the fnum value to zero and put the FRAME address in the dframe field. (Although 0 is the file number of the stdin file, the Console Resource Manager ignores the file reference.)

ALTER modifies the plane according to the two bytes in corresponding planes alterb argument. Alterb is an array of six bytes that determines the alteration of the destination frame.

Bytes 0, 2, and 4 in alterb are ANDed with each cell in, respectively, the character, attribute, and extension planes. Bytes 1, 3, and 5 are XORed with each cell in the same three planes.

COPY copies the contents of one rectangle to another. As with ALTER, each plane is individually selectable in the flag word. Source and destination RECT structures can be on the same or different FRAMEs and when on the same FRAME can overlap. The COPY form is as follows:

```
ret = s_copy(flags,fnum,dframe,drect,sframe,srect);
```

You distinguish memory from screen FRAMEs using specific combinations of fnum, sframe, and dframe. To specify the screen FRAME as the destination FRAME, put the console file number in the fnum field and set the dframe pointer to zero. To specify the screen FRAME as the source, set the sframe pointer to zero and specify the file number. To copy from one memory FRAME to another use a fnum value of 0 and enter the dframe and sframe addresses.

The source rectangle is described by the RECT at the srect address and the destination region by the RECT at the drect address. Rectangles do not have to be the same size. COPY clips the rectangles so that the region modified corresponds to the intersection of the srect and drect. Figure 3-7 illustrates how the excess is trimmed.

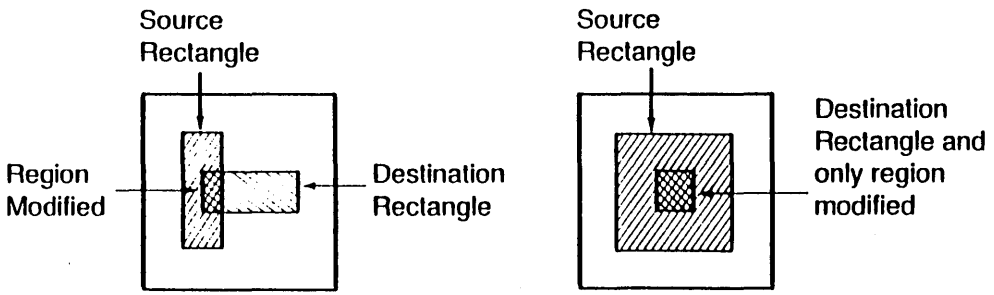


Figure 3-7. Examples of RECT Clipping

Using WRITE

The WRITE SVC sends the contents of the buffer to the console file specified by fnum. Use WRITE to send 8-bit escape sequences, 16-bit characters, and character strings to the console file. Each character output is placed at the current cursor position and the cursor position is updated. The screen scrolls automatically when the bottom line is reached.

The synchronous and asynchronous WRITE forms are as follows:

```
nbytes = s_write(flags,fnum,buffer,bufsiz,offset);
emask = e_write(swi,flags,fnum,buffer,bufsiz,offset);
```

The bufsiz value indicates how many bytes long the buffer is, not the number of characters in it. This is important when outputting 16-bit characters. Similarly, WRITE's return value (nbytes above) indicates the number of bytes, not characters, written. SMODE bit 1 determines if the Console Resource Manager outputs 8- or 16-bit characters.

Use an offset of zero when writing to a console file. Specify the offset relative to the end of file to accommodate redirection to non-console files. The flags and option values must be 0 for console writes.

The character string can contain displayable and non-displayable characters. The latter consist of 8-bit escape sequences, ASCII control sequences, and 16-bit character codes. Appendix A lists and describes the character sets and escape sequences supported by the Console Resource Manager.

3.3 Getting Console Input

Applications get console input from two sources: the keyboard and, if present, a mouse. The keyboard is accessed by reading stdin. The mouse is represented by a separate file. Mouse movement is automatically relayed to the screen without reading the mouse file. You use the mouse file to wait for a button state change--the BWAIT SVC--or for mouse form movement into or out of a RECT--the RWAIT SVC. The SET and GET SVCs are used to define the mouse form and determine its location.

3.3.1 Reading the Keyboard

There are two words in the CONSOLE table relevant to keyboard input: TAHEAD and KMODE. TAHEAD indicates how many characters are waiting in the type-ahead buffer. The KMODE word provides a variety of options including keystroke translation, character echo, 8-bit or 16-bit characters, and escape sequence decoding among others.

The READ SVC gets the characters from the console file's keyboard buffer and puts them in the buffer specified. READ might return fewer characters than requested; your program should be written accordingly. The READ forms are shown below. There are two synchronous forms: one for undelimited reads and one that allows delimiters to specify an end of string.

```
nbytes = s_read(flags,fnum,buffer,bufsiz,offset);
nbytes = s_rdelim(flags,fnum,buffer,bufsiz,offset,delimiters);
emask = e_read(swi,flags,fnum,buffer,bufsiz,offset);
```

Use an offset of 0 in your read calls and make it relative to the file pointer to accommodate redirection to a non-console file. The bufsiz specifies the end of the read event in terms of bytes read. Get the CONSOLE table's TAHEAD value to find out the number of characters waiting to be picked up from the keyboard buffer.

Delimiters let you set up conditions for terminating the read before the buffer is full and editing the character string. Set flag bit 1 to select a delimited read and bit 5 to use the editing characters. Use the READ return value to find the number of bytes read. Delimiters cannot be used with the asynchronous READ and you are limited to a READ buffer size of 256 bytes on delimited reads.

The delimiter specification is an address of a WORD array with two components. The first word is a number indicating the number of delimiters that follow. The remaining words are the delimiters themselves. Set the high order byte in each delimiter to 0 when the keyboard is in 8-bit mode.

The Console Resource Manager provides the line-editing characters listed in Table 3-4 when READ flag bit 5 is set. You can change these definitions with the XLAT SVC.

Table 3-4. Line-Editing Characters

Character	Action
LEFT ARROW	Moves cursor one character to the left
RIGHT ARROW	Moves cursor one character to the right
DELETE	Deletes next character
BACKSPACE	Deletes previous character
CTRL-B	Toggles cursor between beginning and end of line
CTRL-X	Erases from cursor to beginning of line

The Console Resource Manager compares each character read with each delimiting and editing character. READ returns with the number of bytes read when the buffer is filled or one of the delimiters is encountered. Use flag bit to select whether the delimiter is included in or excluded from the character string. When character echo is on (KMODE bit 5), the cursor is positioned at the beginning of the line just edited after a delimited read.

3.3.2 Monitoring the Mouse

Note: This discussion assumes that the mouse device was installed in the CONFIG.SYS configuration script. If it is not, your application can use the INSTALL SVC given the following conditions:

- The application must know the drive location and file name of the loadable mouse driver program.
- The application must have a user and group number of 0.

The INSTALL SVC is described in Section 7.

Mouse information and status is maintained in the MOUSE table. Figure 3-8 illustrates this data structure.

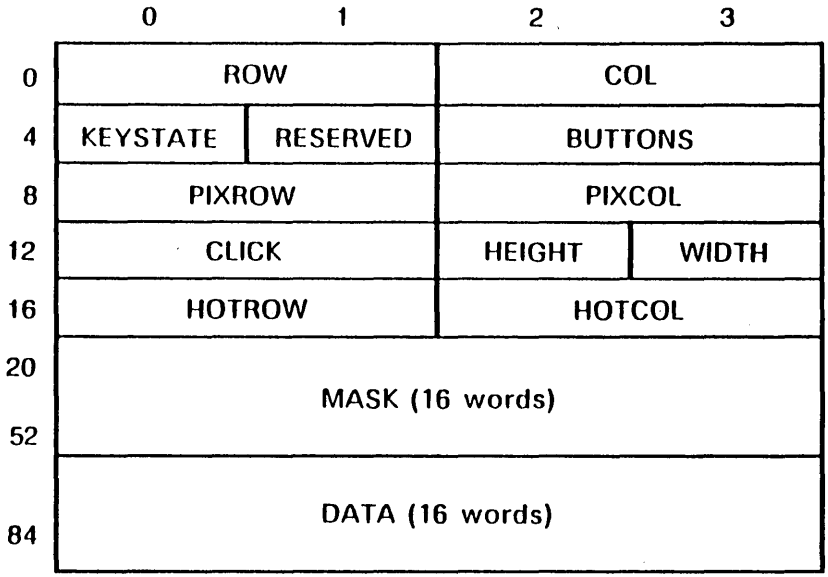


Figure 3-8. MOUSE Table

The PCONSOLE table also includes information on the mouse. See offset 1BH for the number of mouse buttons and offset 1CH for the mouse serial number. The mouse can have up to 16 buttons.

Mouse movement is automatically read from the device and shown on the screen by the mouse driver. Get the ROW and COL values from the MOUSE table to determine the mouse location; set these values to move the form independently of device input. The HOTROW and HOTCOL values set the hotspot--the point of reference within the mouse form. You can set these and all other MOUSE table values except the PIXROW and PIXCOL.

Opening the Mouse File

The mouse is opened by calling OPEN. In your OPEN call you specify the mouse name, the access privileges required, and the access mode. The mouse name is vcxxx/mouse where xxx is a decimal number indicating the current virtual console number. Get the virtual console number from the VCNUM field in your standard input file's CONSOLE table. (Call GET with an ID value of 0 to retrieve stdin's CONSOLE table.) For example, if the VCNUM value is 3, your mouse name would be vc003/mouse.

In your OPEN call, specify at least read access privilege. If you need to set the MOUSE table, request set access as well. For the access mode specify exclusive mode unless mouse access will be shared by multiple processes. In this case, specify shared, shared file pointer mode. Access is restricted to processes with the same family ID.

Your application should close the mouse file when you are done, otherwise you cannot close or delete the virtual console. CLOSE flag bit 0 has no meaning with respect to the mouse and is ignored.

Using BWAIT

Use the BWAIT SVC to monitor button state changes. BWAIT counts the number of times a specified mouse button condition occurs within a given time period. A button condition is defined by two criteria: buttons and their ON or OFF state.

The BWAIT form is as follows:

```
  ret = s_bwait(clicks,fnum,mask,state);
emask = e_bwait(swi,clicks,fnum,mask,state);
```

The fnum value is the file number returned when you OPEN the vcxxx/mouse file. The mask and state parameters are 32-bit values which define the mouse button condition.

You select buttons for the mask value by their position on the mouse. The rightmost button is represented by the least significant bit in the mask; the next button to the left is represented by the next bit, and so forth. To select the button, set its corresponding mask bit.

You define whether the button selected is to be ON or OFF in the state value. The Console Resource Manager looks only at the state bits corresponding to the buttons selected in the mask. Set the bit for ON.

As an example of the use of the mask and state fields, consider a two-button mouse. You can have the following button conditions:

1. The right button is pressed (ON) without concern for the state of any other buttons: mask = 1, state = 1.
2. The right button is pressed while the left button is not: mask = 3, state = 1.
3. The left button is pressed while the right button is not: mask = 3, state = 2.
4. The left button is pressed without concern for the state of any other buttons: mask = 2, state = 2.
5. Both buttons are pressed simultaneously: mask = 3, state = 3.

Use the clicks value to delimit the event by a specific number of incidences of the specified button condition. Any number of clicks can be specified, including 0. Use a click value of 0 to determine the mouse's current condition. BWAIT returns with a value of 0 when you specify 0 clicks and the mouse is in the condition defined in the mask and state.

BWAIT counts button conditions for a limited time period--the CLICK time limit specified in the MOUSE table. If the time period expires before the BWAIT click count is reached, the event terminates. The Console Resource Manager starts the timer upon the first incidence of the condition. Consequently, the count returned is always at least one except as described above.

Using RWAIT

RWAIT establishes an event boundary for the mouse. RWAIT returns with the row and column coordinates of the mouse's hotspot when it crosses the boundary. The RWAIT form is as follows:

```
position = s_rwait(flags,fnum,region);
   emask = e_rwait(swi,flags,fnum,region);
```

Set RWAIT flag bit 0 to clip the region to the current window borders. Otherwise, the region can include areas not visible on the parent screen. Flag bit 1 determines if the event occurs when the form exits or enters the region. The other flag bits are not used.

The region is a RECT structure confined to the calling process's virtual console's FRAME. The position value returned is 32-bits where the high order word indicates the row and the low order word the column.

3.4 Managing Virtual Consoles

For applications with multiple processes sharing access to the console and keyboard, it is often necessary or convenient to have a separate virtual console for each process. The key to these applications is a process--the window manager--which creates the virtual consoles, sets each window's size and position, and passes keyboard and mouse access from one process to another according to a planned transfer scheme. (These are basically the same functions as the FlexOS window manager supplied with the operating system.)

The window manager flow chart would include the following FlexOS functions; the SVCs used appear in parentheses.

1. Create a virtual console (CREATE).
2. Get the virtual console number (GET).
3. Set the virtual console's window size and location (SET).
4. Assign the console file to stdin, stdout, and stderr (DEFINE).
5. Define conditions under which keyboard and mouse ownership is returned (KCTRL and/or MCTRL).
6. Invoke shell or application that will use screen (asynchronous COMMAND).
7. Give keyboard and mouse ownership to the new virtual console (GIVE).
8. Read from your keyboard buffer (READ).
9. Reorder the virtual consoles to put the selected one on top (ORDER).

Steps 1 through 5 are repeated to create each virtual console. You have a numerical limit of 255 virtual consoles.

3.4.1 Creating the Virtual Consoles and Windows

To create a virtual console, you must specify the console screen on which it is to appear. This is called the parent screen. The virtual console created is referred to as a child console. Child consoles created on the same parent screen are referred to as sibling consoles. There are four rules of virtual console management based on these relationships:

- A child console always overlays its parent.
- Sibling consoles are "stacked" on the parent in the order of their creation until reordered by ORDER.
- The ORDER SVC only reorders a "stack" of sibling virtual consoles and cannot be used to put a parent on top of a child.
- An application always has access to its entire console regardless of its virtual console's position in the stack and the size of its window.

Figure 3-9 illustrates the parent, child, and sibling console relationships and the three rules. As shown in this figure, you can have multiple tiers of virtual consoles. As you change tiers, the parent/child relationships change. All virtual consoles on a given level are siblings.

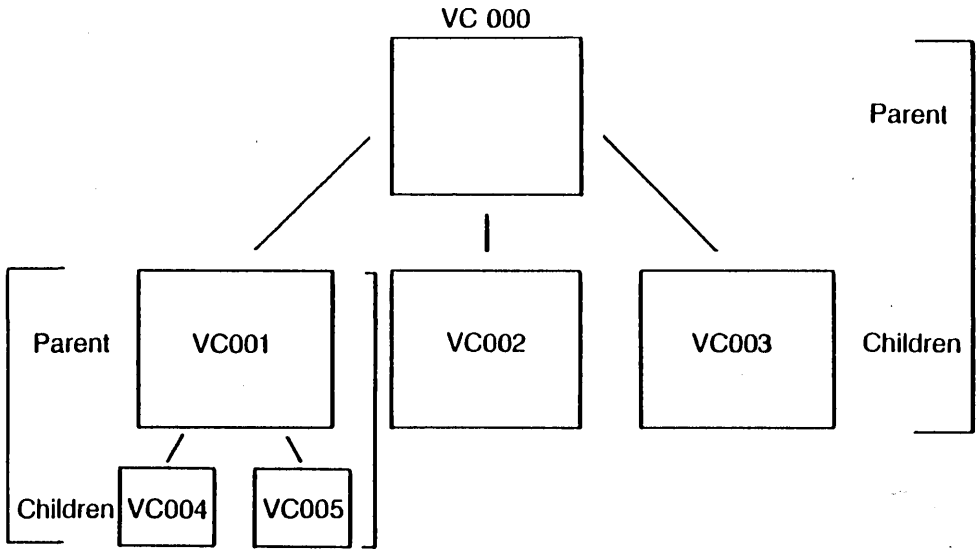


Figure 3-9. Virtual Console Relationships

Creating a virtual console requires write access to the parent console. The form of the CREATE SVC is:

```
fnum = s_vccreate(flags,fnum,rows,columns,top,bottom,left,right);
```

The flag bits select virtual console characteristics as follows:

- Whether the console and border are character- or bit-mapped
- Whether or not the parent's screen dimensions are used.
- Whether or not to keep the parent console contents in memory while the child console exists.
- Whether the virtual console is temporary (delete on last CLOSE) or permanent (delete only with DELETE).

For the fnum value, use the file number of the parent screen.

You specify the virtual console's dimensions in the rows and columns parameters. These become the ROWS and COLS values in the VCONSOLE table. The virtual console size is independent of the parent console's dimensions; you can, for example, create a virtual console larger than its parent. The top, bottom, left, and right parameters define window borders and are described in below.

CREATE returns the file number of your new virtual console file and automatically opens the file. Use this value as the ID number in your GET and SET calls to retrieve and modify the VCONSOLE table.

Virtual Console File Naming

The Console Resource Manager automatically names virtual consoles when you CREATE them. The name consists of the letters vc followed by a three digit decimal number corresponding to the VCNUM value from the virtual console's VCONSOLE table. For example, if the VCNUM is 10, the virtual console name is vc010.

A virtual console is composed of separate files representing the console (keyboard and screen), mouse, and window borders. Table 3-5 lists the names reserved for these files.

Table 3-5. Virtual Console File Names

File Name		Description
device:	vcxxx/console	Keyboard and/or screen file
	vcxxx/left	Left border of window file
	vcxxx/right	Right border of window file
	vcxxx/bottom	Bottom border of window file
	vcxxx/top	Top border of window file
	vcxxx/mouse	Mouse file

xxx = VCNUM, zero-padded left

Use the vcxxx/console file in your DEFINE call to assign the stdin, stdout, and stderr files to the virtual console's console file.

Be sure to define the files before you call COMMAND so that the files are automatically opened. The remainder of the files must be opened explicitly by the process before you can use them.

Windows

The term window refers to the view of the virtual console. When you create a virtual console, the window dimensions are initialized to 0 making the window a point with no height or width.

You set window dimensions in the VCONSOLE table's NROW and NCOL parameters. Set the VIEWROW and VIEWCOL parameters to position the window on the virtual console screen. Finally, set the POSROW and POSCOL parameters to position the window on the parent console's screen. Figure 3-10 illustrates these parameters.

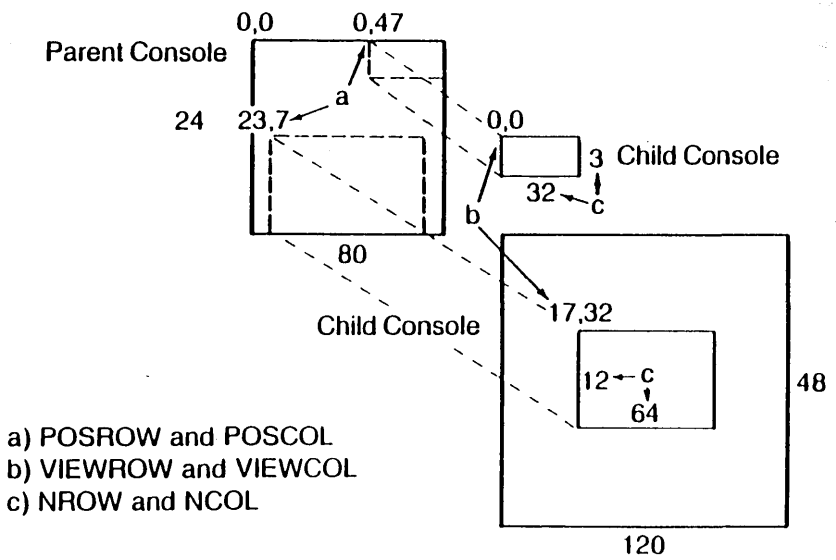


Figure 3-10. Virtual Console Characteristics

The VCONSOLE flag bit 1 gives you the option to have the window view adjust automatically to keep the cursor on-screen or remain fixed on a specific portion of the screen. Other flags determine how and when the view changes with respect to the cursor and freeze the window borders so you can make comprehensive changes to the border files without intermediate states appearing.

The window borders are contained in the vcxxx/top, /bottom, /left, and /right files. The Console Resource Manager creates these files when you specify top, bottom, left, and/or right parameters in your CREATE call. The top and bottom values set the height of the /top and /bottom border files only; the length is determined by the VCONSOLE table's NCOL value. The CREATE left and right values set the width of the /left and /right files; the height is set by the VCONSOLE NROW value.

3.4.2 Keyboard and Mouse Ownership

Keyboard and mouse ownership are always passed as a unit and only one virtual console can have ownership at a time. The window manager controls keyboard/mouse access by passing ownership to another virtual console with the GIVE SVC and specifying the conditions for its return with KCTRL or MCTRL. The conditions specified in KCTRL are keys or ranges of keys. With MCTRL, you specify a rectangle as the condition.

The KCTRL keys and MCTRL rectangles typically serve two purposes. First, they indicate that the user wants to change windows. Second, they indicate the user's choice of virtual consoles. When the user enters one of the specified window-control keys, that key and all subsequent keystrokes are sent to the parent virtual console's keyboard buffer. If there's a mouse keyboard entries a significant key is pressed or the mouse leaves the rectangle, the key and all subsequent keystrokes are sent to the window manager's keyboard buffer and mouse movement is updated in the window manager's MOUSE table. Use the information to determine which window to put on top with your ORDER call.

3.4.3 Deleting a Virtual Console

The virtual console's window remains on the parent screen until the file is closed or overlayed by a sibling virtual console. A partial CLOSE flushes the keyboard's type ahead buffer and, if the echo option (CONSOLE table KMODE bit 5) is selected, writes the buffer contents to the screen. A full CLOSE closes the file but leaves its contents intact unless it is the last close on a temporary console. In this case, the virtual console and all temporary files are deleted.

The Console Resource Manager only lets you delete a virtual console if it has no open /console, /mouse, /top, /bottom, /left, and /right files. Neither can you delete a virtual console with child consoles. If you try, an error message is returned. You can set CREATE flag bit 8 so that the virtual console is automatically deleted when the last of its virtual consoles is closed. Otherwise, use the DELETE SVC to remove the virtual console.

3.5 FlexOS Window Manager

WMEX, the window manager program provided with FlexOS, lets the user create, delete and switch virtual consoles. It also creates a message window you can use to interrupt the user and notify him or her that something has happened. You write to a reserved pipe to activate the window. When you write to this pipe, the message window overlays the current virtual console. You specify in your WRITE call to the pipe if a response is necessary.

To use the message window, you must open the file "wmessage." WMEX defines this file name to the message window's input pipe and waits for a message to appear there. In your OPEN call, specify the write privilege and the shared mode.

WMEX requires the display message to be preceded by a header. When you write to the pipe, format the contents of your WRITE buffer as follows:

UWORD	msgsiz	The total length of the message
LONG	pid	The writing process's process ID
BOOLEAN	rspflg	When true, indicates that a user response is expected; when false, no user response is allowed
UBYTE	rspname[10]	Name of the pipe in which WMEX should put the user's response (only necessary when rsplfg true)
UBYTE	message	The message to be displayed

The message itself can be 10 lines long. Each line must be terminated by a carriage return and line feed. The message is displayed as is.

If no response to the message is required, set the rspflg byte to false. The user enters a carriage return to remove the message window. If you want a response, set rspflg to true and give WMEX the pipe name to write the message to.

The response message is limited to one line in length and WMEX requires the user to enter a carriage return to terminate it. The carriage return is included in the string written to the pipe. If the message can be variable length, use the delimited READ call and specify the carriage return as the delimiter. WMEX removes the message window when the user enters the carriage return.

End of Section 3

Pipe Management

For two or more processes to communicate, a type of file known as a pipe is supported through a special device known as pi:. A file created on this device establishes a buffer used for the deposit and withdrawal of messages. Conceptually, pipe files have two ends, one to write into and the other to read from. Messages are deposited and withdrawn on a first in first out basis. Besides the pipe length, there is no limit to the number of messages you can store in a pipe at one time.

This section describes pipe management in the FlexOS operating system. Table 4-1 lists the pertinent SVCs.

Table 4-1. Pipe-related Supervisor Calls

SVC	Purpose
CLOSE	Close a pipe
CREATE	Create and open a pipe
DELETE	Remove a pipe
GET	Retrieve a pipe table
LOOKUP	Scan and retrieve pipe tables
OPEN	Open a pipe
READ	Read from a pipe
SEEK	Set or retrieve file pointer
WRITE	Write to a pipe

You cannot rename a pipe.

In all calls requiring a pipe name, you must precede the pipe name with the pi: device name or define a logical name that includes the pi: reference. Otherwise, the default: device is assumed.

4.1 Creating and Deleting Pipes

Use the CREATE SVC to make a pipe. The CREATE parameters are used as follows:

- Set the flags to request read, write, or delete privileges and the access mode. The privileges have the same meaning for pipes as they do for disk files. See 4.2 for the use of access modes with pipes. Flag bits 7 and 9 are meaningless with reference to pipes and are ignored.
- Put the address of your pipe name in the name field. The name itself is limited to eight alphanumeric characters.
- Set the record-size parameter to regulate the message blocks. For example, if a record size of four is specified, all pipe I/O is conducted in 4-byte blocks.
- Use the File Security Word to set the owner, group, and world access privileges.
- Set the size to the pipe buffer length. The size is independent of the message length but must be a multiple of the record-size.

The Pipe Resource Manager maintains a directory of all existing pipes. Each directory entry includes the pipe creator's user and group IDs and the File Security Word. The resource manager also makes a PIPE table for each pipe. PIPE table contents indicate the values set by the CREATE pipe call. Use LOOKUP and GET SVCs to retrieve PIPE tables. No special access privilege is required to lookup PIPE tables. However, you must have opened the PIPE to get its table. None of the values in the PIPE table can be set.

Use the DELETE SVC to remove a pipe. A CREATE option can be selected that automatically deletes a pipe on last close. If the pipe is being used solely to communicate between two or more processes for the life of the processes, the pipe is deleted automatically from the system when the processes terminate. This is because files are automatically closed on EXIT or ABORT.

4.2 Pipe Access

Processes must open the pipe before they can read from or write to it. When the OPEN call is made, the Pipe Resource Manager compares the user and group IDs of the calling process with those in the pipe's directory entry. This determines whether owner, group, or world access privileges are available. If both user and group IDs match, owner privileges are available; if only group match, group privileges are available. If there's no match, only world privileges are available.

The OPEN call succeeds when the access privileges requested either match or do not exceed the privileges available for the calling process's access level. If more privileges are requested, the OPEN succeeds or fails depending on the value of the OPEN call's reduced access flag. When this flag is set, the privileges granted are derived by ANDing the requested privileges with those available. Should none of the privileges match, the OPEN fails.

Pipe access privileges are also affected by existing access modes. The following rules govern the privileges available:

- A process's open access is never restricted by an open connection previously made by the same process.
- The read and write ends of a pipe are considered separate with respect to open restrictions. For example, an exclusive read open does not restrict a process from opening a pipe as shared write.
- Any exclusive open prevents other access requests to the same end.
- A shared open prevents other exclusive access requests but allows other shared requests to the same end.
- A shared file pointer request restricts pipe access to processes with the same family ID. All processes sharing the pipe must select the shared file pointer mode; a process that requests a different mode is denied access. For processes outside the family, the request functions as an exclusive request.

A pipe acts differently depending on whether an end is opened exclusive or shared mode. If one end of a pipe is opened in exclusive mode and then closed, a read or write attempt on the other end

results in an end-of-file (EOF) error. This is independent of how the other end was opened. If one end of a pipe has either never been opened, is currently opened, or the last open was in shared mode, the process accessing data through the opposite end waits until the operation is complete.

If one end of a pipe file is opened in shared mode and subsequently closed, FlexOS treats the file as if it were still open on the other end. Therefore, any process accessing it waits until the operation is complete. Note the distinction between shared mode and shared file pointer mode.

A pipe opened in shared file pointer mode is shared only by those processes with the same family ID (FID). After a pipe end opened in shared file pointer mode is closed by all of the processes, processes accessing the other end will receive an end of file error. This tells a process that the process on the other end of the pipe has either closed the file or terminated.

The use of modes to restrict access is consistent with spooler-type applications. For example, consider a spooler process which creates a pipe reserving for itself exclusive access to the read end. The write end is available for shared access by any process. Figure 4-1 illustrates this configuration.

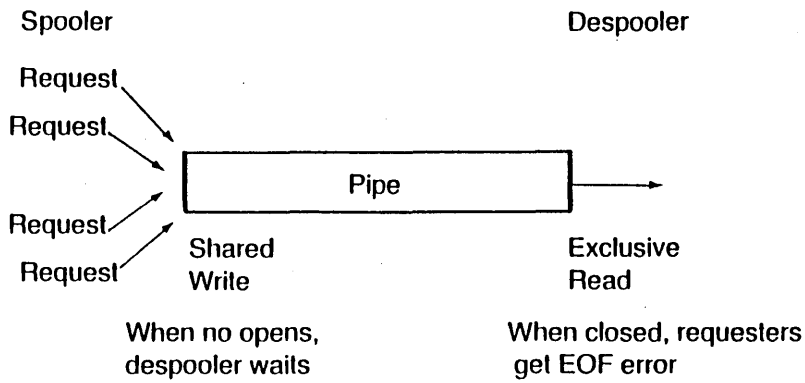


Figure 4-1. Spooler Pipe

Processes open and close the write end when they are sending files to the spooler. After the write end is closed, the despooler waits until the write end is opened by another process.

If the spooler closes the read end, processes attempting to write to the other end get an end of file error. This indicates to the writing process that there is no process at the other end that will read its file.

4.3 Interprocess Communication

Use the READ SVC to get data from the buffer and the WRITE SVC to put data in the buffer. The READ and WRITE flags and parameters are used in the same manner for pipes as they are for disk files and the file pointer is maintained. As many processes can participate in the exchange as you want.

The amount of data written to and read from the pipe can be independent of the pipe size. The following procedures are observed when the amount exceeds the size:

- On writes, the process waits when the pipe is full for another process to read data from the other end. The event completes when the reading process removes enough to compensate for the difference.
- On reads, the process waits when the pipe has been drained for another process to write data to the other end. The event completes when enough data has been written to compensate for the difference.

Pipes are often used to join two or more programs so one program's output becomes the input of another. To do this, a parent process would perform the following steps. The SVCs called are in parenthesis.

1. Create a pipe (CREATE)
2. Redefine stdin to be the name of the pipe (DEFINE).
3. Create the receiving process (COMMAND). The child inherits the parent's PROCDEF table, including the stdin prefix.
4. Reset stdin back to the original name (DEFINE)
5. Redefines stdout to the pipe name (DEFINE).
6. Create the source process (COMMAND). This child inherits the redefined stdout but, unlike the receiving child, has the original stdin.

When the two processes terminate, the parent process closes the pipe. If the parent terminates before the children, the pipe is automatically removed when the children terminate.

4.4 Synchronization and Exclusion

The Pipe Resource Manager lets you create pipes with a zero-length buffer size (bufsiz) for use as a simple semaphore. For semaphore pipes, a READ operation obtains the pipe and a WRITE releases it. If another process has obtained the pipe previously, the calling process waits until a WRITE to that pipe has been performed. WRITE operations, on the other hand, never wait; if the pipe was released previously, the call returns without error.

The process creating the semaphore pipe automatically owns it from the start. Although the Pipe Resource Manager keeps a record of who read the pipe, a WRITE by any process releases it. The process ID is maintained for two other reasons: First, so that a process can call multiple READs on a pipe it already owns and second, so the Pipe Resource manager can release pipes owned by a process that has terminated.

Use a semaphore pipe to regulate access to a resource not managed by the operating system. Any time a process wants to use the resource, it reads the pipe. If the pipe is already owned by another process, the calling process waits until another process releases it with WRITE. Upon return from the READ, the process is free to use the resource. Upon completion, the process writes to the pipe which releases the resource for other processes to use.

4.5 Nondestructive READ

The information stored in a pipe can be previewed using the READ SVC by setting flag bit 2. This allows a pipe to be used as a common data area among multiple applications. It also allows an application to preread a length field or message type field within a message and then read the complete message at a later time.

Note: Nondestructive reads can be dangerous if there are multiple readers of a pipe. It is the responsibility of the application to handle synchronization of pipe usage when there are multiple processes involved.

End of Section 4

Process Management

This section describes process creation, memory management, and process deletion. Table 5-1 lists the SVCs associated with these tasks.

Table 5-1. Process-related SVCs

SVC	Purpose
ABORT	Terminate a process or wait for a process to terminate
COMMAND	Create a process
CONTROL	Run a process under the control of another process
ENABLE	Enable software interrupts
EXCEPTION	Trap error conditions and jump to service routine
EXIT	Terminate a process with return code
DISABLE	Disable software interrupts
MALLOC	Add memory to heap
MFREE	Release memory from heap
SWIRET	Return from a software interrupt
TIMER	Delay process for specified time period
OVERLAY	Load overlay from a command file

The presentation belows describes how to use the ABORT, COMMAND, MALLOC, and MFREE SVCs. See Section 7 for the descriptions of the other SVCs listed in Table 5-1.

Three supervisor tables are pertinent to process management: the CMDENV, ENVIRON and PROCESS tables.

- CMDENV contains the command file specification and command tail from the process's spawning COMMAND call.
- ENVIRON contains the process's stdin, stdout, stderr, and overlay file numbers; user and group numbers; and identification numbers. A process's ENVIRON table contents are inherited from its parent's.
- PROCESS contains the process's identification number, user and group ids, name, current state, parent ID number, virtual console number, and memory allocation. Some PROCESS table values are set with the COMMAND SVC and while others are set by the Supervisor.

5.1 Process Relationships

A process executes program instructions independently of other processes. A process is constrained by a process environment maintained by the operating system. Environment characteristics include the process's logical address space (memory), CPU state and stack condition, user and group ID, and parent process. FlexOS uses these characteristics to manage the proces and protect it from other processes.

Processes are identified by a unique 32-bit process identification number--PID--and a name. The PID is assigned by the kernel when the process is created and remains assigned to the process until it terminates. The Supervisor splits running time for FlexOS processes on a priority basis. The recommended priority for user processes is 200. Processes with the same priority are allocated running time on a round-robin basis.

Besides the process ID, processes are also distinguished by a process family identification number--FID. When one process creates another, they keep the same FID unless you request a new number. Within a family, a process that creates another process is called the parent; the process created is called the child. Typically, the FID is used to distinguish processes running under different shells. That is, the shell is the head of the family.

5.2 Running a Program

Running a program has two steps:

- Loading an executable program file from disk into memory
- Assigning a process to execute the instructions

You use the COMMAND SVC to perform both steps. The process calling COMMAND must have the execute access privilege to the file.

Note: At the driver level, you can also use the PCREATE function to create a process. See the FlexOS System Guide for an explanation of PCREATE.

The COMMAND SVC searches the disk for the command file specified, opens it, and loads it into memory. Running a program does not require the creation of a new process. COMMAND gives you the following options.

- **Run the program as an independent (child) process:** This option creates a new process ID for the program. Child processes get their own memory allocation and execute FlexOSly with the other process.
- **Run the program as a procedure:** This option runs the program as a subroutine of the calling process; no new process ID is assigned. The calling process's memory allocation is supplemented by the new program's specification. When a procedure program exits, control is returned to the next executable statement in the parent process. You must use the synchronous form of COMMAND to use this option.
- **Chain the program to the current program:** This option runs the program as a subroutine within the context of the calling process; no new process ID is assigned nor memory allocated. However, the process never returns to the previous program. The chained program's memory requirements overlay the process's existing allocation. When the chained program exits, the process terminates. You must use the synchronous form of COMMAND to use this option.

When you call the synchronous form of COMMAND, the call does not return until the program exits or the process is aborted. When you use the asynchronous form of COMMAND, the event mask is returned and the child's process ID is recorded at the &pid address you specify in your COMMAND call. The event completes when the child process terminates.

Unless externally aborted, a process executes the program instructions up to and including the EXIT call. When the Supervisor receives the EXIT call, it closes all open files belonging to the process and cancels any outstanding events. This completes the COMMAND event. For the first and third COMMAND options described above, the process ID is then released along with the process's memory; for the second option, the process returns to the next instruction in the previous program.

5.3 Process Termination

The synchronous form of ABORT SVC terminates the process specified. This terminates the COMMAND event; all files belonging to the process are closed, outstanding events cancelled, and memory released.

The asynchronous form of ABORT is useful as a self-preservation measure for processes aborted externally. For example, consider the user who enters a control-C to terminate his or her program. For many applications, it is preferable to return to a previous location in the program rather than abort the program entirely.

To trap the control-C and force the return to a specific location in the program, call the asynchronous form of ABORT; use a process ID of 0 (this indicates current process) and include a software interrupt (swi) pointer. In your software interrupt, use the SWIRET option which keeps the process ID in the swi and then call a jump instruction to return to the program location.

Remember that the stack is in an unknown condition when you make the jump. At the return point in your program you should include instructions to mark the stack frame so it is restored to a known condition.

5.4 Memory Management

You use the MALLOC and MFREE SVCs to manipulate a process's memory allocation. Only the heap portion can be modified: MALLOC extends the heap space or adds a new heap and MFREE releases allocated heap memory back to the kernel for subsequent allocation.

To add contiguous memory to an existing heap, select MALLOC's expand option. In your MALLOC call you also give a pointer to a buffer indicating the minimum and maximum amount of memory and the base address of the heap to expand. Get this address from the process's PROCESS table. The kernel adds as much as can be allocated within the parameters given and returns the new block's starting address and the number of bytes allocated in your buffer The original heap base address and contents are not affected.

To get a new, independent heap select MALLOC's allocate option. The new memory block may or may not be contiguous with an existing heap segment, depending upon current system memory usage. As above, you pass a buffer pointer where a minimum and maximum amount of memory is specified. You do not need to specify a starting address, however. The heap's base address and its actual size are returned in the buffer. When you add a new heap and it is contiguous with an existing heap, the existing heap becomes a fixed data area.

End of Section 5

Miscellaneous Resource Manager

This section describes the SVCs used for device management through the Miscellaneous Resource Manager. All devices except for disk drives, consoles, mouses, and network controllers are controlled by the Miscellaneous Resource Manager. This includes such devices as printers, plotters, modems, and custom, OEM-implemented peripherals. The term device is used in this section as a generic expression to refer to all miscellaneous devices. Table 6-1 lists the SVCs.

Table 6-1. Miscellaneous Device Control Supervisor Calls

SVC	Purpose
CLOSE	Close a device
DEVLOCK	Lock device from access by other processes
GET	Retrieve a device table
SET	Set device table values
OPEN	Open a device
READ	Read from a device
WRITE	Write to a device
INSTALL	Install the device driver or subdriver
SPECIAL	Send data to or receive data from driver

6.1 Device Tables

The Miscellaneous Resource Manager maintains four device-related tables.

- DEVICE: Scan the DEVICE table to get the logical port and printer names. The Miscellaneous Resource Manager manages all devices with type numbers 7xH and 80-FFH.

- PRINTER: Use this table to get and set printer parameters. You cannot get or set a printer's table until you have opened the device.
- PORT: Use this table to get and set I/O port parameters. You cannot get or set a port's table until you have opened it. Ports linked to a driver cannot be accessed with GET and SET; use the SPECIAL functions instead.
- SPECIAL: Devices not adhering to the PRINTER or PORT table models have SPECIAL tables. SPECIAL table contents are OEM-defined.

FlexOS reserves the name prn: for the system list device. Unlike stdin, stdout, and stderr, prn: does not have a reserved file number. Your program must open the prn: device, write data to it, and then close the device.

Note: The following description of device I/O assumes the device driver is already installed If it is not or if your software must establish a driver-to-subdriver link, section 6.3 below reviews device installation. See the FlexOS System Guide for additional information on drivers.

6.2 Device Access

Unlike files, devices are installed and removed rather than created and deleted. Like files, you must open devices to access them. To indicate the device, you its name in the OPEN call. The access privileges and modes characteristic of disk files and pipes also apply to devices. Like pipes and consoles, read and write access privileges are treated separately and can be implemented with different modes.

6.2.1 Opening and Closing

Use the OPEN SVC to open the device. Set the flags to select the access privileges and modes. The privileges and modes supported are determined by INSTALL options selected and the device driver itself. The Miscellaneous Resource Manager compares the privileges requested with those available. Set flag bit 7 if you can accept reduced access. You must set flag bit 0 if you want to set the table values.

Note: The devices with PORT tables cannot be used for data I/O; access to these devices is limited to getting and setting PORT table values.

The OPEN call returns the file number used for all subsequent device access. The file number is also used as the ID number in GET and SET calls and the file number for your CLOSE call. When you close the file, the write buffer contents are output to the device.

After the device is opened, you can get and set table options. Devices are process independent; table variables are not initialized or modified as processes open and close the device. Thus, the PRINTER table typeface mode or PORT table baud rate selected by one process remains set for other processes.

6.2.2 Security

Security options come in two forms: access modes and device locking. The access modes are selected in the OPEN call. If multiple, related processes need to share access to the device, set flag bit 6 to shared file pointer. Although the file pointer may or may not be meaningful, this is the mechanism used to limit device access to those processes in the same family.

The DEVLOCK SVC can also be used to restrict access. This feature is only valid if the INSTALL option allowing DEVLOCK was selected. DEVLOCK options let you limit access to the process or the process family. The lock is removed explicitly using DEVLOCK or implicitly when the process terminates.

6.2.3 Data I/O

Use the READ and WRITE SVCs to get data from and to the driver. The file pointer offset may or may not be meaningful. Although the Miscellaneous Resource Manager does not maintain a file pointer, it does pass the offset to the device. Consequently, you can use an offset if the device supports random I/O. The SEEK SVC is not supported by the Miscellaneous Resource Manager However, the function not implemented error is not returned if you call it. Instead, a zero is returned. (This is done so redirection to a miscellaneous device does not cause an error on seeks.)

All WRITE flag options are supported.

All READ flag options except the edited read (flag bit 5) are supported by the Miscellaneous Resource Manager. This includes the use of delimiters to complete the read event. As with consoles, your program should be able to accept fewer characters on a read than requested.

SPECIAL functions are another way to transfer data to and from a device. However, all SPECIAL functions are driver-dependent; there are no generic functions. The Miscellaneous Resource Manager acts as a conduit for SPECIAL calls and provides no services beyond transferring the SPECIAL databuf and parmbuf contents.

6.3 Device Installation

Device drivers are installed with the INSTALL SVC. The driver can be read from a disk file or replicated from an existing driver. Only privileged users can call INSTALL

FlexOS supports the concept of subdrivers. This allows a driver unit to be independent of specific hardware by accessing the hardware in a generic way For example, multiple units of an RS-232 subdriver can be installed and then linked to printer, network, or communications drivers. This relieves the driver writer of hardware dependent code and provides flexibility when installing add-on or custom peripherals.

6.3.1 Driver and Subdriver Installation

Although drivers and subdrivers are usually installed when the system is loaded, they can be installed after the installation script has been performed as well. (See the CONFIG.SYS description in the FlexOS System Guide for description of the installation script.) You can also uninstall drivers, disconnect a subdriver from a driver, and link a subdriver to a driver dynamically

Once a driver-to-subdriver link is established, the subdriver is no longer individually accessible; the driver owns it. When the link is dissolved, the subdriver is available for linking to another driver. The Miscellaneous Resource Manager manages subdrivers until they are linked to a driver. Then the driver assumes subdriver management responsibilities. Subdrivers can themselves have their own subdriver.

Note: The subdrivers with PORT tables do not have a standard interface to the resource manager. Do not attempt to access these drivers directly.

6.3.2 INSTALL Options

Drivers and subdrivers are installed with the INSTALL SVC. There are four INSTALL options.

- **Load driver from the disk:** Read the driver from the specified disk file, load it into the system space, call the initialization routine for the first unit, and give it a logical name.
- **Add a unit to an existing driver:** Replicate an existing driver in system space, initialize the device, and give it a logical name.
- **Link one driver to another:** Make one driver the subdriver of another. Both drivers must already be installed.
- **Uninstall the driver:** Remove the device driver and release subdriver.

Each unit installed manages a separate device; for example an RS-232 port. Multiple units derived from the same driver are distinguished by unique names, however, they all share the same code.

The driver determines the maximum access privileges supported by the device and the access modes. The maximum access modes are determined when the device is installed.

You do not use the DELETE SVC to remove a driver. Instead, use INSTALL's uninstall option. Only the device specified is removed; if the driver had a subdriver, the subdriver is released and becomes available for direct access or linkage with another driver.

6.4 PORT Table Modification

PORT table devices cannot be accessed directly; they can only be used as subdrivers. You can, however, set PORT table values. There are two ways to do this; depending on whether the device has driver or subdriver status. To determine the device status, look at the INSTAT word in its device table.

A device that is not a subdriver (it as not been linked to another driver with INSTALL), can be opened directly. In your OPEN call, request only the set access privilege (flag bit 0). Use the file number returned as your GET and SET ID.

Devices that are subdrivers cannot be accessed directly. However, you can use SPECIAL functions 13H and 93H to get and set the PORT table values. These SPECIAL functions are described after the SPECIAL disk functions in Section 7.

To use the SPECIAL functions, you must know the driver that owns the subdriver. The OWNERID value from the subdriver's DEVICE table is the significant 16 bits of the subdriver's owner's DEVICE table key value. Use this value in a LOOKUP call to find the device name. If the owner is also a subdriver, repeat this procedure to get the owner. When you determine the owner, open the device and use the file number returned in your SPECIAL calls.

End of Section 6

Supervisor Call Descriptions

This section describes the FlexOS SVCs. The descriptions are presented alphabetically by SVC name and contain explanations of each call's arguments and return codes. See Section 1 for the description of the C and assembler interface conventions used in the descriptions. Appendix B lists the error return codes.

The descriptions also include a general explanation of the function's purpose and effect. For specific information regarding when and how to use the SVCs, refer to the chapters describing disk, console, pipe, process and special device management.

7.1 ABORT

C Interface:

```
LONG        pid;

ret = s_abort(pid);
emask = e_termevent(swi,pid);

ret = __osif(F_ABORT,&parmblk);

parmblk:
```

	0=sync 1=async	0	0
4	swi		
8	pid		

Parameters:

swi	Address of a software interrupt routine
pid	Process ID of target process to abort or to wait to terminate. Use 0 to specify calling process.

Return Code:

ret	Error Code

Description: The synchronous ABORT SVC removes a process from the system. Any outstanding events for that process are canceled, opened files are closed, and memory is released. Performing an ABORT on the calling process is equivalent to an EXIT with a return code of E_ABORTED.

A process can only be aborted by another process with the same user and group or by a superuser.

The asynchronous version of ABORT does not terminate the target process. Instead, it makes the target's termination an event. Specify a process ID (pid) of zero to have the program trap a control-C entered by the user or any other external abort. Use the software interrupt (swi) to control program flow from there.

The return code from ABORT reflects only the operating system's attempt to notify a process to terminate. If the process has a termination swi that does not perform an exit, ABORT's return code indicates success, but the process will still be running.

7.2 ALTER

C Interface:

```
UWORD       flags;
LONG        fnum;
FRAME       *dframe;
RECT        *drect;
BYTE        alterb[6];

ret = s_alter(flags,fnum,dframe,drect,alterb);

ret = __osif(F_ALTER,&parmblk);

parmblk:
```

0	0	0	flags	
4	0			
8	fnum			
12	dframe			
16	drect			
20	and0	xor0	and1	xor1
24	and2	xor2	RESERVED	

Parameters:

flags	Bit map of planes to alter. bit 0: 1 = Alter character plane 0 = Do not alter character plane bit 1: 1 = Alter attribute plane 0 = Do not alter attribute plane bit 2: 1 = Alter extension plane 0 = Do not alter extension plane bits 3-15 are reserved.
fnum	Console screen or border file number; use 0 to specify a memory FRAME
dframe	Address of FRAME to affect; use NULLPTR to indicate screen or border specified by fnum.
drect	Address of RECT specification indicating portion of FRAME to alter
and0	alterb[0] = character plane AND
xor0	alterb[1] = character plane XOR
and1	alterb[2] = attribute plane AND
xor1	alterb[3] = attribute plane XOR
and2	alterb[4] = extension plane AND
xor2	alterb[5] = extension plane XOR

Return Code:

ret
Error Code

Description: ALTER changes a rectangular area of the specified FRAME. The Console Resource Manager changes each cell in the planes selected according to the AND and XOR values you specify for that plane. The rectangular area is defined by a RECT structure. You select the planes in the flag word.

The FRAME can be a screen or memory FRAME. To specify a screen FRAME put its file number in the fnum field and a null pointer in the dframe field. To specify a memory FRAME, put a 0 in the fnum field and the FRAME's address in the dframe field.

The following table lists the AND and XOR bit values used to modify the destination byte or combine it with another value.

Action Performed on Bit in Destination Byte	Bit in AND Byte	Bit in XOR Byte
Clear	0	0
Set	0	1
As is	1	0
Complement	1	1

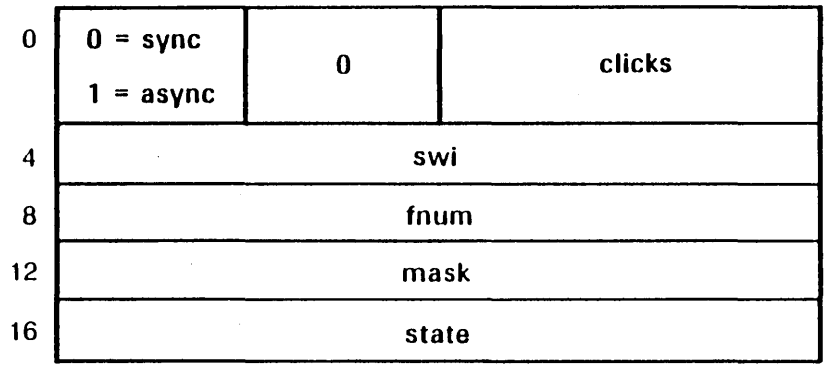
Logical Operation with Data and Bit in Destination Byte		
Load Data	0	data
AND Data	data	0
XOR Data	1	data
OR Data	NOT data	data

7.3 BWAIT

C Interface:

```
UWORD       clicks;
LONG        mask;
LONG        state;

ret = s_bwait(clicks,fnum,mask,state);
emask = e_bwait(swi,clicks,fnum,mask,state);

ret = __osif(F_BWAIT,&parmblk);
```

parmblk:



Parameters:

clicks	Number of times the mouse enters this state within the "click interval" set up in the MOUSE Table after this call is made. If **clicks** is 0 and the mouse is already in this state, the event is already complete.
fnum	Mouse file number
mask	Bit mask of buttons to consider. The lowest order bit is set if the first mouse button to the left is to be considered. The second lowest bit corresponds to the second button from the left. A total of 16 mouse buttons can be supported in the low word of **mask**.
state	Bit mask of buttons that define the button state given the mask that determines the buttons to ignore all together in the low word of **state**.

Return Code:

ret	Number of Clicks Error Code

Description: The BWAIT SVC allows the calling process to wait until a mouse button state is reached. The **mask** determines the number of mouse buttons the calling process wants considered. For example, by setting the mask appropriately, a one button mouse can be expected when there is more than one button.

The **clicks** field allows the calling process to receive multi-click mouse input. When a user presses a mouse button, releases it and presses it again within the "click interval", the mouse has been double clicked.

If **clicks** is set to two, and a second click is not performed within the "click interval", the event is considered complete. The return value indicates the number of clicks actually performed. If **clicks** is set to zero, BWAIT returns a zero if the button state is already in the specified state. Otherwise, it returns one upon the first entry to the state.

The "click interval" is changed in the MOUSE table through the SET SVC.

7.4 CANCEL

C Interface:

```
LONG        dmask;
LONG        events;

dmask = s_cancel(events);

dmask = __osif(F_CANCEL,events);
```

Parameters:

events	Logical OR of event masks to be canceled

Return Code:

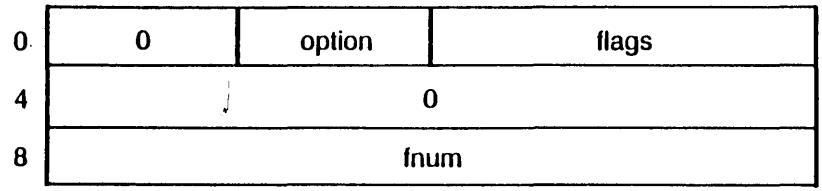
dmask	Bit map of events that could not be canceled because they have already completed

Description: The CANCEL SVC terminates one or more specified asynchronous SVCs. The events argument is the logical OR of the event masks you want to cancel. The dmask return code indicates events that, although requested for termination, had already completed. Use the RETURN SVC to get the return codes for these events so the event bits can be reused.

7.5 CLOSE

Interface:

```
UWORD       flags;
BYTE        option;
LONG        fnum;

ret = s_close(flags,fnum);

ret = __osif(F_CLOSE,&parmblk);

parmblk:
```



Parameters:

option — May be used by SPECIAL devices.

flags — bit 0: 1 = partial close (flush only)
0 = full close

bits 1-15 are reserved.

fnum — File number of file to be closed

Return Code:

ret
Error Code

Description:

CLOSE disassociates an I/O stream from a file number. Before the close is performed, all outstanding asynchronous I/O is completed and locked file areas are unlocked. If a device error occurs on a full close, the file is closed making the file number invalid.

For all types of files, a partial close flushes the associated I/O buffer but leaves the file open. For disk files, a partial close updates the directory.

For disk and pipe files and directories created with the temporary flag set, the last close deletes the files. This also applies to a file marked temporary because an attempt has been made to delete it while any process had it open. In this second case only, the closing process gets an error return code rather than success to indicate that the close also resulted in a file delete.

WARNING: CLOSE with the "full close" option always disconnects an open file from the calling process regardless of error. This can cause a failure to flush intermediate buffers to media if the error is a physical error.

Specifically, if a floppy drive door is open at the time of a close, the final flush does not occur. An application can avoid this problem by performing a "partial close" to flush all intermediate buffers. If an error is returned indicating an "open door", the application can warn the user to replace the media and close the door before attempting the close operation again.

However, if any other activity occurs on the device from the time the door was originally opened, the "partial close" approach fails since all intermediate buffers have been discarded. In such a case, the application must assume the file has not been updated since the last successful partial close. After performing a successful partial close, the application can perform a full close to disassociate the file from the process.

7.6 COMMAND

C Interface:

```
UWORD   flags;
LONG    pid,bufsiz;
BYTE    *command,*buffer;
PINFO   *procinfo;

ret = s_command(flags,command,buffer,bufsiz,procinfo);
emask = e_command(swi,&pid,flags,command,buffer,bufsiz,procinfo);

ret = __osif(F_COMMAND,&parmblk);
```

parmblk:

0	0=sync 1=async	0	flags
4	swi		
8	command		
12	buffer		
16	bufsiz		
20	procinfo		
24	&pid		

Parameters:

flags bits 0-3 are reserved

bit 4: 1 = No new process (set bit 5 to 1)
0 = New process (ignore bit 5)

bit 5: 1 = Chain
0 = Not implemented (returns E_IMPLEMENT error)

bit 6: 1 = Do not release memory on termination of procedure if procedure uses the EXIT SVC with the stay resident flag set.
0 = Not implemented (returns E_IMPLEMENT error)

bit 7: 1 = Assign a new process family ID (FID)
0 = Keep the current process family ID (FID)

bits 8-12 are reserved (must be 0).

bit 13: 1 = Force case to media default
0 = Do not affect name case

bit 14: 1 = Literal command
0 = Prefix substitution allowed

bit 15: reserved (must be 0)

swi Address of a software interrupt routine

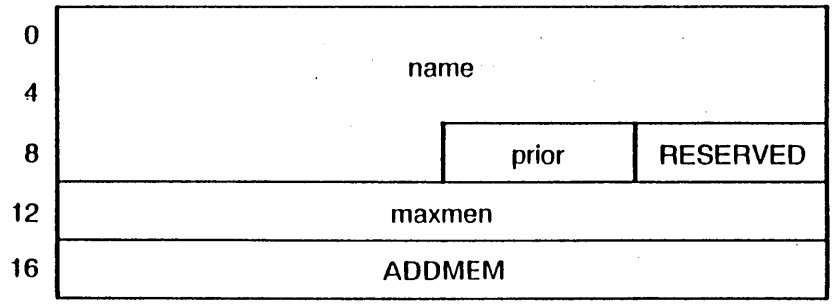
command Address of 128-byte, null-terminated string indicating the name of the loadable file.

buffer Address of a variable length buffer containing a 128-byte, null-terminated command tail and special information to be passed to the new process. (At most, the command tail can be 127 characters and one NULL byte long.) COMMAND puts the tail in the CMDENV table. Data after the first 128 bytes is put in the process's heap.

The PROCESS table contains the heap address and size. Use this buffer area to pass an environment string, common data, or special information to the program.

bufsize — Size of buffer in bytes

procinfo — Address of the PINFO table. PINFO must be constructed as follows:



20 = Length in bytes

name: Process name

prior: Process priority (user processes are usually set to 200)

maxmem: Maximum memory this process can own (larger minimum requirements specified by the command file supercede this amount)

addmem: The amount of memory to be added to the minimum amount specified by the command file (FlexOS allocates the greater of the two values: maxmem or the sum of the command file's specified minimum plus addmem)

pid — Address of new process ID. COMMAND puts the new process's 32-bit PID at this location when flag bit 4 equals 0 and COMMAND is called asynchronously.

Return Code:

ret — Process completion status:
High order word = 0
Low order Word = return status (negative if error)

Error Code: Indicates program load failure

Description: The COMMAND SVC creates a new process or chains a new program to the calling process. The value of flag bit 4 determines which action is taken. When flag bit 4 is set, use flag bit 7 to specify whether you want the current process family ID kept or a new one assigned.

The return code is a long value with two components: if the high order word is zero, the low order word contains an utility return code. See Appendix B for a list of utility return codes. If the high order word is a negative number, the low order word contains an operating system error code. A return code can be used in batch files as an argument in the IF ERRORLEVEL statement.

When COMMAND is called synchronously, the return code is provided when the EXIT SVC is called by the program. When COMMAND is called asynchronously and a new process is requested, an event mask (emask) is returned and the new process ID is stored at the location indicated by pid.

The chain option causes the calling process's current program to be overlaid with the new program. The process ID does not change.

The COMMAND SVC opens the specified command file in EXECUTE mode without accepting reduced access. Any error in the attempt to open the file returns the file not found error.

Priority of 200 is the recommended number for user processes. Higher numbers have lower priority; lower numbers have higher priority.

7.7 CONTROL

C Interface:

```
UWORD       option;
LONG        pid,target,bufsiz,tpid;
BYTE        *buffer;

ret = s_control(option,pid,buffer,bufsiz,target,&tpid);
emask = e_control(swi,option,pid,buffer,bufsiz,target,&tpid);

ret = __osif(F_CONTROL,&parmblk);
```

parmblk:

0	0=sync 1=async	0	option
4	swi		
8	pid		
12	buffer		
16	bufsiz		
20	target		
24	&tpid		

Parameters:

option	0 - Invalid 1 - Load Program for control 2 - Delete Program 3 - Read Target Code Memory 4 - Read Target Data Memory 5 - Write Target Code Memory 6 - Write Target Data Memory 7 - Read Target Registers 8 - Write Target Registers 9 - Go 10 - Single Step (Trace) 11 - Reserved (Force Halt) 12 - 13 Reserved (All Exception Traps ON,OFF) 14 - Select Exception Trap ON 15 - Select Exception Trap OFF 16 - 255 are reserved
swi	Address of a software interrupt routine
pid	For option 1, a pointer to command file specification; for options 2-15, the process ID of the target process
buffer	Address of buffer in calling process's address space; the purpose of this buffer depends on the option selected.
bufsiz	Size of buffer in bytes
target	Address in controlled process's address space: the purpose of this buffer depends upon the option selected.
&tpid	Target process address: tpid is used only with option 1; see the first section of the chip supplement to this book for the description of its use.

Return Code:

ret	Error Code

Description: The CONTROL SVC controls the execution of one or more child processes. Use the CONTROL options to select debugging functions such as setting breakpoints, modifying memory or registers, and starting and stopping process execution. The use of the pid, buffer, target, and &tpid arguments depends upon the option selected.

Option 1--Load: Use this option to create the target process. The pid, buffer, bufsiz, target, and &tpid arguments have the same purpose as the command, buffer, bufsiz, procinfo, and &tpid arguments in the COMMAND SVC. CONTROL opens the specified program (command file) in Execute, Read mode with no reduced access. When called synchronously, the load option returns when the program is loaded; the return code indicates the success or failure of the operation. Similarly, the asynchronous CONTROL load event is complete when the program is loaded. Use the RETURN SVC to get the return code.

Option 2--Delete: Use this option to terminate the program. pid specifies the target process to terminate.

Options 3 and 4--Read target code or data memory: Use these options to transfer a portion of the target process's memory to the calling process's memory. pid specifies the target process, the buffer address points to the calling process's destination buffer area, and target contains the logical address in the target process from which to begin the transfer. The bufsiz value indicates the number of bytes to be transferred.

Options 5 and 6--Write target code or data memory: Use these options to transfer a portion of the calling process's memory to the target process's memory. pid specifies the target process, buffer contains the pointer to the calling process's source buffer, and target contains the first logical address of the target's destination buffer. The bufsiz indicates the number of bytes to be transferred.

Options 7 and 8--Read and write target registers: Use these options to transfer the target process's register data to or from the calling process's buffer. pid specifies the target process and buffer contains the pointer to the destination or source buffer.

Option 9--Go: Use this option to commence execution of the target program. Execution proceeds until one of the following conditions is encountered. The number shown in parenthesis indicates the condition's return code.

- Error code on CONTROL request (<0)
- Target process EXIT (0)
- Target process exception (>0): This condition exists when break point set by CONTROL option 14 or by the EXCEPTION SVC is encountered.
- Target about to be aborted through an external ABORT or Control-C (512): 512 is the return code for the COMMAND SVC when using the go option.

Option 10--Trace: Use this option to step through the target program one instruction at a time. pid specifies the target process and bufsiz must be 1. The return code is the same as the Go option. Resume execution with Go or another Trace.

Options 14 and 15--Trap ON and OFF: Use option 14 to set target program break points at exception handling routines and SVCs; use option 15 to have break points ignored. pid specifies the target process and the target value contains a buffer pointer indicating the exception numbers to break on (see EXCEPTION). When an exception set by the target program is reached, target program execution proceeds with the interrupt service routine (isr). When an exception set by CONTROL is reached, target program execution stops and control returns to the calling process.

You set break points by writing a "break point" instruction into the target buffer, turning the break point exception trap on, and using the Go option. A return code greater than 0, where the number indicates the exception number, indicates that a break point has been encountered. To proceed, restore the target process code and set the instruction pointer to the break point location.

7.8 COPY

C Interface:

```
UWORD     flags;
LONG      fnum;
FRAME     *sframe,*dframe;
RECT      *srect,*drect;

ret = s_copy(flags,fnum,dframe,drect,sframe,srect);
ret = __osif(F_COPY,&parmblk);
```

parmblk:

0	0	0	flags
4	0		
8	fnum		
12	dframe		
16	drect		
20	sframe		
24	srect		

Parameters:

flags — Bit map of planes to copy

bit 0: 1 = Copy character plane
0 = Do not copy character plane

bit 1: 1 = Copy attribute plane
0 = Do not copy attribute plane

bit 2: 1 = Copy extension plane
0 = Do not copy extension plane

bits 3-15 are reserved.

fnum	Console screen or border file number
dframe	Address of destination FRAME; NULLPTR indicates screen or border specified by fnum.
drect	Address of destination RECT description
sframe	Address of source FRAME; NULLPTR indicates screen or border specified by fnum.
srect	Address of source RECT description

Return Code:

ret	Error Code

Description: The COPY SVC copies the specified plane contents from one rectangle to another on the same or different FRAMEs. The drect and srect rectangles are defined in the form of RECT structures. If either the dframe or sframe FRAME specifications are 0, the file number in fnum indicates the proper FRAME. The RECT and FRAME data structures are described in Section 3.

The source and destination rectangles do not need to be the same size and can overlap on the same screen. When the rectangles are different sizes, COPY trims off the larger. The upper lefthand corner of both rectangles is used as the point of reference.

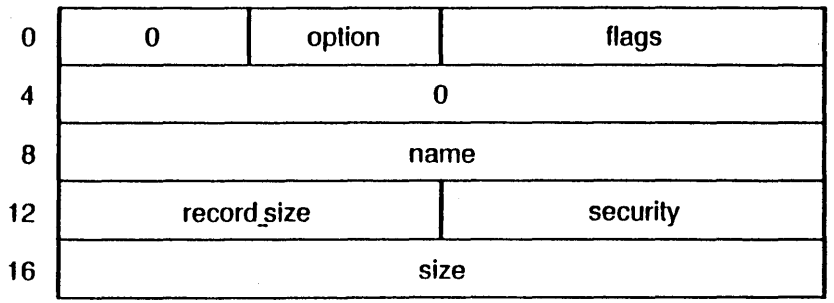
7.9 CREATE

7.9.1 Create a File, Directory, or Pipe

C Interface:

```
UWORD     flags,record_size,security;
BYTE      option,*name;
LONG      size;

fnum = s_create(option,flags,name,record_size,security,size);

ret = __osif(F_CREATE,&parmblk);
```

parmblk:



Parameters:

option
- 0 = Disk file or pipe
- 1 = Disk directory
- 2 = Virtual console (described separately)
- 3-255 Reserved

flags

bit 0: 1 = Delete file/set attributes access
0 = No delete/set access

bit 1: Reserved (must be 0)

bit 2: 1 = Write
0 = No Write

bit 3: 1 = Read
0 = No Read

bit 4: 1 = Shared
0 = Exclusive

bit 5: 1 = Allow Shared Reads if Shared
0 = Allow Shared R/W if Shared

bit 6: 1 = Shared File Pointer
0 = Unique File Pointer

bit 7: 1 = Zero Fill contiguous region*
0 = Do Not Zero Fill

bit 8: 1 = Temporary - Delete on Last Close
0 = Permanent

bit 9: 1 = Allocate space in a contiguous block*
0 = Contiguous block allocation not required

bit 10: 1 = Delete File if it already exists
0 = Return Error if file exists

bit 11 is reserved (must be zero)

bit 12: 1 = Use specified security
0 = Use default security (see ENVIRON table)

bit 13: 1 = Force Case to Media Default
0 = Do not Force Case on name

bit 14: 1 = Literal Name
0 = Prefix Substitution Allowed

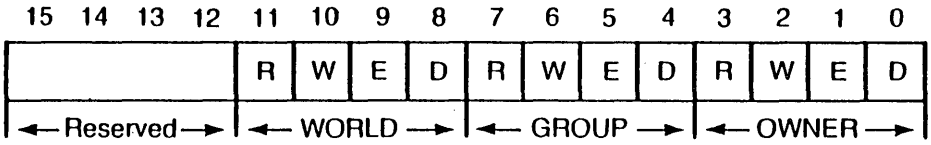
bit 15 is reserved

* Only valid if file's size value is non-zero.

name — Address of NULL-terminated name string: if file is not in default:, the string must include path specification or a previously defined logical name (maximum 128 bytes, NULL terminated)

record_size — File record size: The READ, WRITE and LOCK SVCs use this value to make sure the requested action falls on record boundaries. Use a record_size of 0 OR 1 if you want no boundary checks performed (a record_size of 0 is equivalent to a record_size of 1). FlexOS considers disk files and pipes with a record size of 1 as 8-bit files. Files with a record size of 2 are considered 16-bit files.

security — File Security Word (FSW) describing access rights for file owner, group and world. The FSW is formatted as follows:



User access is restriced according to the privilege level set for owner, group, and world users. See Section 1.4.2 for a description of the R(ead), W(rite), E(xecute), and D(elete) privileges. This value is only valid when flag bit 12 is on. Otherwise, the default security specified in the ENVIRON table is used.

size — Number of bytes to reserve for the file: For disk files, the space is contiguous only if bit 9 is set. Use a size value of 0 when you create directories and files whose size is dynamic. For pipes, the size value specifies the size of the pipe buffer. Size is not applicable to virtual consoles.

Return Code:

fnum — The file number: The file is automatically opened. The calling process must close the file if no access is needed. If the security field conflicts with the flag bits 0-6, then the file is created but not opened, and an error code is returned.

ret — Error Code

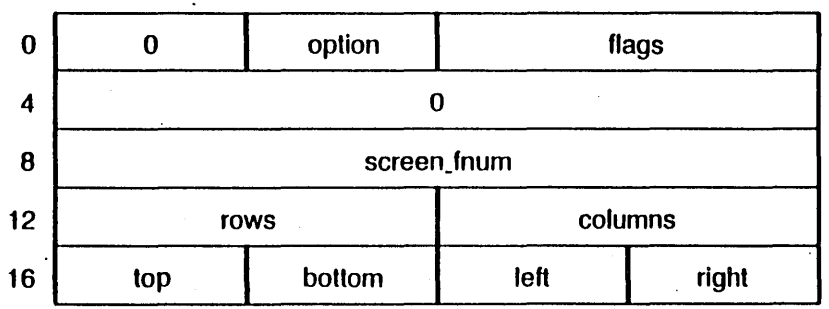
Description: CREATE option 0 adds a new disk file to a directory or a new pipe to the pipe system. CREATE option 1 makes a new directory. The record_size and size fields are only applicable to option 0; for directories, set these values to zero.

7.9.2 Create a Virtual Console

C Interface:

```
UWORD       flags;
LONG        screen_fnum;
WORD        rows,columns;
BYTE        option,top,bottom,left,right;

fnum = s_vccreate(flags,screen_fnum,rows,columns,top,bottom,left,
                  right);

ret = __osif(F_CREATE,&parmblk);
```

parmblk:



Parameters:

option
- 0 = Disk file or pipe (invalid here)
- 1 = Disk directory (invalid here)
- 2 = Virtual console (only valid choice)
- 3-255 Reserved

flags
- bit 0: 1 = Bit mapped screen
- 0 = Character mapped screen

bit 1: 1 = Bit mapped borders
0 = Character mapped borders

bit 2: 1 = Sized as specified
0 = Same size as parent

bit 3: 1 = Remove parent screen memory and restore on delete of last child's virtual console.
0 = Keep screen memory and allow writing to the parent screen

bits 4 - 7 are reserved

bit 8: 1 = Temporary - delete on last close
0 = Permanent

bits 9 - 15 are reserved

screen_fnum	File number of the parent console file on which new virtual console is based.
rows	Number of character rows in new virtual console. If flag bit 2 is zero, the number of rows is the same as the parent.
columns	Number of character columns in the new virtual console. If flag bit 2 is zero, the number of columns is the same as the parent.
top	Height of top border in characters
bottom	Height of bottom border in characters
left	Width of left border in characters
right	Width of right border in characters

Return Code:

fnum	New virtual console's file number: Use this number to GET and SET the virtual console's VCONSOLE table. Only the process that created a virtual console can change VCONSOLE values. The number returned is not the VCNUM referenced in the VCONSOLE and CONSOLE tables.
ret	Error Code

Description: This CREATE SVC option makes a new virtual console. Before you can CREATE a child virtual console, you must have at least write access to the parent console specified in screen_fnum. The row and column values do not need to be the same as the parent console's.

CREATE opens the new virtual console, which allows you to change values in the VCONSOLE table. No other process has access rights to this table. CREATE does not open the console file. Before you can read from and write to a new virtual console, you must open the console file. The name of this file is vcxxx/console where xxx is a 3-digit number indicating the virtual console's number.

Unlike the s_create call, the s_vccreate call does not accept an option.

7.10 DEFINE

C Interface:

```
UWORD       flags;
BYTE        *lname,*prefix;
LONG        size;

ret = s_define(flags,lname,prefix,size);
ret = __osif(F_DEFINE,&parmblk);
```

parmblk:

0	0	0	flags
4	0		
8	lname		
12	prefix		
16	size		

Parameters:

flags

bit 0: 1 = Reference SYSDEF table
0 = Reference PROCDEF table

bit 1: 1 = Return prefix string
0 = Set prefix string

bits 2-13 are reserved

bit 14: 1 = Literal returned prefix
0 = Translated prefix

If bit 14 = 1, the exact prefix string is returned. Otherwise, FlexOS translates the logical name until it cannot find another entry. This is done for a maximum of 99 times, after which an error is returned.

lname — Address of logical name: lname is a NULL terminated string no longer than ten characters.

prefix — Address of prefix string buffer: If flag bit 1 = 0, prefix contents replace lname. Use NULLPTR to delete a lname. Prefix string must be NULL-terminated and cannot exceed 128 bytes. If flag bit 1 = 1, DEFINE stores the current prefix at this address.

size — Size of prefix buffer; cannot exceed 128 bytes

Return Code:

ret — Error Code

Description: The DEFINE SVC either gives a logical name to a prefix string or returns the prefix for the specified name. Use DEFINE to redirect I/O from hardcoded filenames to other filenames or to make program-related assignments for stdin, stdout, stderr, and other logical names. The logical name cannot contain wildcard characters or path delimiters.

Logical name prefixes are kept in two tables: The SYSDEF table holds the system-wide logical name definitions and the PROCDEF table holds the process-bound logical name definitions. Child processes inherit their parent's PROCDEF table. However, DEFINE changes affect the calling process's PROCDEF table only. See Section 8 for the description of the SYSDEF and PROCDEF tables.

Only privileged processes (user and group numbers equal 0) can call DEFINE to modify SYSDEF table assignments. No special privilege is required to return a prefix from the SYSDEF table.

SVCs using names to indicate files have options to ignore prefix translation. When prefix translation is requested, the process's PROCDEF table is checked before the SYSDEF table.

When the file name specified does not include a device, FlexOS applies the special device name "default:" to the file name before attempting prefix substitution. Setting the current default directory of a process is therefore done by defining "default:". Since indirection is allowed, the user can set "default:" to another defined name such as "system:" or "home:". This implies the default directory is not necessarily legal. Programs that set the default directory should check for legality through accessing "default:" in some manner.

FlexOS does not check for loops in the DEFINE SVC. It does prevent infinite loops by only allowing 99 iterations when converting a name. FlexOS also insures that the logical name and the prefix name are not the same.

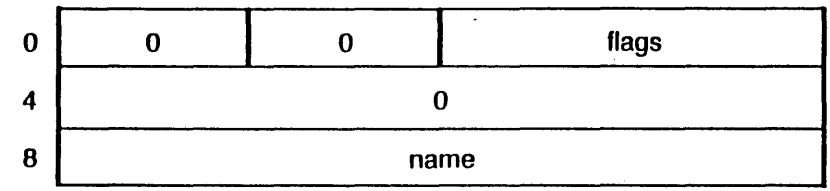
FlexOS does not check for actual device and directory names. Therefore, you can use DEFINE to store any string substitution information needed at either the system or process level. For example, you can store command macros for later translation either by the COMMAND SVC or a user interface program.

The "system:" and "boot:" logical names are initially defined at boot time by the BOOTINIT process.

7.11 DELETE

C Interface:

```
UWORD       flags;
BYTE        *name;

ret = s_delete(flags,name);

ret = __osif(F_DELETE,&parmblk);

parmblk:
```



Parameters:

flags — bits 0 - 12 are reserved

bit 13: 1 = Force case to media default
0 = Do not affect name case

bit 14: 1 = Literal name
0 = Prefix substitution allowed

bit 15 is reserved

name — Address of name of file to be deleted

Return Code:

ret	Error Code

Description: The DELETE SVC removes an existing disk file, pipe, virtual console, or directory file. Before you can delete a virtual console, it must have no open files or child consoles. Before you can delete a directory file, it must be empty.

An attempt to delete an open file returns success, however, the file is not immediately deleted. Instead, FlexOS marks the file as temporary. The temporary classification results in a file that remains available until the last close, when it is deleted.

7.12 DEVLOCK

C Interface:

```
BYTE        option;
LONG        fnum;

ret = s_devlock(option,fnum);

ret = __osif(F_DEVLOCK,&parmblk);

parmblk:
```

0	0	0	option
4	0		
8	fnum		

Parameters:

option	0 - Lock for process 1 - Lock for process family 2 - Unlock
fnum	File number of the opened device

Return Code:

ret	Error Code

Description: The DEVLOCK SVC locks or unlocks a device; restricting or releasing access rights to the device. Use the option field to indicate whether you want access restricted to the calling process alone or to the calling process and other processes with the same family ID (FID).

FlexOS does not lock the device and returns an error if another process has an open file on the device. (FlexOS allows the calling process to have open files, however.) It also returns an error if the device was protected against DEVLOCK when it was installed.

The device can only be unlocked by the process that initiated the lock. The lock is automatically removed when the process terminates and when the device file is fully closed. If the lock is applied to allow only related processes access to the device, FlexOS removes the restriction when the initiating process terminates; related processes no longer have exclusive access.

7.13 DISABLE

C Interface:

```
s_disable();

ret = __osif(F_DISABLE,0);
```

Parameters:

NONE

Return Code:

NONE

Description: The DISABLE SVC suspends the calling process's program jumps to software interrupt routines (SWIs). DISABLE does not, however, suspend software interrupts generated through the EXCEPTION SVC. FlexOS triggers SWIs for events completed while software interrupts are DISABLEd when the ENABLE SVC is called.

7.14 ENABLE

C Interface:

```
s_enable();

ret = __osif(F_ENABLE,0);
```

Parameters:

NONE

Return Code:

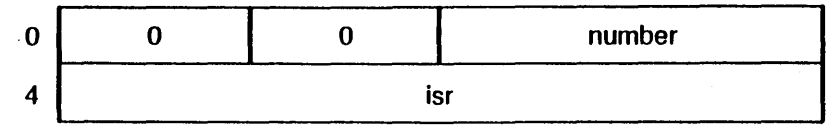
NONE

Description: The ENABLE SVC restores program jumps to software interrupt routines (SWIs). (The DISABLE SVC suspends their execution.) After ENABLE is called, FlexOS triggers the SWIs for events completed while software interrupts were DISABLEd.

7.15 EXCEPTION

C Interface:

```
WORD        number;
LONG        isr;

ret = s_exception(number,isr);

ret = __osif(F_EXCEPTION,&parmblk);

parmblk:
```



Parameters:

number	exception number
isr	Address of Interrupt Service Routine. A NULL pointer removes the software interrupt for the exception number specified.

Return Code:

ret	Error Code

Description: The EXCEPTION SVC allows a user program to trap various conditions that would otherwise result in a program abort or error.

The number parameter is a 16-bit integer specifying the exception condition to trap. Exception condition numbers are assigned as shown in Table 7-1; see the first section of the chip supplement to this book for the relationship between your microprocessor's and FlexOS's condition numbers.

Table 7-1. Exception Condition Numbers

Number	Condition
0	Non-existent memory
1	Memory boundary error
2	Illegal instruction
3	Divide by zero
4	Bound exception
5	Overflow error
6	Privilege violation
7	Trace
8	Breakpoint
9	Floating point exception
10	Stack fault
11	Emulated instruction group 0
12	Emulated instruction group 1
13	Emulated instruction group 2
14	Emulated instruction group 3
15	Emulated instruction group 4
16	Emulated instruction group 5
17	Emulated instruction group 6
18	Emulated instruction group 7
19-255	Reserved
256+n	Software interrupt n
512-64K	Reserved

Emulated instruction group 0 is reserved for software emulation of floating point hardware. Refer to programmer guide supplements for other emulation group assignments.

The Interrupt Service Routine is a machine-specific routine that must save and restore machine state if it is to return to the program causing the exception. This includes an "Interrupt Return" tailored to the CPU architecture to exit the routine. Be careful to monitor your stack utilization; your isr may have to do a stack switch for a program that is tight on stack space. This happens especially when the exception occurs in procedure code loaded through the COMMAND SVC.

7.16 EXIT

C Interface:

```
LONG        status; /*System error code or utility return code*/

s_exit(status);

ret = __osif(F_EXIT,status);
```

Parameters:

status — A 32-bit value setting exit flags in the high order word and passing completion status in the low order word.

Set exit flag bit 0 (status bit 16) to 1 to keep memory resident. Otherwise, FlexOS releases the terminating processes memory. Exit flag bits 1 - 15 are reserved and must be 0. The keep memory resident flag is only valid when the process is created with COMMAND flag bits 5 and 6 set. See Section 7.6

The completion status word is returned to terminating process's parent process.

Return Code:

NONE to calling process

Description: The EXIT SVC terminates the calling process, returns control to FlexOS, and passes back the completion status value to the parent process. Any outstanding events are cancelled and open files closed. Depending on status bit 32 (exit flag bit 16), the terminating process's memory allocation is either released or kept resident.

After a process calls EXIT, its parent's COMMAND call completes. The completion status code is placed into the low order WORD of the return code with the high order word set to 0. (If exit flag 6 was set, FlexOS resets it.) See Appendix B for utility return codes.

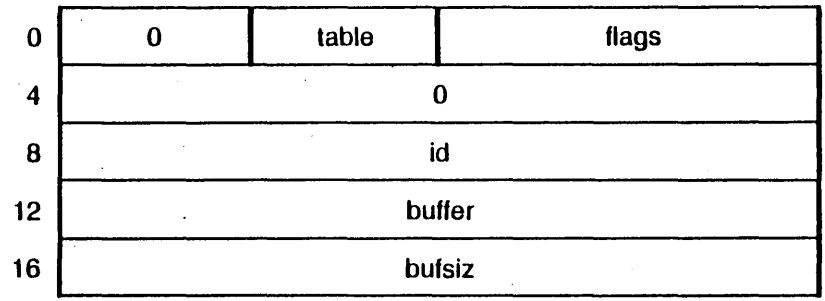
FlexOS sets the high bit of the completion status word to form a negative number when the attempt to create the process resulted in an error or the process was abnormally terminated. You can use the remainder of the bits to return a value to the parent process. By convention, a 0 value is used to indicate success while positive values indicate some form of partial completion.

7.17 GET

C Interface:

```
UWORD       flags;
BYTE        table,*buffer;
LONG        id,bufsiz;

ret = s_get(table,id,buffer,bufsiz);

ret = __osif(F_GET,&parmblk);
```

parmblk:



Parameters:

table	Table Number
flags	bits 0-7 can be used for SPECIAL devices bits 8-15 are reserved
id	File number or process ID
buffer	Address of buffer to place partial or complete table contents
bufsiz	Size of buffer in bytes

Return Code:

ret	Error Code

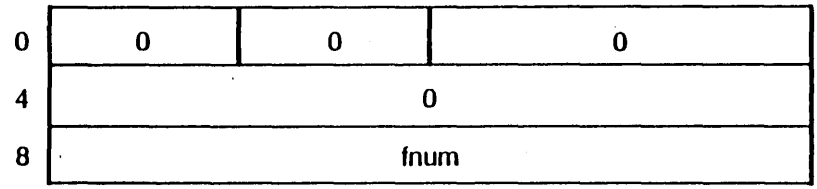
Description: The GET SVC stores partial or full table contents in the buffer specified. You specify the table by its number and, when there is more than one table with the same number, by a unique identifier. If the bufsiz is less than the size of the table structure, only the table contents up to that byte are stored.

Depending on the table type, the table ID is either a process ID or a file number. The table descriptions in Section 8 indicate what the ID is for each table. Not all tables require an ID. Use a NULL ID value for these GET calls.

7.18 GIVE

C Interface:

```
LONG        fnum;

ret = s_give(fnum);

ret = __osif(F_GIVE,&parmblk);

parmblk:
```



Parameters:

fnum	File number of virtual console whose virtual keyboard you want mapped to the physical keyboard.

Return Code:

ret	Error Code

Description: The GIVE SVC transfers access to the physical keyboard and mouse from the current virtual console to the virtual console specified by fnum. The virtual console getting ownership must be the virtual console for the process making the call or a child of that virtual console. Keyboard and mouse ownership is returned through the KCTRL SVC.

Keyboard and mouse ownership is always passed from one virtual console to another as a unit; they cannot be separated.

All characters in the previous owner's keyboard buffer are transferred into the new owner's keyboard buffer. Characters read subsequently from the physical keyboard are appended to the end of the characters in the buffer.

7.19 GSX - Perform Graphic SVC

C Interface:

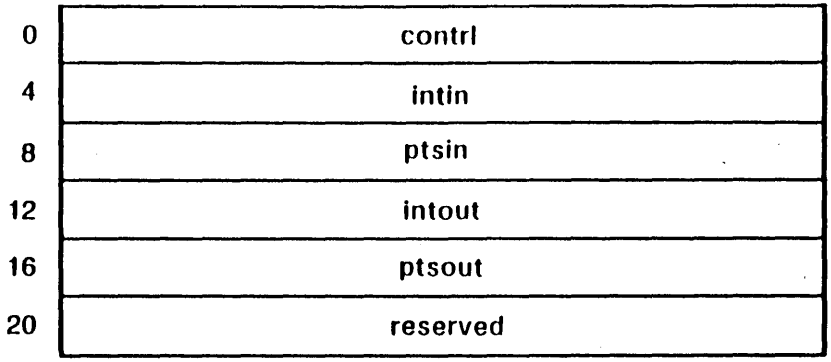
```
ret = s_gsx();

ret = __osif(F_GSX,&parmblk);

parmblk:
```

0	0	option	0
4	0		
8	fnum		
12	PB		

Parameters:

PB	Address of GSX Parameter Block

GSX Parameter Block format:



option	0	normal GSX call
	1	VDI aborting due to a CTRL-C.

Return Code:

ret	Error Code

Description: The GSX SVC allows the calling process to perform a Graphics operation on the indicated file.

7.20 INSTALL

C Interface:

```
BYTE        option,*devname,*parm;
UWORD       flags;

ret = s_install(option,flags,devname,parm);
ret = __osif(F_INSTALL,&parmblk);
```

parmblk:

0	0	option	flags
4	0		
8	devname		
12	parm		

Parameters:

option 0 - Remove previously installed driver unit.

devname = device driver name
parm = NULL

1 - Load device driver from disk

devname = device driver name for unit 0
parm = Loadable driver disk file name

2 - Add unit to existing device driver

devname = device driver name for new unit
parm = device driver name for unit 0

3 - Link a subdriver to a device driver

devname = Front end device driver name
parm = Subdriver device driver name

flags These flags are used for options 1 and 2 only.

bit 0: 1 = Raw SET allowed
0 = Raw SET not allowed

bit 1: Reserved (must be 0)

bit 2: 1 = Raw WRITE allowed
0 = Raw WRITE not allowed

bit 3: 1 = Raw READ allowed
0 = Raw READ not allowed

bit 4: 1 = Shared access allowed
0 = Exclusive access only

bit 5: 1 = Removable device
0 = Permanent device

bit 6: 1 = DEVLOCKs allowed
0 = DEVLOCKs not allowed

bit 7: 1 = Shared access only
0 = Exclusive access allowed

bit 8: 1 = Allow device partitions
0 = Do not allow partitions

bit 9: 1 = Verify after disk writes
0 = Do not verify after disk writes

bits 10 - 12 are reserved and must be 0

bit 13: 1 = Force case to media default
0 = Do not force case

bit 14: 1 = Literal load name
0 = Prefix substitution on load name

bit 15 is reserved and must be 0

devname — Address of the device name

parm — Depending on the option a null pointer or the address of the loadable disk driver file name, unit 0 device name, or subdevice name.

Return Code:

ret — Error Code

Description: The INSTALL SVC loads a device driver, removes a device driver, adds a unit to an existing device driver, or associates a subdevice to an existing device driver. The calling process must have group and user IDs of 0 to call INSTALL. INSTALL's devname and parm values are different for each option.

The device privileges set by the driver override those set by your INSTALL flags. This prevents you, for example, from opening a printer device with read access.

If a physical device driver has more than one unit, you must specify a unique device name to distinguish each unit. Put the unit's name in the devname field and specify the physical device driver in the parm field. devname and parm values must be null terminated and are limited to 128 bytes.

When you call option 3, both drivers must be already installed.

Flag bit 8 is used only by the disk resource manager and indicates whether or not the fixed disk device can have partitions. A disk with partitions cannot be formatted when installed with this bit on. Flag bit 9 is also used only by the disk resource manager. Set it when you want to verify every write to disk. Checksum verification is done.

7.21 KCTRL

C Interface:

```
LONG        fnum;
UWORD       nranges;
UWORD       flags,beg1,beg2,beg3,beg4;
UWORD       end1,end2,end3,end4;
RECT        region;

ret = s_kctrl(fnum,nranges,beg1,end1,beg2,end2,...end4);
ret = s_mctrl(fnum,region);
ret = __osif(F_KCTRL,&parmblk);
```

parmblk:

0	0	0	flags
4	0		
8	fnum		
12	beg1		end1
16	beg2		end2
20	beg3		end3
24	beg4		end4

(if mouse control)

12	region
16	

Parameters:

flags	Reserved, must be 0 bit 0: 1 = Mouse control 0 = Character control If 0, keyboard ownership is controlled through characters typed on the keyboard and the begin range and end range parameters are required. If 1, keyboard ownership is controlled through mouse movement and a region is required.
nranges	The number of beginning and ending ranges to follow--maximum 4.
fnum	Console file number of console to get keyboard; must be console file of the parent virtual console.
begn	First character in range of characters; pressing any character in range causes keyboard to return to specified console.
endn	Last character in the range.
region	RECT structure defining a character rectangle on the parent's virtual console.

Return Code:

ret	Error Code

Description: The KCTRL SVC transfers keyboard ownership to the console file specified by fnum when a character is entered that falls within any of the four ranges specified. The initial transfer of ownership is conferred with the GIVE SVC.

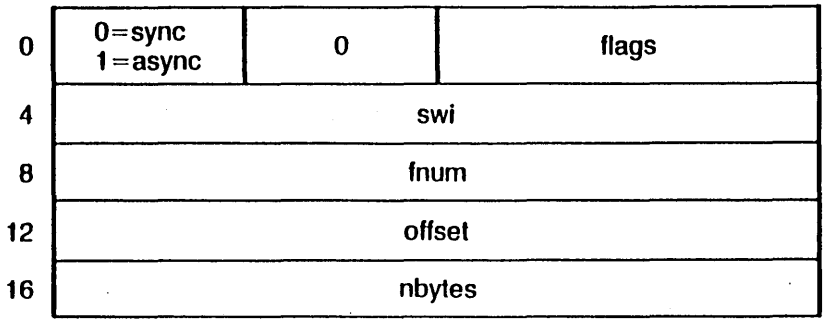
You can specify up to four character ranges. The ranges are inclusive of the first and last characters. A single character is specified by using it as the beginning and ending character. When a character falling in the range is typed, that character and all subsequent characters are diverted to the parent console file's keyboard buffer. The process controlling the virtual consoles can either give control of the keyboard to another virtual console or take some special action on behalf of the user.

You can also use mouse position to change keyboard and mouse ownership. In this case you specify a RECT (see Section 3 for the RECT description) on the parent console in which the mouse form must be resident. This region must be within the virtual console. When the mouse leaves the region, keyboard and mouse ownership go back to the parent.

7.22 LOCK

C Interface:

```
UWORD       flags;
LONG        fnum,offset,nbytes;

ret = s_lock(flags,fnum,offset,nbytes);
emask = e_lock(swi,flags,fnum,offset,nbytes);
ret = __osif(F_LOCK,&parmblk);

parmblk:
```



Parameters:

flags — bits 0 and 1 select the LOCK mode

- 0 = Unlock
- 1 = Exclusive lock
- 2 = Exclusive write lock
- 3 = Shared write lock

bits 2-3 are reserved (must be 0)

bit 4: 1 = Return error on lock conflict
0 = Wait on lock conflict

bits 5-7 are reserved (must be 0)

bits 8 and 9 determine how the offset field is interpreted

0 = Relative to beginning of file
1 = Relative to file pointer
2 = Relative to end of file

bits 10-15 are reserved (must be 0)

swi	Address of software interrupt routine
fnum	File number whose contents you want to lock and unlock
offset	Offset of region to lock in file
nbytes	Length of region to lock

Return Code:

ret	Error Code

Description: The LOCK SVC either locks or unlocks a region of a disk file, restricting or releasing access rights in the process. The disk file is specified by fnum and the area to be locked is determined by flag bits 8 and 9, offset, and nbytes. The Disk Resource Manager verifies that offset and nbytes define a region that falls on record boundaries for files created with a record size. If you specify a region that does not fall on a record boundary, no records are locked or unlocked and an error message is returned.

The lock modes selected by flag bits 0 and 1 are defined as follows:

- **1--Exclusive lock:** Prevents other processes from locking, reading from, writing to, or deleting the region.
- **2--Exclusive write lock:** Lets other processes read from the region but prevents them from locking, writing to, or deleting the region.
- **3--Shared write lock:** Allows other processes to read from and establish a shared write lock on but prevents them from writing to the region

Flag bit 4 determines what happens when the region requested is already locked in an exclusive mode. When you set bit 4 to 1, an error code is returned; when you set bit 4 to 0, LOCK waits for the region to be unlocked, locks the region, and returns.

The offset of the lock region in the file is, depending on the value in flag bits 8 and 9, relative to the beginning of the file, the current file pointer, or the end of the file. The file pointer location is modified by the READ, WRITE and SEEK SVCs. The nbytes value determines how many bytes are locked.

To unlock a region set flag bits 0 and 1 to 0. The offset indicates the first byte of the region to unlock and nbytes the number of bytes to unlock. Because the region unlocked is independent of the region initially locked, you can lock a large region of a file and then release portions as the lock becomes unnecessary so that other processes can have access. Once a region is unlocked, it can be locked by another process.

An unlock specification with flags and offset values equal to 0 and nbytes equal to 0xFFFFFFFF removes all locks on the file made by the calling process. The number of unlock calls does not have to match the number of lock calls.

7.23 LOOKUP

C Interface:

```
UWORD       flags;
BYTE        table,*name,*buffer;
LONG        key,bufsiz,itemsiz,nfound;

nfound = s_lookup(table,flags,name,buffer,bufsiz,itemsiz,key);

ret = __osif(F_LOOKUP,&parmblk);

parmblk:
```

0	0	table	flags
4	0		
8	name		
12	buffer		
16	bufsiz		
20	itemsiz		
24	key		

Parameters:

table	Table Number (Table 10-1 lists the table numbers)
flags	bits 0 - 7 are dependent on table type
	bits 8 -12 are reserved (must be 0)

bit 13: 1 = Force name case to media default
0 = Do not change name case

bit 14: 1 = Literal name
0 = Prefix translation allowed

bit 15 is reserved (must be 0)

name — Address of the table name to search for; names are case sensitive.

buffer — Address of buffer to store information collected.

bufsiz — Size of buffer in bytes.

itemsiz — The number of bytes to store from each table. If itemsiz is less than the table size, only that many bytes from each table found are written in the buffer. If itemsiz is greater than the table size, the excess area is not modified.

key — Key from which to continue searching. The key value depends on the table type. Each table allowing LOOKUP specifies a key for continued search. The LOOKUP SVC continues the search from the first item after the key. A key value of 0 always starts the LOOKUP search from the beginning of the table.

Return Code:

nfound — Number of tables found. LOOKUP stops searching when the end of the buffer is reached or there are no more tables. If the last table does not fit into the remaining buffer space, it is discarded.

ret — Error Code

Description: The LOOKUP SVC searches the system tables for those matching the table and name specified. The key field is used to specify the starting point for the search. A key value of zero specifies the beginning. A table's key value is defined by the resource manager responsible for that table. When a match is found the table, or an excerpt corresponding to the itemsiz in length, is copied into the buffer. The search continues until the buffer is filled or there are no more tables.

The name specification is limited to 128 bytes and must be null terminated. You can use wildcards in the name specification. However, you are restricted to the lowest level of a path name--that is, files within a directory and devices on a node. The name "*" is translated to mean "default:*".

Table names are case sensitive and you must enter your specification with the same case letters to get a match. This is also true when you use wildcards. For example, the entry "s*" returns only those tables beginning with a lowercase s.

A return of 0 indicates success, but means that LOOKUP found no tables.

Table numbers, names, keys and the use of flag bits 0 through 7 are described in Section 8.

7.24 MALLOC

C Interface:

```
LONG        *mpbptr,mpbsiz;
BYTE        option;

ret = s_malloc(option,mpbptr);

ret = __osif(F_MALLOC,&parmblk);
```

parmblk:

0	0	option	0
4	0		
8	0		
12	mpbptr		
16	mpbsiz		

Parameters:

option	0 = Expand existing heap 1 = Allocate a new heap
mpbptr	Address of Memory Parameter Block
mpbsiz	Size of Memory Parameter Block in bytes

The Memory Parameter Block must have the following format:

0	start
4	min
8	max

start: For option equals 0, set the base address of the heap segment to be expanded in this field. MALLOC writes the base address of the added memory portion before it returns. For option equals 1, set this field to zero. MALLOC fills in the base address of the new heap here.

min: Specify the minimum number of bytes required. MALLOC fills in the actual number allocated before returning.

max: Specify the maximum number of bytes required. MALLOC does not change your entry.

Return Code:

ret Error Code

Description: MALLOC either adds contiguous memory to the end of an existing heap or allocates a new heap. Use the option field to select one or the other and the Memory Parameter Block to specify the minimum and maximum memory requirements. Set the Memory Parameter Block's start parameter to the base address of the existing heap for option 0 or to zero for option 1.

Note: Process are not automatically given an initial heap allocation. Consequently, option 1 must be called the first time heap space is needed.

When you select option 0, MALLOC extends the designated heap contiguously and modifies your Memory Parameter Block's start and min parameters to indicate the new allocation's starting address and actual allocation, respectively. The original heap's base address (which is present PROCESS table) and contents remain unchanged.

When you select option 1, the new heap may or may not be contiguous with any previously allocated heap. MALLOC modifies your Memory Parameter Block's start and min values to indicate the new heap's base address and actual allocation. These new values also appear as the PROCESS table's HEAP and HSIZE parameters. The new heap may be allocated such that an existing heap is no longer expandable.

MALLOC use is affected by the type of processor. See the supplement corresponding to your processor for more information.

7.25 MFREE

C Interface:

```
BYTE        *start;

s_mfree(start);

ret = __osif(F_MFREE,start);
```

Parameters:

start	First address in heap to free

Return Code:

ret	Error Code

Description: The MFREE SVC releases the memory in a heap from the address specified to the end of that heap.

7.26 OPEN

C Interface:

```
UWORD       flags;
BYTE        *name;
LONG        fnum;

fnum = s_open(flags,name);

ret = __osif(F_OPEN,&parmblk);

parmblk:
```

0	0	option	flags
4	0		
8	name		

Parameters:

option — May be used by SPECIAL devices

flags

bit 0: 1 = Delete file/set attributes access
0 = No delete/set access

bit 1: 1 = Execute access
0 = No execute access

bit 2: 1 = Write access
0 = No write access

bit 3: 1 = Read access
0 = No read access

bit 4: 1 = Shared
0 = Exclusive

bit 5: 1 = Allow shared reads if shared
0 = Allow shared R/W if shared

bit 6: 1 = Shared file pointer
0 = Unique file pointer

bit 7: 1 = Reduced access accepted
0 = Return error on reduced access

bits 8 - 12 are reserved (must be 0)

bit 13: 1 = Force case to media default
0 = Do not affect name case

bit 14: 1 = Literal name
0 = Prefix substitution allowed

bit 15 is reserved (must be 0)

name Address of file, pipe, or device name

Return Code:

fnum file number
ret Error Code

Description: The OPEN SVC opens an existing file and returns a 32-bit file number used for subsequent I/O. "File" in this context refers to disk files, pipes, and device files used to communicate with printers, mouses, consoles, and special devices. FlexOS sets the file pointer to 0 when you open the file.

Use flag bits 0 through 3 to request the file access privileges--read, write, execute, and delete/set. Use flags 4, 5, and 6 to set the access mode--shared versus exclusive, shared read only versus shared read/write when shared, and shared versus unique file pointer. The use of these flags to monitor file access differs slightly from one type of file to another. See the sections in this manual on disk file, console, pipe, and special device management for the description of flag use with these types of files.

Set flag bit 6 when you want two or more processes to share the same file pointer; this feature is only available to processes with the same family identification number (FID). Each process sharing the pointer must have this flag set. When this bit is set, the value of flag bit 1 is assumed to be 1; the actual value is ignored.

Set bit 7 to accept reduced access privileges. The file's governing privileges for owner, group, and world categories are set when it is created. Reduced access is an issue when a disk label's security flag bit is set and you request a privilege level not available to a process with your ID and group number. Set this flag to 1 if you can accept reduced access; FlexOS ANDs the file's R, W, E, and D privileges corresponding to your category with those you requested to determine the privileges you actually get. Set this flag to 0 if you cannot accept reduced access; FlexOS returns an error code when the privileges do not match.

Files can be opened any number of times. Each open returns a different file number and each must be closed. Use this technique to obtain greater access to a file without losing your previous access. The standard protection rules do not apply on multiple opens of the same file by the same process. For example, if you open a file in SHARED, READ-ONLY mode, you can later open it in EXCLUSIVE, READ-WRITE mode. The protection rules still apply, however, with respect to other processes attempting to open the file.

Pipe file's read and write ends are separate and independent of each other. Similarly, a console file can be opened for read and write access separately. If one process opens a console or pipe file with EXCLUSIVE, READ access, another can open it with EXCLUSIVE, WRITE access. One end of a pipe file can be opened in SHARED mode while the other is opened in EXCLUSIVE mode. For pipes, how you open the file affects the pipe's operation.

7.27 ORDER

C Interface:

```
WORD        order;
LONG        fnum;

ret = s_order(order,fnum);

ret = __osif(F_ORDER,&parmblk);

parmblk:
```

0	0	0	order
4	0		
8	fnum		

Parameters:

order — New virtual console position

- 0 = Bottom
- 1 = Next to Bottom
- 2 = 2nd from Bottom
- n = Nth from Bottom
- -1 = Top

fnum — File number of virtual console to move

Return Code:

ret — Error Code

Description: The ORDER SVC changes the position of the virtual console with file number fnum in a "stack" of sibling virtual consoles. The "order" value specifies the virtual console's new position. Use -1 to specify the top. All other positions are designated by number where 0 is the bottom console, 1 the next, then 2, and so forth. The Console Resource Manager adjusts the position numbers after you make a change.

The initial order of precedence corresponds to the order of creation.

7.28 OVERLAY

C Interface:

```
BYTE        *codeadr,*dataadr;
LONG        fnum,offset;

ret = s_overlay(fnum,codeadr,dataadr,offset);

ret = __osif(F_OVERLAY,&parmblk);

parmblk:
```

0	0	0	0
4	0		
8	fnum		
12	codeadr		
16	dataadr		
20	offset		

Parameters:

fnum	File number of the opened file containing one or more overlay procedures
codeadr	Address in calling process's code area in which to load the overlay code.

dataadr — Address in calling process's data area in which to load the overlay data.

offset — Eyte offset into file of the overlay header. The header must be in the same format as the default program load image used by the COMMAND SVC.

Return Code:

ret — Error Code

Description: The OVERLAY SVC loads the code and data from the designated overlay file into the calling process's memory. The overlay file is specified by fnum and the code and data addresses by the codeadr and dataadr pointers, respectively. Use the offset value to select a specific overlay within a file containing several. Each overlay in a file must have its own header. The overlay file must be open and the calling process must have EXECUTE privilege.

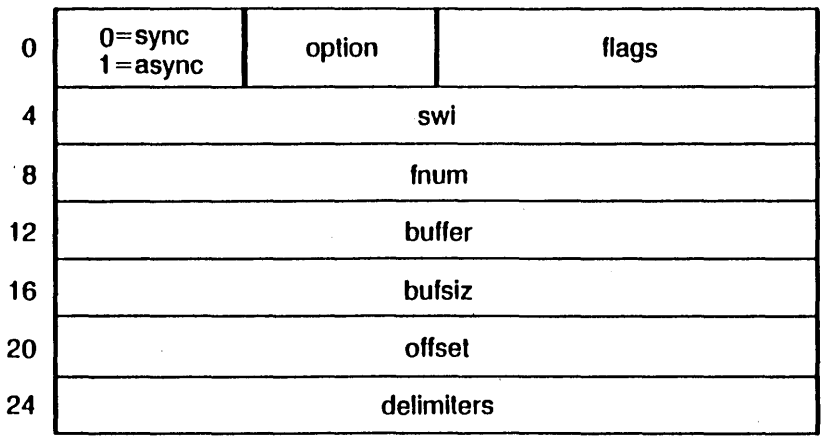
An E_MEMORY error is returned if the overlay does not fit into the calling process's code or data area starting at the specified address.

When the COMMAND SVC detects overlays in the program file, it automatically keeps the file open. The file number can be found in the ENVIRON table.

7.29 READ

C Interface:

```
LONG        fnum,offset,bufsiz,nbytes;
UWORD       flags,*delimiters;
BYTE        *buffer,option;

nbytes = s_read(flags,fnum,buffer,bufsiz,offset);
emask = e_read(swi,flags,fnum,buffer,bufsiz,offset);
nbytes = s_rdelim(flags,fnum,buffer,bufsiz,offset,delimiters);

ret = __osif(F_READ,&parmblk);

parmblk:
```



Parameters:

option — May be used by SPECIAL devices

flags

bit 0: 1 = Read from device. On disk files internal buffers are flushed and discarded before reading. On a keyboard file, the type ahead buffer is flushed.
0 = Allow reading from internal buffers

bit 1: 1 = Read until delimiter
0 = Not delimited

bit 2: 1 = Non-destructive read: Read the internal buffer contents without removing bytes pertinent to keyboard and pipe files only; disk file reads are always non-destructive.
0 = Normal read

bit 3: 1 = Preinitialized read
0 = Normal read

bit 4: 1 = Include delimiter in buffer
0 = Exclude delimiter

bit 5: 1 = Edited read (only relevant when "Read until Delimiter" flag is on.)
0 = Normal Read

bits 6-7 are reserved (must be 0)

bits 8 and 9 determine interpretation of the offset field:

0 = relative to the beginning of file
1 = relative to the file pointer
2 = relative to the end of file

bits 10-15 are reserved (must be 0)

swi	Address of software interrupt routine
fnum	File number of file to read
buffer	Address of buffer in which to place information
bufsiz	Size of buffer in bytes
offset	Byte offset relative to the position indicated by flag bits 8 and 9. Negative offsets are allowed.
delimiters	Address of an array of WORD values. This field is ignored on non-delimited reads. The first item indicates the number of delimiters in the array; 16-bit character delimiters follow. If the file being read is an 8-bit file, the high byte of each delimiter is ignored. Disk files and pipes with a record size of 1 are considered 8-bit files; files with a record size of 2 are considered 16-bit files. If the record size is greater than 2, a record size error is returned. The keyboard mode in the CONSOLE table determines if a console file is 8-bit or 16-bit oriented. On other devices, the device driver determines if it is an 8-bit or 16-bit device.

Return Code:

nbytes	Number of bytes read
	Error Code

Description: The READ SVC extracts data from the specified file. Data can be read either sequentially or randomly. The offset field is always added to either the beginning of a file, the current file pointer, or the end of file (see flag bits 8 and 9). You can specify a negative offset; this is useful, for example, to reread the last record of a file. Set flag bits 8 and 9 to one and the file pointer to one to perform sequential I/O.

The file pointer is updated on every read to the byte position after the transferred data in the file. It is initialized to 0 at OPEN.

The READ SVC verifies that the offset and bufsiz fields are on record boundaries if the file was created with a record size. If the values do not fall on record boundaries, no characters are read and an error code is returned.

The READ SVC can be called asynchronously on character oriented devices such as keyboards and special devices if the delimited read flag is not set. In this case, the number of characters read is at least one before the event is completed. The disk system does not support asynchronous READs. The pipe system supports asynchronous undelimited READs and reads as many characters as requested.

When using the delimited read flag, READ cannot be called asynchronously. The buffer size is limited to 256 bytes. Editing is performed by keyboards on delimited reads only. Common delimiters include the <carriage return>, <line feed> and <help> keys. The standard editing characters are as follows:

LEFT ARROW	Move cursor one character to left.
RIGHT ARROW	Move cursor one character to right.
DELETE	Delete next character
BACKSPACE	Delete previous character
CTRL-B	Move cursor to beginning of line if not at beginning, otherwise move to end of line.
CTRL-X	Erase from beginning of line to cursor

If a standard editing key is used as a delimiter, it has no effect on the returned buffer. These keys can be changed by an application program through the use of the XLAT SVC. The OEM that configures the system can also set the original editing character set.

7.30 RENAME

C Interface:

```
UWORD       flags;
BYTE        *name,*newname;

ret = s_rename(flags,name,newname);

ret = __osif(F_RENAME,&parmblk);

parmblk:
```

0	0	0	flags
4	0		
8	name		
12	newname		

Parameters:

flags — bits 0 - 12 are reserved

bit 13: 1 = Force case to media default
0 = Do not affect name case

bit 14: 1 = Literal name and new name
0 = Prefix translation allowed

bit 15 is reserved

name — Address of string containing name of existing file.

newname	Address of string containing new name of file.

Return Code:

ret	Error Code

Description: The RENAME SVC renames an existing disk file or directory. If the file is currently open by another process, FlexOS does not rename the file and returns an error. For files, if the new name specifies another directory, the file is moved to that location. This feature is limited to directories on the same drive. Attributes, ownership, protection and date stamps are not changed.

7.31 RETURN

C Interface:

```
LONG        emask;

ret = s_return(emask);

ret = __osif(F_RETURN,emask);
```

Parameters:

emask	Event mask of completed event

Return Code:

ret	return code of asynchronous SVC

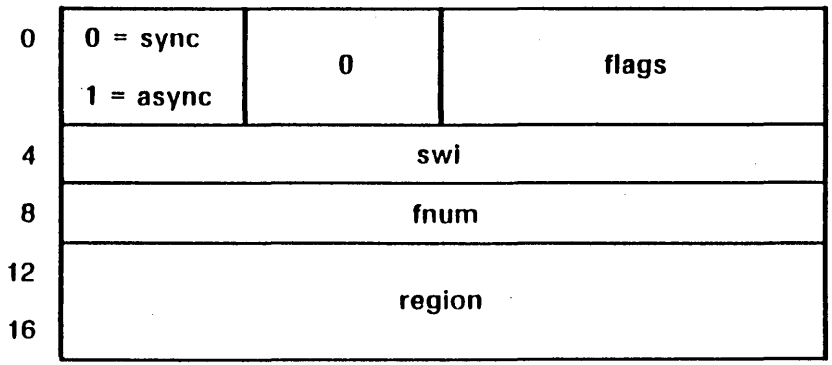
Description: The RETURN SVC retrieves the return code of an asynchronous SVC. If the event is not complete, FlexOS waits for it to complete before returning from the RETURN call. Use WAIT or STATUS to determine if the event has completed. The return code is the code that would have been returned if the SVC had not been called synchronously. Once the RETURN SVC has been called, the event's emask bit is cleared.

Note: You cannot use RETURN for events with a software interrupt (swi). The event's completion is provided to the swi and is not kept available to the parent process.

7.32 RWAIT

C Interface:

```
RECT        *region;

position = s_rwait(flags,fnum,region);
emask = e_rwait(swi,flags,fnum,region);

ret = __osif(F_RWAIT,&parmblk);

parmblk:
```



Parameters:

flags — bit 0: 1 = clip to current window
0 = no clip

bit 1: 1 = return on exit from rectangle
0 = return on entry to rectangle

bits 2-15 are reserved and must be 0.

fnum — File number of open mouse file

region RECT structure describing a rectangular area of the screen associated with the mouse.

0	ROW	COL
4	NROW	NCOL

Return Code:

ret Error Code

Description: The RWAIT SVC allows a process to detect the mouse entering or exiting a described region of the screen.

7.33 SEEK

C Interface:

```
LONG        fnum,offset;
UWORD       flags;

position = s_seek(flags,fnum,offset);

ret = __osif(F_SEEK,&parmblk);

parmblk:
```

0	0	0	flags
4	0		
8	fnum		
12	offset		

Parameters:

flags — bits 0-7 are reserved (must be 0)

bits 8-9 determine how to interpret the offset field

0 - Relative to beginning of file
1 - Relative to file pointer
2 - Relative to end of file

bits 10-15 are reserved

offset — Number of bytes relative to reference selected in flag bits 8 and 9

Return Code:

position — Current position of the file pointer after SEEK call.

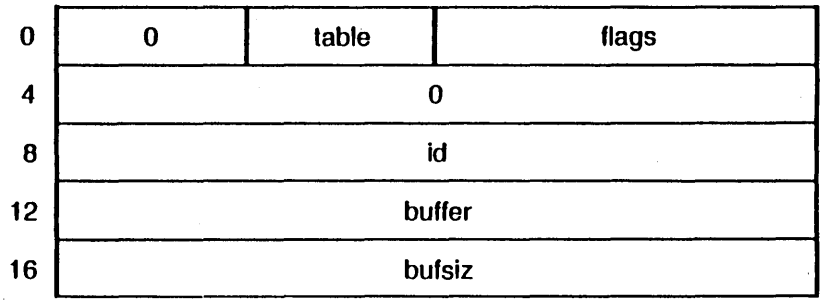
Description: The SEEK SVC either returns or changes the file pointer position of the specified file. To get the current pointer position, select the "Relative to file pointer" option in flag bits 8 and 9 and specify an offset of 0. Any other combination of values for flag bits 8 and 9 and the offset cause a change in the file pointer position. For all SEEK calls, the value returned indicates the current file pointer position.

The offset value can be positive or negative. An error is returned, however, if the new pointer position is less than 0. If the file consists of multibyte records, the offset must fall on a record boundary.

7.34 SET

C Interface:

```
BYTE        table,*buffer;
LONG        id,bufsiz;
UWORD       flags;

ret = s_set(table,id,buffer,bufsiz);

ret = __osif(F_SET,&parmblk);

parmblk:
```



Parameters:

table	Table number
flags	bits 0-7 may be used by SPECIAL drivers bits 8-15 are reserved and must be 0

id	Table identifier (required only when you have more than one table with the same number)
buffer	Address of source buffer with new table contents
bufsiz	Size of buffer in bytes

Return Code:

ret	Error Code

Description: The SET SVC changes table contents. The table is specified by the table number and, if necessary, an id. The id is table dependent; see the individual table explanations in Section 8 for the id value of a specific table. Not all tables can be modified with SET and some tables can only be modified by privileged processes.

If the bufsiz specified is less than the size of the table, the buffer contents replace the table contents starting from the beginning of the table. The remainder of the table is not changed.

7.35 SPECIAL

C Interface:

```
UWORD       flags;
LONG        fnum,dbufsiz,pbufsiz,;
BYTE        func,*databuf,*parmbuf;

ret = s_special(func,flags,fnum,databuf,dbufsiz,parmbuf,pbufsiz
emask = e_special(swi,func,flags,fnum,databuf,dbufsiz,parmbuf,
pbufsiz);

ret = __osif(F_SPECIAL,&parmblk);
```

parmblk:

0	0=sync 1=async	func	flags
4	swi		
8	fnum		
12	databuf		
16	dbufsiz		
20	parmbuf		
24	pbufsiz		

Parameters:

func	SPECIAL function number field: Bits 6 and 7 indicate the data flow direction of the databuf and parmbuf buffers as follows: bit 7--parmbuf: 1 = write buffer, 0 = read buffer bit 6--databuf: 1 = write buffer, 0 = read buffer If no data or parameters are to be transferred, set the bits to 0. The remainder of the bits in the number are determined by the device drivers.
flags	Depends on type of file; however bits 11, 14, and 15 are always reserved and must be 0.
swi	Address of software interrupt routine
fnum	File number returned when device was opened
databuf	Address of data buffer. If dbufsize field is NULL, this field is data.
dbufsiz	Size of data buffer in bytes or NULL to indicate that data is in databuf field or that there is no data.
parmbuf	Address of parameter buffer. If pbufsiz field is NULL, this field is data.
pbufsiz	Size of parameter buffer or NULL to indicate that parameter is in the parmbuf field or that there are no parameters.

Return Code:

ret	Return code depending on type of file
ret	Error code

Description: The SPECIAL SVC provides direct access to a device. The calling process must have opened the device before a SPECIAL function can be used. The function number indicates what type of operation to perform. SPECIAL requires the driver, not the resource manager, to interpret the function number and perform the operation.

Although SPECIAL functions and return codes differ according to the driver, the SPECIAL SVC parameter block is always formatted as shown above. The format rules are as follows:

- The most significant 2 bits of the func field determine the direction of the buffer data flow as described in the func description above. The lower 6 bits of the func field and flag bits 0–10, 12, and 13 are driver dependent.
- The flags field is a bit map of flags affecting the function's mode of operation and are typically function dependent.
- The databuf and dbufsiz fields make up a buffer specifier. If dbufsiz is 0 (NULLPTR), databuf field is a 32 bit data value rather than a pointer.
- The data buffer cannot contain pointers.
- The parmbuf and pbufsiz fields are also buffer specifiers and follow the same rules as the databuf and dbufsiz fields.

There are a maximum of 64 SPECIAL function numbers. (This is because only function number bits 0 through 5 can be used.) The first 32 digits are reserved for use by Digital Research Inc. The second 32 digits are available for use by an OEM.

7.35.1 Disk Resource Manager SPECIAL Functions

The Disk Resource Manager recognizes nine SPECIAL functions for disk initialization and raw disk I/O. These SPECIAL calls allow you to access the disk directly, bypassing normal operations and restrictions. You must specify OEM-defined parameters, such as sector size or file allocation table (FAT) address, to use some functions.

The parameter blocks for the Disk Resource Manager functions adhere to the model shown above but differ in their flag use and buffer requirements. Each function description below includes the flag definitions. Buffer requirements are shown in the parameter block illustrations. If a 0 is shown in the field, there is no corresponding parameter.

The return code for all Disk Resource Manager functions is either E_SUCCESS or E_IOERRS.

Note: Before you can perform the SPECIAL disk initialization functions 1 through 3, you must open the device with exclusive access and call SPECIAL function 8. Read, write, and/or set privileges are also required as described below.

Disk Function 0: Read System Area

SPECIAL disk function 0 reads in the system area of the disk into the data buffer. GET the drive's DISK table before you call function 0 to determine if the system area exists on the disk. The size of the data buffer must be greater than or equal to the size of the system area. FlexOS requires the user to have disk read privilege to perform this function.

0	0	0	flags
4	swi		
8	fnum		
12	databuf		
16	dbufsiz		
20	0		
24	0		

Parameters:

flags Bits 0-15: Reserved

Disk Function 1: Write System Area

SPECIAL disk function 1 writes the contents of the data buffer onto the system area of the disk. GET the drive's DISK table to determine if the disk has a system area before calling function 1. The size of the data buffer must match the size of the system area. You must must open the drive in exclusive mode with write privileges and call SPECIAL disk function 8 before you can write to the system area.

0	41H	flags
swi		
fnum		
databuf		
dbufsiz		
0		
0		

Parameters:

flags Bits 0-15: Reserved

Disk Function 2: Format System Area of Disk

SPECIAL disk function 2 formats the disk's system area according to the convention of the driver. GET the drive's DISK table to determine if the system area exists before calling function 2. You must open the drive in exclusive mode with read, write, and set privileges and call SPECIAL disk function 8 before you can format the system area.

0	2	flags
swi		
fnum		
0		
0		
0		
0		

Parameter:

flags Bits 0-15: Reserved

Disk Function 3: Format Track

SPECIAL disk function 3 formats the disk media according to the specifications in the parameter buffer. You must open the drive in exclusive mode with read, write, and set privileges and call SPECIAL disk function 8 before you can use this function

0	83H	flags
swi		
fnum		
0		
0		
parmbuf		
pbufsiz		

Parameters:

flags Bit 0: Reserved

Bit 1: 1 = Mark the whole track as bad

Bit 2: 1 = Use C, H, S, and N fields

Bit 3: 1 = Use HEAD, CYLINDER, BYTESEC, and SECTOR fields

Bits 4-15: Reserved

Set bit 1 to remove tracks designated bad by the manufacturer from file system access. Set flag bit 3 rather than flag bit 2 and specify the track in the head and cylinder fields. The remainder of the fields are irrelevant in this operation.

You select the format locations and characteristics in the parmbuf (parameter buffer). The data structure provides two, mutually exclusive means for specifying the starting head, cylinder, sector number, and the number of bytes per sector for the format operation. The other fields are valid for both options. Set flag bit 2 or 3 to select one means over the other.

parmbuf Format:

HEAD	0	CYLINDER	
DENS	FILL	BYTESEC	
SECTRK		SECTOR	
C	H	S	N
:			
C	H	S	N

HEAD Starting head number

CYLINDER Starting cylinder number

DENS Format density where

0 - Single density
1 - Double density

FILL Fill character

BYTESEC	Number of bytes per sector
SECTRK	Number of sectors per track
SECTOR	Starting sector number. When you set bit 3, the format operation begins with the sector field specified here
C, H, S, & N	a variable length list of 4-byte fields where: C is a starting cylinder number H is a head number S is a starting sector number N is the number of bytes/sector When you set bit 2, the format operation begins after the sector specified in each entry. The number of items in the list is determined by pbufsiz.

Disk Function 4: Media Check

SPECIAL disk function 4 checks to see if the media has changed or if a physical or logical error condition exists on the media. You must have opened the drive in at least GET-only mode to use this function. (GET-only mode is described in Section 2.6 above.)

0	4	flags
swi		
fnum		
0		
0		
0		
0		

Parameters:

flags Bits 0-15: Reserved

Disk Function 5: Flush Buffers

SPECIAL disk function 5 writes any updated buffers onto the disk. The user must have opened the device, however, no particular privilege is required.

0	5	flags
swi		
fnum		
0		
0		
0		
0		

Parameters:

flags Bits 0-15: Reserved

Disk Function 6: Read Physical Record

SPECIAL disk function 6 either reads data from the media into the data buffer or verifies the data is valid; flag bit 2 determines which operation is performed. The media starting point for both operations is defined in the parameter buffer by head, sector, and cylinder numbers. The dbufsiz value determines how much data is read. dbufsiz must be a multiple of the media's sector size. You must have opened the drive with at least read privilege to use function. No data is read, however, when you select the verify option.

0	86H	flags
swi		
fnum		
databuf		
dbufsiz		
head	sector	cylinder
0		

Parameters:

flags

Bits 0-1: Reserved
Bit 2: 1 = Verify media
0 = Read media
Bits 3-15: Reserved

The starting head, sector and cylinder numbers are specified in the H, S, C fields above.

Disk Function 7: Write Physical Record

SPECIAL disk function 7 writes the data buffer contents to the media. The media starting point is specified in the parameter buffer by head, sector, and cylinder number. The dbufsiz value determines how much data is written. dbufsiz must be a multiple of the media's sector size. You must open the drive in exclusive mode with write access before you can use this function.

0	C7H	flags
swi		
fnum		
databuf		
dbufsiz		
head	sector	cylinder
0		

Parameters:

flags — Bits 0-15: Reserved

The starting head, sector, and cylinder numbers are specified in the H, S, C fields, above.

Disk Function 8: Initialize Format

SPECIAL disk function 8 supplies the file system and the disk driver with the drive's Media Descriptor Block (MDB). This function must be called before the user calls SPECIAL disk functions 1, 2, and 3. To execute this call, the user must have opened the drive in exclusive mode with read, write and set privileges.

0	48H	flags
swi		
fnum		
databuf		
dbufsiz		
0		
0		

Parameters:

flags Bits 0 - 15: Reserved

The Media Descriptor Block is specified in the data buffer as follows:

SECTSIZE		FIRSTSEC	
NSECTORS			
SECTRK		SECBLK	
NFATS	FATID	NFRECS	
DIRSIZE		NHEADS	FORMAT
HIDDEN			
SYSSIZE			

SECTSIZE Size of sectors in bytes

FIRSTSEC First physical sector number of File Allocation Table (FAT) on track 0

NSECTORS Number of sectors in logical image of disk including FATs, directory, and boot record

SECTRK Number of sectors per track

SECBLK Number of sectors per block

NFATS Number of FATs

FATID FAT identification byte

NFRECS Number of sectors in a FAT

DIRSIZE Number of directory entries in the root directory

NHEADS Number of heads

FORMAT	Media format according to the following values 0 = RAW 1 = 1.5 byte FATs 2 = 2 byte FATs
HIDDEN	Number of sectors in partitions preceding the media's logical image
SYSSIZE	Number of bytes in the system area.

7.35.2 Miscellaneous Resource Manager SPECIAL Functions

Two SPECIAL functions are provided for accessing serial-type port devices when they are serving as subdrivers. Use these functions as you would GET and SET to determine the driver's current values and set them. The data structure used for both functions is the PORT table.

The fnum value for both calls is the file number returned when you open the subdriver's owner. See Section 6 for the description of the owner and the procedure for finding it.

Miscellaneous Device Function 0: Get Current PORT Table Values

Use this function to determine the subdriver's current PORT table values.

0	13H	0
0		
fnum		
0		
0		
parmbuf		
pbufsiz		

Parameters:

parmbuf	Address of buffer to place the PORT table.
pbufsize	Length of the buffer; if the number splits a field, that value is not copied.

Miscellaneous Device Function 1: Set Port Table Values

Use this SPECIAL function to set a subdriver's PORT table values.

0	93H	0
0		
fnum		
0		
0		
parmbuf		
pbufsiz		

Parameters:

parmbuf	Address of buffer with source PORT table values.
pbufsize	Length of the buffer; if the number splits a field, that value is not set.

7.36 STATUS

C Interface:

```
LONG        cmask;

cmask = s_status();

ret = __osif(F_STATUS,0L);
```

Parameters:

NONE

Return Code:

cmask	Bit map of completed events

Description: The STATUS SVC informs the calling process of previously initiated asynchronous events that have completed and whose return codes have not been retrieved by the RETURN SVC. If the event specified has a software interrupt (swi), the cmask value for that event is 0 rather than 1. (You do not call RETURN for events with a software interrupt.)

Note: STATUS places a heavy burden on the CPU; excessive use of STATUS impacts program performance.

7.37 SWIRET

C Interface:

```
LONG        option

s_swiret(option);

ret = __osif(F_SWIRET,option);
```

Parameters:

option 0 - return to main program at point of interruption

1 - assume process identity from main program

Return Code:

NONE

Description: The SWIRET SVC is used to return from a software interrupt routine (swi). It provides two options:

- return to the main program at the point of interruption
- retain control of subsequent program execution

"main program" means the process that made the initial asynchronous call. Both options return the registers to their values when the process was interrupted.

When you select SWIRET's second option, the software interrupt assumes the main program's process ID and environment, including the stack.

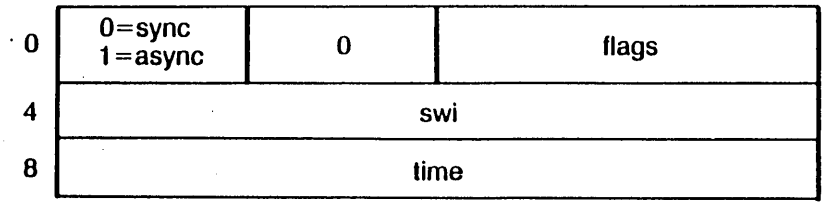
Use this option to return to a location in the main program other than the point of interruption or to assume the entire process identity without returning to the main program. Because the current condition of the stack is unknown when SWIRET is called, you should restore it to a known place before proceeding.

You can exit a program with SWIRET. Specify option 1 and call EXIT in your next instruction.

7.38 TIMER

C Interface:

```
UWORD     flags;
LONG      time;

ret = s_timer(flags,time);
emask = e_timer(swi,flags,time);

ret = __osif(F_TIMER,&parmblk);

parmblk:
```



Parameters:

flags bit 0: 1 = absolute
0 = relative

bits 1-15: Reserved

swi Address of software interrupt routine

time If bit 0 = 1 (absolute), number of milliseconds to delay after midnight. If bit 0 = 0 (relative), number of milliseconds to delay.

Return Code:

ret	Error Code

Description: The TIMER SVC delays the calling process until the specified time or the specified period of time expires. Use TIMER asynchronously with bit 0 = 0 (relative time) when you need a watchdog timer for an asynchronous SVC.

If absolute time is specified and the current time of day is beyond it, the process delays until the specified time the next day.

7.39 WAIT

C Interface:

```
LONG        events,cmask;

cmask = s_wait(events);

ret = __osif(F_WAIT,events);
```

Parameters:

events	Logical OR of emasks to wait for

Return Code:

cmask	Bit map of completed events

Description: The WAIT SVC causes the calling process to wait for an asynchronous event to occur. Specify one or more events by their emask in the WAIT events argument. FlexOS returns when one of these events has run to completion. For events that do not have a software interrupt, the cmask return code indicates which event completed. Subsequently, call the RETURN SVC to retrieve the return code of the completed event. This also releases that emask so it can be reused.

You can wait on events that have a software interrupt (swi). However, the event bit in the cmask returned is 0 rather than 1 when WAIT returns. Also, do not call RETURN to retrieve the completion code after WAIT returns--the completion is no longer available having already been provided to the swi for handling.

7.40 WRITE

C Interface:

```
LONG        fnum,bufsiz,offset,nbytes;
BYTE        option,*buffer;
UWORD       flags;

nbytes = s_write(flags,fnum,buffer,bufsiz,offset);
emask = e_write(swi,flags,fnum,buffer,bufsiz,offset);

ret = __osif(F_WRITE,&parmblk);

parmblk:
```

0	0=sync 1=async	option	flags
4	swi		
8	fnum		
12	buffer		
16	bufsiz		
20	offset		

Parameters:

option	May be used by SPECIAL devices
flags	bit 0: 1 = Flush buffers after WRITE. This forces the data to the media. If this is a zero length request, the media is updated with any pending writes. 0 = Allow optimized internal buffering bit 1: 1 = Truncate file to size specified in offset field. The bufsiz field must be 0 to allow a truncate. 0 = Do not truncate bits 2 - 7 are reserved (must be 0) bits 8 and 9 determine how the offset field is interpreted: 0 - Relative to beginning of file 1 - Relative to file pointer 2 = Relative to end of file bits 10-15 are reserved (must be 0)
swi	Address of software interrupt routine
fnum	File number of file to write to
buffer	Address of buffer from which to write
bufsiz	Size in bytes of buffer
offset	Offset into file to start writing depending on bits 8 and 9.

Return Code:

nbytes — Number of bytes written. When nbytes is less than bufsize, an error ocurred during the write operation. An error code is returned only if no data was written before the error ocurred.

Error Code

Description:

The WRITE SVC places data into the specified file. Flags bits 8 and 9 determine whether the offset value is added to the beginning of file, the current file pointer, or the end of file. The offset can be a negative number, allowing a write to the last record of the file. Sequential I/O is performed by writing relative to the file pointer with an offset of 0.

The file pointer is updated on every write to be the byte position after the transferred data in the file. It is initialized to 0 at OPEN. Use the SEEK SVC to determine the current value of the file pointer.

The WRITE function verifies that the offset and bufsiz are on record boundaries if the file was created with a record size. No data is written if the values do not correspond.

The disk system has an asynchronous interface to allow for I/O redirection from the pipe or console systems. However, the disk system does not support asynchronous WRITE operations. An asynchronous WRITE to disk is slower and requires more memory than a synchronous WRITE.

7.41 XLAT

C Interface:

```
LONG        fnum,bufsiz;
UWORD       flags;
BYTE        *buffer;

ret = s_xlat(flags,buffer,bufsiz);

ret = __osif(F_XLAT,&parmblk);

parmblk:
```

0	0	0	flags
4	0		
8	0		
12	buffer		
16	bufsiz		

Parameters:

flags — bit 0: 1 = replace existing table with buffer contents
0 = add buffer contents to current table

bits 1 - 15 are reserved and must be 0.

buffer — Address of the buffer with the replacement or supplemental keystroke translations

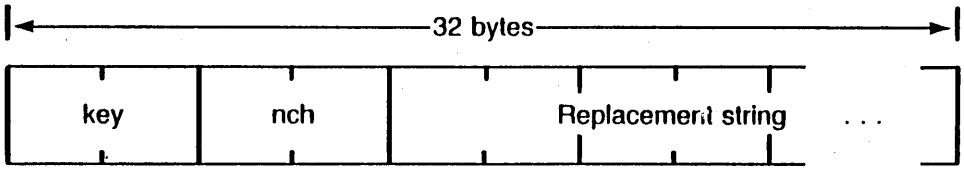
bufsiz — Size of buffer in bytes

Return Code:

ret	Error Code

Description: The XLAT SVC creates, replaces, or supplements a key translation table for the console specified by fnum. When the CONSOLE table KMODE (offset 2) bit 2 is 0, FlexOS translates characters entered from the keyboard into the string specified in the key translation table.

The key translation table consists of an unlimited number of 32 byte entries. Each entry is formatted as follows:



The fields are defined as follows:

- key: The 16-bit character to be translated; fill the high byte with a 0 for 8-bit input.
- nch: A WORD value indicating the number of 16-bit replacement characters; the maximum number of replacement characters is 14
- replacement: The replacement string; all characters are 16-bit

The key translation table is maintained on a per process basis. Child processes inherit their parent's table and share it until either process makes a change. This allows a parent to set up the keyboard environment before an application is run. When XLAT is called to change a table shared by two processes, FlexOS makes a separate copy for the calling process so that the modifications do not affect the other process.

There is no inherent limit to the number of translated keys supported for each process. The space for these keys are taken out of the Transient Program Area (TPA).

End of Section 7

System Tables

System status and parameter values are available to applications through the GET, SET, and LOOKUP SVCs which operate on a set of formalized data structures that comprise FlexOS's system tables. This section presents descriptions of the system tables in alphabetical order.

The GET SVC transfers the table to a buffer in the application's memory space. The SET SVC changes values in a table. For both SVCs, the table is identified by its number and, when that table type has more than one version, a unique ID number. The LOOKUP SVC searches for and retrieves tables of the same type. Each table that can be accessed with LOOKUP has a key value field; use this field to specify a starting point for the search.

The GET, SET, and LOOKUP SVCs will not access all of the system tables. Table 8-1 lists each of the system tables and the SVCs used to access them. Also listed in Table 8-1 are each table's number, ID, and key value.

Table 8-1. System Table Access

Table No. & Name	GET	SET	Unique ID	LOOK UP	Key	Description
0H PROCESS	X	X	pid	X	pid	Process information
1H ENVIRON	X	X	0			Process environment
2H TIMEDATE	X	X	0			System time of day
3H MEMORY	X		0			System memory use
10H PIPE	X		fnum	X	key	Pipe information
20H DISKFILE	X	X	fnum	X	key	Disk file information
21H DISK	X	X	fnum			Disk device information
30H CONSOLE	X	X	fnum			Console file information
31H PCONSOLE	X	X	fnum			Console device information
32H VCONSOLE	X	X	fnum	X	VCNUM	Console information
40H SYSTEM	X	X	0			Global system information
41H FILNUM	X		fnum	X	fnum	File number's table
42H SYSDEF				X	key	System logical name table
43H PROCDEF				X	key	Process logical name table
44H CMDENV	X		pid			Command environment
45H DEVICE				X	key	Device information
46H PATHNAME				X	none	Full path name
71H PRINTER	X	X	fnum			Printer device information
81H PORT	X	X	fnum			Port device information
82H+ SPECIAL	X	X	fnum			Special device information

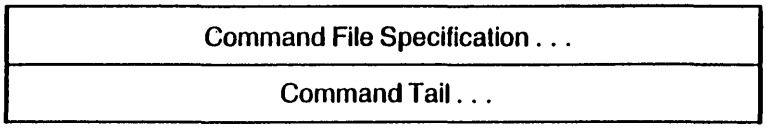
In the following system table descriptions, only those fields marked **R/W** are read-write; all other fields are read-only. In all bit-mapped values the bits for which there are no options are reserved and must be 0.

Note: FlexOS does not maintain memory representations for the tables described in this section. The corresponding resource manager or driver constructs them only when you call the GET, SET, or LOOKUP SVCs.

8.1 CMDENV Table

Number	GET?	SET?	LOOKUP?
44H	Yes	No	No

ID: 0 or process ID
Key: none



256 = Length in bytes.

The CMDENV table contains a process's command file specification and command tail. The strings are set by the COMMAND SVC. Both fields are 128 bytes in length and the strings are NULL terminated. The file specification includes the full pathname.

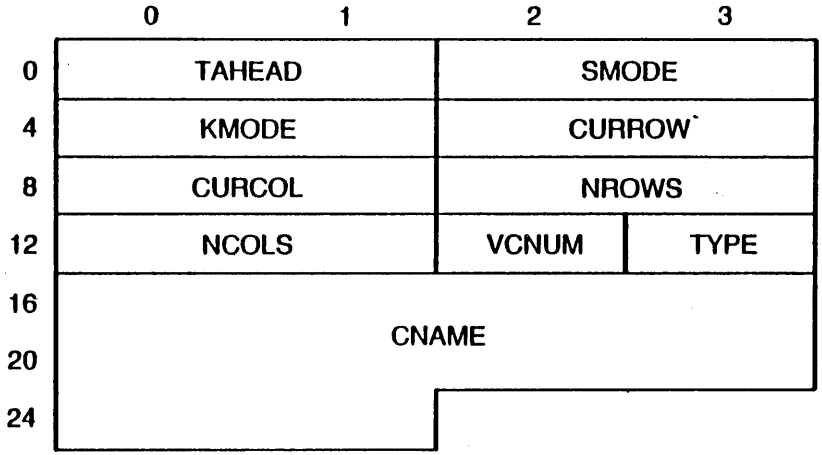
You can get the CMDENV table for the calling process or another process. For the calling process, specify an ID of 0 in the GET ID field. Otherwise, put the process ID of the target in the ID field.

8.2 CONSOLE Table

Number	GET?	SET?	LOOKUP?
30H	Yes	Yes	No

ID: File number of the console file
Key: none

The CONSOLE table describes the screen and keyboard of a con: file.



26 = Length in bytes

- **TAHEAD:** Number of characters waiting in type-ahead buffer
- **SMODE (R/W):** Screen modes

  bit 0: 1 = Disable escape sequence decoding
  0 = Select Escape sequences supported

  bit 1: 1 = Characters are 16-bit values
  0 = Characters are 8-bit values

  bit 2: 1 = Convert <LF> to <CR><LF>
  0 = Do not convert <LF> or <CR>

- **KMODE (R/W):** Keyboard mode

  bit 0: 1 = Disable Control-C
  0 = Control-C attempts external abort

  bit 1: 1 = Disable Control-S/Control-Q
  0 = Allow Control-S/Control-Q

  bit 2: 1 = Disable keyboard translation
  0 = Translate keys

  bit 3: 1 = Disable ESC sequence decoding
  0 = Support ESC sequence

  bit 4: 1 = Characters are 16-bit values
  0 = Characters are 8-bit values

  bit 5: 1 = Disable echo
  0 = Echo input characters on screen

  bit 6: 1 = Disable CTRL-Z
  0 = CTRL-Z = end of file

  bit 7: 1 = Enable toggle characters
  0 = Disable toggle characters

  bit 8: 1 = Convert <LF> or <CR> to <CR><LF>
  0 = Do not convert <LF> or <CR>

  bit 9: 1 = Do not echo carriage returns
  0 = Echo carriage returns

  bit 10: 1 = Do not echo <CR> on any delimiter
  0 = Echo <CR> on any delimiter

- **CURROW (R/W):** Current cursor row position
- **CURCOL (R/W):** Current cursor column position

- **NROWS:** Height of virtual screen in character rows
- **NCOLS:** Width of virtual screen in character columns
- **VCNUM:** Decimal number of virtual console
- **TYPE:** Type of virtual console

  bit 0: 1 = Graphics capability
  0 = Character only

  bit 1: 1 = No numeric keypad
  0 = Keypad

  bit 2: 1 = Mouse support
  0 = No mouse support

  bit 3: 1 = Color
  0 = Black and white

  bit 4: 1 = Memory-mapped video
  0 = Serial device

  bit 5: 1 = Currently in graphics mode
  0 = Currently in character mode

- **CNAME:** Physical console device name

Each console file opened has a corresponding CONSOLE table. The TAHEAD, CURROW, and CURCOL values are initialized to 0 when the console file is opened. NROWS and NCOLS correspond to the rows and columns set in the virtual console. SMODE and KMODE are initialized to 0; TYPE and CNAME are inherited from the parent console.

GET and SET the CONSOLE table using as the ID the file number returned when you OPENed the file vcxxx/console. Do not use the file number returned when you CREATEd the virtual console. For most applications, this file number is contained in the stdout--the screen file number--and stdin--the keyboard file number--in the ENVIRON table. Stdin and stdout can have the same or different file numbers.

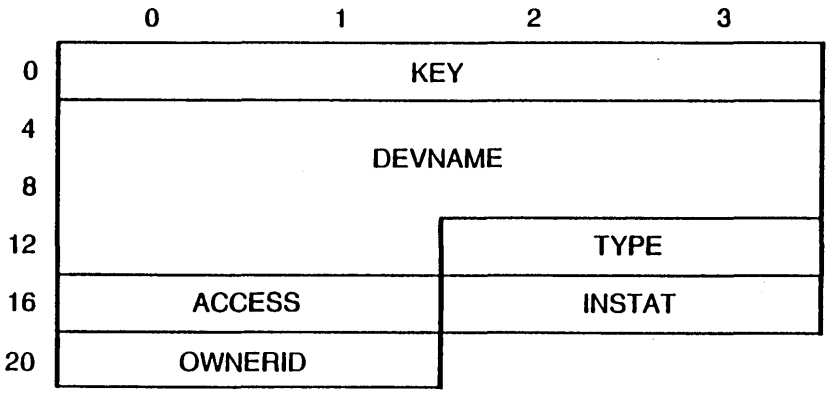
Use SET to change the cursor position and the screen and keyboard modes.

8.3 DEVICE Table

Number	GET?	SET?	LOOKUP?
45H	No	No	Yes

ID: none
Key: Key value assigned by resource manager

This table describes a physical device. Each device installed has a DEVICE table. All fields are read-only.



22 = Length in bytes

- **KEY:** Key field for LOOKUP
- **DEVNAME:** 10-byte device name
- **TYPE:** Type of device

  0xH - Kernel drivers
  2xH - Disk drivers
  3xH - Console drivers
  5xH - Extension drivers
  6xH - Network drivers
  7xh - Miscellaneous drivers
  80-FFH - Special drivers

- **ACCESS**: Access modes

  bit 0 1 = Delete allowed
  0 = Delete not allowed

  bit 1 Reserved

  bit 2 1 = Raw write allowed
  0 = Raw write not allowed

  bit 3 1 = Raw read allowed
  0 = Raw read not allowed

  bit 4 1 = Shared access allowed
  0 = Exclusive access only

  bit 5 1 = Removeable device
  0 = Permanent device

  bit 6 1 = Device lock (DEVLOCK) allowed
  0 = Device lock not allowed

  bit 7 1 = Shared access only
  0 = Exclusive access allowed

  bit 8* 1 = Device partitions allowed
  0 = Device partitions not allowed

  bit 9* 1 = Verify disk writes
  0 = Do not verify disk writes

  bits 10-15 reserved

  * Applicable to disk devices only.

- **INSTAT:** Installation status

  0x00 - Not installed
  0x01 - Requires subdriver
  0x02 - Owned by the Miscellaneous Resource Manager
  0x03 - Owned by another driver

- **OWNERID:** Significant 16 bits of the key field of the owner's DEVICE table entry. Use this value with a LOOKUP to find the driver that owns this subdriver. This field is only valid when INSTAT has a value of 0x03.

The DEVNAME, TYPE, ACCESS, and KEY values are established when the device is installed and do not change. The ACCESS flags override conflicting requests made by programs when they open the device.

The INSTAT and OWNERID values are also static except for subdrivers assigned to different drivers. In this case, the current values are subject to change as the driver is linked and unlinked to different owners.

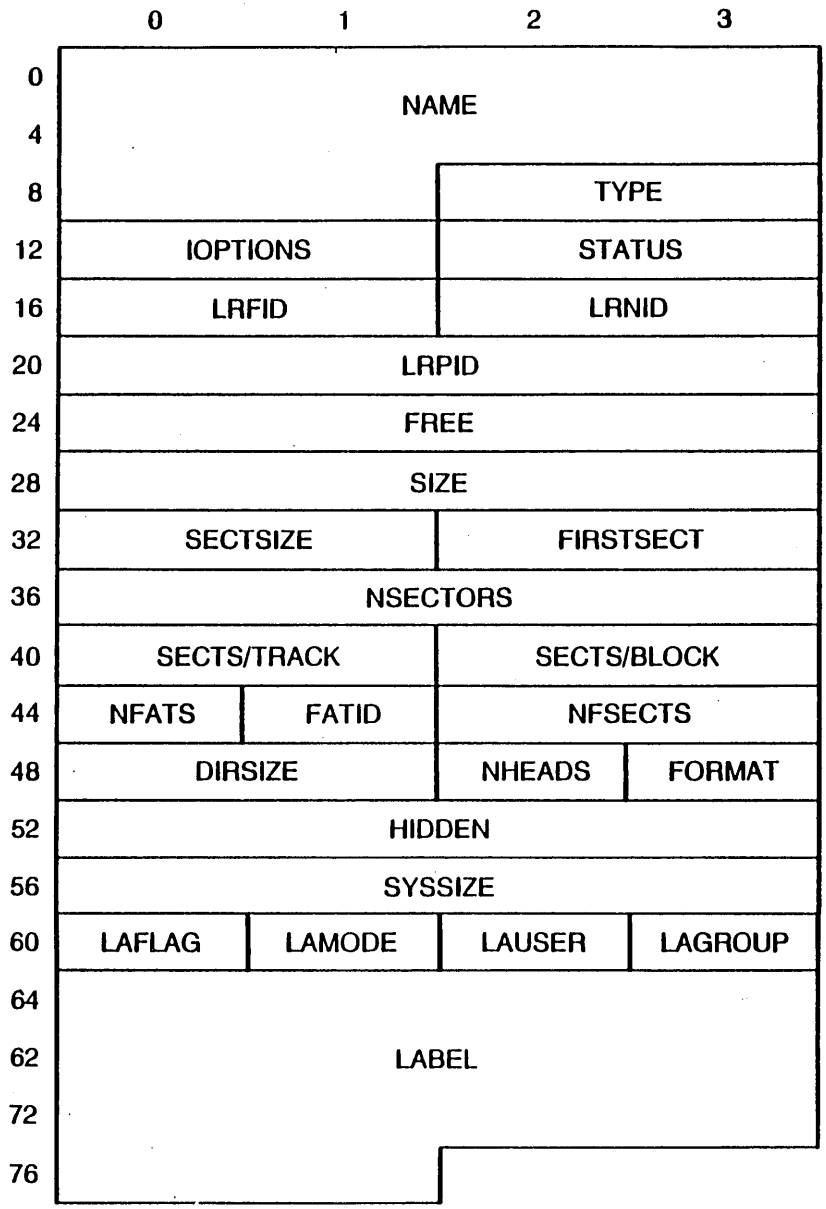
You must use the LOOKUP SVC to get DEVICE tables. Wildcards can be used in the LOOKUP device name specification.

8.4 DISK Table

Number	GET?	SET?	LOOKUP?
21H	Yes	Yes	No

ID: File number returned by OPEN
Key: none

The DISK table describes a disk driver. All fields are read-only except the label options.



78 = Length in bytes

- **NAME:** Disk device driver name
- **TYPE:** Media type

  bit 0: 1 = Removable media
  0 = Permanent media

- **IOPTIONS:** Install options

  bit 0: 1 = Set allowed
  0 = Set not allowed

  bit 1: Reserved

  bit 2: 1 = Raw write allowed
  0 = Raw write not allowed

  bit 3: 1 = Raw read allowed
  0 = Raw read not allowed

  bit 4: Reserved

  bit 5: 1 = Removable device driver
  0 = Permanent device driver

  bit 6: 1 = DEVLOCKs allowed
  0 = DEVLOCKs not allowed

  bit 7: Reserved

  bit 8: 1 = Partitioned disk driver
  0 = Non-partitioned disk driver

  bit 9: 1 = Verify after writes
  0 = Do not verify after writes

- **STATUS:** Disk status

  bit 0: 1 = Disk locked to process
  0 = Disk not locked to process

  bit 1: 1 = Disk locked to family
  0 = Disk not locked to family

  bit 2: 1 = Disk opened for exclusive access
  0 = Disk not opened for exclusive access

  bit 3: 1 = Disk currently in use by other processes
  0 = Disk not currently in use by other processes

  bit 4: 1 = Disk currently in use by processes in other families
  0 = Disk not currently in use by processes in other families

  bit 5: 1 = Disk activated for file system access
  0 = Disk not activated

  bit 6: 1 = File system files currently open
  0 = No open file system files

- **LRFID:** Family ID of locking process
- **LRNID:** Network node ID of locking process
- **LRPID:** Process ID of locking process
- **FREE:** Number of bytes of free space on disk/partition
- **SIZE:** Size in bytes of total file space on disk/partition
- **SECTSIZE:** Sector size in bytes
- **FIRSTSEC:** First sector of logical media
- **NSECTORS:** Number of sectors on disk
- **SECTS/TRACK:** Number of sectors per track
- **SECTS/BLOCK:** Number of sectors per block
- **NFATS:** Number of File Allocation Tables (FATs)

- **FATID:** Implementation-dependent value indicating media format
- **NFSECTS:** Number of sectors per FAT
- **DIRSIZE:** Maximum number of directory entries in root directory
- **NHEADS:** Number of heads on disk
- **FORMAT:** FAT format

  0 - Raw
  1 - 1 1/2 byte FATs
  2 - 2 byte FATs

- **SYSSIZE:** Size of system area in bytes
- **HIDDEN:** Number of hidden sectors on partitioned' disk
- **LAFLAG:** Label flag

  0 - Label does not exist on media
  1 - Label exists
  2 - Return device error on attempts to read label

- **LAMODE (R/W):** Label mode

  bit 0: 1 = File security enabled
  0 = No file security

  bit 1: 1 = Upper and lower case file names
  0 = Upper case file names only

- **LAUSER (R/W):** Label maker's User ID
- **LAGROUP (R/W):** Label maker's Group ID
- **LABEL (R/W):** 11-character label (also referred to as volume) name. Bytes 12 through 14 in LABEL data block are ignored. The name does not need to be null-terminated.

Most of the DISK table's read-only fields are static. The exceptions are:

- STATUS which changes as processes lock, unlock, open, and close files.
- FREE and DIRSIZE which increase and decrease as files are removed and added.
- LRFID, LRNID, and LRPID which change with each change in the locking process.

Use the file number returned by OPEN as the ID in your GET and SET calls.

All of the label-related fields are read/write. However, once they have been set, only the superuser (user and group IDs 0) or the original label setter can make any changes.

8.5 DISKFILE Table

Number	GET?	SET?	LOOKUP?
20H	Yes	Yes	Yes

ID: File number returned by CREATE or OPEN
Key: Key number assigned by resource manager

The DISKFILE table describes a disk file. The disk file must be open before you can GET its table. To SET values in the table, the calling process must have the same USER and GROUP IDs or have GROUP and USER numbers 0. Files do not need to be open for the LOOKUP SVC. LOOKUP flag bits determine the type of file to search for and are used as follows:

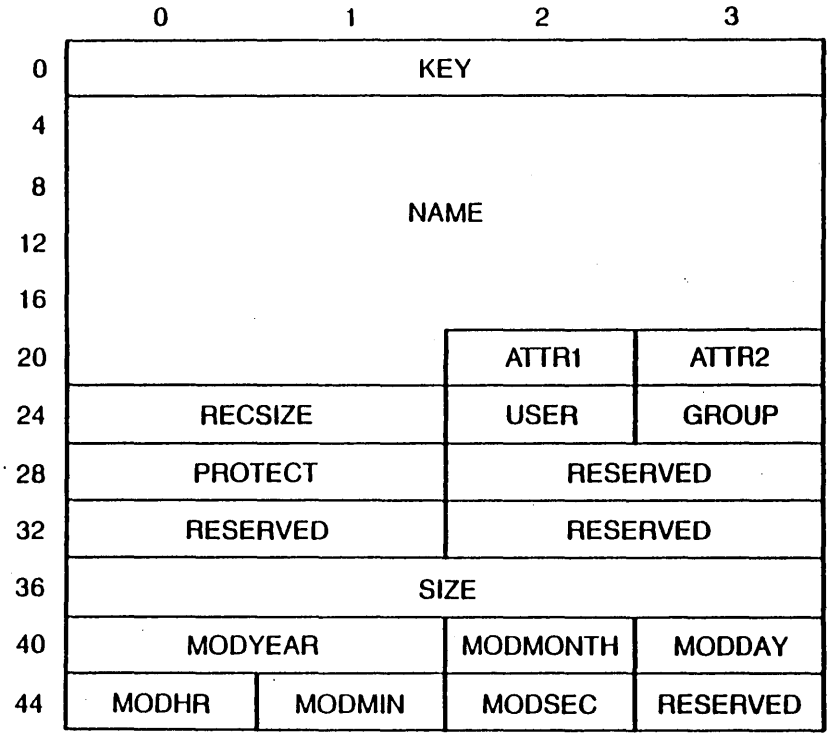
bit 0: 1 - Include HIDDEN files
0 = Exclude HIDDEN files

bit 1: 1 = Include SYSTEM files
0 = Exclude SYSTEM files

bit 2: 1 = Include VOLUME label
0 = Exclude VOLUME label

bit 3: 1 = Include directories
0 = Exclude directories

bit 4: 1 = Exclude normal files
0 = Include normal files



- **KEY:** Key field for LOOKUP
- **NAME:** Disk file name

- **ATTR1 (R/W)**: The sum of the following file attributes:

  01H Read-only
  02H Hidden
  04H System
  08H Volume label
  10H Subdirectory
  20H Archive attribute
  40H Reserved
  80H Reserved

- **ATTR2 (R/W)**: The sum of the following file attributes:

  01H Security enabled (label only)
  02H Disk supports uppercase and lowercase file names (if not set, disk supports uppercase file names only)

  04H through 80H are reserved.

- **RECSIZE**: Record size
- **USER (R/W**)**: User ID of owner
- **GROUP (R/W**)**: Group ID of owner
- **PROTECT (R/W)**: File Security Word
- **SIZE**: File size
- **MODYEAR (R/W)**: Year of last modification
- **MODMONTH (R/W)**: Month of last modification (1 - 12)
- **MODDAY (R/W)**: Day of last modification (1 - 31)
- **MODHR (R/W)**: Hour of last modification (0 - 23)
- **MODMIN (R/W)**: Minute of last modification (0 - 59)
- **MODSEC (R/W)**: Second of last modification (0 - 59)

** These fields are read/write to a superuser only.

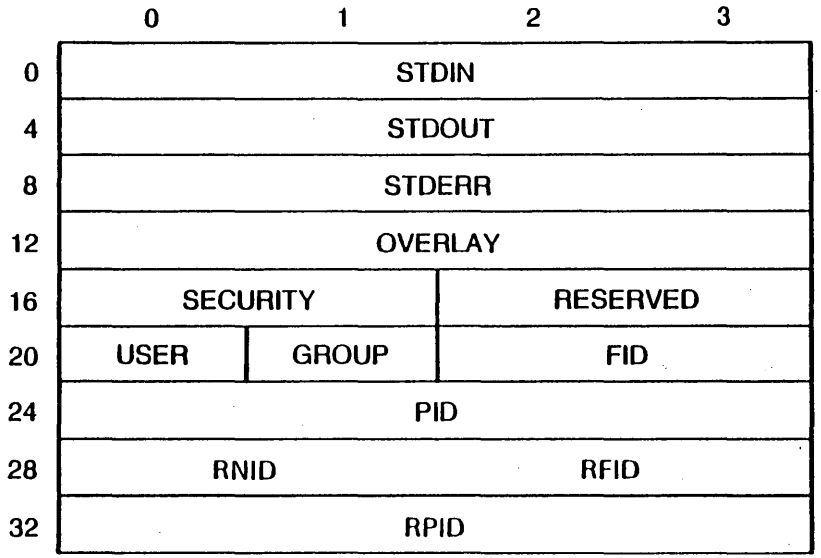
All DISKFILE values are set and updated by the Disk Resource Manager. This does not preclude setting these values yourself. However, you should exercise caution when modifying the attributes and record size.

8.6 ENVIRON Table

Number	GET?	SET?	LOOKUP?
1H	Yes	Yes	No

ID: 0
Key: none

The ENVIRON and PROCESS tables describe the calling process's environment. Although there is some overlap between the two, the standard input, output, error, and overlay file numbers, file security word, and requester node numbers are unique to the ENVIRON table.



36 = Length in bytes

- **STDIN (R/W):** Process's standard input file number
- **STDOUT (R/W):** Process's standard output file number
- **STDERR (R/W):** Process's standard error file number

- **OVERLAY (R/W)**: Current program's file number
- **SECURITY (R/W)**: Default file security word for CREATE
- **USER (R/W**)**: Current User ID
- **GROUP (R/W**)**: Current Group ID
- **FID**: Calling process's family ID
- **PID**: Calling process's ID
- **RNID (R/W*)**: Requester process's remote node ID
- **RFID (R/W*)**: Requester process's family ID
- **RPID (R/W*)**: Requester process's process ID

**These fields are read/write for a superuser only.

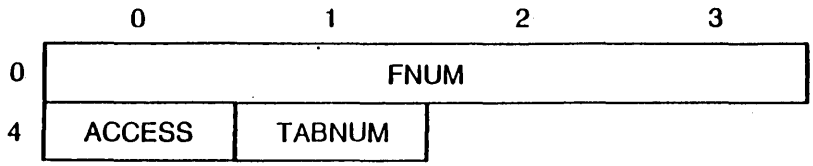
The RNID, RFID and RPID fields are used by network server processes only. See the FlexNet Network Operating System OEM and Programmer's Guide for the description of their use.

8.7 FILNUM Table

Number	GET?	SET?	LOOKUP?
41H	Yes	No	Yes

ID: File number returned by CREATE or OPEN
Key: File number returned by CREATE or OPEN

The FILNUM table provides the table number for a given file number. For example, the Console Resource Manager returns the VCONSOLE table number when you GET the FILNUM table for a virtual console file.



6 = Length in bytes

- **FNUM:** File number and key field for LOOKUP
- **ACCESS:** Access privileges returned from OPEN call

  bit 0: 1 = Delete/set access
  0 = No delete/set access

  bit 1: 1 = Execute access
  0 = No execute access

  bit 2: 1 = Write access
  0 = No write access

  bit 3: 1 = Read access
  0 = No read

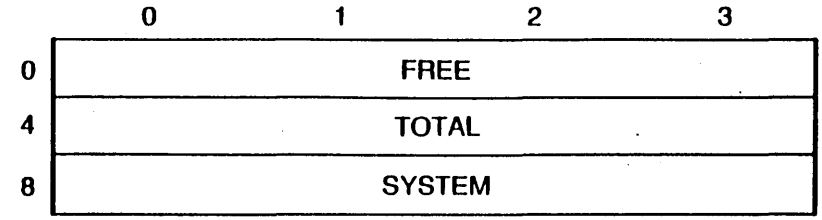
- **TABNUM:** table number for that type of file's table

8.8 MEMORY Table

Number	GET?	SET?	LOOKUP?
3H	Yes	No	No

ID: 0
Key: none

The MEMORY table indicates the system memory usage. The FREE and SYSTEM values change as processes use and release memory and the resource managers take up transient program area.



12 = Length in bytes

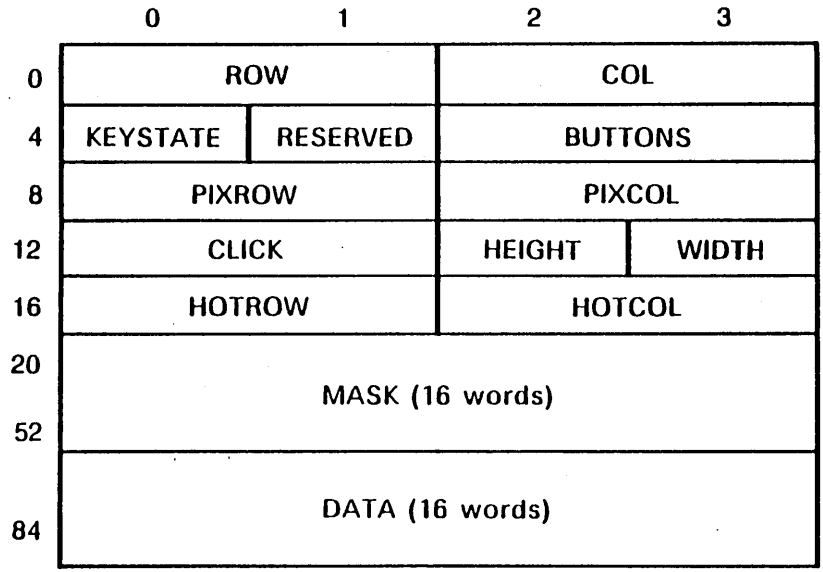
- **FREE:** Total free memory in bytes
- **TOTAL:** Total memory in bytes
- **SYSTEM:** Size of system memory in bytes

8.9 MOUSE Table

Number	GET?	SET?	LOOKUP?
33H	Yes	Yes	No

ID: File number returned by OPEN
Key: none

The MOUSE table describes a pointing device. Every installed pointing device has a MOUSE table. The initial values are set by the driver and you can set all of them except for the PIXROW and PIXCOL.



- **ROW (R/W):** Current row position of mouse
- **COL (R/W):** Current column position of mouse

- **KEYSTATE:** Keyboard state of the right Shift, left Shift, Control, and Alt keys

  Bit 0 right Shift key
  Bit 1 left Shift key
  Bit 2 Control key
  Bit 3 Alt key

  0 - up position
  1 - down position

- **PIXROW:** Number of mickeys per pixel for rows
- **PIXCOL:** Number of mickeys per pixel for columns
- **CLICK (R/W):** Click interval in milliseconds
- **HEIGHT (R/W):** Height of mouse form
- **WIDTH (R/W):** Width of mouse form
- **HOTROW (R/W):** Hot row of mouse form
- **HOTCOL (R/W):** Hot column of mouse form
- **MASK (R/W):** On a bit map screen, a 16 x 16 pixel rectangle that masks the effect of the DATA rectangle.
- **DATA (R/W):** On a bit map screen, a 16 x 16 pixel rectangle to "BLT" to the screen given the mask.

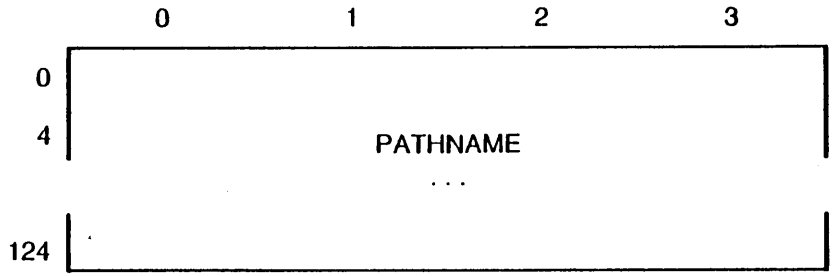
The ROW and COL values are updated by the Console Resource Manager to indicate the current mouse location. You can, however, set these values to move the mouse form to a location without device input. The HEIGHT and WIDTH values have a maximum value of 4, but can be less. If either is less, the length of the MASK and DATA fields is not affected.

8.10 PATHNAME Table

Number	GET?	SET?	LOOKUP?
46H	No	No	Yes

ID: none
Key: none

The PATHNAME table contains the fully-expanded path name for a defined symbol. LOOKUP is the only way to retrieve a PATHNAME table; you cannot SET or GET a PATHNAME.



128 = Length in bytes.

The PATHNAME table consists of a single 128 byte field. Only one path is ever returned when you lookup a defined symbol. If the symbol specified starts with a defined name, the prefix is substituted for the symbol. If the first name in the prefix is itself a defined symbol, the substitution is made again. The search and substitute routine is repeated until no prefix is found for the starting name.

The SYSDEF and PROCDEF tables are searched when you lookup the PATHNAME table. (DEFINE only looks in one or the other.) These tables are searched for the first name in the specification only.

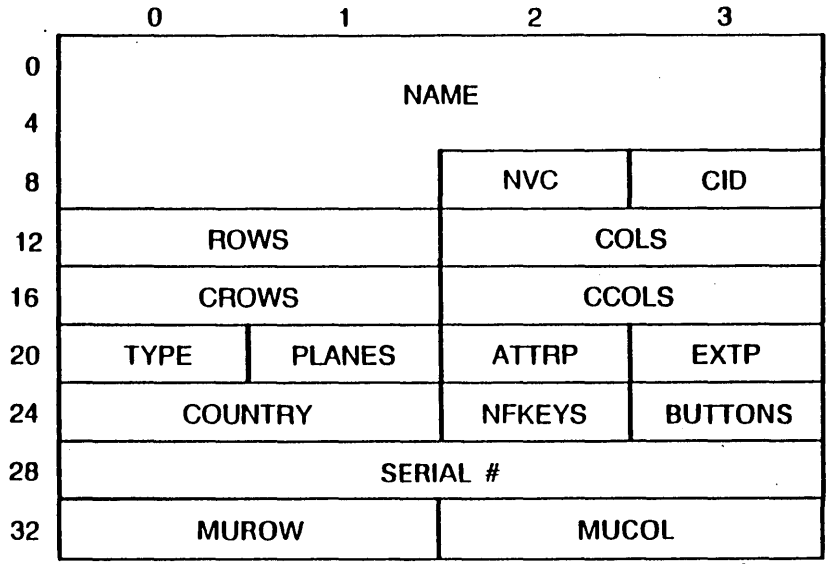
Wildcard characters can be used but they are not expanded; for example, as asterisk is interpreted only as an asterisk.

8.11 PCONSOLE Table

Number	GET?	SET?	LOOKUP?
31H	Yes	Yes	No

ID: File number returned by OPEN
Key: none

The PCONSOLE table describes a physical console device. Each console installed has its own PCONSOLE table. All parameters are read-only except the country code.



36 = length in bytes

- **NAME:** Console device name
- **NVC:** Current number of virtual consoles
- **CID:** Physical console ID number

- **ROWS:** On graphic console devices, this is the number of rows of pixels. On character console devices, this is the number of character rows and is the same as CROWS.
- **COLS:** On graphic console devices, this is the number of pixels in a row. On character console devices, this is the number of character columns and is the same as CCOLS.
- **CROWS:** The number of rows of characters
- **CCOLS:** The number of columns of characters
- **TYPE:** Type of console

  bit 0: 1 = Graphics capability
  0 = Character only

  bit 1: 1 = No numeric keypad
  0 = Keypad

  bit 2: 1 = Mouse supported
  0 = No mouse supported

  bit 3: 1 = Color
  0 = Black and white

  bit 4: 1 = Memory-mapped video
  0 = Serial device

  bit 5: 1 = Currently in graphics mode
  0 = Currently in character mode

- **PLANES:** Planes supported

  Bit 0: 1 = Character plane supported
  0 = No character plane

  Bit 1: 1 = Attribute plane supported
  0 = No attribute plane

  Bit 2: 1 = Extension plane supported
  0 = No extension plane

- **ATTRP:** Bit map of attribute plane bits supported
- **EXTP:** Bit map of extension plane bits supported
- **COUNTRY (R/W):** Country code; in applications that support multiple character sets, use this value to select a specific set. Appendix C lists the country codes.
- **NFKEYS:** Number of function keys supported
- **BUTTONS:** Number of mouse buttons supported
- **SERIAL #** Mouse serial number
- **MUROW** Mouse sensitivity in mickey units per row
- **MUCOL** Mouse sensitivity in mickey units per column

The PCONSOLE values are set by the driver. The Console Resource Manager updates the NVC value as you create and delete virtual consoles on this console.

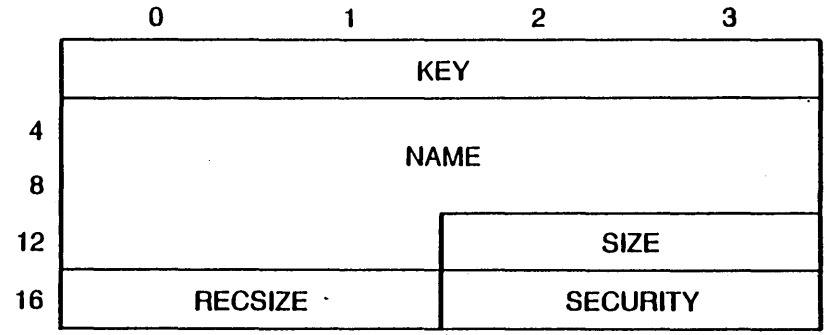
To GET and SET a PCONSOLE table (LOOKUP cannot be used), OPEN the device and use the file number returned as the GET and SET ID number. In your OPEN call, the only access mode flag bit you can set is bit 0 and you only need set it if you want to change the country code.

8.12 PIPE Table

Number	GET?	SET?	LOOKUP?
10H	Yes	No	Yes

ID: File number returned by CREATE or OPEN
Key: Key number assigned by resource manager

The PIPE table describes a pipe. All fields are set when you create the pipe and are read-only.



20 = Length in bytes

- **KEY:** Key field for LOOKUP
- **NAME:** 10-byte pipe name
- **SIZE:** Internal buffer size of pipe
- **RECSIZE:** Record size
- **SECURITY:** File security word

You can retrieve a pipe table with GET or LOOKUP. Use the the file number returned when you CREATEd or OPENed the pipe as your GET ID number. In a LOOKUP call, use the pipe name.

8.13 PORT Table

Number	GET?	SET?	LOOKUP?
81H	Yes	Yes	No

ID: File number returned by OPEN
Key: None

	0	1	2	3
0	TYPE		STATE	
4	BAUD	MODE	CONTROL	RESERVED

8 = Length in bytes

- **TYPE:** Type of port
  - 0 = Undefined
  - 1 = Standard serial driver
  - 2 = Character I/O device
  - 4 = Standard parallel driver
- **STATE (R/W):** Current state of port
  - 0 = Transmit enable
  - 1 = Character has been received
  - 2 = Change in Data Set Ready or Data Carrier Detect
  - 3 = Parity error
  - 4 = Overrun error
  - 5 = Framing error
  - 6 = Carrier present (Data Carrier Detect)
  - 7 = Data Set Ready (DSR) active

- **BAUD (R/W):** A value selecting the baud rate

0 = 50 baud	6 = 600 baude	12 = 4800 baud
1 = 75 baud	7 = 1200 baud	13 = 7200 baud
2 = 110 baud	8 = 1800 baud	14 = 9600 baud
3 = 134.5 baud	9 = 2000 baud	15 = 19200 baud
4 = 150 baud	10 = 2400 baud	
5 = 300 baud	11 = 3600 baud	

- **MODE (R/W):** Bit-mapped description of the word length, parity and stop bits

Value	Bits 0-1 Bits/word	Bits 2-3 Stop Bits	Bits 4-5 Parity
0	5	None	None
1	6	1	Odd
2	7	1.5	
3	8	2	Even

- **CONTROL (R/W):** Bit-mapped description of serial port control parameters

  0 = Enable character transmission
  1 = Force Data Terminal Ready low
  2 = Enable character reception
  3 = Force break signal
  4 = Reset error
  5 = Force Request to Send low

Use the GET and SET SVCs to retrieve and set PORT table values. The ID is the file number returned when the device was opened. When the port is a subdriver, you cannot access the table directly with GET or SET. Instead, use SPECIAL functions 13H and 93H, respectively.

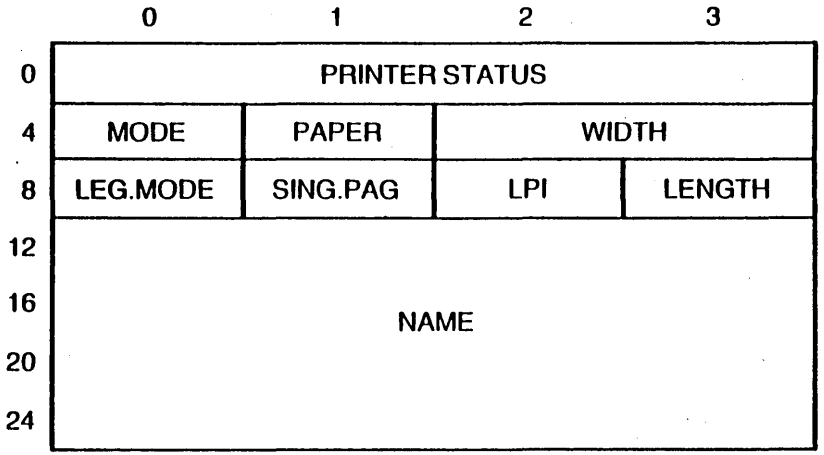
For standard parallel drivers, the STATE, BAUD, MODE, and CONTROL fields are meaningless.

8.14 PRINTER Table

Number	GET?	SET?	LOOKUP?
71H	Yes	Yes	No

ID: File number returned by OPEN
Key: None

The PRINTER table describes an installed printer driver. The printer driver may drive the physical I/O port directly or require a subdriver to conduct character I/O. For all bit maps in this table, the least significant bit is rightmost.



28 = Length in bytes

- **PRINTER STATUS:** Bit map indicating current status; bits are assigned as follows:

Bit	Set Definition	Bit	Set Definition
0	Off line	4	Illegal mode requested
1	Out of paper	5	Framing error
2	Select error	6	Internal buffer full
3	Initialization error	7	Waiting for XON

- **MODE (R/W):** A bit map used to select the current typeface; the bits are assigned as follows:

Bit	Typeface Selected	Bit	Typeface Selected
0	Boldface	4	Superscript
1	Graphics	5	Condensed
2	Italic	6	Elongated
3	Subscript	7	Letter quality

- **PAPERTYP (R/W):** A bit map indicating the current paper type; the default is 8 1/2 x 11. The bits are assigned as follows:

Bit	Paper Type
0	Wide paper
1	Letterhead
2	Labels

- **WIDTH (R/W):** Width of paper in columns for all modes except graphics; in dots if graphics mode.
- **LENGTH (R/W):** Length of paper in lines
- **LEG.MODE:** Bit map of modes available; bit assignments are the same as MODE above.
- **SING.PAG (R/W):** Single-page paper feed select; non-zero when single-page feed mechanism selected.
- **LPI (R/W):** Number of lines printed per inch
- **NAME:** 16-byte field for the brand and mode of the printer in ASCII.

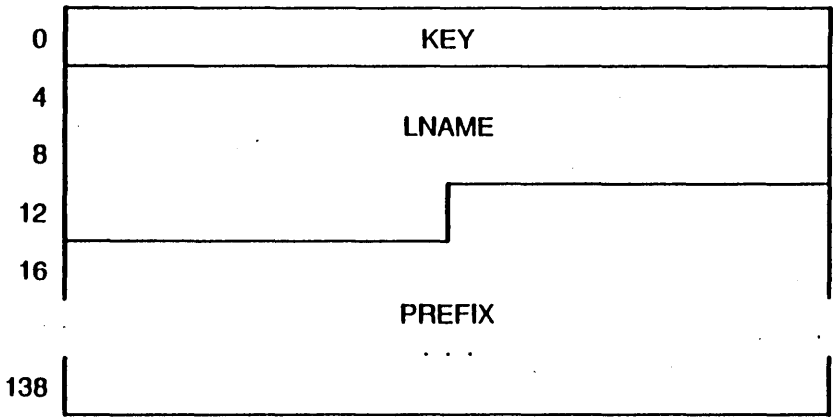
To retrieve a PRINTER table, use the file number returned when the device was opened as the GET ID number.

8.15 PROCDEF Table

Number	GET?	SET?	LOOKUP?
43H	No	No	Yes

ID: none
Key: Key number assigned by resource manager

The PROCDEF table shows the prefix defined for a logical name by the calling process. The LNAME and PREFIX fields are set by the DEFINE call; the key value is set by the resource manager when the name is defined. All fields are read-only.



142 = Length in bytes

- **KEY** Key field for LOOKUP.
- **LNAME:** 10-byte, null terminated logical name string
- **PREFIX:** 128-byte, null terminated prefix substitution string

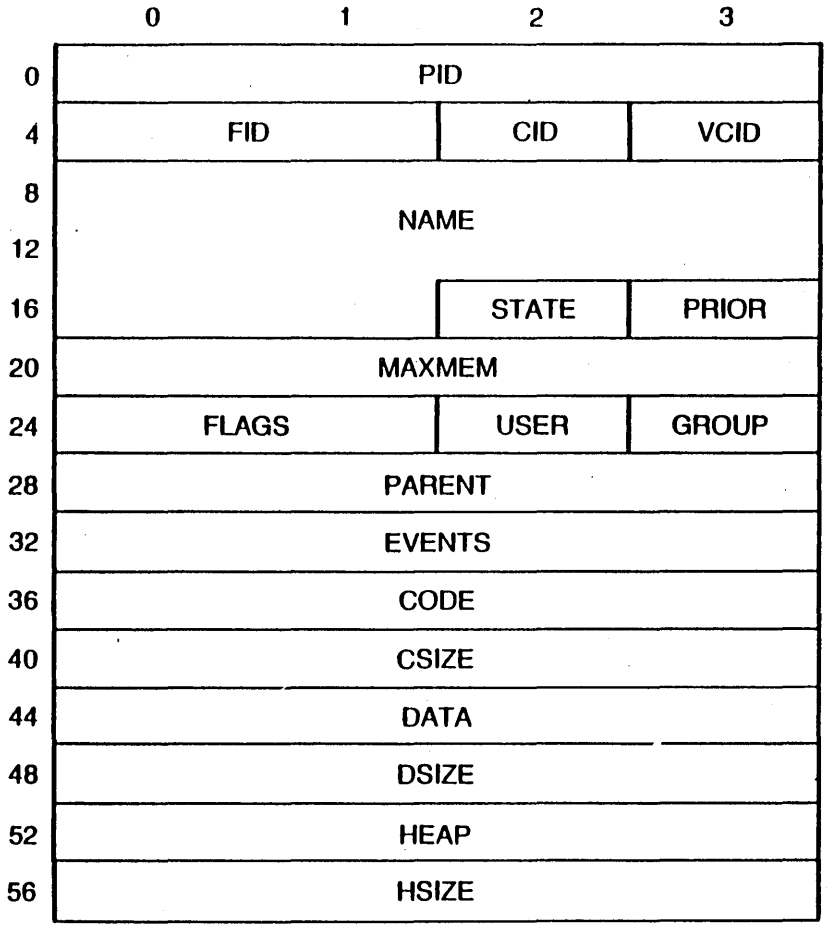
Use LOOKUP to get a PROCDEF table. Use the logical name (wildcards can be used) or key value to specify a table. The maximum name and prefix length is 9 and 127 characters, respectively; the null character is always included in the specification.

8.16 PROCESS Table

Number	GET?	SET?	LOOKUP?
0H	Yes	Yes	Yes

ID: Process ID
Key: Process ID

The PROCESS and ENVIRON tables combine to describe a process's environment. The PROCESS table values are set when the process is created (see the COMMAND SVC description) and maintained by the resource managers. All values are read-only except the priority. This value can be set by a process with the same USER and GROUP numbers or USER and GROUP numbers 0.



60 = Length in bytes

- **PID:** Process ID
- **FID:** Process's family ID
- **CID:** Physical console device number
- **VCID:** Process's virtual console number--only filled after console is opened
- **NAME:** Process name
- **STATE:** Process state

  0 - Run
  1 - Waiting
  2 - Terminating

- **PRIOR (R/W):** Priority
- **MAXMEM** Maximum memory allowed
- **FLAGS:**

  bit 0: 1 = System process
  0 = User process

  bit 1: 1 = Locked in memory
  0 = Swappable

  bit 2: 1 = Running in SWI context
  0 = Running in main context

  bit 3: 1 = Originally a privileged process[1]
  0 = Not originally a privileged process

- **USER:** User number
- **GROUP:** Group number

[1] A privileged process, also called a superuser, is one with USER and GROUP numbers 0.

- **PARENT:** Parent process ID
- **EVENTS:** Bit map of events that have completed but whose return values have not been retrieved.
- **CODE:** Start of code area in user space
- **CSIZE:** Size in bytes of code area
- **DATA:** Start of data area in user space
- **DSIZE:** Size in bytes of data area
- **HEAP:** Start of heap area in user space[2]
- **HSIZE:** Size in bytes of most recently allocated heap area

Use the process ID as the ID in GET and SET calls and as the key value in LOOKUP calls. You can also use the process NAME with LOOKUP. A process ID of 0 selects the calling process.

[2]Information passed to the process in the COMMAND SVC is stored at this location.

8.17 SPECIAL Table

Number	GET?	SET?	LOOKUP?
82H-FFH	Yes	Yes	No

ID: File number returned by OPEN
Key: Key number assigned by resource manager

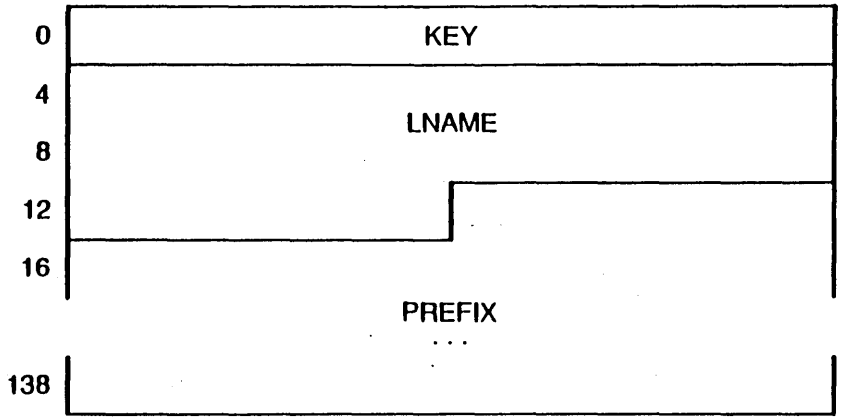
SPECIAL tables describe special devices installed. The format and size of a SPECIAL table is defined by the OEM and set by the device driver. There are two rules, however, for all SPECIAL tables: the first word indicates the size of the table and table number is the same number as the device type.

8.18 SYSDEF Table

Number	GET?	SET?	LOOKUP?
42H	No	No	Yes

ID: none
Key: Key number assigned by resource manager

The SYSDEF table describes the system's logical names. Logical name assignments are made with the DEFINE SVC by privileged (USER and GROUP numbers are 0) processes. Privileged processes can also change existing assignments.



142 = Length in bytes

- **KEY:** Key field for LOOKUP.
- **LNAME (R/W):** 10-byte, null terminated Logical name string.
- **PREFIX (R/W):** 128-byte, null terminated prefix substitution string.

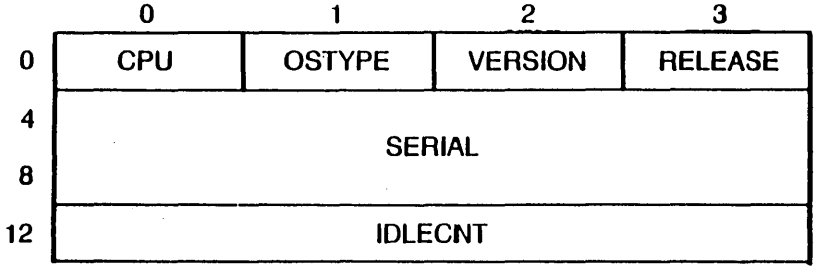
Use LOOKUP to get a SYSTEM table. Use the logical name or key value to specify a table. The maximum name and prefix length is 9 and 127 characters, respectively; the null character is always included in the specification.

8.19 SYSTEM Table

Number	GET?	SET?	LOOKUP?
40H	Yes	Yes	No

ID: 0
Key: none

The SYSTEM table describes the CPU and operating system. All fields are read-only except the IDLECNT. This field is read-write to processes with USER and GROUP numbers 0 only.



16 = Length in bytes

- **CPU:** Type of CPU

  1 - Intel 8080
  2 - Intel 8085
  3 - Zilog Z80
  4 - Intel 8086
  5 - Zilog Z8000
  6 - Motorola 68000
  7 - Motorola 68010
  8 - Motorola 68020
  9 - Intel 80286
  10 - Intel 80386
  11 - Intel 80186
  12 - 255 Reserved

- **OSTYPE:** Type of Operating System

  0 FlexOS
  1-255 Reserved

- **VERSION:** Operating system version number

- **RELEASE:** Release level of version
- **SERIAL:** 8-byte, operating system serial number
- **IDLECNT (R/W for privileged user only):** CPU System idle count

IDLECNT is a value incremented by the CPU when no process is running. Monitor CPU utilization by setting this value to 0 and after a known period of time, GETting the count.

8.20 TIMEDATE Table

Number	GET?	SET?	LOOKUP?
2H	Yes	Yes	No

ID: 0
Key: none

The TIMEDATE table contains the system time of day. All fields are read/write except WEEKDAY. The time is maintained by the kernel once the starting is set. Use SET to establish the starting time.

	0	1	2	3
0	YEAR		MONTH	DAY
4	TIME			
8	TIMEZONE		WEEKDAY	RESERVED

12 = Length in bytes

- **YEAR (R/W):** Year; a literal value (for example, 1987 = 1987)
- **MONTH (R/W):** Month; 1 - 12
- **DAY (R/W):** Day of the month; 1 - 31
- **TIME (R/W):** Number of milliseconds since midnight
- **TIMEZONE (R/W):** Minutes from Universal Coordinated Time
- **WEEKDAY:** Day of the week; 0 = Sunday, 6 = Saturday

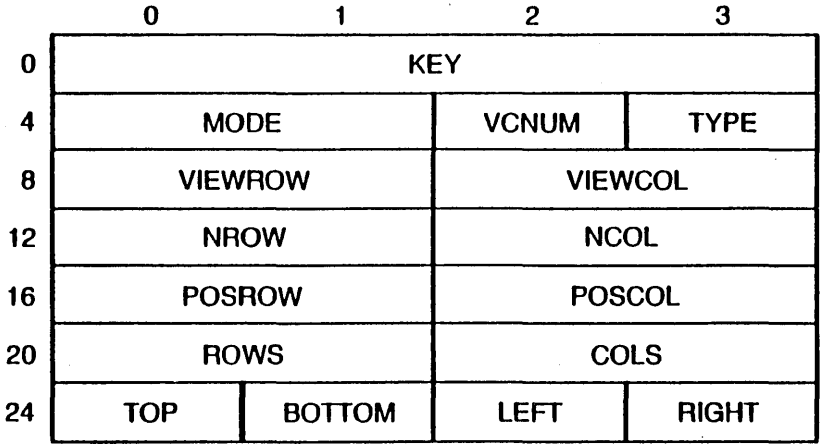
You use an ID value of 0 to GET and SET the TIMEDATE table.

8.21 VCONSOLE Table

Number	GET?	SET?	LOOKUP?
32H	Yes	Yes	Yes

ID: File number returned by CREATE
Key: VCNUM assigned when virtual console created

The VCONSOLE table describes a virtual console. Table values are established when you CREATE the console. Use read/write fields to modify window size, location on the virtual console, and placement on the parent console.



28=Length in bytes

- **KEY:** Key field for LOOKUP

- **MODE (R/W):** Window mode

  bit 0: 1 = Freeze borders
  0 = Synchronize borders (See Note 1, below)

  bit 1: 1 = Allow auto view change (See Note 2, below)
  0 = Keep view fixed

  bit 2: 1 = Keep cursor on edge on auto view change
  0 = Center cursor on auto view change

  bit 3: 1 = Auto view change on output
  0 = Auto view change on input

- **VCNUM:** Decimal virtual console number

- **TYPE:** Type of console.

  bit 0: 1 = Graphics capability
  0 = Character only

  bit 1: 1 = No numeric keypad
  0 = Keypad

  bit 2: Reserved

  bit 3: 1 = Color
  0 = Black and white

  bit 4: 1 = Memory-mapped video
  0 = Serial device

  bit 5: 1 = Currently in graphics mode
  0 = Currently in character mode

- **VIEWROW (R/W):** Row coordinate on the virtual console of window's upper lefthand corner

- **VIEWCOL (R/W):** Column coordinate on the virtual console of the window's upper lefthand corner

- **NROW (R/W)**: Number of character rows in the window
- **NCOL (R/W)**: Number of character columns in the window
- **POSROW (R/W)**: Row coordinate on parent console of window's upper lefthand corner
- **POSCOL (R/W)**: Column coordinate on parent console of window's upper lefthand corner
- **ROWS**: Number of character rows in the virtual console
- **COLS**: Number of character columns in the virtual console
- **TOP**: Height in character rows of the top border
- **BOTTOM**: Height in character rows of the bottom border
- **LEFT**: Width in character columns of the left border
- **RIGHT**: Width in character columns of the right border

Notes:

1. Use bit 0 to freeze a border so that intermediate states are not displayed when you make changes to the border file contents. Before you change the border file contents, set this bit. After you have completed the changes, reset the bit. Normally, keep this flag at 0 so that the borders change as you make changes to the window dimensions and location.
2. Bits 1 through 3 determine whether the window view changes to keep the cursor on-screen or the view remains fixed on the same virtual console coordinates regardless of cursor location. If the cursor leaves the window and bit 2 = 1, bit 3 determines whether the view changes when the cursor leaves the view (output) or when the application READs the keyboard.

Use the file number returned by the CREATE call to GET or SET the VCONSOLE table. Alternatively, use the key value in a LOOKUP call. Changes made to the VIEWROW, VIEWCOL, NROW, and NCOL immediately affect the shape and position of the window on the virtual console. Border files are automatically adjusted accordingly as well. Changes to POSROW and POSCOL are immediately reflected on the parent console.

End of Section 8

Character Sets and Escape Sequences

This appendix describes the Console Resource Manager's built-in escape sequences and character sets. The presentation begins with the description of the 8-bit escape sequences (a superset of the VT-52 escape sequences), continues with the description of the 16-bit output character set, and concludes with the description of the 16-bit input character set.

Output escape sequence decoding is only available with the WRITE SVC. You cannot use COPY or ALTER to output escape sequences.

The descriptions below cross-reference bits in the CONSOLE table's SMODE and KMODE fields. See Section 8, "System Tables," for the complete description of these fields.

A.1 Escape Sequences

You select escape sequence decoding to manipulate the screen display by setting bits 0 and 1 of the CONSOLE table's SMODE word to 0. Escape sequence decoding of keyboard input is selected by setting bits 3 and 4 of the CONSOLE Table's KMODE word to 0.

An escape sequence consists of at least two 8-bit characters, where the first is always an ESC (ASCII character 1B hex). The second character selects a function. Three functions require additional numeric values to select a foreground or background color or set the cursor position. Table A-1 lists the functions supported and the escape sequence that invokes it.

Table A-1. Escape Sequence Functions

ESC Sequence	Description
<ESC>A	**Cursor Up:** Move cursor up to beginning of previous line.
<ESC>B	**Cursor Down:** Move cursor down one line without changing column position.
<ESC>C	**Cursor Right:** Move cursor one character position right.
<ESC>D	**Cursor Left:** Move cursor one character position left.
<ESC>H	**Cursor Home:** Move cursor to first column of first line.
<ESC>I (uppercase i)	**Reverse Index:** Move cursor up one line without changing column position.
<ESC>j	**Save Cursor Position:** Store current cursor position for subsequent restore.
<ESC>k	**Restore Cursor Position:** Move cursor to position previously saved.
<ESC>Y(c_1)(c_2)	**Set Cursor Position:** Move cursor to specified coordinates; first character is the ASCII equivalent of the row number + 31D and second character is ASCII equivalent of column number + 31D.
<ESC>E	**Clear Display:** Erase entire screen and home cursor.
<ESC>J	**Erase to End of Display:** Erase from cursor to end of display.
<ESC>K	**Erase to End of Line:** Erase from cursor to end of line.

Table A-1. (Continued)

ESC Sequence	Description
<ESC>l (lowercase L)	**Erase Entire Line:** Erase current line contents.
<ESC>d	**Erase Beginning of Display:** Erase from beginning of display through cursor.
<ESC>o	**Erase Beginning of Line:** Erase from beginning of line through cursor.
<ESC>L	**Insert Blank Line:** Move current and all subsequent lines down one line; keep cursor on current line.
<ESC>M	**Delete Line:** Remove current line from display and add blank line at bottom.
<ESC>N	**Delete Character:** Remove character at cursor.
<ESC>b(n)	**Set Foreground Color:** Set character color for current cursor position where n is a decimal value that determines the color as follows: 0 - Black 1 - Blue 2 - Green 3 - Cyan 4 - Red 5 - Magenta 6 - Brown 7 - Light Gray 8 - Dark gray 9 - Light blue 10 - Light green 11 - Light cyan 12 - Light red 13 - Light magenta 14 - Yellow 15 - White

Table A-1. (Continued)

ESC Sequence	Description
<ESC>c(n)	**Set Background Color**: Set screen color for current cursor position where n is a decimal value that determines the color as follows: 0 - Black 1 - Blue 2 - Green 3 - Cyan 4 - Red 5 - Magenta 6 - Brown 7 - Light Gray 8 - 15 are the same as 0 - 7, except the foreground blinks.
<ESC>e	**Enable Cursor**: Show cursor.
<ESC>f	**Disable Cursor**: Remove cursor.
<ESC>p	**Enter Reverse Video Mode**: Swap foreground and background colors.
<ESC>q	**Exit Reserve Video Mode**: Return to original foreground and background color scheme.
<ESC>r	**Enter Intensify Mode**: Turn on the console's intensity option.
<ESC>u	**Exit Intensify Mode**: Turn off the console's intensity option.

Table A-1. (Continued)

ESC Sequence	Description
<ESC>s	**Enter Blink Mode:** Start character blinking for all characters.
<ESC>t	**Exit Blink Mode:** Stop character blinking.
<ESC>@	**Enter Insert Mode:** Insert subsequent characters from current cursor position, moving existing characters over; characters pushed off end of line are lost.
<ESC>O	**Exit Insert Mode:** Replace existing characters with characters entered.
<ESC>V	**Wrap at End of Line:** Automatically scroll cursor to beginning of next line when end of line reached.
<ESC>W	**Drop Characters at End of Line:** Ignore characters entered after end of line reached.

A.2 16-bit Output Character Set

When SMODE bit 2 is 1, the Console Resource Manager accepts 16-bit characters output with the WRITE SVC. Table A-2 defines the 16-bit output character set.

Table A-2. Output 16-bit Character Set

Range	Description
00xxH	Same as 8-bit; each character takes one character position in FRAME. Characters in the range 80H-FFH are defined on a per country basis.
01xxH - 0FxxH	Alternate character sets provided by the system implementer; each character takes one character position where the low byte is stored in the Character Plane and the low nibble of the high byte is stored in the low nibble of Extension Plane.
1xxxH	Non-visible characters (take no space).
2xxxH	Editing characters functionally equivalent to the VT-52 ESC sequences defined above: 2040 Enter insert character mode 2041 Cursor up 2042 Cursor down 2043 Cursor right 2044 Cursor left 2045 Clear display 2048 Cursor home 2049 Reverse index 204A Erase to end of display 204B Erase to end of line

Table A-2. (Continued)

Range	Description
	204C Insert blank line
	204D Delete line
	204E Delete character
	204F Exit insert character mode
	2064 Erase beginning of display
	2065 Enable cursor
	2066 Disable cursor
	206A Save cursor position
	206B Restore cursor position
	206C Erase entire line
	206F Erase beginning of line
	2070 Enter reverse video mode
	2071 Exit reverse video mode
	2072 Enter intensify mode
	2073 Enter blink mode
	2074 Exit blink mode
	2075 Exit intensify mode
	2076 Wrap at end of line
	2077 Discard at end of line
3xxxH	Set cursor to row xxx (0 origin)
4xxxH	Set cursor to column xxx (0 origin)
51xxH	Set background color to xx (see <ESC>c above)
52xxH - 7xxxH	Non-visible characters (take no space)
8000H - FCFCH	16-bit language; each character takes two character positions on FRAME (the corresponding Extension Plane bytes are modified to indicate byte order).

A.3 16-bit Input Character Set

When the CONSOLE table's KMODE bit 4 is 1, the Console Resource Manager accepts 16-bit characters input with the READ SVC. In a 16-bit character, the low byte contains the ASCII character code. The high byte is used as shown in Figure A-1. Table A-3 defines the 16-bit character set.

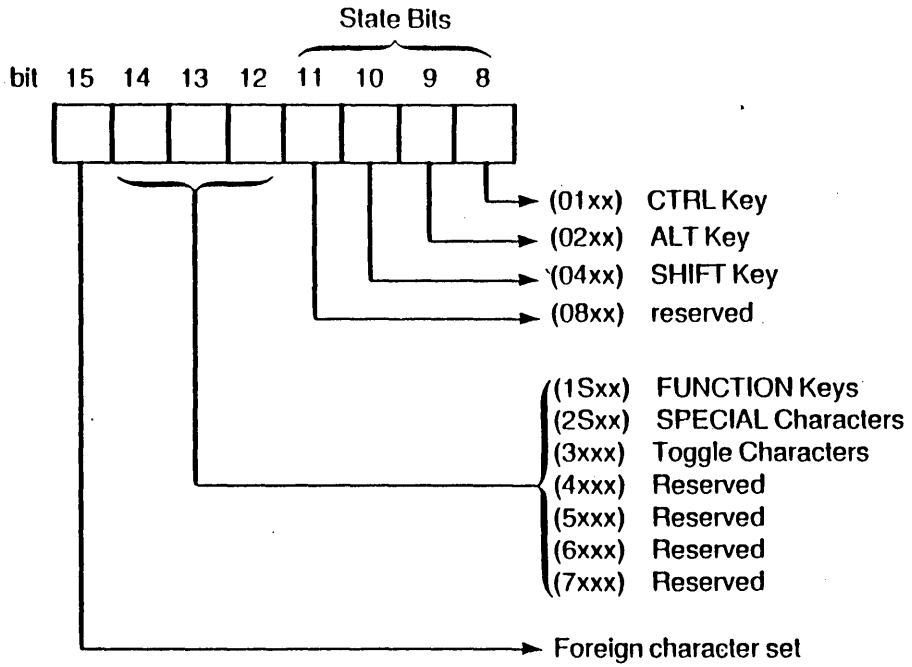


Figure A-1. High Byte Bit Usage of 16-bit Input Character

Table A-3 lists the 16-bit characters. The "S" in the table represents the value of CTRL, ALT and SHIFT state bits 8, 9, and 10. If these keys are depressed when another key is pressed, the corresponding bits come on. If the ASCII standard includes this character, the standard ASCII character is generated instead of the state value.

Table A-3. 16-bit Input Character Set

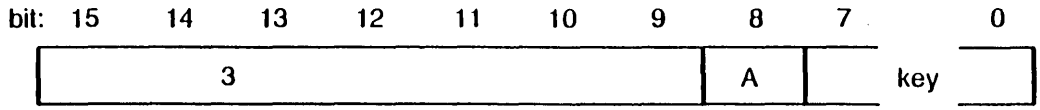
Range	Description	
0000 - 00FFH	ASCII character set	
1SxxH	Function keys	
2SxxH	Special keys defined as follows:	
	2S00	HELP
	2S01	WINDOW
	2S02	NEXT
	2S03	PREVIOUS
	2S04	PRINT SCREEN
	2S05	BREAK
	2S06	REDRAW (screen)
	2S07	BEGIN
	2S08	END
	2S09	INSERT
	2S0A	DELETE
	2S0B	SYS REQ
	2S10	Cursor up
	2S11	Cursor down
	2S12	Cursor left
	2S13	Cursor right
	2S14	Page up
	2S15	Page down
	2S16	Page left
	2S17	Page right
	2S18	Home
	2S19	Reverse tab

Table A-3. (Continued)

Range	Description
2S30	Numeric keypad 0
2S31	Numeric keypad 1
2S32	Numeric keypad 2
2S33	Numeric keypad 3
2S34	Numeric keypad 4
2S35	Numeric keypad 5
2S36	Numeric keypad 6
2S37	Numeric keypad 7
2S38	Numeric keypad 8
2S39	Numeric keypad 9
2S3A	Numeric keypad A
2S3B	Numeric keypad B
2S3C	Numeric keypad C
2S3D	Numeric keypad D
2S3E	Numeric keypad E
2S3F	Numeric keypad F
2S40	Numeric keypad ENTER
2S41	Numeric keypad COMMA
2S42	Numeric keypad MINUS
2S43	Numeric keypad PERIOD
2S44	Numeric keypad PLUS
2S45	Numeric keypad DIVIDE
2S46	Numeric keypad MULTIPLY
2S47	Numeric keypad EQUAL

Table A-3. (Continued)

Range	Description
3xxxH	Toggle character where xxx defines a toggle key as follows:



A - Action 0 - OFF
1 - ON

key
0 - Caps Lock
1 - Shift Lock
2 - Scroll Lock
3 - Num Lock
10 - Right Shift
11 - Left Shift
12 - Insert
13 - Control
14 - Alternate

When the user presses and releases keys 0 - 3 a single character is sent. For keys 10 - 14, a character is sent when the key is pressed and another is sent when it is released.

Toggle characters are only available if the hardware supports them.

Table A-3. (Continued)

Range	Description
4xxxH - 7xxxH	Reserved
8xxxH - FCxxH	15-bit Foreign language character sets including KANJI.

End of Appendix A

System Return and Error Codes

All FlexOS SVCs return 32 bit values. A negative number--the high order bit is set--indicates an error occurred. The remainder of the value is allocated as shown in Figure B-1.

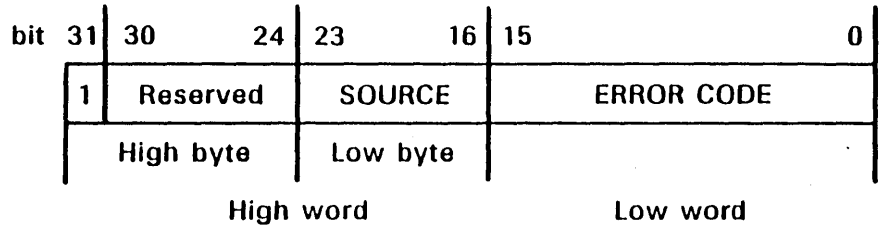


Figure B-1. Error Code Conventions

In the high order word, only the low byte is significant; the high byte is reserved. The low byte indicates the source of the error as indicated in Table B-1. By convention, operating system resource managers and modules have a zero-value in the low order nibble.

Table B-1. Error Source Codes--High Order Word

Value	Source
00H	Kernel or Supervisor
10H	Pipe Resource Manager
20H	Disk Resource Manager
21H - 2FH	Disk Drivers
30H	Console Resource Manager
31H - 3FH	Console Drivers
40H	Command/Load
50H	OEM Extension Resource Manager
51H - 5FH	OEM Extension Drivers
60H	Network Resource Manager
61H - 6FH	Network Drivers
70H	Miscellaneous Resource Manager
71H - 7FH	Miscellaneous Drivers
81H - FEH	Special Drivers

The low order word indicates the error condition. The codes are assigned in ranges of values again to indicate the source. Table B-2 lists the ranges and their corresponding source.

Table B-2. Low-order Word Error Code Ranges

Error Code Range	Source
0000 - 3FFF	Drivers
4000 - 407F	Errors Common to All Resource Managers
4080 - 40FF	Supervisor
4100 - 417F	Memory
4180 - 41FF	Kernel
4200 - 427F	Pipe and Miscellaneous Resource Managers
4280 - 42FF	Console System
4300 - 437F	File System
4400 - FFFF	Reserved

For the source of one of the common error codes, see the low byte in the high order word. The remaining tables in this appendix list define the error messages by their source. No error codes are currently associated with the Pipe, Console and Miscellaneous Resource Managers.

Table B-3. Driver Error Codes

Mnemonic	Code	Description
E_WPROT	0x00	Write protect violation
E_UNITNO	0x01	Illegal unit number
E_READY	0x02	Drive not ready
E_INVCMD	0x03	Invalid command issued
E_CRC	0x04	CRC error on I/O
E_BADPB	0x05	Bad parameter block
E_SEEK	0x06	Seek operation failed
E_UNKNOWNMEDIA	0x07	Unknown media present
E_SEC_NOTFOUND	0x08	Requested sector not found
E_DKATTACH	0x09	Attachment did not respond
E_WRITEFAULT	0x0A	Write fault
E_READFAULT	0x0B	Read fault
E_GENERAL	0x0C	General failure
E_RES1	0x0D	Reserved
E_RES2	0x0E	Reserved
E_RES3	0x0F	Reserved

Table B-4. Error Codes Shared by Resource Managers

Mnemonic	Code	Description
E_SUCCESS	0x0L	No Error
E_ACCESS	0x4001	Cannot access file--ownership differences
E_CANCEL	0x4002	Event Cancelled
E_EOF	0x4003	End of File
E_EXISTS	0x4004	File (CREATE) or device (INSTALL) exists
E_DEVICE	0x4005	Device does not match; for RENAME, on different devices
E_DEVLOCK	0x4006	Device is LOCKed
E_FILENUM	0x4007	Bad File Number
E_FUNCNUM	0x4008	Bad function number
E_IMPLEMENT	0x4009	Function not implemented
E_INFOTYPE	0x400A	Illegal Infotype for this file
E_INIT	0x400B	Error on driver initialization
E_CONFLICT	0x400C	Cannot access file due to current usage; for DELETE on open file or directory with files; for INSTALL, attempted replacement of driver in use
E_MEMORY	0x400D	Not enough memory available
E_MISMATCH	0x400E	Function mismatch--file does not support attempted function; for INSTALL, mismatch of subdrive type
E_NAME	0x400F	Illegal file name specified
E_NO_FILE	0x4010	File not found; for CREATE, device or directory does not exist
E_PARM	0x4011	Illegal parameter specified; for EXCEPTION, an illegal number
E_RECSIZE	0x4012	Record Size does not match request
E_SUBDEV	0x4013	INSTALL only: Sub-drive required
E_FLAG	0x4014	Bad Flag Number
E_EMEMACCESS	0x4015	Non-existent memory

Table B-4. (Continued)

Mnemonic	Code	Description
E_BOUNDS	0x4016	Memory bound error
E_EINSTRUCT	0x4017	Illegal instruction
E_EDIV0	0x4018	Divide by zero
E_EBOUNDEX	0x4019	Bound exception
E_OVERFLOW	0x401A	Overflow exception
E_PRIV	0x401B	Privilege violation
E_ETRACE	0x401C	Trace
E_EBREAK	0x401D	Breakpoint
E_EFLOAT	0x401E	Floating point exception
E_ESTACK	0x401F	Stack fault
E_EGENERAL	0x4020	General Exception

Table B-5. Supervisor and Memory Error Codes

Mnemonic	Code	Description
E_ASYNC	0x4080	Function does not allow asynchronous I/O
E_LOAD	0x4082	Bad load format
E_LOOP	0x4083	Infinite recursion (99 times) on prefix substitution; for INSTALL, subdrive type mismatch
E_FULL	0x4084	File number table full
E_DEFINE	0x4085	DEFINE only: illegal name
E_UNIT	0x4086	Too many driver units
E_UNWANTED	0x4087	Driver does not need subdriver
E_DVRTYPE	0x4088	Driver returns bad driver type
E_LSTACK	0x4089	Stack not defined in load header
Memory Error Codes		
E_POOL	0x4100	Out of memory pool
E_BADADD	0x4101	Specified bad address to free

Table B-6. Kernel Error Codes

Mnemonic	Code	Description
E_OVERRUN	0x4180	Flag already set
E_FORCE	0x4181	Return code of aborted process
E_PDNAME	0x4182	Process ID not found on abort
E_PROCINFO	0x4183	COMMAND only: no procinfo specified
E_LOADTYPE	0x4184	COMMAND only: invalid loadtype
E_ADDRESS	0x4185	CONTROL only: invalid memory access
E_EMASK	0x4186	Invalid event mask
E_COMPLETE	0x4187	Event has not completed
E_STRL	0x4188	Required SRTL could not be found
E_ABORT	0x4189	Process cannot be terminated
E_CTRLC	0x418A	Process aborted by Ctrl-C
E_CONTROL	0x418B	Slave process running
E_SWIRET	0x418C	Not in SWI context
E_UNDERRUN	0x418D	Flag already pending
E_SPACE	0x4300	Insufficient space on disk or in directory
E_MEDIACHANGE	0x4301	Media change occured
E_MEDCHGERR	0x4302	Detected media change after a write
E_PATH	0x4303	Bad path
E_DEVCONFLICT	0x4304	Devices locked exclusively
E_RANGE	0x4305	Address out of range
E_READONLY	0x4306	RENAME or DELETE on R/O file
E_DIRNOTEMPTY	0x4307	DELETE of non-empty directory
E_BADOFFSET	0x4308	Bad offset in read, write or seek
E_CORRUPT	0x4309	Corrupted FAT
E_PENDLK	0x430A	Cannot unlock a pending lock
E_RAWMEDIA	0x430B	Not FlexOS media
E_FILECLOSED	0x430C	File closed before asynchronous lock could be completed
E_LOCK	0x430D	Lock access conflict

Utility return codes follow the same format of operating system error return codes, as illustrated in Figure B-1, with the following exceptions:

- Utility return codes are positive numbers (LONGS) because the high order bit (31) is always zero.
- When possible, you should use the error codes listed in Table B-7 in the error code field (bits 0-15).
- You can designate given modules within an application in the source field (bits 16-23).

To return errors generated within your application, OR the source field (module) with the error code field. For example, to indicate that an application has detected a parameter error, use:

```
return( UR_SOURCE | UR_PARM );
```

Do not OR a source field value with UR_SUCCESS, which is a LONG of zeroes.

Table B-7. Utility Return Codes

Mnemonic	Code	Description
UR_SOURCE	(LONG)0	Utility return
UR_SUCCESS	(LONG)0	Success
URPARM	0x0001	Parameter error
UR_CONFLICT	0x0002	Contention conflict
UR_UTERM	0x0003	Terminated by user
UR_FORMAT	0x0004	Data structure format error
INTERNAL	0x0005	Internal utility error
UR_UR_DOSERR	0x0006	PC DOS error

End of Appendix B

Country Codes

All FlexOS console drivers indicate the country code that is currently supported. These country codes are used by applications to distinquish character sets, accounting practices, currency symbols presentation, date presentation and many other country or region dependent practices.

Code	Country or Region
10	Afghanistan
20	Albania
30	Algeria
40	Andorra
50	Angola
60	Antigua
70	Argentina
80	Austria
90	Australia
100	Bahama Islands
110	Bahrein
120	Bangladesh
130	Barbados
140	Belgium
150	Bermuda Islands
160	Bhutan
170	Bolivia
180	Botswana
190	Brazil
200	British Honduras
210	Brunei
220	Bulgaria
230	Burma
240	Burundi
250	Cameroun
260	Canada
270	Central African Republic

Code	Country or Region
280	Ceylon
290	Chad
300	Chile
310	China
320	Colombia
330	Congo
340	Costa Rica
350	Cuba
360	Cyprus
370	Czechoslovakia
380	Dahomey
390	Denmark
400	Dominica
410	Dominican Republic
420	East Germany
430	Ecuador
440	Egypt
450	El Salvador
460	Equatorial Guinea
470	Ethiopia
480	Fiji
490	Finland
500	France
510	French Guiana
520	French Somaliland
530	Gabon
540	Gambia
550	Ghana
560	Greece
570	Greenland
580	Grenada
590	Guadeloupe
600	Guatemala
610	Guinea
620	Guyana

Code	Country or Region
630	Haiti
640	Honduras
650	Hong Kong
660	Hungary
670	Iceland
680	Indonesia
690	India
700	Iran
710	Iraq
720	Ireland
730	Israel
740	Italy
750	Ivory Coast
760	Jamaica
770	Japan
780	Jordan
790	Kenya
800	Khmer Republic
810	Kuwait
820	Laos
830	Lebanon
840	Lesotho
850	Liberia
860	Libya
870	Liechtenstein
880	Luxembourg
890	Malagasy Republic
900	Malaysia
910	Malawi
920	Malaysia
930	Maldive Islands
940	Mali
950	Malta
960	Mauritania

Code	Country or Region
970	Mauritius
980	Mexico
990	Moldavian SSR
1000	Monaco
1010	Mongolia
1020	Morocco
1030	Mozambique
1040	Nepal
1050	Netherlands
1060	New Caledonia
1070	New Guinea
1080	New Hebrides
1090	New Zealand
1100	Niger
1110	Nigeria
1120	Nicaragua
1130	North Korea
1140	Norway
1150	Oman
1160	Pacific Islands
1170	Pakistan
1180	Panama
1190	Papua
1200	Paraguay
1210	People's Democratic Republic of Yemen
1220	Peru
1230	Philippines
1240	Poland
1250	Portugal
1260	Portuguese Guinea
1270	Puerto Rico
1280	Qatar
1290	Rhodesia
1300	Rumania

Code	Country or Region
1310	Rwanda
1320	St. Kitts-Nevis-Anguilla
1330	St. Lucia
1340	St. Vincent
1350	San Marino
1360	Saudi Arabia
1370	Senegal
1380	Sierra Leone
1390	Sikkim
1400	Singapore
1410	Somalia
1420	South Africa
1430	South Korea
1440	South-West Africa
1450	Spanish Sahara
1460	Spain
1470	Sudan
1480	Surinan
1490	Swaziland
1500	Sweden
1510	Switzerland
1520	Syria
1530	Tahiti
1540	Taiwan
1550	Tanzania
1560	Thailand
1570	Tibet
1580	Timor
1590	Togo
1600	Trinidad and Tobago
1610	Tunisia
1620	Turkey
1630	Uganda

Code	Country or Region
1640	Union of Soviet Socialist Republics
1650	United Arab Emirates
1660	United Kingdom
1670	United States of America
1680	Upper Volta
1690	Uruguay
1700	Vatican City
1710	Venezuela
1720	Vietnam
1730	West Germany
1740	Western Samoa
1750	Yemen Arab Republic
1760	Yugoslavia
1770	Zaire
1780	Zambia

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FlexOS™
System Guide

Version 1.3

1073-2013-001

First Edition: November 1986

Foreword

This guide is for the original equipment manufacturer (OEM) and system programmers who install and use FlexOS.

The FlexOS System Guide is intended for the original equipment manufacturer (OEM) and system programmer responsible for implementing FlexOS on a specific computer system. The text describes FlexOS architecture, its interface to hardware devices, and the functions available to the driver writer. To use this guide, you should be familiar with device drivers and the C programming language.

Digital Research supplies FlexOS as a set of compiled operating system modules and device drivers for a variety of consoles, disk drivers, and printers. You can compile these samples to interface to the corresponding device or use them as models for building your own hardware interfaces.

The driver routines are written in the C programming language and make use of the FlexOS C run-time library. Although FlexOS allows you to write device drivers entirely in C, you might need or prefer to use assembly language routines in your code where speed of execution cannot be compromised.

To complete your understanding of FlexOS, you should read the FlexOS Programmer's Guide for its programming interface and Supervisor calls description. For the description of the user interface, read the FlexOS User's Guide. The FlexOS documentation set also includes the supplements describing important, microprocessor-specific information. Refer to the supplement corresponding to the microprocessor in your computer.

Hardware Requirements

You can tailor FlexOS to run in systems based on a variety of microprocessors. While FlexOS can take advantage of built-in memory management found in advanced microprocessors, it does not require such memory management units to create a multitasking environment. See the processor-specific supplements to this manual for more information on memory management.

Digital Research® suggests that a minimum FlexOS system contain 512 kilobytes of RAM. FlexOS supports 2 gigabytes of disk storage space.

FlexOS supports a variety of clock devices and memory management units. FlexOS supplies application programmers with a standard console and disk interface that supports integrated multi-window and desktop applications. FlexOS provides support for a broad range of hardware environments.

Sample device driver code is distributed as models for floppy and hard disk drives; serial, bit-mapped, and character-mapped consoles; and serial I/O and printer ports.

About this Manual

This manual is organized into the following sections:

Section 1 Introduction to the FlexOS operating system.

Section 2 Overview of the FlexOS I/O system.

Section 3 System configuration.

Section 4 Synchronous driver interface to Resource Managers.

Section 5 Use and function of the FlexOS driver services.

Section 6 Driver interface to the Supervisor module.

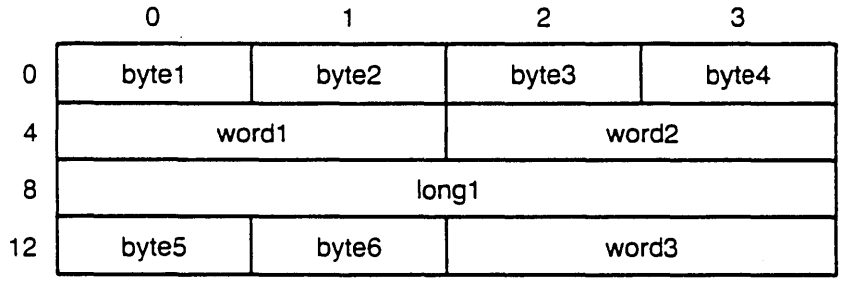
Sections 7 through **11**
I/O functions for console, disk, printer, port, and special drivers.

Section 12 The FlexOS bootstrap program requirements, memory image, and SYS utility.

Appendixes System character sets, support for foreign languages, and window management.

Data Structure Convention

Throughout this manual, data structures are represented in diagram form as shown below. The corresponding C listing for the diagram follows the illustration. Word and byte order are important when using these structures.



Data Structure

```
struct thisstruct
{
        BYTE    byte1;  /* byte offset = 0  */
        BYTE    byte2;  /* byte offset = 1  */
        BYTE    byte3;  /* byte offset = 2  */
        BYTE    byte4;  /* byte offset = 3  */
        WORD    word1;  /* byte offset = 4  */
        WORD    word2;  /* byte offset = 6  */
        LONG    long1;  /* byte offset = 8  */
        BYTE    byte5;  /* byte offset = 12 */
        BYTE    byte6;  /* byte offset = 13 */
        WORD    word3;  /* byte offset = 14 */
};                      /*       length = 16 */
```

Contents

Figures

Listings

System Overview

This section presents a basic overview of the FlexOS operating system, including a description of its various modules.

1.1 Features

FlexOS is a real-time, multitasking operating system for single- and multi-user microcomputer systems. It is written to be independent of a system's microprocessor and peripheral equipment. FlexOS's programming interface allows a programmer to take maximum advantage of advanced hardware technology, such as bit-mapped graphics devices or high-capacity disk storage units. The programming interface is machine-independent, so applications need not be rewritten for different machines or different sets of peripherals.

The following is a list of the prominent features of FlexOS:

- Runs multiple applications in an asynchronous environment that allows real-time response to external events.
- Interfaces to microprocessors that provide memory mapping and memory protection through memory management hardware.
- Allows inter-process communication synchronization through a pipe system.
- Allows asynchronous I/O and timing through an event system. A process can wait for multiple events or handle asynchronous events through software interrupts.
- Provides a standard terminal interface and standard character- and bit-mapped screen interfaces.

- Provides standard keyboard interfaces independent of physical console types. Supports 8-bit and 16-bit keyboard input modes with keyboard translation, which allows support for special characters, function keys, multi-keyed characters and foreign languages with 16-bit characters, such as KANJI.
- Manages multiple virtual consoles on each physical console.
- Supports real-time data acquisition and background communications.
- Allows device drivers to be linked with the system or dynamically loaded at run-time.
- Supplies country codes to determine character set, accounting, monetary, and date presentation.
- Provides applications with full error recovery facilities from physical I/O errors on any device.

1.2 Operating System Organization

Figure 1-1 illustrates three distinct parts of FlexOS.

The FlexOS **program** part consists of utilities, user shell programs, shared run-time libraries, applications, window managers, and any other loadable programs calling operating system services. You define the FlexOS user interface in the program portion.

The **system** part contains the device and program independent portions of the operating system. The elements of this portion are the Supervisor, kernel and resource manager.

The **physical** part contains all of the system's device-dependent code for the system's disk drives, consoles, and other peripheral devices. The code is organized in the form of independent drivers controlled by a single resource manager.

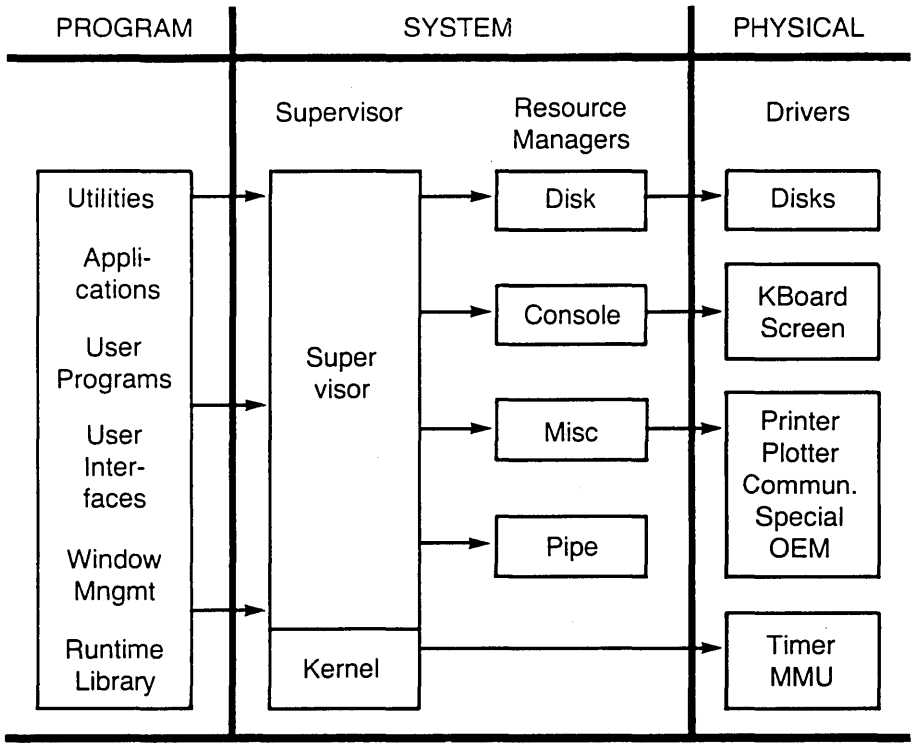


Figure 1-1. Structure of FlexOS Operating System

1.2.1 Programs

All programs loaded from disk, whether applications, utilities, or user interface programs, run independent of each other. Each runs under a process context and has separately addressable User Memory. Programs call the Supervisor for operating system or machine services.

1.2.2 The Supervisor Module

The Supervisor controls the flow of requests to the Resource Managers. The Supervisor parses all names and file numbers to determine which Resource Manager should obtain a function request. It handles the DEFINE, CONTROL, COMMAND and OVERLAY Supervisor Calls (SVCs) directly. These functions do no actual resource management, but call the Resource Managers for services.

1.2.3 The Kernel

The kernel manages processes and memory. This facilitates intermachine communications, networking, multi-user, and multitasking environments. The kernel controls the timer driver and any special routines for memory management based on the type of memory management unit. The kernel is based on an event-driven dispatcher that schedules on a priority basis. Time slicing is done by a timer event occuring once per tick. A tick occurs every 16 to 20 milliseconds, depending on the implementation of the Timer driver. Scheduling of equal priority processes is done in a round-robin fashion.

1.2.4 Resource Managers

A Resource Manager controls the resources associated with it and provides a standard interface to the device drivers for each category of device.

The Disk Resource Manager manages the disk file systems on disk drives. It supports DOS disk media and provides a single interface to floppy and hard disks.

The Console Resource Manager manages physical consoles, including the screen and keyboard devices. FlexOS supports virtual consoles through the console drivers. Applications create virtual consoles through a Supervisor Call.

The Miscellaneous Resource Manager manages all devices not managed by other Resource Managers, including plotters, printers, ports, and communications devices. Drivers for these devices are referred to as special drivers. The Miscellaneous Resource Manager places more responsibility on the driver than the other Resource

Managers do, passing requests from a calling process to the appropriate special driver with a minimum of processing.

The Pipe Resource Manager manages interprocess communications and synchronization through named FIFO memory files called pipes. These "in-memory" files are used to pass messages from one process to another or to synchronize activities. There are no devices associated with the Pipe Resource Manager.

1.2.5 Device Drivers

A device driver is the software interface to a physical device. Device drivers contain all of the machine- and device-specific code in the system. Each driver is separately built and is independent of other drivers.

A device driver is managed by a single resource manager. A device driver can, however, control multiple devices of the same type. For example, a disk driver can control a disk controller, which in turn controls multiple disk drives. Table 1-1 lists the driver types and indicates the resource manager that controls it.

Table 1-1. Driver/Resource Manager Relationships

Driver Type	Resource Manager
Disk	Disk
Console	Console
Port	Miscellaneous
Printer	Miscellaneous
Communications	Miscellaneous
Special OEM	Miscellaneous

There are three ways to install drivers:

- Integrating the drivers with the system.
- Installing them dynamically when FlexOS is loaded.

- Installing them when the system is up and running.

Link the compiled driver files into the system image to permanently install a driver. To install a driver while FlexOS is loading, add a DVRLOAD command to the boot script. Use the DVRLOAD command once the system is running or add an INSTALL supervisor call to your application to install a driver once the system is up and running.

FlexOS also supports sub-drivers. A sub-driver is constructed just like a driver, however, the sub-driver is controlled by the driver rather than a resource manager. In this case, the controlling driver functions as the subordinate driver's resource manager. Through sub-drivers, one driver can control multiple devices of the same type with different I/O interfaces.

1.3 File Management

FlexOS has a hierarchical, shared-disk file system with record- and file-locking mechanisms. The disk file system is protected at several levels. Access to files is based on file and directory ownership through user and group identification numbers. Users identify themselves through login procedures that can include password protection. The disk file system thus provides integrity and data protection in both multi-user and single-user systems.

FlexOS distinguishes between removable and permanent media. It gives special recognition to removable media on devices supporting open door interrupts. By knowing the environment, FlexOS optimizes performance and minimizes lost data.

1.4 Memory Management

FlexOS supports mapped and protected memory management hardware. Because of the diversity in memory management units, FlexOS supports a simple memory model that maps into the more common MMUs on various CPUs.

1.5 Printer Management: Print Spooler

FlexOS includes a print spooler system in the form of a driver. To include the spooler, load the driver SPLDVR.DVR, define a subdirectory as tempdir: (the subdirectory must exist), and make a couple of logical name definitions for the system printer in your boot script. See the example boot script in Section 3 for the commands used to load the spooler driver and to make the appropriate logical name assignments.

To run the spooler, the following files must be present with your printer driver on the boot: drive:

SPLDRV.DRV	Application program interface for spooler
SPOOL	Executable spooler module
DESPOOL	Executable despooler module

In addition, you need the PRINT utility on the system: drive. Only the PRINT utility is invoked by the user. SPOOL and DESPOOL are invoked by the spooler driver.

The following spooler description assumes that the spooler driver has been installed and defined as the prn: device. If you do not intend to use the spooler, be sure to define another list device as prn:.

Note: Although you define one printer to be the spooler's output device, the spooler can make use of multiple printers. The destination printer is selected by the user via the PRINT utility. If you are going to have multiple printers, the device driver must be loaded before the selection is made. The spooler automatically links to the driver when the user requests the device; however, it cannot load the device. If the device specified is not present, the spooler returns an error message.

The spooling system has three components: the spooler driver, the spooler process, and the despooler process. The spooler driver creates the spooler and despooler processes and a set of pipes used to control the system. The driver provides both command-line and application interfaces.

The command line interface uses the PRINT utility to print files. When the user invokes PRINT, the utility parses the command line and groups the file specifications in a job. PRINT then sends each file in the job to the prn: device. Because the spooler driver is defined as the prn: device, the files are added to the spooler system's print queue.

See the FlexOS User's Guide for the description of the PRINT utility and its options.

Application programs access the spooler driver through the prn: device. Like any device, the program must open prn: before it can use it. When the application writes to the prn:, the spooler automatically creates a file in the system temporary file directory tempdir: and records the output therein. The spooler driver closes the file when the program closes the prn: and adds the file name to its print queue.

The spooler is a user process created by the spooler driver that waits on a pipe for the file names of files to be printed. The spooler driver provides the file specifications in this pipe. When a name is received, the spooler adds it to the end of a print queue. The print queue is recorded on disk in the system: directory and maintained on a first in first out. When the spooler is created, it looks to this file to see if there are any entries. Thus, if the system crashes, jobs in the queue are preserved and printed when the system is restarted.

The despooler is also a user process created by the spooler driver. The despooler reads the queue file and prints the file at the top of the list on the device assigned as the bgprn: device. When the file output is complete, the despooler removes the entry, moves the next file to the top of the queue, and prints it. If no file is present, the despooler waits for an entry to be made.

For the description of spooler use with FlexNet™, see the FlexNet User's Guide.

End of Section 1

I/O Overview

This section explains, in broad terms, how FlexOS performs input and output. It defines the system I/O modules and describes their interaction. This section also contains an overview of the flow of control in an I/O operation and concludes with a discussion of driver installation.

2.1 File-Oriented Input and Output

FlexOS performs input and output by treating a device as a special kind of file. Programs initialize I/O with the OPEN or CREATE Supervisor Call (SVC). Multiple devices and files can be open simultaneously. Use the OPEN SVC to open an existing disk file, pipe, console, or device. Use the CREATE SVC to create and open a new disk file, virtual console, or pipe.

Both OPEN and CREATE calls return a 32-bit value called the file number. This value uniquely identifies a specific communication channel between a process and a device. All device-related I/O SVCs reference this number. The Supervisor then uses the file number to decide which Resource Manager should receive the request.

You break a communication channel with the CLOSE SVC. Subsequent attempts to access the device or file return with an error message. Before the file is closed, FlexOS flushes the write buffers, unlocks locked regions, and completes outstanding asynchronous events.

The FlexOS file-oriented I/O scheme is normally device-independent. SPECIAL functions are available to perform certain device-dependent functions.

2.2 Organization of I/O Modules

This section discusses the principal components in FlexOS relating to I/O: device drivers, units, and Resource Managers.

2.2.1 Device Drivers

A device driver is the system software that translates logical I/O requests into physical commands to specific devices. Drivers contain all of the device-specific code in the system. FlexOS does not create a process for a driver. A driver's code is run by the application and system processes working through a driver's resource manager.

A driver is composed of a code group and a data group. The code group consists of a set of primitive functions that control the driver's devices. FlexOS prescribes a set of functions for each type of driver. Each driver type is described in a separate section of this manual. A driver's functions can use the SVCs available through the programmer's interface. In addition to the SVCs, drivers can take advantage of the FlexOS set of driver services, described in Section 5.

The data group contains a data structure called the Driver Header and the remainder of the driver's image. FlexOS controls a driver through its Driver Header, which contains entry points to the driver's functions, indicates whether and to what degree a driver can operate asynchronously, and holds other information about the driver. The Driver Header must be the first structure within the driver's data area.

Functions within a driver's code group access the FlexOS driver services through the Driver Services Table. FlexOS places the address of the Driver Services Table in the Driver Header.

FlexOS supports both statically- and dynamically-loadable device drivers. Both types of drivers have the same structure, so that drivers can be written without regard for the time they are linked or loaded.

2.2.2 Units

Each loaded device driver supports one or more units. Units are specific instances of physical devices. FlexOS manages devices at the unit level. Each unit is treated as an independent functional entity with its own

- name,
- access level, and
- (optionally) associated sub-driver(s).

Defined from a unit point-of-view, a device driver is a collection of functions that control related units. The only time FlexOS deals with device drivers, rather than units, is when a driver is installed or removed from the system. Both installation and removal of drivers is performed with the FlexOS INSTALL SVC command.

The organization of units into device drivers allows a higher level of management for groups of associated devices. For example, consider a system where a single disk controller controls multiple disk drives. A single device driver manages the controller, while the units designate individual drives. As far as possible, the device driver uses the same code to control all of the drives.

FlexOS logically calls each disk drive unit independent of other disk drives. However, because of driver organization, the disk device driver can force access to the individual drives to be serial.

2.2.3 Resource Managers

Each driver unit in the system is controlled by a Resource Manager. Resource Managers translate I/O requests, such as READ or WRITE, into calls to the appropriate driver unit. Typically, an application process runs the code in a Resource Manager.

Through the Driver Header, the driver makes available to the Research Manager the addresses of all its primitive functions. After receiving a function request, a Resource Manager maps the request to a specific unit and passes control to the appropriate function in the unit's driver.

A driver is defined by the type of Resource Manager controlling it. Resource Managers and their drivers fall into four categories: console, disk, kernel, and miscellaneous. FlexOS also has a Pipe Resource Manager; however the Pipe RM does not have any drivers associated with it.

2.3 Driver Unit Flow of Control

The following diagram illustrates the flow of control from an application to a driver unit.

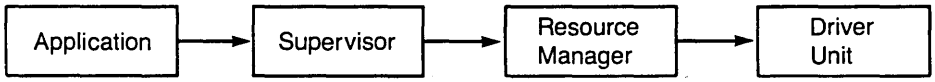


Figure 2-1. I/O Flow of Control

In Figure 2-1, a file number is passed from the application to the Supervisor, which enables the Supervisor to select the appropriate Resource Manager. In turn, information passed from the Supervisor enables the Resource Manager to select the correct unit.

2.4 Steps in Servicing I/O Request

Applications must open a file by name before they can access that file. In FlexOS, by definition, a file specification includes the driver unit name. Thus, a minimum file specification takes the form "device:filename." When the file is recorded in a subdirectory rather than the device's root directory, place the path specification between the device name and the file name.

The FlexOS Supervisor associates each device with a unique name defined through the INSTALL SVC. A device name indicates a particular driver unit and the resource manager that controls it.

When a device open call is received, the Supervisor calls the appropriate resource manager to establish the connection between the calling process and unit. If the call is successful, the Supervisor sets up internal control information and returns a file number for the opened file.

For all file I/O calls, the Supervisor translates the specified file number, calls the appropriate Resource Manager, and provides it with the control information. The Resource Manager uses this information to select the appropriate driver unit. The control information is maintained by the Supervisor until it receives a CLOSE call.

2.5 Asynchronous I/O

FlexOS supports asynchronous I/O functions in its programming and driver interfaces. Applications can start an I/O operation, perform other activities, then wait for the I/O operation to finish at a later time.

2.5.1 Support for Handling Asynchronous Events

Typically, applications use the WAIT SVC to wait for the completion of one or more I/O event, then call the RETURN SVC to obtain the return code of the completed event. To enable applications to use the FlexOS asynchronous capabilities, drivers perform their I/O asynchronously.

FlexOS provides support for asynchronous drivers with a flag system whose functions, a subset of the driver services, communicate with the WAIT and RETURN SVCs. The flag system driver services are typically called from Asynchronous Service Routines (ASRs), which in turn, are initiated by Interrupt Service Routines (ISRs). Driver writers must write their own ASRs and ISRs, according to the requirements of their hardware and the guidelines given in Section 5.

FlexOS also provides a polling function for non-interrupt-driven drivers and functions to create and declare critical regions, such as mutual exclusion regions. These mechanisms for dealing with asynchronous events are also described in Section 5.

2.5.2 Synchronous and Asynchronous Interfaces

A driver's external interfaces can be divided into two classes, synchronous and asynchronous. The synchronous interface is the interface between a resource manager and a driver's primitive functions. Processes request device I/O by calling the synchronous portion of a driver through the resource manager. The asynchronous interface is the driver's interface to the physical device, represented by a unit. The following figure illustrates the interaction between the synchronous and asynchronous portions of an I/O request.

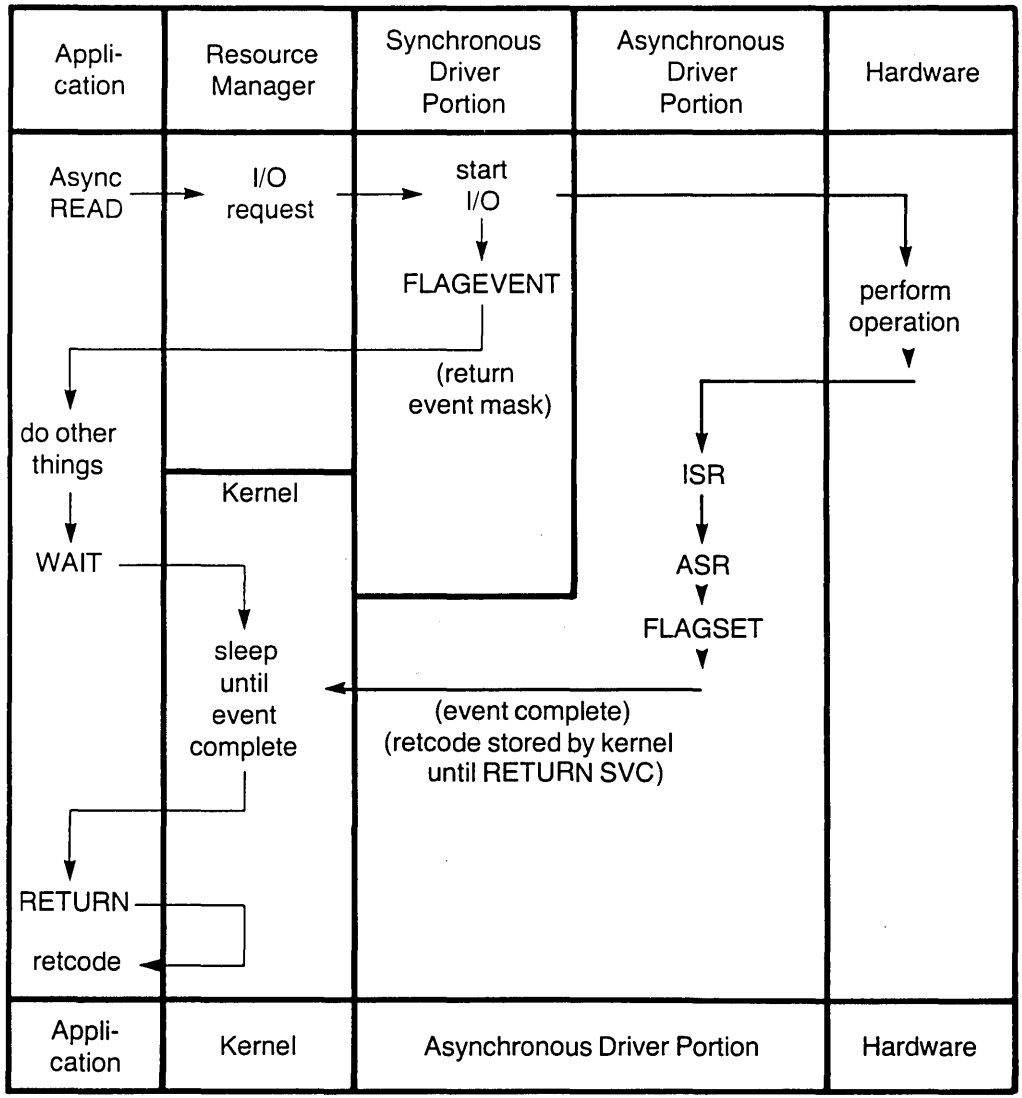


Figure 2-2. Asynchronous I/O Request

In Figure 2-2, FLAGEVENT and FLAGSET are driver services provided by FlexOS. They are described in Section 5.1.

2.6 Sub-drivers

FlexOS allows a driver to become the Resource Manager of another driver, through a concept called sub-drivers. Under this concept, a driver can access a specific piece of hardware through the functions contained in another driver, which becomes the sub-driver to the first driver. This allows the first driver to access a specific piece of hardware, while maintaining device-independence.

In response to a request from a driver, a sub-driver can respond in any of three ways. It can

- perform the requested function,
- pass the request on to its own sub-driver, or
- perform part of the function and pass the request on to a sub-driver for further processing.

Sub-drivers work at the unit level of a driver. Each driver unit can independently request one or more sub-drivers of specified types. Sub-drivers themselves are driver units.

FlexOS guarantees that each driver in the system, including sub-drivers, has only one owner at a time. The owner is either a Resource Manager or another driver.

A sub-driver's place in the FlexOS I/O scheme is shown in Figure 2-3.

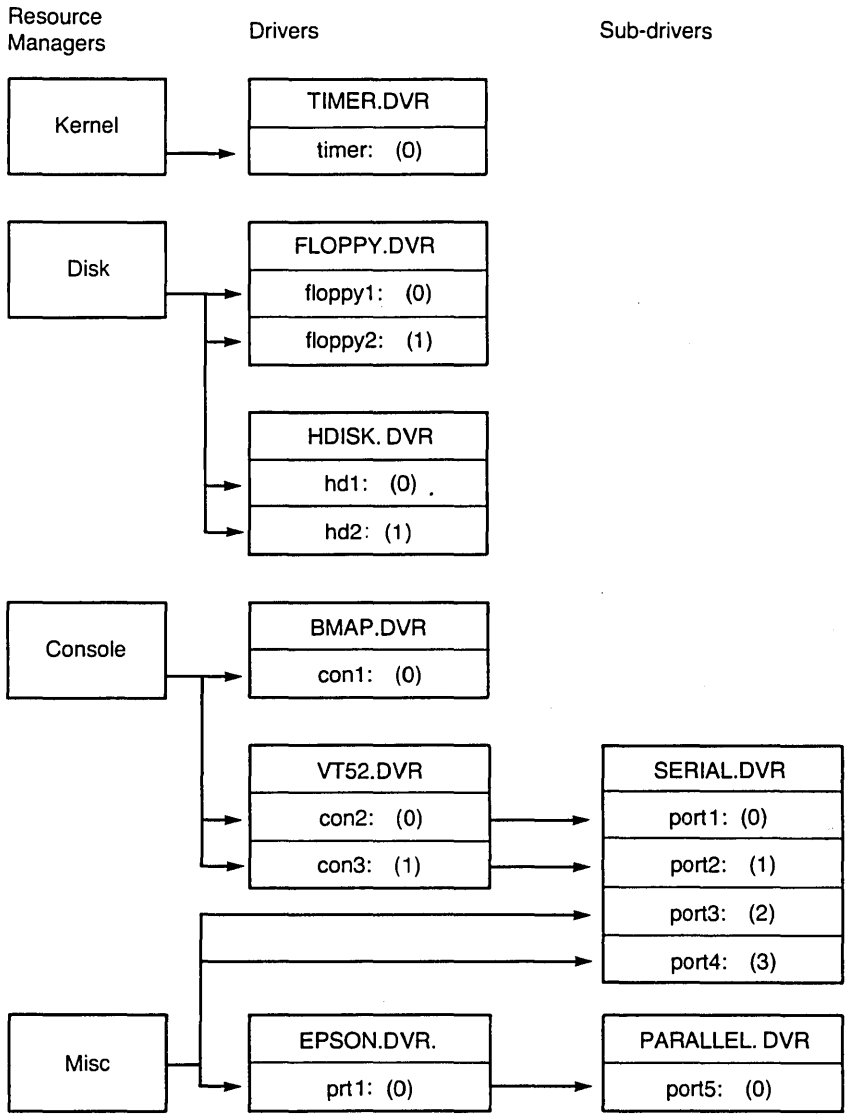


Figure 2-3. Relationship of Sub-drivers to Drivers

In the preceding figure, numbers in parentheses designate driver units. Port 1: and port 2: under the serial port driver are sub-drivers to console 2: and 3: under the VT52 driver. In this scheme, con2: and con3: are the resource managers to port1: and port2:, respectively.

At the same time, port3: and port4: under the serial port driver are drivers controlled by the Miscellaneous Resource Manager. port5: under the parallel port driver is a sub-driver to port1: of the printer driver.

Use of sub-drivers adds flexibility to a system, as the following two examples illustrate.

Through the use of sub-drivers, you can offer a system that allows the use of a number of different terminals. FlexOS lets you write a console driver for a DEC VT-100 terminal that requires a port type of sub-driver. The same VT-100 driver could drive a number of different terminals, as long as there existed port drivers to interface to the terminals' serial controllers.

To change a terminal, a user need only change a terminal emulation module, rather than replacing the entire terminal driver code. An OEM can provide several different terminal emulation modules, which a user could install through a FlexOS-supported utility or a simple boot script.

2.7 Installing Drivers

FlexOS lets you install a driver by either of two methods:

- Static: Linking a driver into the system
- Dynamic: Linking a driver to a Driver Run-time Library and loading the driver independently

Dynamically-installed drivers are loaded from disk either through a boot script or a user commands.

Drivers installed at system link time are linked into the operating system image and are loaded with FlexOS at boot time. These drivers are linked with the Driver Run-time Library, which contains addresses that the driver will need for successful operation. Dynamically-installed drivers are discussed in Section 3.

FlexOS loads drivers into memory in the same way it loads applications, with the exceptions that a driver is loaded into system space and that FlexOS does not create a process for a driver.

Because all drivers are identical in structure, drivers are written without regard for the time or method they are to be installed.

End of Section 2

System Configuration

This section explains, in general terms, how to install drivers and other implementation-specific modules in a FlexOS system. FlexOS is shipped with operating system modules, drivers, and boot loaders for target systems. If your system matches one of the target systems, you can compile, link, and load FlexOS without writing any code.

Refer to the microprocessor-specific supplements shipped with this manual for configuration information pertinent to your particular system. The System Release Notes contain specific directions for a implementing a FlexOS system based on a given CPU. They also identify the console, disk, port, and printer hardware for which FlexOS provides sample drivers.

You can use the sample drivers without modification if your system uses devices identical to those for which these drivers were written. The rest of this manual provides guidelines for writing your own drivers or modifying the sample drivers.

Section 3.1 outlines the steps involved in creating a FlexOS system. Creating a system involves linking drivers and any OEM-supplied modules into a system.

Section 3.2 describes how to edit the source code for the CONFIG module to link drivers and OEM-supplied modules into the system. The CONFIG module drives the FlexOS initialization and configuration.

Section 3.3 explains how to install drivers with the system using the boot script.

Section 3.4 explains run-time installation.

3.1 System Creation

The FlexOS OEM distribution diskettes contain the FlexOS object module files. The modules you can modify are distributed in source code form. These files have a .C file extension. The diskettes also contain all the programming tools required to compile, link, and debug a system. You create a FlexOS system using the linker provided to link the FlexOS modules and your driver modules.

3.1.1 Required Modules

The link input files (.INP files) on the FlexOS distribution diskettes indicate the various combinations of object and library files needed to create FlexOS. See the System Release Notes for detailed instructions on object link order. Typically, you link at least one disk driver into the system image.

3.1.2 Steps in Creating FlexOS

The Programmer's Utilities Guides contains explicit instructions on the use of the tools used to create a system. In general terms, the steps in creating a FlexOS system are:

1. Write FlexOS drivers and sub-drivers according to the guidelines presented in this manual or modify the sample drivers provided to match your system configuration.
2. Compile all source code with the appropriate C compiler, using appropriate options and parameters.
3. Add the names of any OEM-supplied object modules to the list of modules in the CONFIG modules. OEM-supplied modules can include user interface programs as well as drivers. Section 3.2 tells you how to modify the CONFIG modules.
4. Link the object modules with the link utility appropriate to your system's microprocessor.
5. Process the file containing the operating system file with a chip-specific FIX utility that creates a file containing the absolute memory image of FlexOS.

The boot loader gets its addresses for loading the FlexOS segments from the file produced by the FIX utility. Consequently, you can boot FlexOS in a target system without modifying the boot loader.

Section 12 explains how to build a boot disk.

3.2 The CONFIG Module

The CONFIG modules drive the configuration and initialization of FlexOS. Edit the source files of the CONFIG modules to add or delete modules for your particular FlexOS system.

Within the CONFIG modules, the list of Resource Manager modules to be linked in the operating system is contained in the MODULES Table. To add a module, you add the file specification of that module to the MODULES Table.

The code contained in the CONFIG modules is the first code run in the system at boot time. This code initializes the system modules by calling the main () routine. After the modules are initialized, the BOOTINIT function is entered.

The BOOTINIT function executes the commands in the boot script CONFIG.BAT, a modified batch file. BOOTINIT accepts standard batch commands (see the FlexOS User's Guide), the boot script commands described below, and OEM-written commands. The boot script commands call the INSTALL SVC to install drivers.

3.3 Boot Script Installation

The boot script lets you install drivers and sub-drivers, as well as user interface or window management programs, at boot time.

Drivers installed with the boot script are read from a disk file and loaded into memory. These drivers are linked with the Driver Run-time Library (DRTL), which supplies critical information on driver service routine and data addresses in a driver's Driver Header. The Driver Header is defined in Section 4.2.

A sample boot script is supplied with FlexOS in the CONFIG.BAT file. Another example is provided at the end of this section. You can

modify CONFIG.BAT or create a new boot script. You can also change the name of CONFIG.BAT. If you change the name of CONFIG.BAT, you must edit the CONFIG modules from which the boot script is called, and replace CONFIG.BAT with the new name.

3.3.1 Boot Script Commands

The boot script commands are described below. For each command, you must specify an access level. FlexOS returns an error if the access level is missing.

DVRLOAD--Load a device driver from disk

Syntax: **DVRLOAD** loadfile devicename accesslevel

Return code:
0 Success
1 Parameter error
2 Failure
3 Sub-driver needed

Where:

loadfile is the name of a loadable driver file.

devicename is the logical device name of a driver's unit 0. A colon after the devicename is optional

accesslevel is any combination of the following options:

P = Permanent driver (cannot be removed)
R = Raw READ access allowed
W = Raw WRITE access allowed
S = Raw SET access allowed
E = No exclusive access
L = Lockable (through the DEVLOCK SVC)
M = Multiple partitions allowed
N = Shared access allowed
V = Verify writes allowed

DVRUNIT--Add a new unit to an existing driver

Syntax: **DVRUNIT** olddevice devicename accesslevel

Return code:
0 Success
1 Parameter error
2 Failure
3 Sub-driver needed

Where:

olddevice is the device name of the existing driver

devicename is the logical name of the driver's new unit. A colon after the device name is optional.

accesslevel is any combination of the above options.

DVRLINK--Link an existing driver to another driver

Syntax: **DVRLINK** devicename subdriver

Return code:
0 Success
1 Parameter error
2 Failure
3 Sub-driver needed

Where:

devicename is the name of previously installed device

subdriver is the name of previously installed device which will be used as a sub-driver by the device designated by devicename.

DVRUNLK--Remove a driver

Syntax: **DVRUNLK** device:

Return code: 0 Success
2 Failure

Where:

device is the name of an installed device

Note: If the driver removed has a sub-driver associated with it, the sub-driver becomes associated with the uninstalled driver's resource manager.

3.3.2 Logical Name Definitions

A typical boot script contains logical name definitions appropriate to the hardware implementation. These definitions are made through the DEFINE SVC which updates the SYSDEF Table, which contains system-wide logical name definitions, or the PROCDEF Table, which contains definitions for a given process. Which table to modify is indicated in bit 0 of DEFINE's flags field.

The following logical names are reserved by FlexOS and should be defined in your CONFIG.BAT file:

- "system:" indicates the global system directory. It is defined in the SYSDEF Table.
- "a:" - "p:" represent the root directories of the disk drives present. For example, if there are four disk drives, they would be called drives "a:" through "d:" and drives "e:" through "p:" would be undefined. Disk drives are defined in the SYSDEF Table.

- "protect" enables or disables system-wide password protection at log on. Put the statement:

  define -s protect=on

  in CONFIG.BAT to select password protection. If password protection is not required, include the statement:

  define -s protect=off

  instead. When password protection is required, the LOGON utility prompts the user to enter his or her password. The "protect" status is defined in the PROCDEF Table.

- "shell" represents the default user interface program. The corresponding shell program is run on each virtual console and is defined in the PROCDEF Table.

- "home:" indicateas the user's initial default directory. It is defined in the PROCDEF Table.

- "default:" indicates the current directory. It is defined in the PROCDEF Table.

- "wmanager" indicates the default window manager to run on each physical console. If you don't want window management, set "wmanager" to "shell". wmanager is defined in the PROCDEF Table.

- "con:" determines the physical console that the next LOGON program runs on. The value following "con:" is changed for each invocation of LOGON. "con:" is defined in the PROCDEF Table.

- "prn:" is the logical device name for the default list device. It is defined in the SYSDEF Table

- "tempdir:" indicates the directory for temporary files. It is defined in the SYSDEF Table.

- "bgprn:" is the despooler's default output device when the user does not specify a device name with the PRINT command. If you install the spooler driver, be sure to define prn: as the bgprn: device.

The sample CONFIG.BAT defines the shell to the FlexOS "command" utility and a: as the home: and default: devices.

3.4 Run-time Driver Installation

Drivers installed at run-time are installed identically to those drivers installed via a boot script. Both kinds of installation use the INSTALL SVC. Like drivers installed with a boot script, drivers installed at run-time are linked with the Driver Run-time Library, which places critical driver service routine and process data addresses in the Driver Header. See Section 4.2 for a description of the Driver Header.

3.5 Example Boot Script

The following is an example boot script. Do not take it as a rigid template, but rather as an example showing the general mechanisms available. The CONFIG.BAT file distributed with FlexOS contains a "bare bones" boot script that you can modify according to your needs.

This example assumes that the system boots from a diskette and that the driver contained in FLOPPY.DVR was installed at system link time. The example also assumes that "floppy1:" was established at system link time as the logical device name for the boot drive.

The boot script contains a series of logical name definitions. These definitions, made through the DEFINE SVC, are explained following the listing.

Listing 3-1. Example Boot Script

```
REM  START OF BOOT SCRIPT
REM
     define switchar = -
REM
REM  Set up user's default environment.
REM  For protect=off systems, add defines for home:,
REM  wmanager:, and shell:
REM
     define -s boot:=hd1:
     define -s system:=hd0:commands/
     define -s protect=on
     security -O=RWED -G=RWED -W=RE
     define -s helplvl = 2
     define default = d:
REM
REM  Install other disk devices: floppy0: is name
REM  of floppy disk driver linked in with system
REM
     dvrunit floppy0:  floppy1: prwsln
     dvrload hd0:  floppy0:hdisk.dvr lnwrsm
     dvrunit hd0:  hd1: lnwrsm
REM
REM  Define directory on system disk for tempdir:
REM
     define -s tempdir:=system:/temp/
REM
REM  Set up the logical names A: - D: for installed
REM  drives
REM
     define -s a:=floppy0:
     define -s b:=floppy1:
     define -s c:=hd0:
     define -s d:=hd1:
REM
REM  Install serial and parallel port drivers
REM
     dvrload port1: boot:serial.dvr prwsel
     dvrunit port1: port2: prwsel
     dvrunit port1: port3: prwsel
     dvrunit port1: port4: prwsel
     dvrload port5: boot:parallel.dvr prwsel
REM
REM  Install consoles: For consoles or any driver
REM  that needs a sub-driver, you must check the
REM  error level of the driver installed.
```

```
REM
     dvrload con1: boot:bmap.dvr prwsl
     dvrload con2: boot:vt52.dvr prwsl
     if errorlevel 3 dvrlink con2: port3:
     dvrunit con2: con3: p
     if errorlevel 3 dvrlink con3: port4:
REM
REM  Note:  port1: and port2: can be accessed
REM  directly by the application program as serial
REM  ports or linked later to a dynamically
REM  installed special driver.
REM
REM  Install print spooler
REM
     dvrload prt1: boot:printer.dvr lnrws
     define -s bgprn:=prt1:
     dvrload spldrv: boot:spldvr.dvr lnrws
     define -s prn:=spldvr:
REM
REM  Startup LOGON program on consoles: LOGON opens
REM  "con:" for its physical console and runs
REM  defined wmanager.  LOGON must run in
REM  background for bootinit to continue.
REM
     define con:=con1:
     back logon
REM
     define con:=con2:
     back logon
REM
     define con:=con3:
     back logon
REM
     end
```

End of Section 3

Driver Interface

This section describes the FlexOS driver interface. The interface is discussed in terms of driver load format (4.1); the driver header, its data fields, driver type values, and interface flags (4.2); the calling conventions for interfacing with the driver I/O function entry points (4.3); and the driver installation functions (4.4).

4.1 Driver Load Format

Drivers are divided into two separate portions, the code group and the data group. The code group portion of a driver contains all of the driver's executable code. Once the driver has been loaded into memory, its code group cannot be modified. The data group contains the remainder of the driver's image including the Driver Header, the GET/SET Table, and any fixed heap areas. See Figure 4-1.

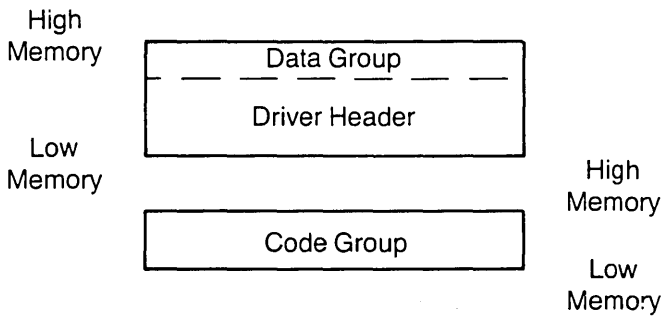


Figure 4-1. Driver Load Format

The method of loading a driver with respect to memory independence for load image portions and address relocation is dependent upon computer's CPU and the program load format. Generally, driver loading procedures are the same as those used to load normal application programs. There are three major exceptions:

- Drivers are loaded into System Space.
- A process is not created to run the driver code.
- A driver header is required in the beginning of the data group.

4.2 Driver Header

FlexOS installs and manages a driver through its driver header. The Driver Header must be at offset 0 relative to the driver's data group. It contains the entry points to the driver's functions used by the resource manager. The interface to the Driver Header entry points makes up the synchronous driver interface. Figure 4-2 shows the format of the driver header. Listing 4-1 contains a C language definition of the driver header structure. Table 4-1 describes the driver header contents.

Listing 4-1. C Language Definition of a Driver Header

```
Define struct DriverHdr
{
 UWORD  dh_reserve   ;/* Reserved                          */
 UBYTE  dh_nbrunits  ;/* Max Number of Units Supported     */
 UBYTE  dh_flags     ;/* Flag Word                         */
 LONG   dh_init()    ;/* INIT Code Entry Point             */
 LONG   dh_subdrv()  ;/* SUBDRV Code Entry Point           */
 LONG   dh_uninit()  ;/* UNINIT Code Entry Point           */
 LONG   dh_select()  ;/* SELECT Code Entry Point           */
 LONG   dh_flush()   ;/* FLUSH Code Entry Point            */
 LONG   dh_read()    ;/* READ Code Entry Point             */
 LONG   dh_write()   ;/* WRITE Code Entry Point            */
 LONG   dh_get()     ;/* GET Code Entry Point              */
 LONG   dh_set()     ;/* SET Code Entry Point              */
 LONG   dh_special() ;/* SPECIAL Code Entry Point          */
 LONG   dh_ctl1      ;/* Reserved                          */
 LONG   dh_ctl2      ;/* Reserved                          */
 LONG   dh_ctl3      ;/* Reserved                          */
 LONG   dh_rlr       ;/* Pointer to Ready List Root        */
 LONG   dh_functab   ;/* Pointer to Driver Services Table  */
}
```

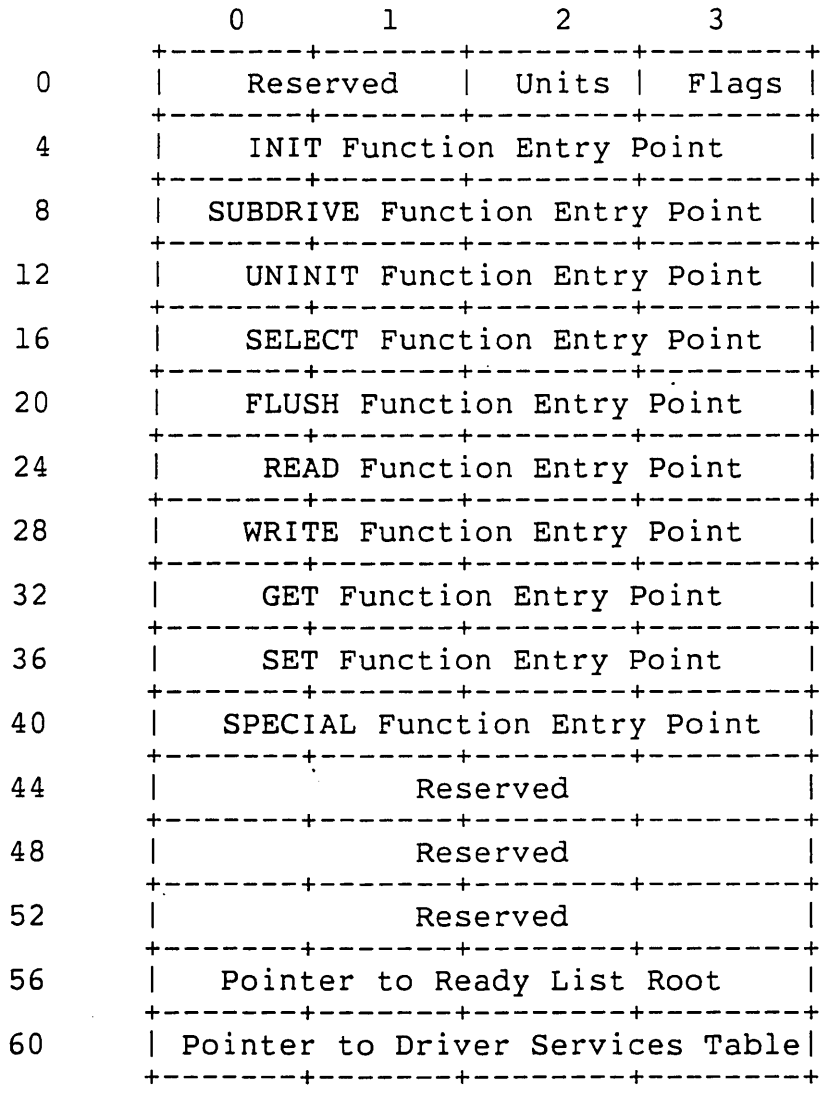


Figure 4-2. Driver Header Format

Table 4-1. Driver Header Data Fields

Data Field	Explanation
Units	This unsigned byte indicates the maximum number of units supported by this driver. A value of 0 indicates support for an unspecified number of units. INIT for unit 0 is called immediately following the first INSTALL. The unit number is incremented on each subsequent INSTALL.
Flags	The first four bits of this unsigned byte are used to specify driver interface information. See Table 4-2.
INIT	Address of the driver installation function called by the INSTALL SVC to initialize each unit of the driver.
SUBDRIVE	Address of the driver installation function that manages this driver's sub-driver information.
UNINIT	Address of the driver function called by INSTALL to uninitialize (remove) a driver unit.
SELECT	Address of the driver function that prepares a driver unit for subsequent I/O. SELECT is used in conjunction with the OPEN SVC.
FLUSH	Address of the driver function that "closes" a previously opened driver unit. The CLOSE SVC is mapped directly to this entry point.
READ	Address of the driver function called when a READ SVC has been specified.
WRITE	Address of the driver function called when a WRITE SVC has been specified.
GET	Address of the driver function called to fill a buffer with information about a driver unit.
SET	Address of the driver function called to control the SET function for the driver's units.

Table 4-1. (Continued)

Data Field	Explanation
SPECIAL	Address of the driver function called when a process requests special, device-specific functions.
Pointer to Ready List Root	Address in the FlexOS internal data area of the Process Descriptor for the process running before the current asynchronous I/O event was begun. This is the PDADDR of the process waiting for a system flag to be set which you pass to the FLAGSET driver service. This field is filled in by the Supervisor when the driver is installed.
Pointer to Driver Services Table	Address of a table containing the addresses of the FlexOS driver service routines (see Section 5). This table is used by the Driver Run-time Library linked with dynamic drivers. This field is also filled in by the Supervisor when the driver is installed.

The INIT, SUBDRIVE, and UNINIT driver installation functions are common to all driver types. See Section 4.4 for their descriptions. The remaining functions are driver-type dependent and described separately according to their resource manager in Sections 7, 8, 9, 10, and 11.

4.2.1 Driver Header Synchronization Flags

Three driver header flags indicate to the driver's resource manager if that driver can handle multiple I/O requests. The resource manager then controls the flow of requests to the driver depending upon the status of these bits. Another bit indicates whether the device controlled by the driver is 8- or 16-bit oriented. The following table lists the bit values:

Table 4-2. Driver Header Synchronization Flags

Flag	Value	Meaning
Bit 0:	0	I/O reentrant at the driver level
	1	Synchronize at the driver level
Bit 1:	0	I/O reentrant at the unit level
	1	Synchronize at the unit level
Bit 2:	0	I/O reentrant at the Resource Manager Level
	1	Synchronize at the Resource Manager Level
Bit 3:	0	Byte-oriented device
	1	Word-oriented device
Bit 4:	0	Use systems delimited read routine
	1	Use driver-supplied routine for delimited read requests

Flag bit 0 is the driver level synchronization flag. Set this flag to zero if the driver is able to handle multiple I/O requests simultaneously. If the driver must get I/O requests one at a time, set flag bit 0 to one.

Flag bit 1 is the unit level synchronization flag. As with the driver, set this flag to zero if the unit can handle multiple I/O requests simultaneously. Set this flag to one if the unit must complete one request before receiving another.

If the Resource Manager level interface flag, bit 2, is set, the resource manager allows the driver to perform a series of I/O operations for a single unit before permitting a different unit to perform another series of operations. Set this flag when a device being managed by this driver must be deactivated before another device can be used. If flag bit 2 is off, each unit can accept multiple outstanding I/O requests.

Flag bit 3 establishes a record size on a device as 1 or 2 bytes. This flag is used for delimited READs, to determine whether FlexOS will interpret a device's data as 8- or 16-bit characters.

Note: The GET function is not considered an I/O request and can be called at any time regardless of the synchronization flag value.

4.3 Entry Point Parameter Interface

The resource manager provides the driver installation and I/O functions with a 32-bit parameter and expects a 32-bit return code. The parameter is data or the address of a parameter block. The return code by definition indicates success with a positive value and failure with a negative value. The success return codes are described in the function descriptions below. See Appendix B in the FlexOS Programmer's Guide for the description of the FlexOS error codes. Error codes in the range of $-64x10^3$ to $-2x10^9$ are driver-type specific.

The C language entry point parameter interface convention is shown in Listing 4-2.

Listing 4-2. C Language Calling Convention

```
Calling Sequence:       ret = function(parm);

Function Interface:     LONG function(arg)
                        LONG arg;
                        {
                                LONG ret_code;
                                . . .
                                return(ret_code)
                        }
```

SELECT and SPECIAL return driver-type-specific error codes. INIT and FLUSH return driver-type-specific error codes through the driver's synchronous interface.

The READ, WRITE, and SPECIAL driver I/O functions are expected to return event masks through the driver's synchronous interface. These driver functions pass the completion code through the asynchronous interface.

4.4 Driver Installation Functions

This section describes the three driver installation functions common to all driver types: INIT, SUBDRIVE, and UNINIT. These functions map to the INSTALL SVC's options as follows:

- INIT is called to execute INSTALL options 1--load driver--and 2--add a unit.
- SUBDRIVE is called to execute INSTALL option 3--link two drivers.
- UNINIT is called to execute INSTALL option 0--remove a driver unit.

4.4.1 INIT--Initialize the specified driver unit

Parameter:

High Word	INSTALL Flags--see Table 4-4 below
Low Word	Unit number to be initialized

Return Code:

Success	**High word:** Return either 0 or sub-drive driver type value. A zero value indicates that initialization is complete--no sub-driver is required. At this point the unit is operational and mapped to a resource manager. If a sub-driver is required to make this driver operational, return the sub-driver's driver type value here. The driver type values are listed in Table 4-3 below. **Low word:** Return this driver's driver type value (see Table 4-3.
E_HARDWARE	Hardware not available
E_EXISTS	Specified unit already initialized
E_INIT	Driver unit could not be initialized
E_MEMORY	Could not allocate enough System Memory for the unit
E_xxx	Driver-specific type of error

The INIT driver function is called by the INSTALL SVC for each unit in the driver. The INIT driver function must initialize the specified unit's hardware. This function should also initialize any Mutual Exclusion Parameter Blocks (MXPBs) the unit will require, call FLAGGET for any flags to be used by the unit, establish the Interrupt Service Routine (ISR) vector through a call to the SETVEC driver service, and allocate System Memory for the unit. You can also use INIT to allocate buffers for initialized units.

The INSTALL flags selected by the user are specified in the high word of the entry parameter; the unit number is provided in the low word. The meaning for each flag value is listed in Table 4-4. INSTALL flag bit 8 is used by the Disk Resource Manager to determine if the disk device may have partitions. A disk device installed with partitions allowed cannot be formatted.

INIT must return the installed driver's type value. If the driver unit requires a sub-driver, INIT must also return the driver type of the required sub-driver. The following table lists the driver type values:

Table 4-3. Driver Type Values

Hex Value	Driver Type
0	Invalid or No Driver
1	Timer Driver
11	Pipe Driver
21	Disk Driver
31	Console Driver
38	Screen VDI driver
5x	Extension Drivers
61	Network Protocol Driver
62	Network Transport Driver
63	Network Transaction Server Driver
64	NET: Device Driver
65	Name Server Driver
71	Printer Driver
72	Serial Driver
78	Printer VDI driver
79	Metafile VDI driver
7D	Network Resource Manager
7E	DOS Clock Driver Emulator
7F	Null Device
81	Port Driver
82-FF	OEM Specific (Special)

Driver type values never end in zero; for example, 70 is an illegal driver type value. Zero in the second digit is reserved for resource managers.

Table 4-4. INSTALL Flags

Flag	Meaning
Bit 0:	0 = User Raw SET not allowed 1 = Raw SET allowed
Bit 1:	Reserved--must be 0
Bit 2:	0 = User Raw WRITE not allowed 1 = Raw WRITE allowed
Bit 3:	0 = User Raw READ not allowed 1 = Raw READ allowed
Bit 4:	0 = Exclusive access only 1 = Shared access allowed
Bit 5:	0 = Permanent device 1 = Removable device
Bit 6:	0 = DEVLOCKs not allowed 1 = DEVLOCKs allowed
Bit 7:	0 = Exclusive access allowed 1 = Shared access only
Bit 8:	0 = Device partitions not allowed 1 = Partitions allowed
Bits 9:	0 = Do not verify after disk writes 1 = Verify after disk writes
Bits 10-12	Reserved--must be 0

Table 4-4. (Continued)

Flag	Meaning
Bit 13:	0 = Do not force case to media default 1 = Force case to media default
Bit 14:	0 = Prefix substitution on load name 1 = Literal load name
Bit 15:	Reserved--must be 0

4.4.2 SUBDRIVE--Associate driver to a sub-driver

Parameter: Address of SUBDRIVE parameter block (see Figure 4-3 below)

Return Code:

Success **High word:** Set to either 0 or sub-drive. A zero value indicates that initialization is complete; the unit is operational and mapped to a driver. Return the required sub-driver's driver type value if another sub-drive is needed to complete the hardware interface. Table 4-3 lists the driver type values.

Low word: Set to 0.

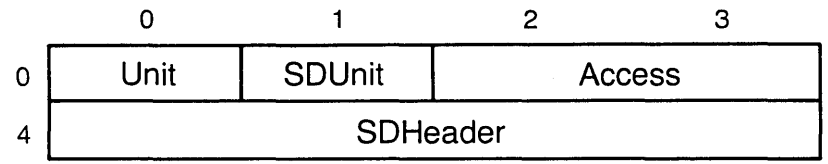


Figure 4-3. SUBDRIVE Parameter Block

Table 4-5. SUBDRIVE Parameter Block Data Fields

Field	Meaning
Unit	Driver unit that requires this sub-driver
SDunit	Sub-driver unit number
Access	The sub-driver's INSTALL access flags (see above). It is the higher-level driver's responsibility to honor these flags.
SDheader	Address of sub-driver's Driver Header

The SUBDRIVE function links one driver to another. Both drivers must be previously loaded and initialized. The user specifies in the INSTALL call which driver is to act as the resource manager and which driver is to act as the sub-driver. The SUBDRIVE parameter block provides you with the user's driver selections in the form of their unit numbers. Also provided in the parameter block are the subdriver's access flags (specified when that driver was installed) and the address of the sub-driver's driver header. The higher-level driver controls the sub-driver through the entry points at this address.

Sub-drivers are previously initialized units not currently in use. Once a unit has been declared a sub-driver, it cannot be addressed through its previous device name--it becomes dedicated to the higher-level driver. The higher-level driver becomes the sub-driver's resource manager.

4.4.3 UNINIT--Uninitialize the Specified Driver Unit

Parameter: Unit Number

Return Code: 0

The UNINIT driver function removes a driver unit from the system. UNINIT is responsible for releasing any system resources and for determining that the unit's hardware has been placed in a quiescent state before it is removed from the system.

Any files open to the unit are closed by the Resource Manager that controls the unit's driver. The Resource Manager also FLUSHs any buffers used by the unit.

UNINIT should not call a sub-driver's UNINIT function because FlexOS may map the sub-driver to another driver. It is important that UNINIT call the sub-driver's FLUSH function.

If every unit in a driver has been uninitialized, the driver can be removed from System Memory.

End of Section 4

Driver Services

FlexOS provides a number of services to drivers not available through the normal programmer interface. This section describes those services and where a driver would use them.

The driver service functions are described in C and are available to drivers whether they are dynamically installed or linked into the system image. Drivers linked with the system can access driver services directly. Drivers loaded from disk can link to a Driver Run-time Library, which indirectly calls the appropriate operating system routines.

The Driver Run-time Library accesses operating system functions by looking up the addresses of these routines in a table supplied by the operating system. The location of this table is placed into the driver header at the time the driver is installed.

The driver service functions are grouped into the following seven categories:

- the flag system (Section 5.1)
- Asynchronous Service Routines (5.2)
- device polling (5.3)
- memory management (5.4)
- critical regions (5.5)
- system process creation (5.6)
- interrupt service routines (5.7)

Driver services are listed alphabetically within each category.

Besides the driver services described below, drivers can make Supervisor calls through the Supervisor Interface (SUPIF). Section 6 describes how to call the Supervisor and the precautions you must observe.

5.1 Flag System

The FlexOS flag system acts as a logical interrupt system in which a process begins an asynchronous event and indicates that it will wait for the future completion of the event. The process that began the event then continues its execution asynchronously with respect to the hardware interrupt or process that completes the event. The flag system indicates the event's completion and awakens the original process.

The FlexOS flag system provides five driver service functions that enable the Supervisor to coordinate and acknowledge asynchronous events: FLAGGET, FLAGEVENT, FLAGSET, FLAGCLR, and FLAGREL. The Supervisor allocates flags to drivers with FLAGGET. FLAGEVENT enables a process to signal that it has begun an asynchronous event and will wait for the event's completion. The calling process is notified of the event's completion when another process or an Asynchronous Service Routine (ASR) calls FLAGSET. A process uses FLAGCLR to return a flag to its clear state and FLAGREL to release a flag back to the system.

A flag is similar to a binary semaphore - it is a single-event communication channel between two asynchronous routines. Unlike a binary semaphore, a process can use a flag to return a 32-bit value. The communication channel is established when a driver's INIT code calls FLAGGET. A flag can be in one of four states:

- unused - the flag has not been allocated
- clear - flag has been allocated but is not currently in use
- pending - A process has an event waiting for the I/O to complete
- completed - An I/O event has completed, but no process has performed a FLAGEVENT driver service function on it

There is a limit of 31 flags per process. The total number of flags in the system cannot be specified; FlexOS dynamically allocates new system flags as they are needed.

FLAGGET allocates a flag to the driver by searching for a system flag that is in the unused state and returning a flag number to be used by the driver in all future references to that particular flag. The Supervisor initializes the allocated flag by placing it in the clear state.

A driver must allocate a sufficient number of flags to handle the maximum number of asynchronous events that might occur at a given time. For example, a driver should allocate separate flags for READ operations and WRITE operations so that a READ and a WRITE event can be processed simultaneously.

For drivers using the flag system, an I/O operation takes place in the following sequence of events.

1. A process starts an I/O event by calling the appropriate driver function through the driver's synchronous interface. This begins an I/O operation that causes a hardware interrupt when the driver unit completes the I/O. At this point, the calling process actually runs the code in the driver.

2. The driver, under the process's control, then calls FLAGEVENT with a flag number to indicate which flag to mark as pending. The flag number was obtained through FLAGGET at the time the driver was initialized.

3. FLAGEVENT returns an event mask used by the calling process to wait for the completion of the event. The calling process passes the event mask to the WAIT SVC to wait for event's completion. If the event is already completed, i.e., FLAGSET has already been called and the flag is marked as completed, FLAGEVENT causes the flag to be marked as clear and the event itself is noted as completed.

4. When the I/O is completed, a hardware interrupt occurs that results in an Interrupt Service Routine (ISR) being executed. The ISR calls the DOASR driver service to schedule an ASR for execution. The ASR notifies the system that the event is completed by calling the FLAGSET driver service with the flag number, process descriptor address, and completion code as arguments.

If the original process has not caused FLAGEVENT to be called, FLAGSET sets the flag to completed, or, if the flag was pending, to clear. If the requesting process is waiting for the event, it is awakened. If the process canceled the event or the process was terminated, FLAGSET returns an error code.

Because of the asynchronous nature of FlexOS, it is possible for the I/O event to complete before the process starting the I/O has a chance to call the FLAGEVENT driver service. Once FLAGEVENT is called, the calling process returns from the driver code with the event mask as a return code.

When a flag is set to the clear state, the event it marked is placed on a list indicating it is waiting for the original process that called FLAGEVENT to perform the RETURN SVC. The flag can then be used by other processes, even though the event is not satisfied through RETURN.

The driver must remember the process descriptor address of the running process before the I/O event is actually started. This value is obtained through the Ready List Root (RLR) address field in the driver header. The driver must store this value locally until it is used by the ASR, or process, that calls FLAGSET.

The flag system driver services return error codes if a logic error has taken place. A FLAGEVENT performed on a flag in the pending state returns an E_UNDERRUN error; another process is already using this flag for another I/O event. A FLAGSET performed on a flag in the completed state returns an E_OVERRUN error; an I/O request completed and set a flag that was previously set. This error is also occurs when a process has not performed a FLAGEVENT function on the previous I/O event.

FlexOS returns an E_EMASK error if a process attempts, through a driver's FLAGGET call, to obtain more than 31 flags or when a driver calls FLAGEVENT when the calling process already has 31 outstanding I/O events.

When the driver is finished using a flag, it can release it with FLAGREL. FLAGREL places the flag back into the unused state. An error occurs if a flag is not in the clear state when the release is attempted (see FLAGCLR). If a driver is to use a flag frequently, the driver should not release the flag until its UNINIT code is executed.

When the communication between routines gets crossed up, the driver can force the flag into a clear state with the FLAGCLR driver service. This happens, for example, when the hardware produces spurious interrupts. FLAGCLR should be called before an I/O request is started.

Table 5-1 shows the results of the flag system driver service functions on system flags according to their state.

Table 5-1. Flag Operations and Flag States

Flag State	FLAGGET	FLAGREL	FLAGEVENT	FLAGSET	FLAGCLR
unused	clear	--	--	--	--
clear	--	unused	pending	completed	clear
pending	--	E_INUSE	UNDERRUN	clear	clear
completed	--	E_INUSE	clear	OVERRUN	clear

5.1.1 FLAGCLR--Clear a system flag

C Interface:

```
LONG    flagno;
LONG    retcode;

retcode = flagclr(flagno);
```

Parameters:

flagno System flag number to clear

Return Code: E_SUCCESS to indicate success

FLAGCLR forces a system flag into the clear state. In hardware environments where spurious interrupts might occur, the driver should call FLAGCLR before the process initiates the I/O operation.

5.1.2 FLAGEVENT--Return an event mask

C Interface:

```
LONG    swi;
LONG    flagno;
LONG    emask;

emask = flagevent(flagno,swi);
```

Parameters:

flagno	System flag number previously allocated by FLAGGET
swi	Software interrupt routine to be called when the event completes. This address is originally passed to the driver in the Supervisor call's parameter block. A zero value indicates that no swi was specified.

Return Code:

emask	Event mask. The calling process uses this value to wait for a subsequent FLAGSET on the given flag number.
E_UNDERRUN	Logic Error. A process is already waiting on this flag.
E_EMASK	No event mask is available. The calling process has 31 outstanding events. This error does not occur when FLAGEVENT is called by an ASR.

FLAGEVENT returns an event mask (emask) which allows the caller to wait for the setting of a system flag. It is assumed that the flag will be set asynchronously, however, in some instances the driver's synchronous code can call FLAGSET. The calling process can wait for the event through the WAIT SVC. The driver typically returns the event mask received through this driver service back to the resource manager that called the driver. The resource manager is responsible for either waiting for the event or returning to the calling process, depending on the type of call made.

5.1.3 FLAGGET--Allocate a system flag number

C Interface:

```
LONG    flagno;
flagno = flagget();
```

Parameters: None

Return Code:

flagno	Flag number
E_EMASK	31 flags have already been allocated to this process

The FLAGGET driver service allocates a system flag number. This operation is typically done in the driver's INIT code.

5.1.4 FLAGREL--Release a system flag

C Interface:

```
LONG    flagno;
LONG    retc;

retc = flagrel(flagno);
```

Parameters:

flagno	Flag number to be released

Return Code:

E_SUCCESS	Flag is released
E_INUSE	Flag is not in the clear state

FLAGREL releases a system flag number. This driver service is typically called from the driver's UNINIT code. FLAGREL returns an error if the flag to be released has not been previously cleared.

5.1.5 FLAGSET--Set a system flag

C Interface:

```
LONG    flagno;
LONG    pdaddr;
LONG    retcode;
LONG    retc;

retc = flagset(flagno,pdaddr,retcode);
```

Parameters:

flagno — System flag number as previously allocated by the FLAGGET driver service.

pdaddr — Process descriptor address of process waiting for this flag. Get this value from the RLR address in the driver header.

Note: This is NOT the pdaddr normally passed with parameter blocks into the driver entry points. The pdaddr normally indicated in the entry point Parameter Block is the process in whose memory the buffer belongs. The original calling process may be a different process.

retcode — Completion code for this operation.

Return Code:

E_SUCCESS Flag is set
E_CANCELLED Process canceled the FLAGEVENT
E_OVERRUN Logic error - flag is already set

The FLAGSET driver service notes the completion of an asynchronous operation. The process that is waiting for this operation previously called--or is about to call--FLAGEVENT with the indicated flag number, from FLAGGET. If the process was aborted while waiting for this flag to be set or if the process canceled its WAIT, the E_CANCELLED error is returned.

5.2 Asynchronous Service Routines

Asynchronous Service Routines (ASRs) are routines within a driver's code that execute asynchronously to processes. FlexOS provides five driver service functions for executing ASRs:

- DOASR schedules an ASR for execution at the next dispatch.
- NEXTASR and EVASR schedule an ASR for execution upon the completion of an event.
- ASRWAIT suspends ASR execution until an event completes.
- DSPTCH forces a dispatch which results in the execution of all pending ASRs.

Because ASRs are run by the dispatcher, they have a higher priority than processes. At every process dispatch, the dispatcher checks to see if any ASRs have been scheduled to run. If there are one or more ASRs ready, it runs the first one to completion and checks for more. FlexOS schedules ASRs in priority order. ASRs of equal priority are scheduled on a first-come, first-serve basis. When there are no more ASRs, the dispatcher runs the next ready process.

The routines that respond to hardware interrupts are called Interrupt Services Routines, or ISRs. To allow FlexOS to respond to multiple interrupts, ISRs should be very short. Typically, an ISR schedules an ASR to complete the work required by the interrupting event. For example, in response to an interrupt, an ISR can call DOASR to schedule an ASR to perform I/O.

When an ASR starts an event through an SVC or a driver service, FlexOS returns an event number instead of an event mask. An event mask allows synchronous processes to wait for up to 31 different events; event numbers allow ASRs to wait for an unlimited number of events. Use multiple ASRs, each receiving its own event number, to wait on multiple events.

SVCs requiring an event mask parameter can be called from either an ASR or a process. If an ASR is calling, an SVC accepts event numbers instead of event masks.

When you receive an event number (or, in other contexts, an event

mask), you must call the RETURN SVC to clear the event from the system. This is true even for events used to synchronize ASRs and even if the STATUS SVC indicates the event is already complete. In response to an ASR, STATUS returns a 0 if the event is not complete. Any other value indicates completion.

To clear an event from the system, the ASR that generates an event number should call NEXTASR, EVASR, or ASRWAIT. For all three, the event is specified as a parameter in the call. For NEXTASR and EVASR, if you do not pass the event number in the call, you must store it in a global area accessible by the ASR scheduled. ASRs scheduled by NEXTASR or EVASR should call RETURN, passing the event number as the parameter. Call RETURN or STATUS through the Supervisor Interface (SUPIF) defined in Section 6. ASRs calling ASRWAIT should not call RETURN, the event is cleared and the completion code is returned by ASRWAIT.

ASRs scheduled by NEXTASR can wait on only one event before being scheduled. The event specification must be an event number; it cannot be a process's event mask. EVASR, on the other hand, accepts either a process event mask or an ASR event number. Like NEXTASR, EVASR is restricted to scheduling one ASR for an event completion. Use EVASR when you do not know whether the call is made from ASR context or process context.

ASRWAIT is a functional alternative to NEXTASR and EVASR that takes an event number (but not a event mask) and returns when the event completes. In general, it is more expensive in both CPU and memory utilization to use ASRWAIT versus next ASR or EVASR . However, if the current ASR stack is complex (that is, the current state of the logic is not easily reproduced), ASRWAIT can simplify reproducing it. ASRWAIT is a simple way to break up an ASR, since other ASRs can run before ASRWAIT returns.

An ASR may not call the WAIT SVC. Polling operations are strongly discouraged. ASRs may effectively perform a block by calling ASRWAIT or by chaining to another ASR with NEXTASR or EVASR, which executes after a specified event has occurred.

The priority of ASRs ranges from 0, the highest priority, to 255, the lowest. Digital Research recommends that most ASRs run at priority 200, allowing room for ASRs driven by real-time events to have higher priority than ASRs that need not be so timely.

ASRs run to completion. If a hardware interrupt occurs during the execution of an ASR, the dispatcher will continue execution of the ASR after the ISR completes. This occurs even if a higher-priority ASR is scheduled by the ISR.

ASRs can be disabled through the NODISP driver service, as described in Section 5.5. The DSPTCH driver service, described below, takes the currently running process out of context and forces all scheduled ASRs and poll routines to run.

5.2.1 ASRWAIT--Wait for event to complete

C Interface:

```
LONG    evnum;
LONG    ev_return;
BYTE    *stack_save_area;

ev_return = asrwait(evnum,stack_save_area);
```

Parameters:

evnum — Event number returned by SVC or driver service call

stack_save_area — Address of buffer for temporary stack storage

Return Code:

ev_return	Event's completion code
E_SUCCESS	No event number was specified

The ASRWAIT driver service suspends ASR execution until the specified event is complete. The event is designated by its number. The event must have been initiated by the ASR; it cannot be a process event mask. Specify a null event number to reschedule an eventless ASR. While the ASR is suspended, other ASRs are executed at the next dispatch.

The second ASRWAIT parameter is a buffer address. ASRWAIT copies a

portion of the dispatcher stack into this buffer and restores the stack from it. The area must be big enough to hold all of the stack used by this ASR since it was called, plus 50 to 100 bytes. No error or range checking is performed.

The ASR is rescheduled for the next dispatch after the event completes. The event's completion code is returned by ASRWAIT. Do not call the RETURN SVC after an ASRWAIT. When a null event number is specified, the ASR is rescheduled for the next dispatch and receives an E_SUCCESS event completion.

IMPORTANT: If you called MAPU before calling ASRWAIT, you must call MAPU again when the function returns to get the memory back.

5.2.2 DOASR--Schedule an ASR

C Interface:

```
VOID    asr_routine();
LONG    parm1;
LONG    parm2;
BYTE    prior;

doasr(asr_routine,parm1,parm2,prior);

VOID asr_routine(parm1,parm2)
LONG parm1;
LONG parm2;
{
/* perform activity */

return;
}
```

Parameters:

asr_routine	Address of ASR routine
parm1	First general parameter to pass to the ASR
parm2	Second general parameter to pass to the ASR
prior	ASR priority

Return Code:

E_SUCCESS	Successful operation
E_POOL	Out of memory

The DOASR driver service schedules an ASR for execution. Typically, Interrupt Service Routines call DOASR when the ISR needs more work done than can be performed in a timely manner from within the ISR. The ASR is placed in the ASR dispatch queue according to the priority parameter (0 = best, 255 = worst). All ASRs with equal priority are dispatched on a first-in, first-out basis.

ASRs run to completion before another ASR is run. While ASRs are running, hardware interrupts are enabled. This allows ISRs to run and to schedule other ASRs. When an ISR is complete, an interrupted ASR continues to run even if the ISR has scheduled a higher-priority ASR. After the ASR is complete, the scheduled ASR with the highest priority is run next.

5.2.3 DSPTCH--Force a dispatch

C Interface:

```
dsptch();
```

Parameters: None

Return Code: None

The DSPTCH driver service takes the currently running process out of context, reschedules it, runs all scheduled ASRs and poll routines, then brings the best priority, runnable process into context. The calling process is rescheduled as a running process. DSPTCH returns to the calling process when it comes back into context.

DSPTCH is useful in guaranteeing that all scheduled ASRs have run. The DOASR driver service, described above, does not force a dispatch but only schedules the ASR to run at the next dispatch.

5.2.4 EVASR--Schedule ASR from Process Context

C Interface:

```
VOID    asr_routine();
LONG    emask;
LONG    parm2;
BYTE    prior;

evasr(emask,asr_routine,parm2,prior);

VOID asr_routine(evnum,parm2)
LONG evnum;
LONG parm2;
{
   return;
}
```

Parameters:

asr_routine	Address of an ASR
emask	Process event mask or ASR event number
parm2	General parameter to ASR
prior	ASR priority

Return Code: None

The EVASR driver service schedules an ASR for dispatching upon the completion of the specified event. If EVASR is called in ASR context, this service is equivalent to NEXTASR with the event number as parm1. When EVASR is called in process context, EVASR converts the process event mask to an ASR event number, frees the process's event bit, and disassociates the event from the process. The new event number is passed as the first parameter to the ASR so that the ASR can call the RETURN SVC on the event number.

5.2.5 NEXTASR--Schedule ASR from an ASR

C Interface:

```
LONG    evnum;
VOID    asr_routine();
LONG    parm1;
LONG    parm2;
BYTE    prior;

nextasr(evnum,asr_routine,parm1,parm2,prior);

VOID asr_routine(parm1,parm2)
LONG parm1;
LONG parm2;
{
/* perform activity */

return;
}
```

Parameters:

evnum	Event number of event to wait for
asr_routine	Address of ASR routine
parm1	First general parameter to pass to the ASR
parm2	Second general parameter to pass to the ASR
prior	Priority of ASR

Return Code: None

The NEXTASR driver service schedules an ASR for dispatching upon completion of the event specified by the event number.

Call NEXTASR from within an ASR when an ASR needs to wait for the completion of an event. NEXTASR can be called only by the ASR that initiated the event upon which NEXTASR is waiting.

If you run an ASR that generates an event number, you must call NEXTASR to schedule an ASR to call the RETURN SVC, which clears the event from the system.

NEXTASR accepts only event numbers; an ASR cannot use an event mask generated by a process. The pending event must have been generated from within an ASR, not a process.

5.3 Device Polling

For devices not interrupt-driven, FlexOS supports the software mechanism of device polling. In single-tasking systems, these devices are usually polled with a hard CPU loop. However, this type of polling severely degrades the performance of a multitasking system. By using the POLLEVENT driver service, a device is polled periodically, allowing processes to run between polls.

Use POLLEVENT to emulate an asynchronous event when there is no hardware interrupt to determine completion of an event. POLLEVENT is not meant to replace the FLAGEVENT/FLAGSET method of communicating with an application, which is described in Section 5.1.

POLLEVENT is usually called from within an ASR. If called from an ASR, it returns an event number. The event number is used to perform a NEXTASR driver service, which performs a FLAGSET upon completion of the poll event.

Following the completion of the poll event, the driver must call the RETURN SVC to clear the event from the system.

The dispatcher calls the poll routine at process context switches. Therefore, poll routines run under the dispatcher process context. If the poll routine returns true (non-zero), the poll event is noted as completed. If a NEXTASR driver service was called based on the poll event, NEXTASR schedules an ASR to run.

5.3.1 POLLEVENT--Poll for event completion

C Interface:

```
WORD    poll_routine();
LONG    emask;
LONG    swi;

emask = pollevent(poll_routine,swi);
```

```
WORD    poll_routine()
{
/* check device */

if (device_ready)
return(-1);
else
return(0);
}
```

Parameters:

poll_routine	Address of poll routine. This routine returns 0 if the event is not complete. A non-zero return code indicates the poll event is complete. This routine is called at each process dispatch until the event is complete.
swi	Address of user software interrupt routine

Return Code:

emask	Event mask used to perform a WAIT based on this event (or a NEXTASR on this event number)

The POLLEVENT driver service establishes a poll routine which is called periodically to determine the completion of an event. POLLEVENT returns an event mask which allows the calling process to wait, through the WAIT SVC, for the software-determined event.

The poll routine is called under the dispatch-process context and is similar in nature to an ASR. If POLLEVENT is called by an ASR, an event number is returned instead of an event mask. Following completion of the polled event, the driver must call the RETURN SVC, through SUPIF, to clear the event from the system.

5.4 System Memory Management

FlexOS supports mapped and protected memory management units (MMUs). The following terms are used in the description of the FlexOS memory model.

- Physical Memory - all physically addressable memory in the system. This includes memory used for specific types of hardware, such as bit maps for video displays.
- Physical Space - the address space of Physical Memory. The addresses in Physical Space might be used when communicating with hardware, such as DMA controllers.
- User Memory - Physical Memory allocated for use by a particular process. Programs loaded from disk are placed into User Memory. Memory allocated through the MALLOC SVC is also placed in User Memory. Each process has its own User Memory.
- User Space - memory that can be addressed while running code in User Memory. Each process running code in User Memory is running in its own User Space. Each User Space is a separate address space. With supporting hardware memory protection, a process running in its User Space cannot address memory in another User Space. While running code in User Space, System Memory and Physical Memory are also not addressable.
- System Memory - Physical Memory allocated for use by the operating system. All drivers are loaded into System Memory. All memory allocated to drivers through the SALLOC function, described below, is also placed in system memory.
- System Space - System Space is the memory that can be addressed while running code in System Memory. At any point in time this space includes all System Memory as well as the User Memory of the currently running process.

  Some processes, called system processes, do not own User Memory. While system processes are running, there is no addressable User Memory.

All driver code resides in System Memory and therefore executes in System Space. This code is always running under a process context and therefore includes the process's User Memory. Asynchronous Service Routines (ASRs) run under the dispatch-process context and are considered system processes.

The addressing of User Memory is not necessarily the same in System Space as it is in User Space. For example, a buffer address supplied by an application while in User Space cannot be used directly while in System Space. The address must be translated into System Space before it addresses the same physical User Memory.

- User Address - an address that points to User Memory relative to User Space. While in System Space a User Address must be converted to a System Address before use.
- System Address - an address directly addressable while in System Space.

Figure 5-1 shows the relationship of User Space to System Space.

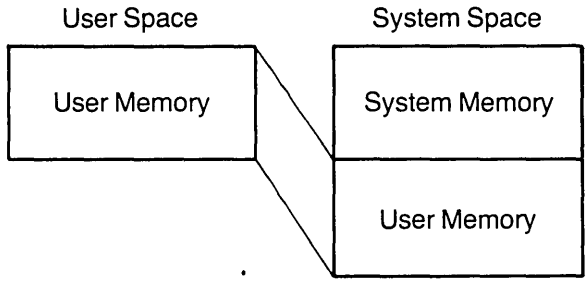


Figure 5-1. User Space and System Space

FlexOS supplies a number of driver service functions to drivers that facilitate the use of various types of addresses and also allocate and free system memory. These services are as follows:

- SADDR - converts a User Address in User Memory to a System Address.
- UADDR - converts a System Address in User Memory to a User Address. An error is returned if the System Address points to System Memory.
- PADDR - converts a System Address to a Physical Address.
- MAPU - allows a process to change the User Memory currently mapped in system space to another process's User Memory. The calling process loses access to its own User Memory until the UNMAPU function is called.
- UNMAPU - restores a process's User Memory.
- MLOCK - locks the current User Memory in Physical Memory. This prevents moving the memory to another physical location.
- MUNLOCK - allows User Memory to be swapped out to disk or moved to another physical memory location. System Addresses of User Memory may change while the memory is unlocked. System Addresses of User Memory should be converted to a User Address before the MUNLOCK function is called and converted back to a System Address after the MLOCK function has been called.
- MRANGE - checks the start and length of a buffer in User Memory to verify it is within the process's current User Space.
- SALLOC - allocates System Memory from the free pool of Physical Memory. This is the same pool used by applications.
- SFREE - frees System Memory and places it back into the free pool of Physical Memory.
- MAPPHYS - maps physical memory not in the free pool into System Space and returns a System Address for that memory. This is used to address "device memory" such as bit maps or read-only Memory. If the device memory is already mapped to System Space, the System Address is returned. MAPPHYS should be called only at INIT time.

Resource Managers call the driver entry points to I/O functions with pointers to buffers that can be either User or System Addresses. If the buffer resides in User Memory the pointer is a User Address. If the buffer resides in System Memory, the pointer is a System Address. The resource manager sets a flag to indicate whether the address is in User or System memory. Along with the flag, drivers receive the process descriptor address (PDADDR) of the process that owns the buffer's memory.

A User Address is not directly usable until it is converted to a System Address. The User Address is relative to a particular process. SADDR converts a User Address into a System Address for the currently addressable User Memory.

When drivers pass a User Address to ASRs or other processes, it must be passed as a User Address and process descriptor address pair. This allows the ASR or process to call the MAPU driver service to assume the original User Memory, then call the SADDR driver service to obtain the System Address of the correct Physical Memory. Passing a System Address of User Space to an ASR or another process results in addressing the wrong Physical Memory or a memory violation upon use of that address.

Driver entry points are called with User Memory locked in Physical Memory. A driver has the option of unlocking the memory to allow moving the memory to another physical location.

Moving memory might be done by the memory manager during garbage collection. If the driver calls MUNLOCK to unlock User Memory, all System Addresses that refer to User Memory become invalid. Before MUNLOCK is called, UADDR must be used to convert to user addresses all System Addresses that refer to User Memory. These converted addresses cannot be used either by the driver or hardware until the User Memory is locked into Physical Memory through the MLOCK driver service. The driver can then use SADDR to convert User Addresses to System Addresses and Physical Addresses for use by the driver and its hardware.

For all SVCs for which the user program specifies a buffer, FlexOS does buffer range checking to ensure that all buffers sent to drivers are contiguous in physical memory and legal. An exception to this is the SPECIAL SVC, where a buffer is not assumed but might be sent to

the driver by an application. In this case, the driver must perform its own range checking though the MRANGE driver service.

A driver can call the SALLOC driver service to allocate System Memory to be used by the driver for buffers and other memory resources. This is usually done in the driver's INIT code. Allocating memory at INIT time allows a driver's load image to be small. It also allows a driver to handle an arbitrary number of units by allocating memory as INIT is called for each unit.

Memory allocated through SALLOC should be freed with the SFREE driver service in the driver's UNINIT code.

SALLOC takes memory out of the Transient Program Area (TPA), which is the same Physical Memory pool from which User Memory is allocated during program loading. Thus, memory allocated by SALLOC is not available to loadable programs.

Before using SALLOC, you should also consider that more memory than requested might be taken out of the Transient Program Area (TPA). This potential for wasted memory ranges from 512 to 16K bytes. The exact amount depends on the granularity of the MMU's mapping ability or, in segmented architectures, on the minimum size of a segment. The amount of wasted memory is also related to the minimum fragmentation allowed by implementation-dependent memory management routines.

5.4.1 MAPU--Map another process's User Memory

C Interface:

```
LONG    pdaddr;

ret=mapu(pdaddr);
```

Parameters:

pdaddr — Process descriptor address of process whose User Memory is to be mapped. No checking is done to verify that the pdaddr is valid.

The driver usually receives this address through the PDADDR field of a parameter block passed through one of the driver's entry points. The buffer is specified in the same parameter block.

Return Codes:

E_SUCCESS	Successful operation
emask	Designated process is currently swapped out. It will be swapped in asynchronously to the calling process. A WAIT on this event mask returns when the specified process's memory is in place.

MAPU removes the calling process's current User Memory and replaces it with the indicated process's User Memory.

5.4.2 MAPPHYS--Map Physical Memory

C Interface:

```
BYTE    *saddr
MAPPB   *parmblk;
WORD    type;

saddr = mapphys(parmblk,type);
```

Parameters:

parmblk	Address of map parameter block describing physical memory (see Figure 5-2)
type	0 = code 1 = data

Return Code:

saddr	System Address of mapped physical memory

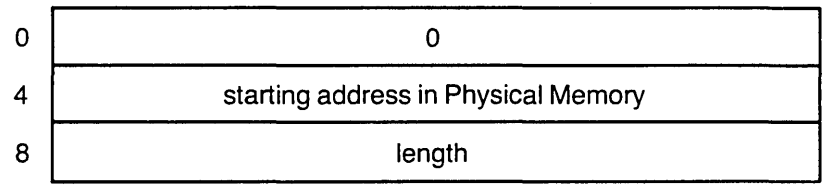


Figure 5-2. Map Parameter Block

MAPPHYS puts the specified Physical Memory into System Memory. The specified Physical Memory cannot be part of the TPA. MAPPHYS should be called only once, at the time a driver is initialized. If the memory is to contain executable code, the type parameter must be zero. If the type parameter is zero, mapped memory cannot be modified as data.

Use MAPPHYS to obtain System Addresses of device memory, such as bit maps, or other memory not intended for the direct use of applications. An example of this type of memory is read-only memory that can be accessed only from System Space.

5.4.3 MLOCK-- Lock the User Memory

C Interface: mlock();

Parameters: None

Return Code: None

MLOCK locks the current User Memory in Physical Memory. MLOCK prevents moving the memory to another physical location. The Supervisor automatically locks memory whenever an application calls an SVC.

The driver is responsible for matching MLOCK and MUNLOCK calls. FlexOS maintains a count of the number of locks in force and will not unlock the memory until the number of MUNLOCK calls matches the number of MLOCK calls applied to the User Memory.

5.4.4 MRANGE--Perform range checking

C Interface:

```
BYTE    *start;
LONG    length;

retc = mrange(start,length);
```

Parameters:

start	Starting User Address of buffer in User Memory
length	Number of bytes in the buffer

Return Code:

E_SUCCESS	Legal buffer
RD_ONLY	Buffer is read only
SYS_SPC	Buffer is in system space
	These two bits indicate the designated buffer status on a successful return from MRANGE ().
E_RANGE	Range error

The MRANGE driver service allows a driver to verify that a buffer in User or System Memory does not violate memory protection before the buffer is used. Following a successful return from MRANGE, a driver can call a DMA device knowing a memory violation trap will not occur.

5.4.5 MUNLOCK--Unlock User Memory

C Interface: munlock();

Parameters: None

Return Code: None

MUNLOCK unlocks the current User Memory in Physical Memory. MUNLOCK allows moving the memory to another physical location. The Supervisor automatically locks the current User Memory whenever an application calls an SVC.

The driver is responsible for matching MLOCK and MUNLOCK calls. FlexOS maintains a count of the number of locks in force and will not unlock the memory until the number of MUNLOCK calls matches the number of MLOCK calls applied to the User Memory. If memory is unlocked by a driver, the driver must lock the memory before returning to the calling process.

5.4.6 PADDR--Convert address: System to Physical

C Interface:

```
BYTE    *physadr;
BYTE    *sysadr;

physadr = paddr(sysadr);
```

Parameters:

sysadr	System Address to convert

Return Code:

physadr	The physical address of the specified System Address

PADDR converts a System Address to a physical address. Use PADDR to convert a buffer address in System Space to a physical address and then give the address to a hardware device, such as a DMA controller.

5.4.7 SADDR--Convert address: User to System

C Interface:

```
BYTE    *usradr;
BYTE    *sysadr;

sysadr = saddr(usradr);
```

Parameters:

usradr	Address of User Memory from User Space

Return Code:

sysadr	System Address of converted User Address

SADDR converts a User Address into a System Address relative to the current User Memory. The User Address of another process's User Memory can be converted to a System Address by first calling the MAPU driver service, described above, and then SADDR.

5.4.8 SALLOC--Allocate System Memory

C Interface:

```
LONG    length;
BYTE    *sysadr;

sysadr = salloc(length);
```

Parameters:

length	Number of bytes to allocate

Return Code:

sysadr	Address of memory block allocated in System Memory
0	No memory available to satisfy the request

The SALLOC driver service allocates System Memory from the TPA.

5.4.9 SFREE--Free System Memory

C Interface:

```
BYTE    *sysadr;

ret = sfree(sysadr);
```

Parameters:

sysadr	Address of previously allocated System Memory

Return Code:

E_SUCCESS	Successful operation
E_MEMORY	Illegal memory reference

SFREE frees memory allocated through the SALLOC driver service. The address to be freed must be one returned through SALLOC.

5.4.10 UADDR--Convert address: System to User

C Interface:

```
BYTE    *sysadr;
BYTE    *usradr;

usradr = uaddr(sysadr);
```

Parameters:

sysadr	Previously converted System Address of User Memory

Return Code:

usradr	User Space address of User Memory
E_MEMORY	sysadr not in User Memory

UADDR converts a System Address to a User Address. The System Address must point into User Memory. An error occurs if the System Address points into System Memory.

5.4.11 UNMAPU--Restore User Memory

C Interface: unmapu();

Parameters: None

Return Code: None

UNMAPU restores the calling process's User Space. MAPU allows a process to map temporarily another process's User Memory into System Space. UNMAPU removes the current User Memory and restores the process's own User Memory into System Space. If the calling process is a system process, no User Memory is mapped.

5.5 Critical Regions

FlexOS supplies routines to allow a driver to set up critical regions without turning off hardware interrupts. FlexOS recognizes three types of critical regions:

- Mutual exclusion regions - allow a driver to restrict multiple processes from accessing a resource or data structure. Driver services are MXINIT, MXEVENT, ASRMX, MXREL, and MXUNINIT.
- No-abort regions - guarantee that a particular process will not abort while in the no-abort region. Drivers can use this type of region to ensure that a set of tasks will be completed by the calling process. The driver services are NOABORT and OKABORT.
- No-dispatch regions - guarantee that no other processes or ASRs will run while the system is in the no-dispatch region. Typically, this region is used where a resource, such as a linked list, is accessed by many processes from many different locations in the code. A no-dispatch region guarantees that no other process will access the resource while it is being used by the current process. You can also use this type of region where the calling process cannot "hang," waiting for a mutual-exclusion region. The no-dispatch region should be used with care, because it directly affects the response time of a process to an external event. The driver services are NODISP and OKDISP.

FlexOS allows drivers to set up mutual exclusion regions to protect data structures from multiple processes accessing them, without turning off hardware interrupts. These mutual exclusion regions can also be used to protect non-reentrant code and make it a serially reusable resource.

The mutual exclusion primitives are similar to a semaphore system, where a process must get a semaphore before using a resource. The semaphore is released when the resource is no longer needed. If the semaphore is in use by another process, the calling process receives an event mask which can be used to wait for the semaphore. When multiple processes wait for the same semaphore, the requests are queued on a a first-come, first-serve basis.

FlexOS maintains the semaphore, its current owner, and a list of processes waiting for the semaphore in a data structure called the Mutual Exclusion Parameter Block, or MXPB. Drivers interface with MXPBs through routines described below.

A driver creates an MXPB through the MXINIT driver service. MXINIT returns a 32-bit value that identifies the MXPB for future use. Typically, a driver stores this value in its data area and accesses the value whenever a process attempts to use a protected resource. The driver usually calls MXINIT from its INIT code.

FlexOS provides two driver services for obtaining an MXPB: MXEVENT and ASRMX. You use MXEVENT when you are in process context; use ASRMX when in ASR context. For both functions, the caller becomes the owner if the MXPB is not in use. If the MXPB is owned by another process when you call the service, MXEVENT returns an event mask. ASRMX returns an event number when the MXPB is owned by any process, including the calling process.

Use WAIT or EVASR with the event mask to wait for the MXPB to be released. The WAIT SVC is only valid when you are in process context. If you are in ASR context, use NEXTASR or ASRWAIT to reschedule the ASR upon the release of the MXPB. When you use WAIT, EVASR, or NEXTASR, you must call the RETURN SVC to clear the event after you receive control of the MXPB. Do not call RETURN, however, if you use ASRWAIT; the event number is cleared and the completion code returned by the function.

Use the MXREL driver service to release the MXPB when you are done with it. If you acquired the MXPB with ASRMX, you must make the MXREL call from within ASR context. If you call MXEVENT from within a process's context, you must call MXREL from within the same process's context. This is almost impossible to do if you go into ASR context between the MXEVENT and MXREL calls. Consequently, most calls to obtain an MXPB should be made from within ASR context.

If a process is aborted while it owns an MXPB, the MXPB is automatically released.

A driver can remove an MXPB from the system through the MXUNINIT driver service. An error is returned if the MXPB is in use. MXUNINIT is usually called in the driver's UNINIT code.

5.5.1 ASRMX--Obtain MXPB ownership

C Interface:

```
LONG    mxid;
LONG    retc;

retc = asrmx(mxid);
```

Parameters:

mxid	MXPB ID as returned by MXINIT

Return Codes:

E_SUCCESS	MXPB obtained
evnum	Event number. MXPB is owned.

The ASRMX driver service obtains ownership of an MXPB. If the MXPB is already owned, either by the calling process or another process, an event number is returned. Use this number in a NEXTASR or ASRWAIT call to schedule ASR execution to wait upon the release of the MXPB.

5.5.2 MXEVENT--Obtain MXPB ownership

C Interface:

```
LONG    mxid;
LONG    retc;

retc = mxevent(mxid);
```

Parameters:

mxid	MXPB ID as returned by MXINIT.

Return Code:

E_SUCCESS	MXPB obtained
emask	Event Mask--MXPB owned by another process

The MXEVENT driver service obtains ownership of an MXPB. If the MXPB is already owned, that is, if the object to be locked is in use, the return value will be an event mask that can be used to wait, through the WAIT SVC, for ownership.

5.5.3 MXINIT--Create an MXPB

C Interface:

```
LONG    mxid;

mxid = mxinit();
```

Parameters: None

Return Code:

mxid	New MXPB's ID

The MXINIT driver service returns a 32-bit value identifying a Mutual Exclusion Parameter Block (MXPB) to be used with the MXEVENT and MXREL driver services. MXINIT is usually called from the driver's INIT code.

The MXPB is an abstract structure to the driver writer, who passes the structure pointer to the MXEVENT and MXREL driver services. FlexOS allocates space for the MXPB out of System Memory.

5.5.4 MXREL--Release an MXPB

C Interface:

```
LONG    mxid;

retc = mxrel(mxid);
```

Parameters:

mxid	MXPB ID as returned from MXINIT

Return Code:

E_SUCCESS	Successful operation
E_OWNER	Calling process is not owner of MXPB

The MXREL driver service releases an MXPB and therefore exits a mutual exclusion region. If another process is waiting for the MXPB, it receives ownership of it.

5.5.5 MXUNINIT--Remove an MXPB from the system

C Interface:

```
LONG    mxid;
LONG    retc;

retc = mxuninit(mxid);
```

Parameters:

mxid	MXPB ID as returned by MXINIT

Return Code:

E_SUCCESS	Successful operation
E_INUSE	MXPB currently in use.

The MXUNINIT driver service removes an MXPB from the system. In response to MXUNINIT, FlexOS deletes the specified MXPB from the MXPB list and frees the memory containing the MXPB for other uses. MXUNINIT is usually called from a driver's UNINIT code.

5.5.6 NOABORT--Enter no-abort region

C Interface: noabort();

Parameters: None

Return Code: None

The NOABORT driver service begins a no-abort region, that is, NOABORT disables abort routines. A no-abort region prevents abort routines from executing as long as the region is active. As soon as abort routines are enabled (see the OKABORT driver service) all pending abort requests for the process are attempted. In the case of multiple NOABORT calls, each NOABORT call must be matched by an OKABORT call to reenable abort routines.

5.5.7 NODISP--Enter a no-dispatch region

C Interface: nodisp();

Parameters: None

Return Code: None

The NODISP driver service begins a no-dispatch region and thereby disables dispatches of processes and ASRs. Execution of NODISP allows you to disable dispatching of user tasks and ASRs until OKDISP is executed. In the case of multiple NODISP calls, each NODISP call must be matched by an OKDISP call to reenable process and ASR dispatches.

5.5.8 OKABORT--Exit no-abort region

C Interface: okabort();

Parameters: None

Return Code: None

The OKABORT driver service ends a no-abort region and thereby enables abort routines. Any abort routines called during the no-abort region are executed.

5.5.9 OKDISP--Exit a no-dispatch region

C Interface: okdisp();

Parameters: None

Return Code: None

The OKDISP driver service ends a no-dispatch region and therefore enables dispatching of processes and ASRs.

5.6 System Process Creation

You create system processes with the PCREATE function driver service. A system process runs in System Space and owns no User Memory. In your PCREATE call you specify the address in System Memory where the process is to start execution, the stacksize, the priority, and the name of the process. PCREATE lets you send two parameters to the process as it starts execution.

PCREATE allocates a process data space, including a system stack and initializes the process name, priority, and other data. PCREATE then initializes the stack to contain the specified parameters and finally schedules the new process to run. FlexOS starts the process at the address you pass as a parameter to PCREATE.

The process has the full context and flexibility of any other process in the system, with the sole exception that the process does not own any User Memory.

5.6.1 PCREATE--Create a system process

C Interface:

```
LONG    pid;
VOID    start();
BYTE    *name;
BYTE    prior;
LONG    stacksize;
LONG    parm1;
LONG    parm2;
LONG    emask;

emask = pcreate(&pid,start,name,prior,stacksize,parm1,parm2);

VOID start(parm1,parm2)
LONG parm1;
LONG parm2;
{
/* first line of "C" Code that the new process  */
/*      will execute follows:                   */

            . . .

/* Terminate the system process                 */

s_exit(0);
}
```

Parameters:

&pid	Address of a 32-bit variable that will be modified by this routine to contain the process ID of the new process. This value is needed to abort the process and to obtain information about it.
start	Address of first instruction the new process will execute
name	Address of process name. The name is null-terminated. If the string is longer than eight bytes, only the first eight bytes are used.
prior	Initial process priority, ranging from 0 to 255. The guidelines for selecting the priority are:

1	INIT process
2-31	High-priority system process requiring immediate response to external events
32-63	System process
64-128	Undefined
129-199	High-priority user process
200	Normal user process
201-254	Low-priority user process
255	Idle process

stacksize	Size of the system stack for the new process. If this value is 0, a default value is used that allows SVCs to be called.
parm1	First 32-bit parameter to new process
parm2	Second 32-bit parameter to new process

Return Code:

emask	Event mask that can be used to wait, through the WAIT SVC, for the termination of the created process. Upon completion of the WAIT, that is, when the process has terminated, use the RETURN SVC to obtain the process's exit code.
E_MEMORY	Cannot allocate System Space for this process.

5.7 Interrupt Service Routines

Interrupt Service Routines (ISRs) are established through the SETVEC function described below. FlexOS transfers control to the Entry Point of the ISR as though it were calling a C routine.

It expects back one of two possible WORD values:

- true (1), meaning dispatching is required
- false (0), meaning no dispatching is required

Ideally, the ISR should work along the following lines:

1. The driver's INIT function sets up the ISR vector through a SETVEC call. SETVEC is described below. The driver's SELECT function enables hardware and software interrupts.
2. The driver's READ or WRITE code starts an operation that results in an interrupt, which transfers control to the ISR. If the device is of a type that does not require immediate service, the ISR might do no more than execute the DOASR function. If the device requires immediate service, e.g., a serial driver or a disk driver, the ISR might set up a DMA transfer or input or output the next data byte, then execute a DOASR to clean up.
3. The ISR determines whether or not a significant event, that is, an event which requires dispatching, has occurred. If it has, the ISR should return a true value; otherwise, the ISR should return a false value.

The following guidelines should be kept in mind when using ISRs.

- FlexOS takes care of stack switching, dispatch scheduling, and CPU-dependent interrupt resets.
- Interrupts are disabled upon entry to the ISR. Interrupts can be subsequently enabled by the ISR to allow nested interrupts.
- FlexOS saves all registers for the ISR. Therefore, it is not necessary for the ISR itself to preserve any registers.

- To allow FlexOS to respond to other interrupts in a timely way, ISRs should be kept as short as possible. In most cases, the majority of the work should be carried out by an ASR.
- Forcing a dispatch by returning "true" has overhead. If the external event is not required to be handled in real time, a "false" should be returned, even if the DOASR driver service function has been called. If the dispatch is not forced, the ASR will run at the next dispatch. The worst that could happen is that the ASR would have to wait for the next tick.

5.7.1 SETVEC--Set interrupt vector to ISR

C Interface:

```
LONG    intno;
WORD    isr_routine();
WORD    prev_isr();

prev_isr = setvec(isr_routine,intno);

WORD isr_routine()
{
/* service interrupt condition */

/* schedule ASR */
do_asr( ... );

/* dispatch or not depending on how critical */
/* it is to run the ASR if one was scheduled */

if (dispatch)
return(-1);   /* TRUE = force dispatch */
else
return(0);    /* FALSE = no dispatch */
}
```

Parameters:

isr_routine	Address of Interrupt Service Routine
intno	Interrupt vector number

Return Code:

E_SUCCESS	Successful operation
prev_isr	Address of previous ISR routine. A return code of zero indicates that this is the first time SETVEC has been called for this interrupt vector. If prev_isr is non-zero, SETVEC has already been called for this vector.

The SETVEC driver service sets the specified interrupt vector to execute the specified Interrupt Service Routine. The physical interrupt vector will actually refer to an operating system routine which sets up the ISR environment, that is, saves registers.

Once the ISR returns, the registers are restored and the operating system routine either restores the environment and returns to the interrupted process or forces a dispatch to occur. If a dispatch is forced, the interrupted process is rescheduled and will run at a later time, according to its priority.

End of Section 5

Supervisor Interface

This section describes how drivers interface to the FlexOS Supervisor.

6.1 Supervisor Entry Point

Drivers can use the Supervisor Calls (SVCs) available to user programs and described in the FlexOS Programmer's Guide. Drivers linked with the system directly access the operating system services. Drivers loaded from disk link to a Driver Run-time Library which indirectly calls the appropriate operating system services.

Do not call an SVC which forces the driver to be reentered. This can result in a deadlock situation.

ASRs cannot call SVCs that result in a process waiting. If this occurs, the Dispatcher cannot schedule any tasks, including ASRs. This results in a system crash.

Calls passed to the Disk, Console, and Network Resource Managers might cause a process to wait. The Pipe Resource Manager is designed to be used by ASRs. However, even when performing operations on pipes, you must call SVCs asynchronously so that event masks are returned, instead of performing a wait.

ISRs cannot call SVCs.

When drivers access SVCs through SUPIF:

- The Supervisor does not perform buffer range checking.
- Parameter blocks are always 32 bytes and must be in System Memory.

- Bit 1 of the mode field in the parameter block must be set to 1 if the addresses in the parameter block are User Addresses. The mode field is the first byte (lowest address) of the parameter block. Set bit 1 to 0 if the parameter block addreses are System Addresses. Note that bit 0, the least significant bit, is the asynchronous bit.

The specific interface to SUPIF is described below.

6.1.1 SUPIF--Make a Supervisor call

C Interface:

```
WORD    funcno
LONG    param;
LONG    ret;

ret = supif(funcno,param);
```

Parameters:

funcno	SVC number
param	32-bit parameter, typically a parameter block address

Return Code:

ret	32-bit return code

The SUPIF driver service allows code within System Space to make SVC calls. The specific SVC numbers, parameters, and expected return codes are specified in the FlexOS Programmer's Guide.

End of Section 6

Console Drivers

This section describes the specific driver interface to character console drivers. It provides an overview of console drivers, discusses the FRAME and RECT data structures, and defines entry and return parameters for each console driver I/O function.

7.1 Console Driver Overview

A console driver is composed of one or more driver units. The Console Resource Manager (RM) manages each unit as a separate physical console device. Each physical console device has two components: a video display and a keyboard. There is no explicit limit to the number of physical consoles or the number of console drivers managed by the Console RM. Limits depend only on memory constraints.

FlexOS supports a standard console environment model independent of physical console device type. As a console driver writer, you must translate this model to your specific physical device. All device-dependent code is in the console driver.

The foremost consideration in writing a console driver is performance: the console must appear lively to the user. To help you implement your drivers, two sample drivers, a serial driver for a Zenith® Z-29 VDT and a character/bit-mapped driver for an IBM PC/AT, are distributed with FlexOS.

The sample drivers take advantage of the sub-driver architecture, described in Section 2.6. The use of this architecture eases the task of implementing console drivers for similar types of console devices.

Each console driver manages a class of console devices. The console driver can directly control each physical console it manages or can control individual physical consoles through sub-drivers. Each unit of a console driver corresponds to a single physical console device. FlexOS does not require that a driver's physical consoles be of a similar type. However, to conserve memory for both driver code and

data, it is desirable to have all consoles of similar types controlled by the same driver.

For example, consider a FlexOS system with three terminals; two serial consoles and one memory-mapped character console. This system should have two console drivers; one driving the memory-mapped console, while the other drives the two serial consoles. The serial consoles can be of different types if sub-drivers are used to hide differences between them. Figure 7-1 illustrates this example system.

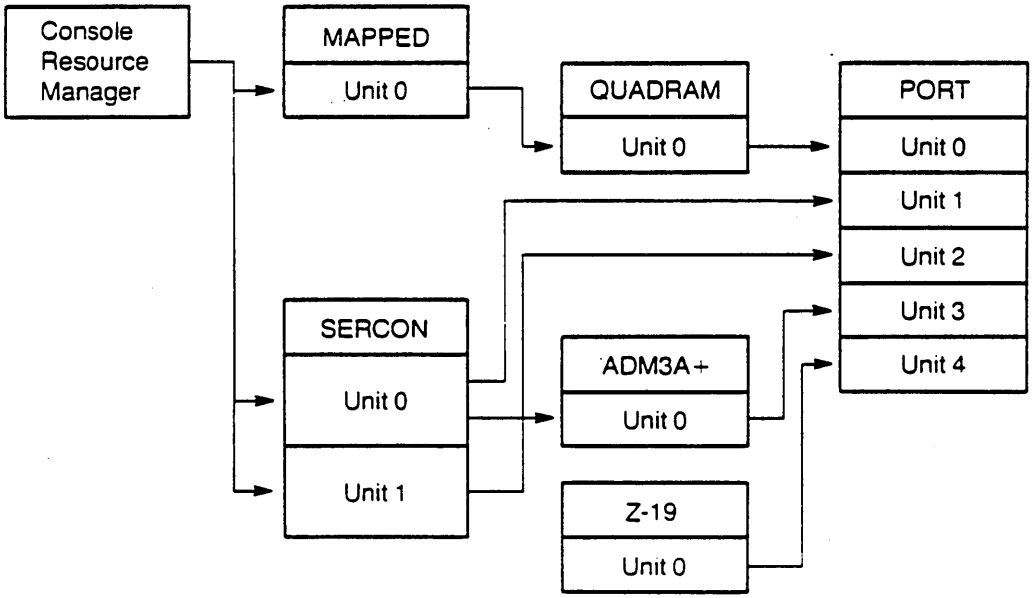


Figure 7-1. Console Drivers

In Figure 7-1, the console driver MAPPED supports a single physical console. MAPPED interfaces directly to the keyboard and screen hardware. It uses a subdriver to interface to the character-mapped hardware associated with this physical console. The driver QUADRAM handles the video display and keyboard interfaces, but is written to be

independent of the actual port hardware. QUADRAM uses the port driver PORT as a sub-driver to interface with the port hardware.

The driver SERCON handles much of the higher-level interface to serial consoles independent of the type of terminal. SERCON calls the sub-drivers ADM3A+ and Z-19 for the screen and keyboard interfaces. ADM3A+ and Z-19 handle the specific terminal interfaces and use PORT as a sub-driver to interface with specific port hardware.

7.2 The FRAME and RECT Structures

A FRAME is a logical representation of a screen. It is a three-dimensional structure consisting of one or more planes of character cells, with one byte per character cell. Each plane consists of either a two-dimensional byte array or a single byte which the Console RM uses to define all the bytes in the plane.

A FRAME's height and width are defined in terms of character columns and rows of its planes. A FRAME's depth is defined in terms of the number of planes in the FRAME.

On a FRAME, a rectangle can be described that descends through all of the FRAME's planes. This piece of the FRAME is a data structure called RECT. COPY and ALTER (see Section 7.4) manipulate FRAMEs by acting on RECTs. Figure 7-2, below, illustrates a FRAME with a RECT descending through its planes.

7.2.1 Planes

FlexOS defines parameters for three planes: the character (plane 0), the attribute (plane 1), and extension plane (plane 2). Figure 7-2, above, depicts these planes. Support for planes 1 and 2 is optional. These planes are defined as follows:

- Character plane - consists of alphanumeric characters. This plane uses an 8-bit character set defined on a per-country basis. This plane supports two-byte characters, such as KANJI, through the implementation of the extension plane (see below).

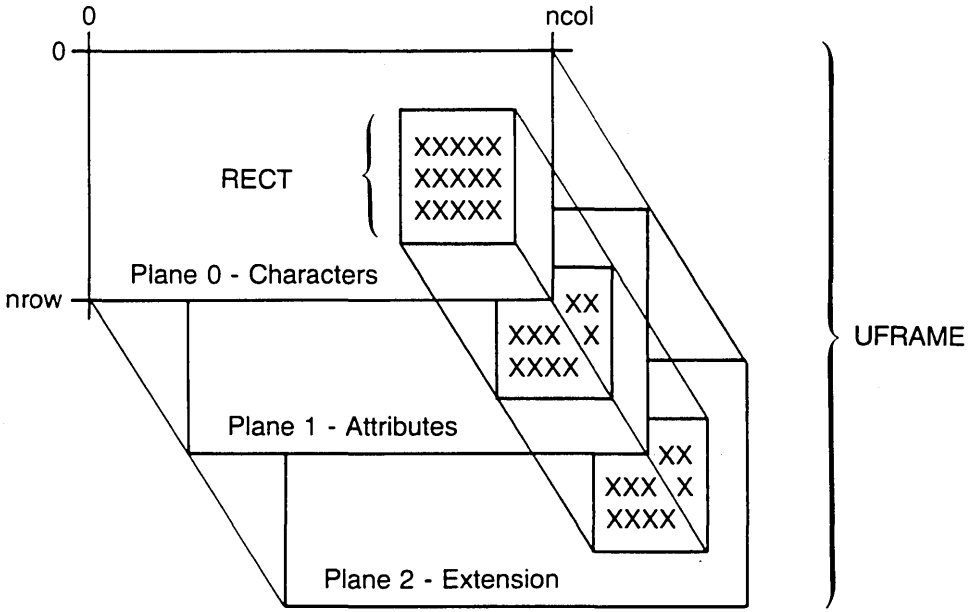


Figure 7-2. FRAME and RECT

- Attribute plane - describes the display characteristics of the characters in the character plane. Each byte in the attribute plane defines the foreground color, background color, color intensity, and blink status (on or off) for the corresponding character cell in plane 0.

The attribute byte is formatted as follows for monochrome and color video display drivers:

Bits 0-2	Foreground color
Bit 3	Intensity
Bits 4-6	Background color
Bit 7	Blink

For video displays supporting the blink attribute, set the blink bit in a given attribute byte to cause the corresponding character to blink.

The three-bit foreground and background color fields are defined as follows:

low bit	blue
middle bit	green
high bit	red

Use of the three color bits provide the following eight colors:

Table 7-1. Colors Defined in Attribute Byte

3-bit Value	Color
0	Black
1	Blue
2	Green
3	Cyan
4	Red
5	Magenta
6	Brown
7	Light Gray

The foreground color, specified by bits 0-2, is modified by the intensity bit, bit 3. When the intensity bit is set, the low nibble of the attribute byte allows for the following colors:

Table 7-2. Foreground Colors with Intensity Bit Set

Low Nibble Value	Color
8	Dark Gray
9	Light Blue
AH	Light Green
BH	Light Cyan
CH	Light Red
DH	Light Magenta
EH	Yellow
FH	White

The attribute byte has the same format for monochrome video displays as for color. Certain color selections effect monochrome display output. For example, when the foreground color is black and the background color white, a monochrome display will appear in reverse video.

- Extension plane - allows support for alternate character set or other extensions to the standard FRAME. Implement this plane if you intend to support foreign languages. Extension plane bytes have the following format:

Bit 0	Cell type
Bit 1	Cell number
Bits 2 & 3	Reserved
Bits 4-7	OEM extension

Cell type (bit 0) determines whether the character corresponding to an extension byte is one byte or two. A one-byte character, such as an ASCII character, takes up one character position on the screen. A two-byte character, such as a KANJI character, takes up two character positions. Bit 0 is set to zero to display one-byte characters; Bit 0 is set to 1 to display two-byte characters.

Cell number (bit 1) indicates whether a corresponding byte in the character plane is either: a) the first part of a two-byte character or a one-byte character or b) the second part of a two-byte character. Bit 1 is set to 0 when the corresponding character plane byte is the first part of a character or when displaying one-byte characters. Bit 1 is set to 1 when a corresponding character plane byte is the second part of a character.

You can customize the OEM extension field (bits 4-7) for your own purposes. This field allows the implementation of alternate character sets. This field is set to zero when the FlexOS standard character set is supported.

7.2.2 FRAME Types

There are three types of FRAMEs: a user FRAME (UFRAME), a virtual FRAME (VFRAME), and a physical FRAME (PFRAME). The driver writer creates the PFRAME and VFRAME; FlexOS defines the UFRAME.

The UFRAME is a device-independent representation of a console screen used by applications. It is based on the model of the IBM PC video map. The FlexOS Programmer's Guide describes the UFRAME for the applications programmer.

The VFRAME is the storage form of a virtual console, as defined by the console driver writer. The Console RM stores a virtual console's current screen image in the VFRAME that the driver creates. The VFRAME can be created to be different sizes, where size is measured in rows and columns. FlexOS makes no assumptions regarding the VFRAME's format.

The Console RM calls the SPECIAL entry point to create and delete VFRAMEs as virtual consoles are created and deleted. See "SPECIAL Entry Point" for a description of the FlexOS support for creating and deleting VFRAMEs.

The Console RM uses the WRITE and COPY/ALTER functions to update the VFRAME. The WRITE entry point updates a VFRAME and returns a "dirty region" that allows the Console RM to determine the portions of the VFRAME that must be copied to the PFRAME. The VFRAME's design should provide for fast VFRAME to PFRAME COPY.

Through the SPECIAL functions 0, 2, and 3, FlexOS supports systems

whose VFRAME is modeled after the video map of an IBM PC. These SPECIAL functions are described below, under "SPECIAL Entry Point."

The PFRAME is a direct representation of the physical screen. Like the VFRAME, the PFRAME is defined by the console driver writer. Any change to the PFRAME must be reflected on the physical screen. The console driver must be able to COPY/ALTER the physical screen and therefore needs a copy of the PFRAME in memory. Most memory-mapped screen devices already have a PFRAME: the mapped memory itself.

If your PFRAME does not follow the IBM PC video map model, you must translate between your PFRAME and an IBM PC-type of PFRAME.

Most implementations of FlexOS console drivers simplify the FRAME transformation by defining the VFRAME and PFRAME to have the same memory representation. For serial devices, all three types of FRAME can have the same representation.

7.3 Console Driver Entry Points

Like all FlexOS drivers, console drivers consist of a driver header and entry points for driver functions. Section 4 describes the general format of a FlexOS driver. The entry points to a console driver are SELECT, FLUSH, COPY/ALTER, WRITE, SPECIAL, GET, and SET.

The SELECT function activates the keyboard. SELECT contains a pointer to the keyboard Asynchronous Service Routine (ASR) which calls the Console RM asynchronously. This ASR buffers the characters to be used by an application. FlexOS calls the SELECT entry point for keyboard information; there is no READ entry point.

FLUSH deactivates keyboard activity by disabling interrupts. Typically, the driver activates and deactivates keyboard hardware with SELECT and FLUSH calls.

WRITE and COPY/ALTER act on FRAMEs. These entry points are called to perform updates to the physical console. COPY/ALTER replaces READ in the standard FlexOS Driver Header. The Console RM performs range checking of the UFRAME before it calls COPY/ALTER.

Note: The WRITE and COPY/ALTER entry points are called from ASRs

and therefore can never wait. These functions return a zero if the operation is completed successfully. WRITE returns an event mask if the driver must wait for an event, or an error code if an error occurs.

The Console RM calls the SPECIAL entry point to

- create and delete virtual consoles (VFRAMEs)
- convert VFRAMEs to conform to an IBM® PC video map model
- convert VFRAMEs from IBM PC model back to original form
- change VFRAME configuration

The SPECIAL functions need not be implemented if you do not support virtual consoles or if you do not support PC DOS applications.

GET provides information on the physical console. SET changes the country code for a console for systems that support foreign character sets. The SET function is optional.

7.4 Console Driver I/O Functions

7.4.1 SELECT--Activate keyboard

Parameter: Address of SELECT parameter block

Return Code: E_SUCCESS Operation was successful

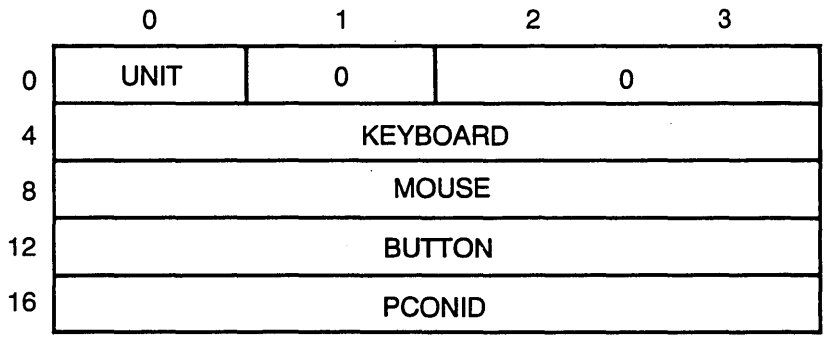


Figure 7-3. SELECT Parameter Block

Table 7-3. Fields in SELECT Parameter Block

Field	Description
UNIT	Driver unit number
KEYBOARD	Address of the keyboard ASR. Use this address in your DOASR or NEXTASR call to transfer a character from the keyboard to the input buffer. You must translate the character into the FlexOS 16-bit input character set (see Appendix A). If the keyboard generates toggle characters, they should always be passed to the keyboard ASR. When you call DOASR or NEXTASR, the first parameter is PCONID and the second is the character received.
MOUSE	Address of the mouse ASR. Use this address in your DOASR or NEXTASR call to transfer the change in the mouse position. When you call DOASR or NEXTASR, the first parameter is PCONID and the second is the address of the mouse movement packet with the delta x and delta y values.
BUTTON	Address of the button ASR. Use this address in your DOASR or NEXTASR call to indicate the mouse button pressed. When you call DOASR or NEXTASR, the first parameter is PCONID and the second is a long indicating the button pressed where bit 31 represents the leftmost mouse button, bit 30 represents the next button to the right, and so forth.
PCONID	Physical console identifier for the driver unit being SELECTed. The Console RM gives the PCONID to the driver of this unit. The driver must pass the PCONID to the keyboard ASR to allow it to identify which physical console is sending information.

The Console RM calls the SELECT function to initialize the keyboard. Once SELECT has been called, the keyboard is considered live.

Typically, SELECT turns on the hardware interrupts. FlexOS calls only the SELECT entry point for input data.

The interrupt vector itself is usually initialized in the INIT entry point at the time the driver is installed. Initialize the interrupt vector with the SETVEC driver service. Section 5.7 explains SETVEC and offers guidelines for using ISRs under FlexOS.

In response to an interrupt, the keyboard interrupt service routine should use the DOASR driver service to schedule the keyboard ASR. You must use the ASR provided in the SELECT parameter block, so be sure to save this address in your routine.

Non-interrupt-driven console devices use the POLLEVENT driver service to establish a poll routine to receive a physical input. POLLEVENT is described in Section 5.3.

The console driver must perform any necessary translation of hardware data to logical information that can be used by FlexOS. If translation is required, the driver, upon receiving a physical input, calls the DOASR driver service from an ISR to schedule an ASR to perform physical-to-logical translation. The translation should not be done in the ISR itself. Such translation might include translation to the FlexOS 16-bit character set. The FlexOS standard input character set is defined in Appendix A.

When translation is finished, the driver should call DOASR again to schedule the keyboard ASR, passing the translated information. The Console RM places the data into the present keyboard owner's input buffer.

Call the DOASR driver service with a priority of 200 when scheduling a translation ASR and the keyboard ASR.

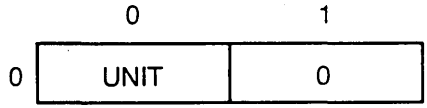
7.4.2 FLUSH--Deactivate keyboard

Parameter: Address of FLUSH parameter block

Return Code:

E_SUCCESS	Operation was successful
IOERROR	Console driver error code

The Console RM calls FLUSH with the address of the following parameter block:



The UNIT field contains the driver unit to be FLUSHed.

The FLUSH function is the reverse of SELECT. It must perform all operations (either hardware or software) required to stop the physical input of characters and/or interrupt sources. If a console driver owns a sub-driver, it must call the sub-driver's FLUSH function to make the sub-driver quiescent.

7.4.3 COPY/ALTER--Modify a RECT

Parameter: Address of COPY/ALTER parameter block

Return Code:

E_SUCCESS Operation was successful

COPY and ALTER share the same entry point. You determine which operation to perform from the OPTION field in the parameter block. Figure 7-4 illustrates the format of the COPY/ALTER parameter block. The fields are described in Table 7-4. The FRAME and RECT data structures referenced in the parameter block are illustrated following the parameter block description.

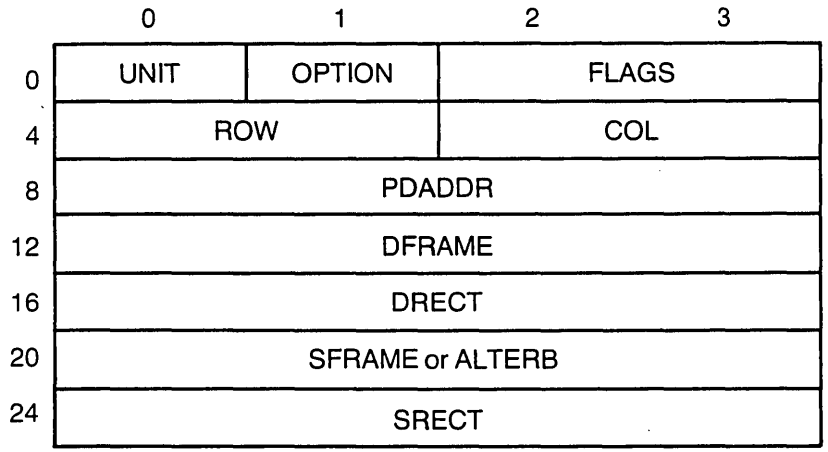
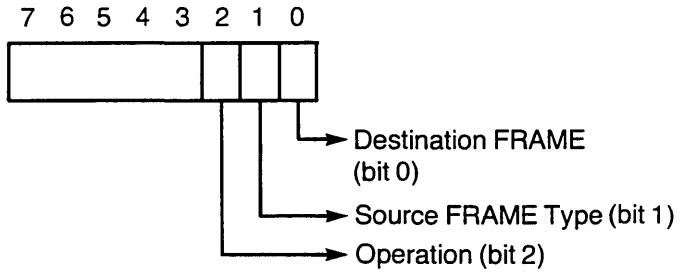


Figure 7-4. COPY/ALTER Parameter Block

Table 7-4. Fields in COPY/ALTER Parameter Block

Field	Description
UNIT	Driver unit number
OPTION	Bit map of operation and FRAME types:



Where FRAME type is: 0 - VFRAME/PFRAME
1 - UFRAME

Operation is: 0 - COPY source to destination
1 - ALTER destination

RECT and FRAME addresses for a UFRAME are always in User Memory. You must convert them to system addresses (see the SADDR driver service). The driver creates the PFRAME and VFRAME; consequently, these FRAMEs are in System Memory.

FLAGS Bit map of flag usage.

Bit 0: 1 = Modify plane 0
0 = Do not modify plane 0

Bit 1: 1 = Modify plane 1
0 = Do not modify plane 1

Table 7-4. (Continued)

Field	Description
	Bit 2: 1 = Modify plane 2 0 = Do not modify plane 2
	Bits 3-6: Reserved
	Bit 7: 1 = This is top virtual console. Update the cursor position when this bit is set. 0 = This is not the top virtual console.
	Bits 8-11: Reserved
	Bit 12: 1 = This call is to move the cursor only. Only UNIT, FLAGS, ROW, and COL have meaning. 0 = All fields have meaning
	Bit 13: 1 = This is an update of a dirty RECT passed from WRITE driver function. 0 = This is not a RECT passed from WRITE.
	Bit 14: 1 = Update PFRAME and VFRAME. This means the virtual console is the same size as the physical, windowed full-screen, and on top. 0 = Update as indicated with option. If VFRAME is modified, the Console RM updates windowed RECTs on PFRAME as appropriate.
	Bit 15: 1 = Buffer is in User Memory. Use the SADDR driver service to convert User to System Address before accessing this address. 0 = Buffer in System Memory.

Table 7-4. (Continued)

Field	Description
ROW	With COL, defines current cursor position. When COPY/ALTER is exited, this is where cursor should be.
COL	With ROW, defines current cursor position. When COPY/ALTER is exited, this is where cursor should be.
PDADDR	Process descriptor address of user process whose memory contains the UFRAME. This may not be the calling process for FLAGEVENT and FLAGSET. Get the pdaddr of the process accessing the COPY/ALTER entry point from the RLR Address field in the Driver Header.
DFRAME	Destination FRAME. Address of UFRAME, virtual console identifier (VCID) of VFRAME, or 0 if PFRAME.
DRECT	Address of destination RECT describing region in DFRAME.
SFRAME or ALTERB	For COPY operation, address of source RECT describing region in SFRAME. For ALTER operation, address of ALTERB; a six-byte array indicating the alteration of the destination RECT. The array is arranged as follows: alterb[0] = character plane AND alterb[1] = character plane XOR alterb[2] = attribute plane AND alterb[3] = attribute plane XOR alterb[4] = extension plane AND alterb[5] = extension plane XOR
SRECT	Source FRAME. Address of UFRAME, virtual console identifier (VCID) of VFRAME, or 0 if PFRAME. Not used for ALTER operation. The VCID is returned from SPECIAL function 0, Create VFRAME. SPECIAL function 0 is described later in this section.

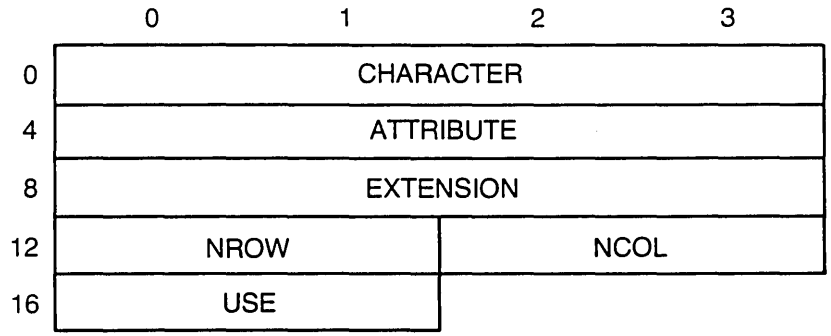


Figure 7-5. FRAME Structure

Table 7-5. FRAME Fields

Field	Description
CHARACTER	Address of the character plane of this FRAME
ATTRIBUTE	Address of the attribute plane of this FRAME
EXTENSION	Address of the extension plane of this FRAME
NROW	Number of rows; indicates each FRAME's height.
NCOL	Number of columns; indicates each FRAME's width.

Table 7-5. (Continued)

Field	Description
USE	Bit map describing how the three plane fields are used. When the bit value is 0, the byte at the address specifies the value for each element in the plane. Bit 0:1 = CHARACTER addresses a two-dimensional array of bytes making up the character plane. 0 = CHARACTER addresses a single byte. Bit 1:1 = ATTRIBUTE addresses a two-dimensional array of bytes making up the attribute plane. 0 = ATTRIBUTE addresses a single byte. Bit 2:1 = EXTENSION addresses a two-dimensional array of bytes making up the extension plane. 0 = EXTENSION addresses a single byte.

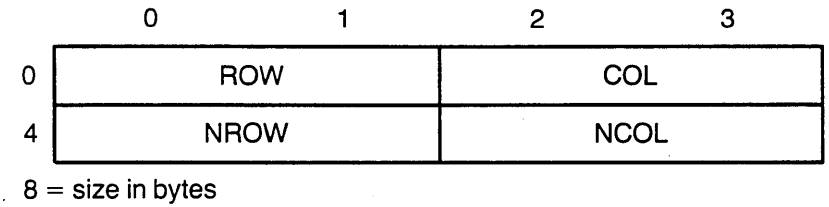


Figure 7-6. RECT Structure

Table 7-6. RECT Fields

Field	Description
ROW	Row position of the upper left corner of the RECT. The upper left corner, as specified by ROW and COL, is the reference point for a RECT.
COL	Column position of the upper left corner of the RECT.
NROW	Number of rows, indicating the RECT's height.
NCOL	Number of columns, indicating the RECT's width.

COPY copies the bytes from the region described by the source RECT into the region described by the destination RECT. If the RECTs are different sizes, the driver should trim them to the same size, using the upper left corner of each RECT as a reference point. The driver should store trimmed RECTs locally. If both RECTs are on the same FRAME and they overlap, care should be taken to copy the RECT in the appropriate direction.

ALTER alters the destination RECT by performing a logical AND operation with a specified AND byte and a logical XOR operation with a specified XOR byte on each byte of a given plane. Separate AND and XOR bytes are specified for each plane in the ALTERB array, defined above. The FLAGS parameter determines which planes will be effected.

The ALTER driver function allows an application to set, clear, complement, or leave unchanged any bit in the raw bytes of the destination RECT. This function should enable an application to perform such operations as clearing a portion of the screen, displaying strings of identical characters in different parts of the screen, or changing the attributes of a portion of the display without effecting the character or extension plane.

7.4.4 WRITE--Write data to VFRAME

Parameter: Address of WRITE parameter block

Return Code:

E_SUCCESS	Operation was successful
Event Mask	Event mask if operation will complete asynchronously

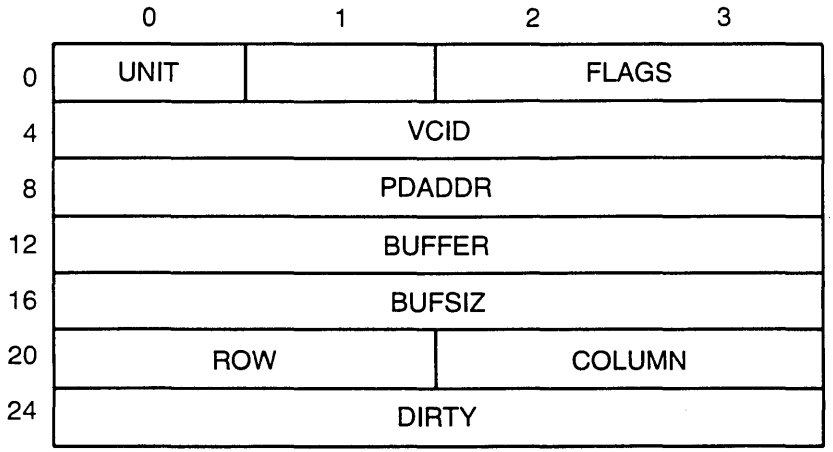


Figure 7-7. WRITE Parameter Block

Table 7-7. Fields in WRITE Parameter Block

Field	Description
UNIT	Driver unit number
FLAGS	Bit map of flags
	Bit 7: 1 = This is the top virtual console. 0 = This is not the top virtual console. This bit determines whether the WRITE operation should affect the cursor position on the physical console. If bit 7 is set, update the cursor position in the WRITE operation. If it is not set, do not update the cursor.
	Bit 14: 1 = Update PFRAME. 0 = Update VFRAME or PFRAME as indicated. Set Bit 14 to 1 when the virtual console is full screen, on top. This setting allows optimized use of screen-editing commands in 16-bit character set.
	Bit 15: 1 = Buffer is in User Memory. 0 = Buffer is in System Memory. If bit 15 is set to 1, use the SADDR service to convert User to System Address before accessing this address.

Table 7-7. (Continued)

Field	Description
VCID	Virtual console identifier of VFRAME or, if writing to the PFRAME, 0. The VCID is returned from SPECIAL function 0, described later in this section.
PDADDR	Address of process in whose memory BUFFER (see below) resides. This is not necessarily the calling process as needed in the FLAGEVENT and FLAGSET driver services. Obtain the pointer to the calling process's pdaddr from the RLR field in the Driver Header.
BUFFER	Address of buffer of 16-bit characters used to update the indicated VFRAME or PFRAME.
BUFSIZ	Size in bytes of BUFFER. This is not the number of characters. To obtain the number of characters divide BUFSIZE by two.
ROW	Current cursor row position on which to start placing characters.
COLUMN	Current cursor column position on which to start placing characters.
DIRTY	Address of structure to be filled in by WRITE indicating new cursor position and dirty region. Figure 7-8 illustrates the format of the dirty region.

	0	1	2	3
0	Cursor ROW		Cursor COL	
4	Dirty ROW		Dirty COL	
8	NROWS		NCOLS	

Figure 7-8. Dirty Region Format

Cursor ROW and Cursor COL indicate the cursor's new location. Dirty ROW and Dirty COL are the coordinates of the upper left corner of the dirtied RECT. NROWS and NCOLS indicate the size of the dirtied RECT.

WRITE updates a VFRAME with a specified buffer of 16-bit characters. The driver should write the string buffer at the specified cursor position. Before returning you must update the cursor position (the ROW and COLUMN values) and fill in the dirty region data structure.

7.4.5 SPECIAL Entry Point

The Console RM calls the SPECIAL entry point to perform the following functions:

- Special Function 0: Create a virtual console (VFRAME)
- Special Function 1: Delete a virtual console (VFRAME)
- Special Function 2: Convert a VFRAME to a PCFRAME
- Special Function 3: Convert a PCFRAME to its original form (inverse of Function 2)
- Special Function 4: Change VFRAME configuration

The SPECIAL functions operate on VFRAMEs, the storage form of a virtual console (see Section 7.2.2). A driver that does not support virtual consoles should return a not implemented (E_IMPLEMENT) error to the Console RM when the SPECIAL entry point is called.

Note: A PCFRAME is a VFRAME with the following characteristics:

- **For a character-mapped screen:** A 25 row by 80 column display with the characters arranged in character/attribute pairs
- **For a bit-mapped screen:** A 200 by 640 pixel display

FlexOS defines the UFRAME to allow a fast transformation to an IBM PC-type of PFRAME.

SPECIAL Functions 2 converts a VFRAME from its original form to a model that replicates an IBM PC video map. SPECIAL Function 3 converts the VFRAME from the IBM PC model back to its original form. These functions are provided to allow applications that poke the IBM PC model video map to run in a multiple-virtual console environment.

SPECIAL Function 0--Create a VFRAME

Parameter: Address of SPECIAL parameter block

Return Code:

VCID — An identifier of this VFRAME for use in the WRITE, COPY/ALTER and SPECIAL functions 1-3. This is typically the address of an internal data structure known by this driver. The VCID cannot be 0.

0 — Error. The Console RM assumes a memory allocation error has occured. A negative error code cannot be returned here since addresses may look like a negative number.

E_IMPLEMENT — Virtual consoles are not implemented

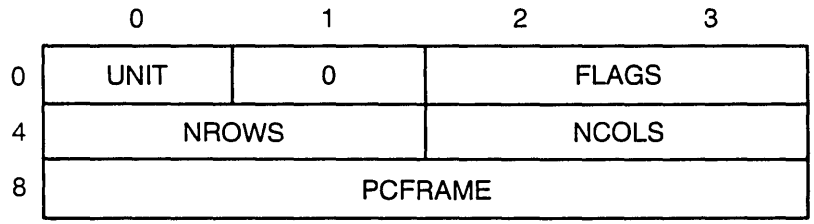


Figure 7-9. SPECIAL Function 0 Parameter Block

Table 7-8. Fields in SPECIAL Function 0 Parameter Block

Field	Description
UNIT	Driver unit number
0	One byte set to zero
FLAGS	Bit map of flag usage Bit 0: 1 = bit-mapped device 0 = character-mapped device Bits 1-6: Reserved Bit 7: 1 = creating a PFRAME 0 = creating a VFRAME
NROWS	Number of rows in VFRAME
NCOLS	Number of columns in VFRAME
PCFRAME	Preset to zero. If this field is non-zero, the value is the address of an IBM PC-compatible character or bit map.

The Console RM calls SPECIAL Function 0 to create a VFRAME. When the PCFRAME field contains the address of an IBM PC-type video map, use the FLAGS field to determine whether the display is bit- or character-mapped.

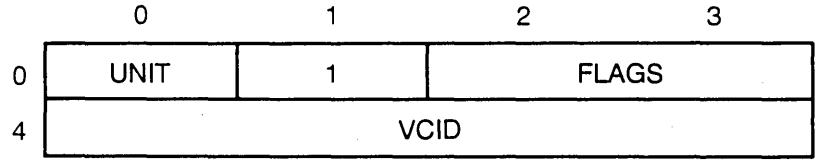
SPECIAL Function 1--Delete a VFRAME

Parameter: Address of SPECIAL parameter block

Return Code:

E_SUCCESS Operation was successful
E_IMPLEMENT Virtual consoles are not implemented

The Console RM calls SPECIAL function 1 to delete a VFRAME and provides the following information in the parameter block:



The UNIT field contains the driver unit number. 1 is the SPECIAL function number. The word at offset 2 is set to zero. VCID is the VFRAME identifier of the VFRAME to delete. The VCID is returned from SPECIAL function 0.

SPECIAL Function 2--Initialize a PCFRAME

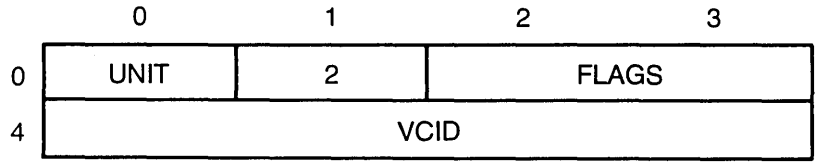
Parameter: Address of SPECIAL parameter block

Return Code:

address	Video map address
0	Operation not allowed

The Console RM calls SPECIAL function 2 when an application attempts to write directly to an IBM PC video map. Use this function to convert the specified VFRAME to a facsimilie of an IBM PC video map and return the address of the replacement video map. FlexOS directs subsequent console output to the video map address returned.

The SPECIAL parameter block provided by the Console RM is formatted as follows:



The UNIT field contains the driver unit number. 2 is the SPECIAL function number. The Console RM uses flag bit 0 only. If it is set to 1, it indicates that the application attempted to output to a bit-mapped display (address B800:0 in the IBM PC). If bit 0 is set to 0, the application attempted to output to a character-mapped display (address B000:0 in the IBM PC). The VCID identifies the VFRAME to convert.

SPECIAL Function 3--Revert to VFRAME

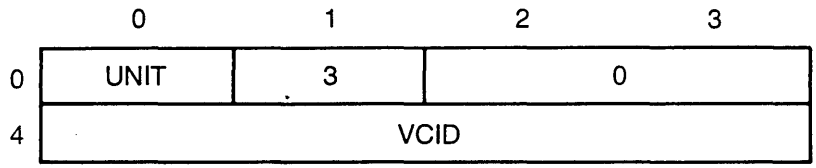
Parameter: Address of SPECIAL parameter block

Return Code:

address	Original VFRAME video map address
0	Operation not allowed

The Console RM calls SPECIAL function 3 when an application has stopped writing directly to an IBM PC video map. Use this function to convert the designated PCFRAME back to the VFRAME originally created.

The SPECIAL Function 3 parameter block is formatted as follows:



The UNIT field contains the driver unit number. 3 is the SPECIAL function number. The word at offset 2 is set to zero. VCID identifies the PCFRAME to convert back to a VFRAME.

SPECIAL Function 4--Change VFRAME Configuration

Parameter: Address of SPECIAL parameter block

Return Code:

address Video map address

E_IMPLEMENT Virtual console change does not match physical capabilities of console device

E_MEMORY Not enough memory to change virtual console configuration

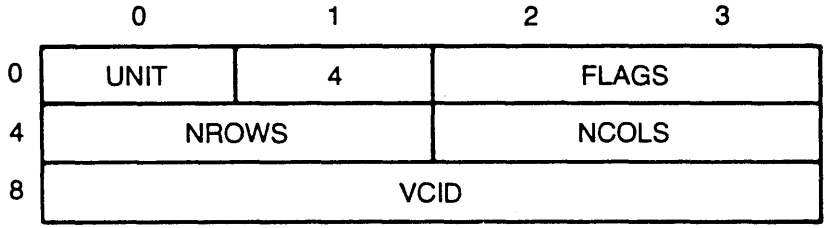


Figure 7-10. SPECIAL Function 4 Parameter Block

The Console RM calls SPECIAL Function 4 to reconfigure a virtual frame to a new configuration; for example, to convert a 80 x 25 black and white character screen to a 320 x 200 pixel color graphics screen.

Table 7-9. Fields in SPECIAL Function 4 Parameter Block

Field	Description
UNIT	Driver unit number
4	SPECIAL function number
FLAGS	Bit map of flag usage Bit 0: 1 = Graphics virtual console requested 0 = Character virtual console requested Bits 1-2: Reserved Bit 3: 1 = Color display 0 = Black and white display Bits 4-15: Reserved
NROWS	VFRAME's number of rows (bit 0 = 0) or height in pixels (bit 0 = 1)
NCOLS	VFRAME's number of columns (bit 0 = 0) or width in pixels (bit 0 = 1)
VCID	Identification number of VFRAME to reconfigure.

7.4.6 GET--Provide physical console description

Parameter: Address of GET parameter block

Return Code:

E_SUCCESS	Operation was successful
IOERROR	Driver-specific error code

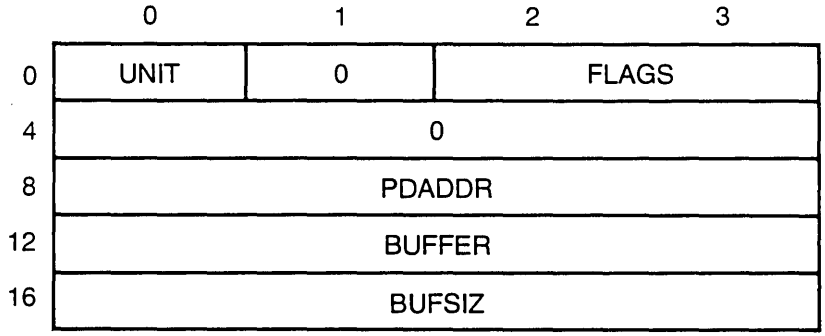


Figure 7-11. GET Parameter Block

Table 7-10. Fields in GET Parameter Block

Field	Description
UNIT	Driver unit number
0	Byte set to zero
FLAGS	Bit map of flag usage Bit 15: 1 = Buffer in User Memory 0 = Buffer in System Memory
0	Long word set to zero
PDADDR	Address of process descriptor of process owning BUFFER
BUFFER	Address of PCONSOLE Table--see Figure 7-12
BUFSIZ	Size of BUFFER. If this is less than the size of the PCONSOLE Table, only complete fields should be filled in.

GET must provide information for the FlexOS PCONSOLE Table. The PCONSOLE Table describes a physical console device and contains the information described in Table 7-11, below.

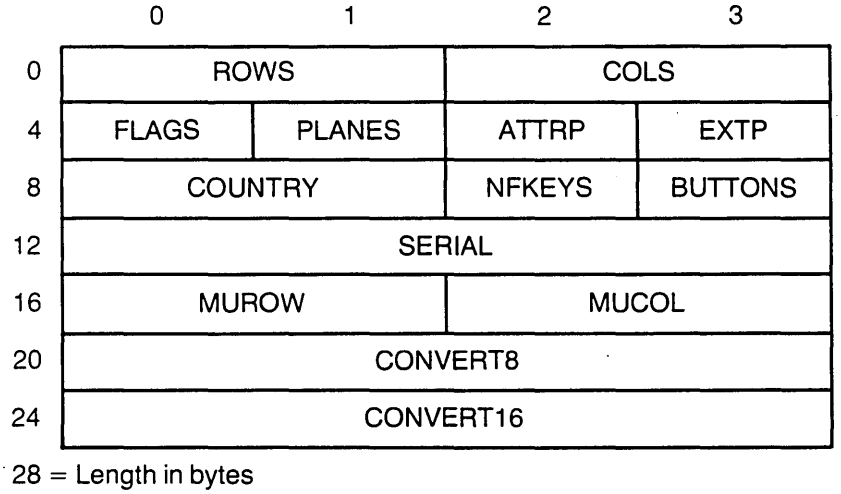


Figure 7-12. PCONSOLE Table

GET provides routines to translate the 8-bit output character set to the 16-bit output character set and the 16-bit input character set to the 8-bit input character set. If the driver does not provide these routines, the Console RM uses the standard conversion routines when interfacing with a given unit. The FlexOS standard input and output character sets and escape sequences are defined in Appendix A. Country codes are listed in Appendix C of the FlexOS Programmer's Guide.

For the use of computers in Japan, GET might provide a routine to translate 8-bit SHIFT-JIS characters to 16-bit SHIFT-JIS characters as defined by Digital Research/Japan.

Table 7-11. Fields in PCONSOLE Table

Field	Description
ROWS	Number of rows on physical console
COLS	Number of columns on physical console
FLAGS	Bit map of capabilities: Bit 0: 1 = graphic and character-mapped display 0 = character-only display Bit 1: 1 = no numeric keypad 0 = numerical keypad Bit 2: Reserved Bit 3: 1 = color screen 0 = monochrome screen Bit 4: 1 = memory-mapped video 0 = serial device Bit 5: 1 = currently in graphics mode 0 = currently in character mode
PLANES	Planes supported on PFRAME. FlexOS assumes whatever planes are supported on PFRAME are supported on VFRAME. Bit 0: 1 = character plane supported Bit 1: 1 = attribute plane supported Bit 2: 1 = extension plane supported Bits 3-7: Set to zero
ATTRP	Attribute plane bits supported
EXTP	Extension plane bits supported
COUNTRY	Country code
NFKEYS	Number of function keys

Table 7-11. (Continued)

Field	Description
BUTTONS	Number of mouse buttons
SERIAL	Serial number of mouse
MUROW	Number of mickey units per row
MUCOL	Number of mickey units per column
CONVERT8	Address of 8-bit to 16-bit output conversion routine. If NULLPTR, the FlexOS standard conversion routine is called internally. See the sample driver code for the specific interface expected of this routine.
CONVERT16	Address of 16-bit to 8-bit input conversion routine. If NULLPTR, the FlexOS standard conversion routine is called internally. See the sample driver code for the specific interface expected of this routine.

7.4.7 SET--Change the PCONSOLE Table

Parameter: Address of SET parameter block.

Return Code:

E_SUCCESS	Operation was successful
IOERROR	Driver-specific error code

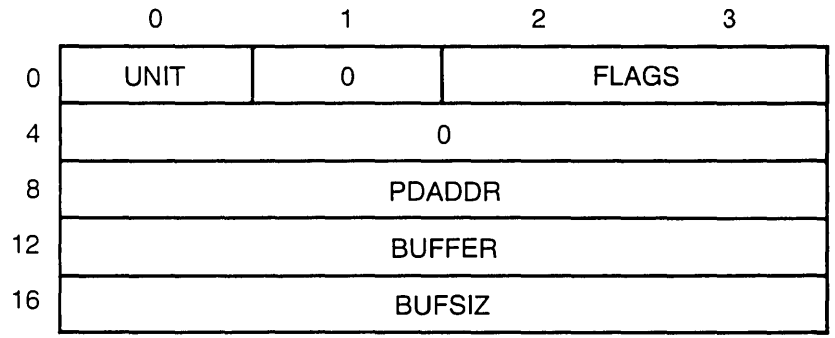


Figure 7-13. SET Parameter Block

Table 7-12. Fields in SET Parameter Block

Field	Description
UNIT	Driver unit number
0	Byte set to zero
FLAGS	Bit map of flag usage Bits 0-14: Reserved Bit 15: 1 = Buffer in User Memory 0 = Buffer in System Memory
0	Long word set to zero
PDADDR	Address of process descriptor of process containing BUFFER
BUFFER	Address of PCONSOLE Table

SET changes the COUNTRY field in the PCONSOLE Table. (See Table 7-11.) This is the only PCONSOLE Table value that can be modified. Support for this console function is optional.

End of Section 7

Disk Drivers

This section describes how FlexOS performs reads and writes to disk and defines I/O functions for disk drivers.

8.1 Disk Driver Input/Output

FlexOS supports an extended PC DOS 2.0 disk file format. The file system primitives are contained in the Disk Resource Manager (RM). The Disk RM manages the disk file system through the interface with the disk driver(s).

All hardware-dependent code is within the disk drivers. The Disk Resource Manager deals with a single, uniform disk driver interface. All types of disk media are handled through this single interface.

FlexOS supports three extensions to the PC DOS 2.0 disk file format. The first two extensions are required for file security, the third to support variable record sizes on files. These extensions take the form of fields in each directory entry that specify a file's User/Group ID, protection level, and record size. The FlexOS file system is described in detail in the FlexOS Programmer's Guide.

With minor modifications, the FORMAT and FDISK utilities, distributed in source code, support non-DOS disk formats. COPYCPM, also distributed in source code, allows you to copy to and from CP/M media.

8.1.1 Reentrancy at the Driver/Disk Controller Level

Disk drivers are organized at the controller level and the unit level. Each disk driver controls one disk controller and as many units as are controlled by that controller. Each unit represents a logically separate disk drive. A unit might be a single diskette drive or one partition of a partitioned hard disk.

The Disk Resource Manager supports reentrancy only at the controller/driver level. The unit level is always synchronized. A disk

driver can choose to allow only one operation at a time for all units of the driver or it can allow each unit to operate independently of the other. In either event, there can be only one operation at a time at the unit level.

In the FLAGS field of a disk driver's driver header, bit 0 can be 0 if the controller can handle multiple I/O requests. However, bit 1 must be 1, indicating that the disk driver synchronizes I/O requests at the unit level. See Section 4.2 for a complete description of the driver header.

8.1.2 Disk Driver Types

The Disk Resource Manager supports three types of disk drivers: removeable with open door support, removeable, and permanent. The Disk Resource Manager deals with each of these types differently to take advantage of each type's capabilities.

With all disk driver types, FlexOS allows delayed READs and WRITEs for those drivers performing intermediate buffering of data on I/O operations. The READ and WRITE disk driver functions have "normal read (or write)" and "read (or write) through" options. Normal reads and writes can take advantage of buffering, if implemented at the driver level. The read or write through option forces a direct read from or write to the actual medium, bypassing any intermediate buffering.

Delayed WRITEs are forced out to disk when FlexOS performs a CLOSE operation on a unit and on WRITE through and READ through operations. I/O will always occur in response to any of these three operations.

The disk drivers shipped with FlexOS do not use intermediate buffering.

Disk driver units inform the Disk RM of their driver type, size, and file structure information through a data structure called the Media Descriptor Block. The driver returns the Media Descriptor Block through the SELECT entry point. The Media Descriptor Block is described in detail in the explanation of SELECT, later in this section.

Removeable with Open Door Support

With disk drive hardware providing "open door" detection, the Disk Resource Manager ensures the integrity of removeable media.

To take advantage of the FlexOS open-door support, the disk driver must be able to respond to the hardware's open door interrupt. The driver responds to such an interrupt by setting an open door flag. The address of the open door flag is given to the Disk Resource Manager through a disk driver's GET entry point at the time a driver unit is initialized.

At each I/O operation, the Disk Resource Manager checks the address of the open door flag for a non-zero value. If it finds a non-zero value, the Disk RM requires verification that the disk has not been changed before passing the next I/O request. If a change is detected, the Disk RM calls the SELECT function to reinitialize the driver unit. Any intermediate buffers are not written to the disk.

The Disk RM does not do media verification at any time other than in response to the open door flag, thereby improving performance significantly over hardware and software without open door support.

Removable Without Open Door Support

While FlexOS obtains optimum performance from floppy disk hardware and software supporting an open door interrupt, FlexOS also supports disk drivers that do not have such an interrupt. For drives in this category, the Disk RM maintains checksum information on critical portions of the system area of the disk medium. If the drive is not used within a certain time interval, the volume is marked as suspect. At the next disk access, the checksum is verified. If the verification fails, the Disk RM calls the SELECT function to allow the disk driver unit to specify which type of media is in place.

After a failed verification, the Disk RM takes the following steps:

- The Disk RM assumes that the disk has been changed and disregards all buffers pertaining to the drive.

- If there are opened files on the removed medium, the Disk RM closes the files without flushing any intermediate buffers to the disk.
- The Disk RM attempts to re-login the disk. Then, if the SVC request did not assume an open file, the Disk RM retries the request. LOOKUP, OPEN, and RENAME are examples of SVCs that do not assume open files.
- The Disk RM sets the open door flag (see previous subsection) and returns an error code to the process that requested I/O.

To improve performance, FlexOS does not perform checksum verification on READs and WRITEs. This means that, if a file is active when a disk is changed, FlexOS could write data from that file to a changed disk. Digital Research recommends that you implement an open door interrupt to eliminate this possibility and to significantly enhance floppy disk performance.

Permanent

In this usage, "permanent" means that you cannot change the medium during the life of the system. The Disk RM does no checksum verification and does not check the open door flag. Because of these facts, I/O system performance is faster with permanent media than with either sort of removable media.

8.2 Logical Disk Layouts

This section illustrates a generalized logical disk layout and a logical layout for hard disks.

Each disk driver unit interfaces to a logical disk drive with the layout shown in Figure 8-1; Table 8-1 explains each field.

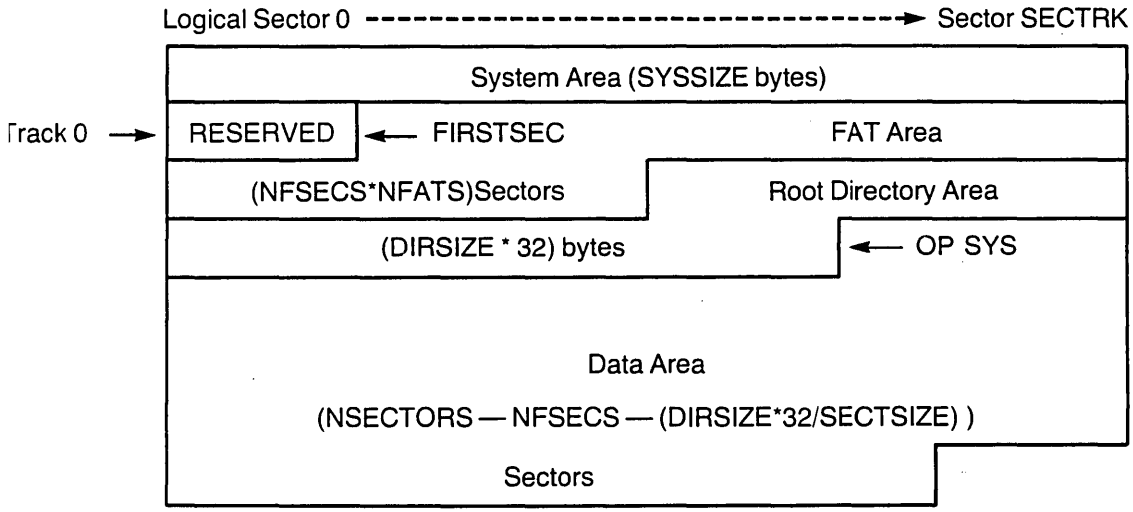


Figure 8-1. Logical Disk Layout

Table 8-1. Fields in Logical Disk Layout

Field	Description
Logical Sector 0	The first sector of the track containing the beginning of the FAT (File Allocation Table) area. This sector is also the sector identified by head 0, track 0, sector 0. By definition, track 0 contains the first sector of the FAT area. If the FAT area does not exist (NFSECS and NFATS are both zero), then track 0 is the track containing the first sector of the root directory. The Disk RM handles both one- and zero-based sector numbering. Programs in User Memory and disk drivers must have the same numbering scheme.
SECTRK	Specifies the number of physical sectors per track.
System Area	Usually defined as the area used for booting. The system area is considered outside of the disk medium and can be formatted independently of the disk medium. For hard disks, the system area is zero length and is therefore not counted in sequential sector numbering. For a disk containing tracks with different densities, the system area must end on a track boundary as defined for that disk. For a disk with a uniform density, if the system area extends into the beginning of the first track of the disk, it must end on a physical sector boundary, as defined for that disk.

Table 8-1. (Continued)

Field	Description
SYSSIZE	Size of the system area, in bytes.
RESERVED	Normally, when the system area is zero, this field contains the boot sector. At offset 0 in the boot sector is the BIOS Parameter Block, illustrated in Figure 8-4, below.
FIRSTSEC	The physical sector number of the first FAT sector on track 0. If no FAT exists, FIRSTSEC is the first sector of the root directory area.
NFSECS	The number of sectors in each FAT. NFSECS is zero for CP/M media.
NFATS	The number of FATs in the FAT area. NFATS is zero for CP/M media.
DIRSIZE	The number of root directory entries. A directory entry is 32 bytes long. The physical sectors occupied by the directory area must be contiguous.
NSECTORS	Specifies the total number of sectors on the disk. See below for the formula for determining NSECTORS.
SECTSIZE	Specifies the physical sector size of the disk, in bytes. Legal sizes are 128, 256, 512, 1024, 2048 and 4096.

The formula for determining the total number of sectors on a disk (NSECTORS) is as follows:

```
NSECTORS = FIRSTSEC + (NFATS*NFSECS) +
           (DIRSIZE * 32) + (SECSIZE - 1))/SECSIZE +
           (Number of Clusters * (Sectors per Cluster))
```

A cluster is the number of physical sectors per file allocation unit on a given disk.

If a disk is bootable, the operating system must be stored starting with first sector following the directory area.

Model Hard Disk Layout

Figure 8-2 illustrates a model logical hard disk. The following table describes the components.

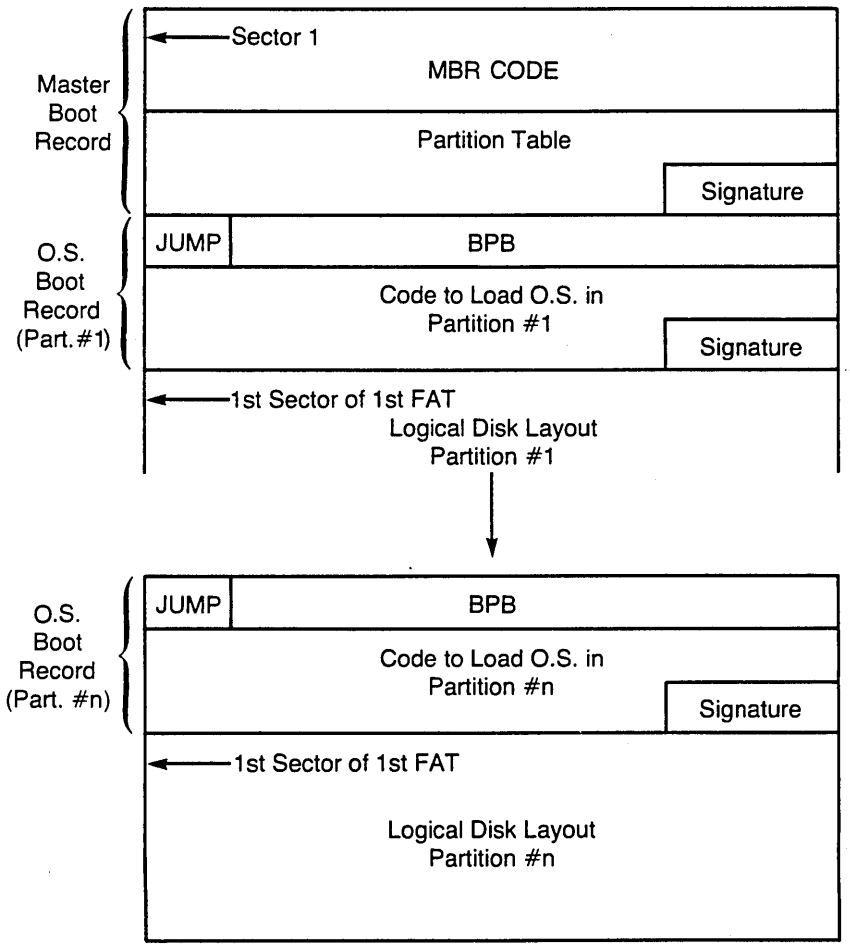


Figure 8-2. Hard Disk Layout

Table 8-2. Fields in Hard Disk Layout

Field	Description
Master Boot Record (MBR)	Contains code to load and pass control to the boot record for one of four possible operating systems. Also contains the Partition Table. For hard disks with a sector size of 512 bytes, the MBR is usually one sector long.
MBR_CODE	Code portion of Master Boot Record.
Partition Table	Contains information on each of four possible partitions on the hard disk. See Figure 8-3, below.
SIGNATURE	Two-byte field at offset 1FEH from the beginning of the MBR. A value of 55AAH indicates a valid partition.
O.S. Boot Record	Contains code and data to load an operating system. For hard disks with a sector size of 512 bytes, the O.S. Boot Record is usually one sector long.
JUMP	Instruction to pass control to boot loader code after ROM monitor reads boot record into memory.
BPB	BIOS Parameter Block. Table describing a given operating system's partition. See Figure 8-4, below.
Code to Load O.S.	Code portion of an operating system's boot record.
Logical Disk Layout	The LDL as it is illustrated in Figure 8-1, above.

The Partition Table is a structure beginning at offset 1BEH from the beginning of the Master Boot Record. Figure 8-3 illustrates its format.

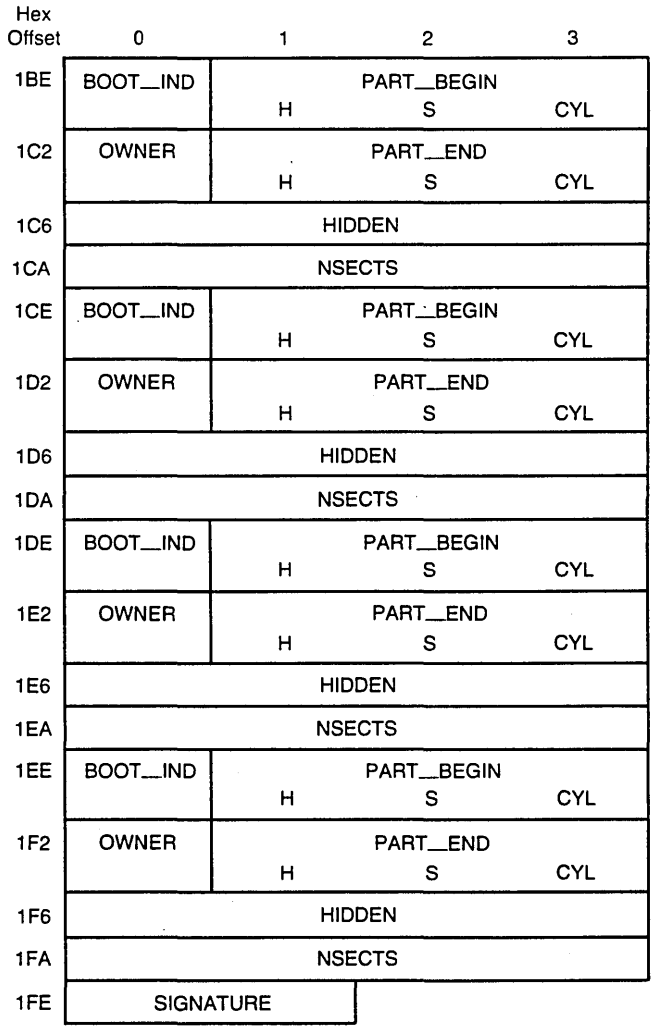


Figure 8-3. Partition Table

Table 8-3. Fields in Partition Table

Field	Description
BOOT_IND	Indicates whether a partition is bootable, where 0 indicates non-bootable and 80H indicates a bootable partition. Only one partition can be marked as bootable.
PART_BEGIN	Three-byte field indicating the head (H), sector (S), and cylinder (CYL) number where a partition begins. The head number is stored in the H field. The sector number is stored in the low order 6 bits of the S field. The cylinder number is 10 bits; the low order eight bits are stored in the CYL field, while the high order two bits are stored in the high order two bits of the S field. All partitions are usually allocated on track boundaries and begin on sector 1, head 0.
OWNER	One byte field indicates which operating system owns the partition. This field can contain one of the following values: 00H = unknown 01H = DOS 12-bit FAT entries 04H = DOS 16-bit FAT entries
PART_END	Three-byte field indicating the head (H), sector (S), and cylinder (CYL) numbers where a partition ends. See PART_BEGIN, above, for an explanation of how these values are stored.
HIDDEN	Four-byte field contains the number of sectors preceding a partition. Count sectors starting with cylinder 0, sector 1, head 0, incrementing the sector number up to the beginning of a partition. Store this value least significant word first.

Table 8-3. (Continued)

Field	Description
NSECTS	Number of sectors allocated to a partition. Store this four-byte value least significant word first.
SIGNATURE	Two-byte field at offset 1FEH from the beginning of the MBR. A value of 55AAH, stored high order byte first, indicates a valid partition.

The BIOS Parameter Block (BPB) is stored at offset 0 in an operating system's boot record. Each partition must contain a BPB, even if it is not bootable. Figure 8-4 illustrates the format of a BPB.

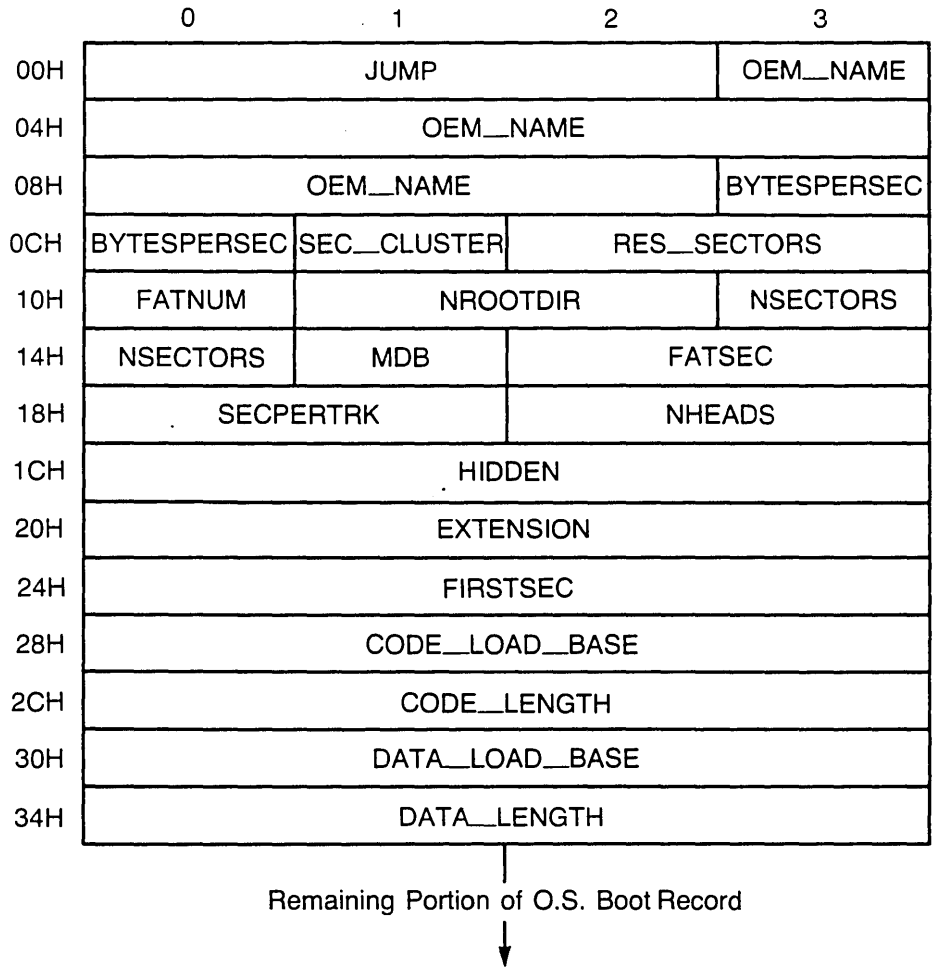


Figure 8-4. BIOS Parameter Block

Table 8-4. Fields in BPB

Field	Description
JUMP	A jump instruction to transfer control to an operating system's loader. See the chip-specific supplements for a description of the jump instruction.
OEM_NAME	The OEM name and version number identifying the boot record's operating system.
BYTESPERSEC	Number of bytes per sector.
SEC_CLUSTER	Number of sectors per file allocation unit in a partition. This value must be a power of two.
RES_SECTOR	Number of sectors reserved by the operating system, starting at logical sector 0.
FATNUM	Number of FATs in a partition.
NROOTDIR	Maximum number of root directory entries in a partition.
NSECTORS	Total number of sectors in a partition, including boot, directory, and reserved sectors. If this field value is 0, the EXTENSION field contains the total.
MDB	Media Descriptor Byte. Describes disk characteristics; MDB values are listed in Table 8-5, below.
FATSEC	Number of sectors occupied by one FAT.
SECPERTRK	Number of sectors per track in a partition.
NHEADS	Number of heads in partition.
HIDDEN	Total number of sectors preceding a partition, including sectors occupied by the MBR.

Table 8-4. (Continued)

Field	Description
EXTENSION	If NSECTORS contains zero, EXTENSION contains the total number of sectors in a partition. The total is here when the partition's size is too big for recording in NSECTORS.
FIRSTSEC	First sector of data area.
CODE_LOAD_BASE	Address where the operating system code is to be loaded.
CODE_LENGTH	Length, in bytes, of code segment.
DATA_LOAD_BASE	Address where the operating system data is to be loaded.
DATA_LENGTH	Length, in bytes, of data segment.

From the EXTENSION field through the end of the BPB is Digital Research's extension to the standard DOS BPB. The FORMAT utility fills in the fields from BYTESPERSEC through FIRSTSEC. The code and data load addresses and segment lengths are filled in by the SYS utility.

The Media Descriptor Byte have the following values:

Table 8-5. Media Descriptor Byte Values

Value	Meaning
F8H	Hard disk
F9H	Double-sided, 15 sectors per track
FCH	Single-sided, 9 sectors per track
FDH	Double-sided, 9 sectors per track
FEH	Single-sided, 8 sectors per track
FFH	Double-sided, 8 sectors per track

Values F9H through FFH refer to 5 1/4-inch diskettes.

8.3 Error Handling

The method used by Disk RM in handling errors depends on the error code returned by the driver unit and the type of media.

All FlexOS function return codes are 32-bit values. If the value is a negative number, it represents an error code. Error codes in the range from -64 to -2 gigabytes are driver-specific error codes. FlexOS system-wide error codes are listed in Appendix B of the FlexOS Programmer's Guide.

Disk driver functions that return physical errors return the error code to the application process, allowing the application to inform the user of the problem.

When I/O operations to removable media without open door support return a timeout error, the Disk RM automatically sets the open door flag and returns the error to the calling process. At the time of the next operation, the Disk RM performs a check to ensure that the medium has not changed.

8.4 Disk Driver I/O Functions

The following section describes the functions called by the Disk Resource Manager through the entry points contained in the disk driver's Driver Header. Of these functions, READ and WRITE are expected to be asynchronous; the remaining functions are synchronous. The physical I/O within the READ and WRITE functions is performed by Interrupt Service Routines (ISRs) and Asynchronous Service Requests (ASRs). Examples are contained in the source code for the sample disk drivers on the FlexOS distribution diskettes.

8.4.1 SELECT--Initialize driver unit

Parameter: Address of SELECT parameter block

Return Code:

E_SUCCESS	Successful operation
E_UNITNO	Drive has been installed to allow partitions (see FLAGS field of the INSTALL SVC's parameter block in the FlexOS Programmer's Guide) but driver is unable to read partition.
E_READY	Door open on a removable medium
E_CRC	Cyclical Redundancy Check error
E_SEEK	Non-existent track or sector
E_SEC_NOTFOUND	Sector or record not found
E_MISADDR	Missing address mark
E_DKATTACH	Attachment failed to respond
E_READFAULT	Read error
E_GENERAL	Undetermined source of failure

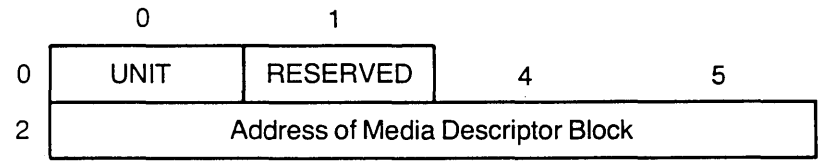


Figure 8-5. SELECT Parameter Block

In the figure above, UNIT refers to the driver unit number of a specific disk drive.

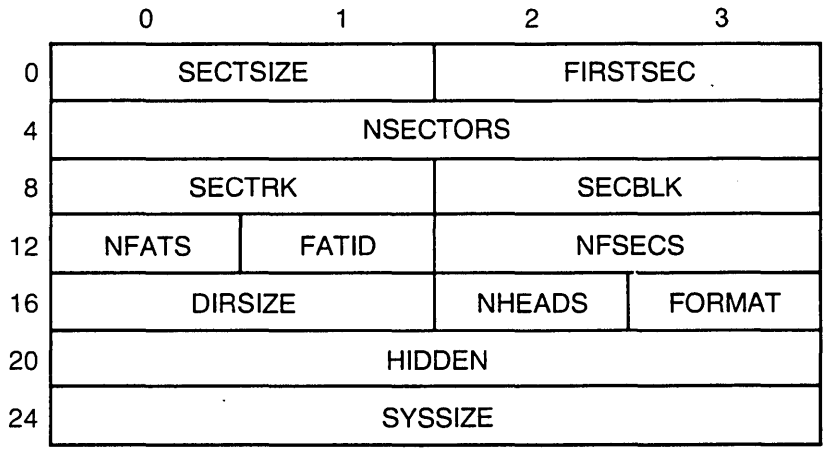


Figure 8-6. Media Descriptor Block

Table 8-6. Media Descriptor Block Fields

Field	Description
SECTSIZE	Physical sector size, in bytes. This value is required for a partial MDB.
FIRSTSEC	First physical sector number of FAT on track 0
NSECTORS	Number of sectors in logical disk image. This includes boot sector, FATs, directories, and data. The boot sector consists of a BIOS Parameter Block and code to load the operating system. Figure 8-4 illustrates the format of a BIOS Parameter Block. NSECTORS does not include system track(s). This value is required for a partial MDB.
SECTRK	Number of sectors per track
SECBLK	Number of sectors per block (file allocation unit)
NFATS	Number of FATs
FATID	Implementation-dependent value indicating media format
NFSECS	Number of physical sectors in a single FAT
DIRSIZE	Number of directory entries in the root directory
NHEADS	Number of heads
FORMAT	FAT format 0 = Raw 1 = 1 1/2-byte FATs 2 = 2-byte FATs For a partial MDB, FORMAT must be set to zero.

Table 8-6. Continued)

Field	Description
HIDDEN	Number of hidden sectors, that is, number of sequential physical sectors preceding a partition. HIDDEN is used only for partitioned disks. See the HIDDEN fields in the Partition Table (Figure 8-3) and BIOS Parameter Block (Figure 8-4).
SYSSIZE	Size of the system area of the disk, in bytes. The system area is outside of the disk medium and can be formatted independently of the disk medium. The system area might contain code to support an operating system other than FlexOS.

The Disk Resource Manager calls the SELECT function to initialize the driver unit for subsequent READ, WRITE, FLUSH and SPECIAL calls on the current medium. The Disk RM calls SELECT only once until either the "Media Change" error is detected or the drive has been opened exclusively.

SELECT is called with address of the SELECT parameter block. This parameter block contains the address of the Media Descriptor Block. The Media Descriptor Block determines the type (removable, permanent, and so forth) and size of the media as well as the file structure to be managed. It is a static structure and can be used for multiple units of the same driver if the MDB is identical for those units.

If SELECT is called for a unit containing an unformatted disk or a disk whose format is not supported by the Disk RM, the driver should not return an error code. Instead, the driver should return a partly filled-in MDB. By filling in the SECTSIZE, NHEADS, and FORMAT fields of the SELECT parameter block, the driver allows utilities, such as COPYCPM, to use the SPECIAL SVCs to initiate raw I/O to non-DOS media.

8.4.2 FLUSH--Flush intermediate buffers to media

Parameter: Address of FLUSH parameter block,

Return Code:

E_SUCCESS	Operation was successful
E_UNITNO	Invalid unit number
E_BADPB	Bad parameter block
E_READY	Door open on a removable medium
E_SEC_NOTFOUND	Sector or record not found
E_MISADDR	Missing address mark
E_SEEK	Non-existent track or sector
E_DKATTACH	Attachment failed to respond
E_WPROT	Disk write-protected
E_WRITEFAULT	Write error
E_GENERAL	Failure from undetermined source

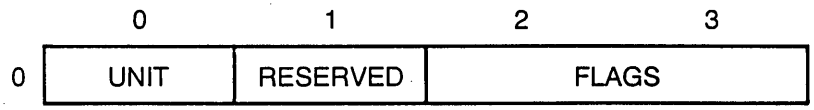


Figure 8-7. FLUSH Parameter Block

The UNIT value indicates the driver unit number of the drive to be flushed. The FLAGS field is reserved for future use.

The Disk Resource Manager calls the FLUSH function to flush any intermediate buffers to a medium and to make sure the driver is not in any intermediate state.

The disk drivers provided with FlexOS do not use intermediate buffering. When the Disk RM calls FLUSH in a FlexOS disk driver, FLUSH returns E_SUCCESS.

8.4.3 READ--Obtain data from disk medium

Parameter: Address of READ parameter block

Return Code:

emask	The return code from FLAGEVENT

The read event's completion code is returned through the FLAGSET function and should be one of the following:

E_SUCCESS	Successful operation
E_UNITNO	Drive has been installed to allow partitions (see FLAGS field of the INSTALL SVC's parameter block in the FlexOS Programmer's Guide) but driver is unable to read partition.
E_READY	Door open on a removable medium
E_CRC	Cyclical Redundancy Check error
E_SEEK	Non-existent track or sector
E_SEC_NOTFOUND	Sector or record not found
E_MISADDR	Missing address mark
E_DKATTACH	Attachment failed to respond
E_READFAULT	Write error
E_GENERAL	Failure from undetermined source

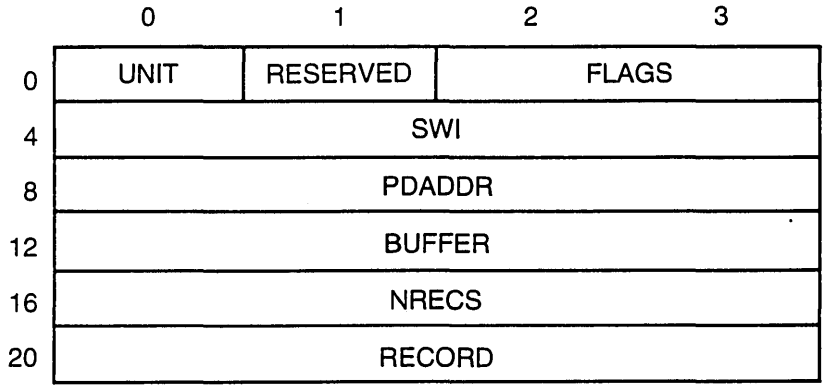


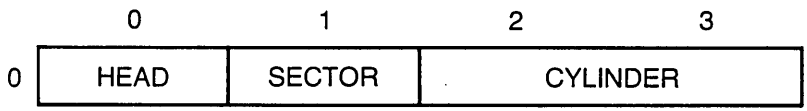
Figure 8-8. READ Parameter Block

Table 8-7. READ Parameter Block Fields

Field	Description
UNIT	Driver unit number
FLAGS	Bit map of flags
	Bit 0: 1 = Read through 0 = Normal read Read through option forces direct read from the medium, bypassing intermediate buffers. This flag is meaningless for drivers without intermediate buffers.
	Bit 1: 1 = RECORD formatted as head, sector, cylinder 0 = RECORD formatted as the logical sector number from the beginning of the disk medium.
	Bit 2: 1 = Verify medium, do not read 0 = Read
	Bit 8: 1 = Write 0 = Read
	Bits 9-10: 0 = Not Applicable 1 = FAT 2 = DIR 3 = Data
	Bit 11-14: Reserved
	Bit 15: 1 = User Address 0 = System Address

Table 8-7. (Continued)

Field	Description
SWI	User-supplied software interrupt to be passed as a parameter to the FLAGEVENT driver service function.
PDADDR	Process descriptor address of process calling READ SVC. If an address is specified and it is a User Address, this is the pdaddr you use for the MAPU driver service. This is not necessarily the process calling this entry point, and therefore not the pdaddr used in the FLAGSET function. The pdaddr obtained before calling FLAGEVENT is found via the driver header's Ready List Root (RLR) address.
BUFFER	Address of buffer to place information into.
NRECS	Number of physical sectors to READ
RECORD	First sector to READ. This field is either a logical sector number or a head, track, sector specification, depending on the value in bit 1 of the FLAGS field. A logical sector number is the number of physical sectors from the beginning of the disk medium, where Sector 0 is Track 0, Head 0, Sector 0. If bit 1 of the FLAGS field is set, the RECORD parameter is formatted as follows:



The Disk Resource Manager calls the READ function to obtain data from the disk medium. The Disk RM assumes this function is asynchronous.

To work asynchronously, the READ driver function must call the FLAGEVENT driver service function to receive an event mask, which is returned to the Disk Resource Manager. Upon completion of the READ, FLAGSET is called by the asynchronous portion of the driver to return a completion code. FLAGEVENT and FLAGSET are explained in Section 5.1, "Flag System."

8.4.4 WRITE--Write data to disk medium

Parameter: Address of WRITE Parameter Block

Return Code:

emask	Return code from the FLAGEVENT driver service

The write events completion code is returned through the FLAGSET function and should be one of the following:

E_SUCCESS	Successful operation
E_UNITNO	Invalid unit number
E_BADPB	Bad parameter block
E_READY	Door open on a removable medium
E_SEC_NOTFOUND	Sector or record not found
E_MISADDR	Missing address mark
E_SEEK	Non-existent track or sector
E_DKATTACH	Attachment failed to respond
E_WPROT	Disk write-protected
E_WRITEFAULT	Write error
E_GENERAL	Failure from undetermined source

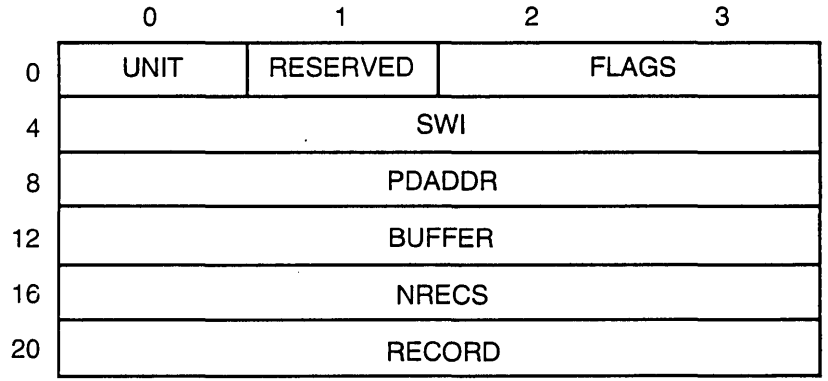


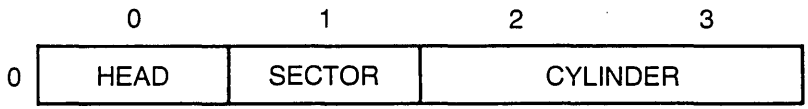
Figure 8-9. WRITE Parameter Block

Table 8-8. WRITE Parameter Block Fields

Field	Description
UNIT	Driver unit number
FLAGS	Bit map of flags
	Bit 0: 1 = Write through 0 = normal write The write through option forces a direct write to the actual media, bypassing any intermediate buffers. This flag has no meaning for disk drivers not using intermediate buffering.
	Bit 1: 1 = RECORD is formatted as head, track, cylinder 0 = RECORD is formatted as the logical sector number from the beginning of the disk medium.
	Bit 8: 1 = Write 0 = Read
	Bits 9-10: 0 = Not Applicable 1 = FAT 2 = DIR 3 = Data
	Bits 11-14: Reserved
	Bit 15: 1 = User Address 0 = System Address

Table 8-8. (Continued)

Field	Description
SWI	User-supplied software interrupt to be passed as a parameter to the FLAGEVENT driver service function.
PDADDR	Process descriptor address of process initiating the WRITE request. If an address is specified and the address is a User Address, this is the pdaddr you use for the MAPU driver service function. This is not necessarily the process calling this entry point and therefore not the pdaddr used in the FLAGSET function. The pdaddr obtained before calling FLAGEVENT is found through the Ready List Root (RLR) address in the driver header.
BUFFER	Address of buffer to obtain data from
NRECS	Number of physical sectors to WRITE
RECORD	First sector to WRITE. This field is either a logical sector number or a head, sector, cylinder specification, depending on the value in bit 1 of the FLAGS field. A logical sector number is the number of physical sectors from the beginning of the disk medium, where sector 0 is track 0, head 0, sector 0. If bit 1 of the FLAGS field is set, the RECORD parameter is formatted as follows:



The Disk Resource Manager calls WRITE to place data onto the disk medium. WRITE is assumed to be asynchronous.

The WRITE driver function must call the FLAGEVENT driver service to receive an event mask, which is returned to the Disk Resource Manager. Upon completion of the WRITE, the asynchronous portion of the driver calls the FLAGSET driver service to return a completion code. WRITE should then call the RETURN SVC through SUPIF to clear the event from the system.

8.4.5 SPECIAL Entry Point

The Disk Resource Manager calls the SPECIAL entry point to perform actions that cannot be performed by other disk driver functions. FlexOS defines six SPECIAL disk driver functions, 0 through 3, 8, and 9. The Disk RM reserves functions 10-31 for future use. Functions 32-63 are OEM-dependent and can be used for special activities particular to a given hardware implementation.

SPECIAL Function 0--Read from System Area of disk

Parameter: Address of SPECIAL parameter block

Return Code:

E_SUCCESS	Successful operation
E_UNITNO	Invalid unit number
E_READY	Door open on a removable medium
E_CRC	Cyclical Redundancy Check error
E_SEEK	Non-existent track or sector
E_SEC_NOTFOUND	Sector or record not found
E_MISADDR	Missing address mark
E_DKATTACH	Attachment failed to respond
E_READFAULT	Write error
E_GENERAL	Failure from undetermined source

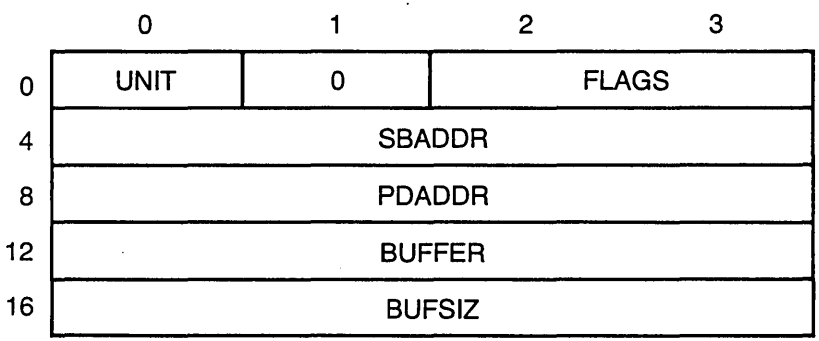


Figure 8-10. SPECIAL Function 0 Parameter Block

Table 8-9. SPECIAL Function 0 Parameter Block Fields

Field	Description
UNIT	Driver unit number
0	SPECIAL function number
FLAGS	Bit map of flags Bits 0-13: Driver-type specific Bit 14: Reserved Bit 15: 1 = User Address 0 = System Address
SBADDR	System address of special buffer for blocking/deblocking. The drivers shipped with FlexOS do not use blocking/deblocking.
PDADDR	Process descriptor address of process initiating the SPECIAL request. If an address is specified and the address is a User Address, this is the pdaddr you use for the MAPU driver service function. This is not necessarily the process calling this entry point and therefore not the pdaddr used in the FLAGSET function. The pdaddr obtained before calling FLAGEVENT is found through the Ready List Root (RLR) address in the driver header.
BUFFER	Address of buffer where data will be placed.
BUFSIZ	Size of buffer, in bytes

SPECIAL function 0 reads the data in the system area of the disk and places the data into the specified buffer. This function is performed synchronously and does not return until the read is complete.

SPECIAL Function 1--Write to System Area of disk

Parameter: Address of SPECIAL parameter block

Return Code:

E_SUCCESS	Successful operation
E_UNITNO	Invalid unit number
E_BADPB	Bad parameter block
E_READY	Door open on a removable medium
E_SEC_NOTFOUND	Sector or record not found
E_MISADDR	Missing address mark
E_SEEK	Non-existent track or sector
E_DKATTACH	Attachment failed to respond
E_WPROT	Disk write-protected
E_WRITEFAULT	Write error
E_GENERAL	Failure from undetermined source

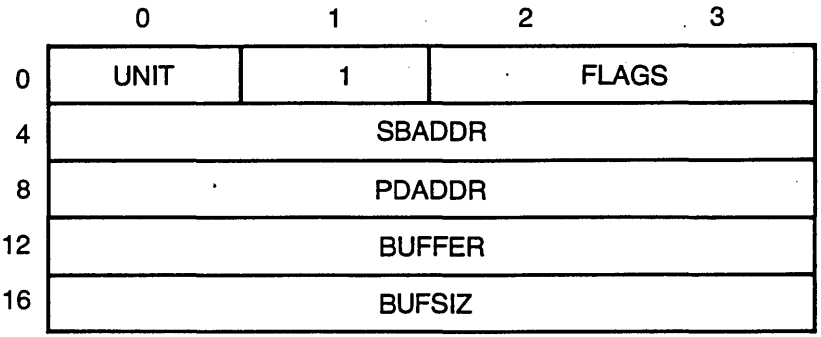


Figure 8-11. SPECIAL Function 1 Parameter Block

Table 8-10. SPECIAL Function 1 Parameter Block Fields

Field	Description
UNIT	Driver unit number
41	SPECIAL function number (in hex)
FLAGS	Bit map of flags Bits 0-13: Driver-type specific Bit 14: Reserved Bit 15: 1 = User Address 0 = System Address
SBADDR	System Address of special buffer for blocking/deblocking. The disk drivers shipped with FlexOS do not use blocking/deblocking.
PDADDR	Process descriptor address of process initiating the SPECIAL request. If an address is specified and the address is a User Address, this is the pdaddr you use for the MAPU driver service function. This is not necessarily the process calling this entry point and therefore not the pdaddr used in the FLAGSET function. The pdaddr obtained before calling FLAGEVENT is found through the Ready List Root (RLR) address in the driver header.
BUFFER	Address of buffer from which data will be written.
BUFSIZ	Size of buffer, in bytes

SPECIAL function 1 writes the data in the specified buffer to the system area of the disk. This function is performed synchronously and does not return until the write is complete.

SPECIAL Function 2--Format System Area of disk

Parameter: Address of SPECIAL parameter block

Return Code:

E_SUCCESS	Successful operation
E_UNITNO	Invalid unit number
E_BADPB	Bad parameter block
E_READY	Door open on a removable medium
E_SEC_NOTFOUND	Sector or record not found
E_MISADDR	Missing address mark
E_SEEK	Non-existent track or sector
E_DKATTACH	Attachment failed to respond
E_WPROT	Disk write-protected
E_WRITEFAULT	Write error
E_GENERAL	Failure from undetermined source

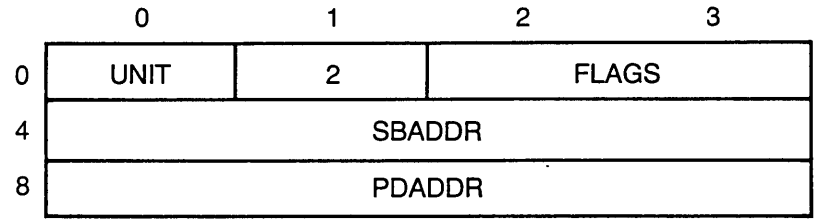


Figure 8-12. SPECIAL Function 2 Parameter Block

Table 8-11. SPECIAL Function 2 Parameter Block Fields

Field	Description
UNIT	Driver unit number
2	SPECIAL function number
FLAGS	Bit map of flags Bits 0-14: Reserved Bit 15: 1 = User Address 0 = System Address
WSBADDR	System address of buffer
PDADDR	Process descriptor address of process initiating the SPECIAL request. If an address is specified and the address is a User Address, this is the pdaddr you use for the MAPU driver service function. This is not necessarily the process calling this entry point and therefore not the pdaddr used in the FLAGSET function. The pdaddr obtained before calling FLAGEVENT is found through the Ready List Root (RLR) address in the driver header.

SPECIAL function 2 formats the system area of the disk managed by the specified driver unit. Function 2 only formats the system area if it resides in those tracks preceding the data area of the disk. In the FlexOS logical disk layout, the system area is not considered part of the disk medium and so can be formatted independently of the disk medium. This function is performed synchronously and does not return until the function is complete.

SPECIAL Function 3--Format track

Parameter: Address of SPECIAL parameter block

Return Code:

E_SUCCESS	Successful operation
E_UNITNO	Invalid unit number
E_BADPB	Bad parameter block
E_READY	Door open on a removable medium
E_SEC_NOTFOUND	Sector or record not found
E_MISADDR	Missing address mark
E_SEEK	Non-existent track or sector
E_DKATTACH	Attachment failed to respond
E_WPROT	Disk write-protected
E_WRITEFAULT	Write error
E_GENERAL	Failure from undetermined source

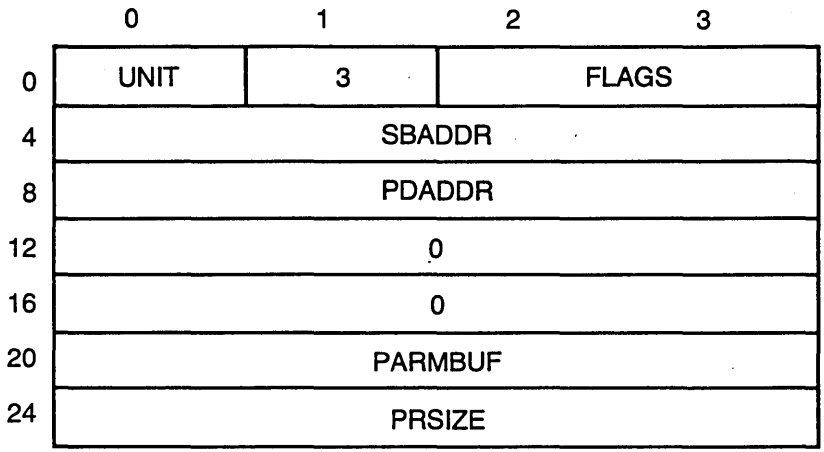


Figure 8-13. SPECIAL Function 3 Parameter Block

Table 8-12. SPECIAL Function 3 Parameter Block Fields

Field	Description
UNIT	Driver unit number
3	SPECIAL function number (in hex)
FLAGS	Bit map of flags:
	Bit 0: Reserved
	Bit 1: 0 = Track map is valid 1 = Map bad tracks
	Bit 2: 0 = Use HEAD, SECTOR, and BYTESPERSPEC fields. 1 = Ignore HEAD, SECTOR, and BYTESPERSEC fields. Instead, use a table of four-byte C-H-S-N fields as defined in the PARMBUF structure in Figure 8-13, below.
	Bit 3: 0 = SECTOR field is the starting sector number. This field is the first in variable-length list, whose length is the number of sectors per track. 1 = HEAD is the valid head number.
	Bits 4-14: Reserved
	Bit 15: 0 = System Address 1 = User Address

Table 8-12. (Continued)

Field	Description
SBADDR	System address of special buffer for blocking/deblocking. The drivers shipped with FlexOS do not use blocking/deblocking.
PDADDR	Process descriptor address of process initiating the SPECIAL request. If an address is specified and the address is a User Address, this is the pdaddr you use for the MAPU driver service function. This is not necessarily the process calling this entry point and therefore not the pdaddr used in the FLAGSET function. The pdaddr obtained before calling FLAGEVENT is found through the Ready List Root (RLR) address in the driver header.
PARMBUF	Address of data structure illustrated in Figure 8-13, below.
PRSIZE	Length, in bytes, of data buffer.

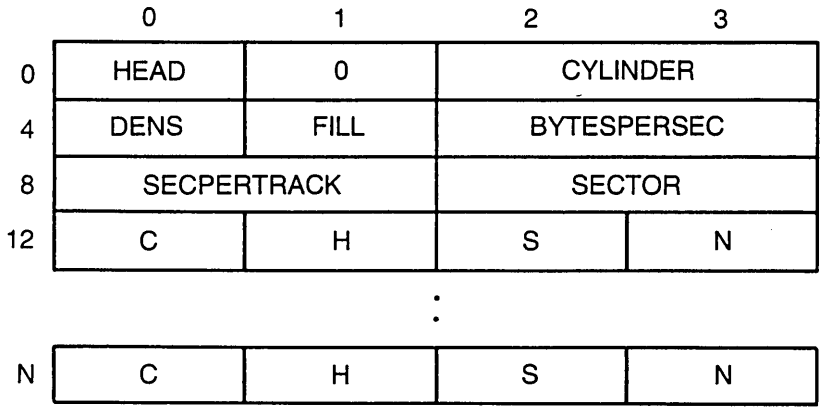


Figure 8-14. PARMBUF Structure

Table 8-13. PARMBUF Structure Fields

Field	Description
HEAD	If FLAGS bit 1 in SPECIAL Function 3 parameter block is zero, HEAD is a valid starting head number.
0	One byte set to zero
CYLINDER	Cylinder number
DENS	Density, where: 0 = single density 1 = double density
FILL	Fill character
BYTESPERSEC	If FLAGS bit 2 in SPECIAL Function 3 parameter block is zero, BYTESPERSEC is the number of bytes per sector.
SECPERTRACK	Number of sectors per track
SECTOR	This field's value depends on the settings for bits 2 and 3 in the FLAGS field of the SPECIAL Function 3 parameter block. If bits 2 and 3 are off, SECTOR contains the starting sector number. Use only bytes 0 through 11 of the PARMBUF Structure. If bit 2 is on and bit 3 is off, ignore SECTOR and use list starting with byte 12 in the PARMBUF Structure, as shown in Figure 8-13. If bit 2 is off and bit 3 is on, SECTOR is the first in variable-length list of sectors whose length is the number of sectors per track.
C-H-S-N	If FLAGS bit 2 in SPECIAL Function 3 parameter block is one, this is a variable-length list of four-byte fields, where C is cylinder, H is head, S is sector, and N is bytes per sector.

SPECIAL function 3 is used to format the disk medium and to map bad tracks out of the data area of a disk. SPECIAL function 3 maps bad tracks by marking a track in the FAT Table as allocated and without an owner. This function does not deal with the system area of a disk.

SPECIAL function 3 is called by the FORMAT utility.

SPECIAL Function 8--Initialize format

Parameter: Address of SPECIAL parameter block

Return Code:

E_SUCCESS	Successful operation
E_BADPB	Bad MDB parameters

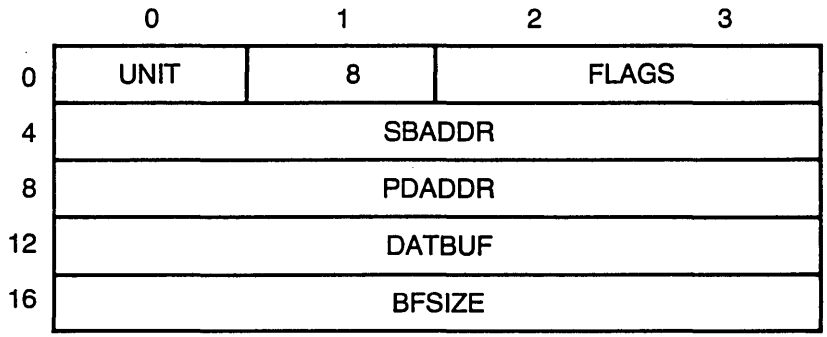


Figure 8-15. SPECIAL Function 8 Parameter Block

Table 8-14. SPECIAL Function 8 Parameter Block Fields

Field	Description
UNIT	Driver unit number
8	SPECIAL function number (in hex)
FLAGS	Bits 0-15 are reserved
SBADDR	System Address of special buffer
PDADDR	Process descriptor address of process initiating the SPECIAL request. If an address is specified and the address is a User Address, this is the pdaddr that must be used for the MAPU driver service function. This is not necessarily the process calling this entry point and therefore not the pdaddr used in the FLAGSET function. The pdaddr obtained before calling FLAGEVENT is found through the Ready List Root (RLR) address in the driver header. The RLR address is explained in Section 4, "Driver Interface."
DATBUF	Address of buffer containing Media Descriptor Block (MDB). The MDB is described under the SELECT function, in Figure 8-6 and Table 8-6, above.
BFSIZE	Size, in bytes, of DATBUF

SPECIAL function 8 resets the Media Descriptor Block in system and driver memory, but does not transfer the MDB information to the disk. This function enables a user program to begin formatting a disk by establishing a new set of guidelines for the disk. When formatting is complete, the MDB is written to the disk's system area.

SPECIAL Function 9--Get Drive Information

Parameter: Address of SPECIAL parameter block

Return Code:

E_SUCCESS	Successful operation
E_UNITNO	Invalid unit number
E_BADPB	Bad parameter block

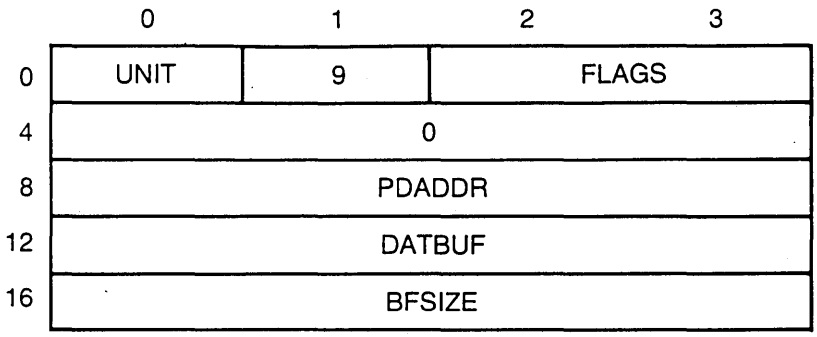


Figure 8-16. SPECIAL Function 9 Parameter Block

Table 8-15. SPECIAL Function 9 Parameter Block Fields

Field	Description
UNIT	Driver unit number
9	SPECIAL function number (in hex)
FLAGS	Bits 0-15 are reserved
PDADDR	Process descriptor address of process initiating the SPECIAL request. If an address is specified and the address is a User Address, this is the pdaddr that must be used for the MAPU driver service function. This is not necessarily the process calling this entry point and therefore not the pdaddr used in the FLAGSET function. The pdaddr obtained before calling FLAGEVENT is found through the Ready List Root (RLR) address in the driver header. The RLR address is explained in Section 4, "Driver Interface."
DATBUF	Address of buffer for Physical Unit Descriptor. (see Listing 8-1).
BFSIZE	Size, in bytes, of DATBUF

SPECIAL Function 9 requests disk-dependent information. You return the data in the buffer provided in the parameter block. Listing 8-1 describes the buffer contents.

Listing 8-1. SPECIAL Function 9 Physical Unit Descriptor

```
/*  PUD - Physical Unit Descriptor     */

PUD
{
    UWORD   pu_maxcyl ;      /*  max cyl number for i/o      */
    UWORD   pu_precomp ;     /*  precompensation cyl number  */
    UWORD   pu_crashpad ;    /*  landing zone cyl number     */
    UBYTE   pu_nheads ;      /*  no of heads                 */
    UBYTE   pu_sectors ;     /*  no sectors/track            */
    UBYTE   pu_step ;        /*  step rate                   */
    UBYTE   pu_eat ;         /*. even (unused)               */
} ;
```

8.4.6 GET--Provide unit-specific information

Parameter: Address of GET parameter block

Return Code:

E_SUCCESS	Successful operation
E_BADPB	Bad parameter block

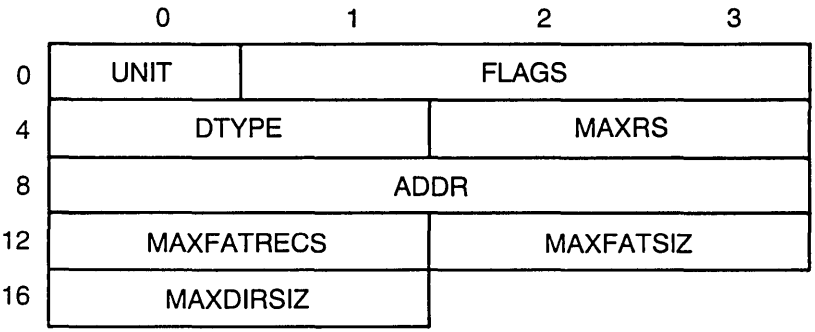


Figure 8-17. GET Parameter Block

Table 8-16. GET Parameter Block Fields

Field	Description
UNIT	Driver unit number
FLAGS	Reserved
DTYPE	Type of disk medium Bit 0: 1 = Removable media 0 = Permanent media Bit 1: 1 = Open door support 0 = No open door support Bit 2: Reserved
MAXRS	Maximum Record Size. This is the maximum physical sector size of all media types supported through this disk driver unit. For example, if this unit supports both single- and double-density diskettes, the larger of the physical sector sizes should be stated here. This field determines the size of the buffers the Disk Resource Manager maintains for the unit.
ADDR	Address of the open door byte if this is a disk drive with open-door-interrupt support.
MAXFATRCS	Maximum number of FAT records in a single FAT for all media types supported through this driver unit.
MAXFATSIZE	Maximum size of FAT, in bytes.
MAXDIRSIZE	Maximum number of root directory entries.

The Disk Resource Manager calls the GET function during the installation of the driver unit. GET is responsible for passing information to the Disk Resource Manager that is unit-specific, but does not pass the current disk medium-specific information.

The GET function passes the address of the GET parameter block to the driver unit and expects all of the fields of the parameter block except the UNIT and FLAGS fields to be filled in before returning.

8.4.7 SET--Change unit-specific information

Parameter: None

Return Code: E_IMPLEMENT Not Implemented

The Disk Resource Manager never calls the SET disk driver entry point. SET should return the "Not Implemented" error code.

End of Section 8

Port Drivers

This section describes the driver interface for interrupt-driven serial port drivers. All port drivers fall under the category of special drivers and are managed by the Miscellaneous Resource Manager.

Many serial interfaces generate interrupts only when a character is received, not when the port is ready to transmit a character. To account for this situation, the READ function in the sample port driver uses an ISR-ASR method of receiving characters, while the WRITE function uses the POLLEVENT driver service (see Section 5.3) to poll the selected port. Section 5, "Driver Services," discusses methods for responding to interrupts.

9.1 Port Driver Overview

A single port driver can control multiple units of the same type of port. FlexOS does not have a theoretical limit to the number of ports that are part of a system.

To allow multiple processes to perform serial I/O, the port driver should be I/O re-entrant at the driver and Resource Manager levels, and synchronized at the unit level. This means that bit 1 in the flags field of the port's Driver Header should be set. See Section 4.2, "Driver Header," for a definition of the Driver Header. See Section 11.1 for a discussion of how the Miscellaneous Resource Manager protects its drivers from user processes.

9.2 Port Driver I/O Functions

This section describes the port I/O functions accessed by the Miscellaneous Resource Manager through entry points in the port driver's Driver Header.

The port driver contains the SELECT, FLUSH, READ, WRITE, GET, and SET functions. The SPECIAL function is not required by the port driver and should return E_IMPLEMENT unless you provide support for SPECIAL calls.

See Section 4.4, "Driver Installation Functions," for a description of the INIT, SUBDRIVE, and UNINIT driver installation functions.

9.2.1 SELECT--Enable the specified unit

Parameter: Address of SELECT parameter block

Return Code:

E_SUCCESS Port is enabled

IO_ERROR Port not enabled

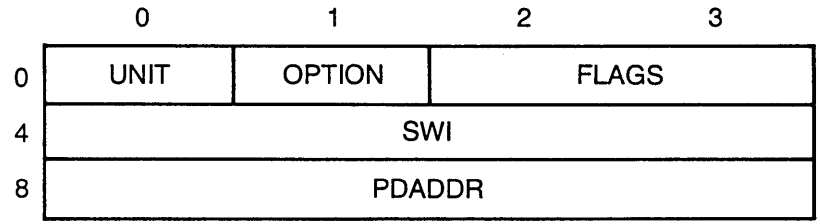


Figure 9-1. Port Driver SELECT Parameter Block

Table 9-1. Port Driver SELECT Parameter Block Fields

Field	Description
UNIT	Unit number of port being enabled
OPTION	User-defined option
FLAGS	User flags field
SWI	Address of optional Software Interrupt Routine. 0 if there is no SWI
PDADDR	Process descriptor address of process attempting to open this device (via the OPEN SVC)

The Miscellaneous RM calls SELECT to enable a specific port unit for I/O. SELECT clears all buffers for the selected unit, excluding the Interrupt Service Routine (ISR) buffer and then enables serial interrupts.

9.2.2 FLUSH--Disable port

Parameter: Address of FLUSH parameter block

Return Code:

E_SUCCESS	Port is deselected
IO_ERROR	Port not deselected

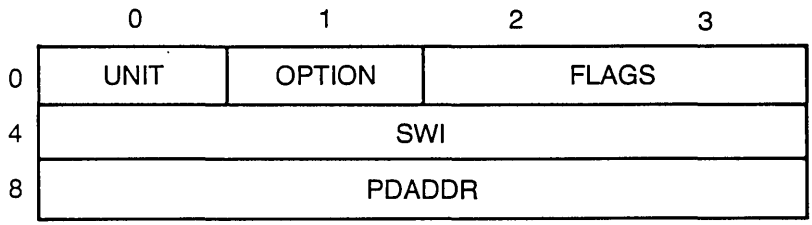


Figure 9-2. Port Driver FLUSH Parameter Block

Table 9-2. Port Driver in FLUSH Parameter Block Fields

Field	Description
UNIT	Unit number of port to be disabled
OPTION	User-defined option
FLAGS	User flags field
SWI	Address of optional Software Interrupt Routine. 0 if there is no SWI
PDADDR	Process descriptor address of process attempting to close this device (via the CLOSE SVC)

The Miscellaneous Resource Manager calls FLUSH before writing to another unit connected to the same driver or before uninstalling the driver.

I/O is not allowed past the point of invoking FLUSH without first calling SELECT. Because of this, FLUSH should clear any buffers not yet sent to the port, including the ISR buffer, before disabling serial interrupts.

9.2.3 READ--Read data from port

Parameter: Address of READ parameter block

Return Code:

emask	Event mask used by the calling process to wait for port to finish reading the character or characters into buffer
IO_ERROR	Unable to read from port

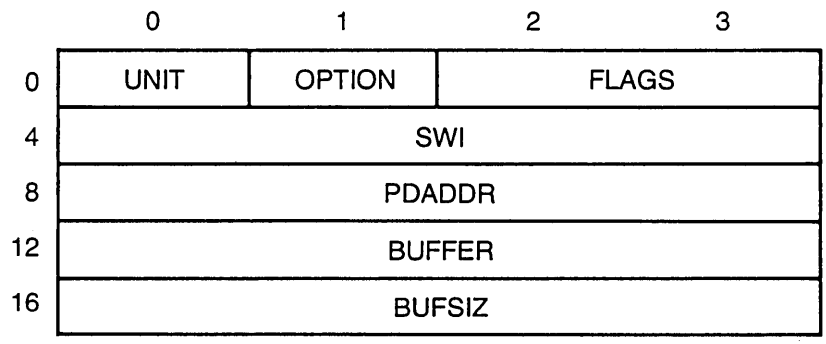


Figure 9-3. Port Driver READ Parameter Block

Table 9-3. Port Driver READ Parameter Block Fields

Field	Description
UNIT	Unit number of port being read
OPTION	User-defined option
FLAGS	User flags field
SWI	Address of optional Software Interrupt Routine; the value is 0 if there is no SWI
PDADDR	Process descriptor address of process attempting the read. This is not necessarily the process calling this entry point and therefore not the PDADDR used with FLAGEVENT and FLAGSET. Find the PDADDR of the process calling FLAGEVENT through the RLR field of the Driver Header. If an address is specified and it is a User Address, this is the PDADDR you use with MAPU.
BUFFER	Pointer to user's buffer
BUFSIZ	Size of buffer indicated in BUFFER

The Miscellaneous RM calls READ to read characters from a selected port. FlexOS assumes that the serial interface produces an interrupt when a character arrives. For those ports not interrupt-driven, see Section 5.3, "Device Polling."

READ must be able to buffer characters arriving at the port when the user process is not ready to read them. The READ function in FlexOS's sample serial driver works in the following sequence:

1. A character arrives at the serial port, causing an interrupt.
2. The operating system receives the interrupt via the exception vector established by the SETVEC driver service in the serial driver's INIT code. FlexOS passes control to the driver's Interrupt Service Routine (ISR).
3. The ISR reads the character from the serial port and calls the DOASR driver service to queue an ASR, passing DOASR the character as an argument.
4. The ASR puts the character into a buffer, then exits.

READ must transfer the characters from the ISR buffer into the user buffer. To do this, READ calls FLAGEVENT with the number of a clear flag and the address of the SWI in the READ parameter block. FLAGEVENT returns an event mask, which the driver saves.

The driver then calls DOASR with the address of the READ parameter block and the address of an ASR that performs the actual reading from ISR buffer to user buffer. When the READ ASR has completed, the driver calls FLAGSET to note the completion of the read.

9.2.4 WRITE--Send data to port

Parameter: Unsigned word (UWORD) with the unit number in the high order byte and the character in the low order word

Return Code:

emask	Event mask use by calling process to wait for port to be ready for more characters
IO_ERROR	Unable to write to port

The Miscellaneous RM calls WRITE to write the character provided to the specified unit.

If a port does not generate an interrupt when it is ready to transmit a character, WRITE can use the POLLEVENT driver service to poll. Alternatively, if the amount of data to write is small and/or the serial baud rate is fast, the driver can keep reading the status port until it becomes ready.

9.2.5 GET--Provide unit-specific information

Parameter: Address of GET parameter block

Return Code:

E_SUCCESS	Write to buffer completed - no error
E_xxx	Driver-specific error code

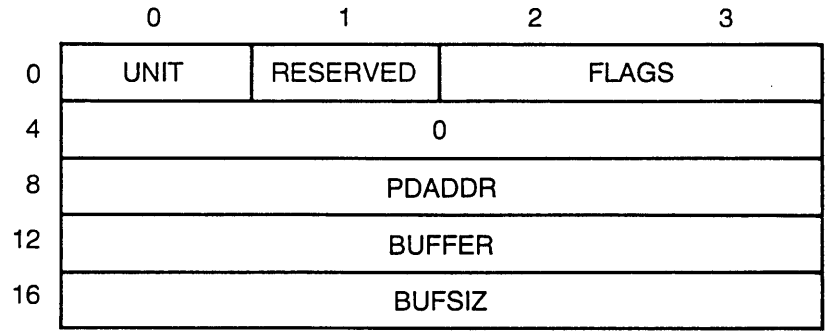


Figure 9-4. Port Driver GET Parameter Block

Table 9-4. Port Driver GET Parameter Block Fields

Field	Description
UNIT	Port driver unit number
FLAGS	Bit map of flags Bits 0-7: Defined by driver Bits 8-14: Reserved Bit 15: 0 = System Address 1 = User Address
PDADDR	Process descriptor address of the process that initiated the GET request. If the buffer address is a User Address, and the asynchronous portion of the driver is required to access the buffer, this parameter is used to call the MAPU driver service.
BUFFER	Address of buffer in which to write information from the driver's GET/SET Table; see Figure 9-5 below.
BUFSIZ	Size of buffer. This field determines the amount of information returned from the driver's GET/SET Table.

The Miscellaneous Resource Manager calls the GET entry point to place information from the port driver's GET/SET Table into a buffer whose address is specified as a parameter. The BUFSIZ parameter is passed to determine the amount of information to be obtained. If the buffer's size is less than the size of the table, only those fields that fit into the buffer are written there.

The GET and SET routines are not expected to return an event mask. The calling process should not return until the operation is complete. If the asynchronous portion of the driver is required to initiate an I/O event to obtain the information, the GET and SET routines must perform their own WAIT and RETURN SVCs through the Supervisor interface described in Section 6.

Many of the GET/SET Table values cannot be determined until they are placed in the table by SET. GET/SET Table values are set by one process for use by another.

The port driver GET/SET Table format is shown in Figure 9-5. Table 9-5 describes the GET/SET Table fields.

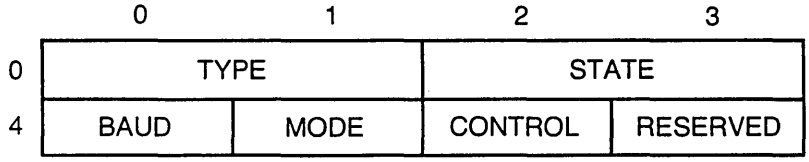


Figure 9-5. Port Driver GET/SET Table

Table 9-5. Port Driver GET/SET Table Fields

Field	Description
TYPE	Type of port, where: 0 = Undefined 1 = Standard serial driver 2 = Character I/O device 3 = Standard parallel driver
STATE	Bit map of port's state including error conditions. A bit set to 1 indicates the following conditions: Bit — Condition 0 — Ready to send a character (RTS) 1 — Character has been received 2 — Change in DSR or CD 3 — Parity error 4 — Overrun error 5 — Framing error 6 — Carrier present (CD) 7 — DSR
BAUD	Baud rate, as indicated by the following values: Value — Rate — Value — Rate 0 — 50 — 8 — 1800 1 — 75 — 9 — 2000 2 — 110 — 10 — 2400 3 — 134.5 — 11 — 3600 4 — 150 — 12 — 4800 5 — 300 — 13 — 7200 6 — 600 — 14 — 9600 7 — 1200 — 15 — 19200

Table 9-5. (Continued)

Field	Description

MODE — Bit map indicating word length, parity, and stop bits as follows:

Bits	Value	Mode
0-1	0	5 bits/word
	1	6 bits/word
	2	7 bits/word
	3	8 bits/word
2-3	0	0 stop bits
	1	1 stop bit
	2	1.5 stop bits
	3	2 stop bits
4-5	0	no parity
	1	odd parity
	3	even parity

CONTROL — Bit map describing serial port control parameters. This field is intended for the use of the driver's SET function. A bit set to 1 indicates the following conditions:

Bit	Condition
0	Enable character transmission
1	Force DTR low
2	Enable character reception
3	Force break signal
4	Reset error
5	Force RTS low

9.2.6 SET--Change unit-specific information

Parameter: Address of SET parameter block.

Return Code:

E_SUCCESS	Write completed - no error
E_xxx	Driver specific error code

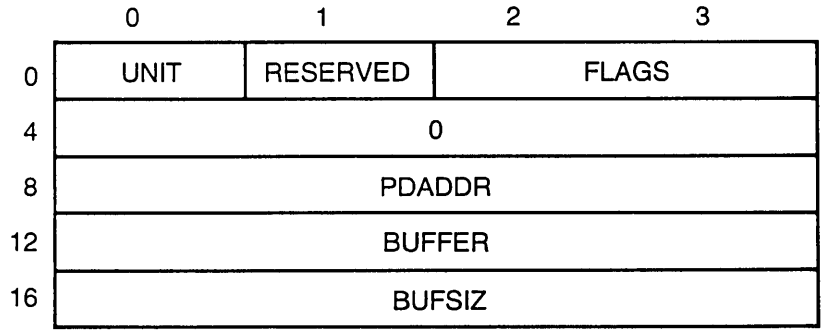


Figure 9-6. Port Driver SET Parameter Block

Table 9-6. Port Driver SET Parameter Block Fields

Field	Description
UNIT	Port driver unit number
FLAGS	Bit map of flags: Bits 0-14: Reserved Bit 15: 0 = System Address 1 = User Address
PDADDR	Process descriptor address of the process that initiated the SET call. This parameter is used to call the MAPU driver service if the buffer address is a User Address and the asynchronous portion of the driver is required to access the buffer.
BUFFER	Address of buffer containing information to be written to the driver's GET/SET Table. See Figure 9-5.
BUFSIZ	Size of buffer. This field determines the amount of information returned from the driver's GET/SET Table.

The Miscellaneous Resource Manager calls the SET entry point to set or modify unit-specific information in the port driver's GET/SET Table. The buffer indicated in the SET parameter block contains the information to be set. A buffer size parameter is passed by the calling process to determine the amount of information to be written to the driver's GET/SET Table.

See the explanation of the port driver's GET function for the description of the GET/SET Table.

End of Section 9

Printer Drivers

This section describes the driver interface for printer drivers. Printer drivers fall under the category of special drivers and are managed by the Miscellaneous Resource Manager.

10.1 Support for Printers

FlexOS supports multiple parallel and serial printers. Printers can be interrupt-driven or polled. The printer driver shipped with FlexOS is for a non-interrupt-driven parallel printer. You can implement a serial printer driver by installing a new unit to a serial driver or defining a new name (such as PRN: or LST:) for an existing serial unit.

A single printer driver can control multiple units of the same type of printer. The example driver supports up to four printers. FlexOS does not have a theoretical limit to the number of printing devices connected to a system.

The example printer driver uses the POLLEVENT driver service to emulate interrupts and maximize operating speed in a multitasking environment. POLLEVENT is described in Section 5.3, "Device Polling."

To allow multiple print jobs, the printer driver should be I/O reentrant at the driver and Resource Manager levels, and synchronized at the unit level. This means that bit 1 in the flags field of the printer's Driver Header should be set. See Section 4.2, "Driver Header" for a definition of the Driver Header. See Section 11.1 for a discussion of how the Miscellaneous Resource Manager protects drivers from user processes.

10.2 Printer Driver I/O Functions

This section describes the printer I/O functions accessed by the Miscellaneous Resource Manager through entry points in the printer driver's Driver Header.

The printer driver contains the SELECT, FLUSH, WRITE, GET, and SET functions. The READ function is meaningless for printers; it should return E_IMPLEMENT. The SPECIAL function is also not required by the printer driver and should return E_IMPLEMENT unless you support this SPECIAL functions in your driver.

See Section 4.4 for a description of the INIT, SUBDRIVE, and UNINIT driver installation functions.

10.2.1 SELECT--Enable the specified unit

Parameter: Address of SELECT parameter block

Return Code:

E_SUCCESS	Printer is enabled
IO_ERROR	Printer not enabled

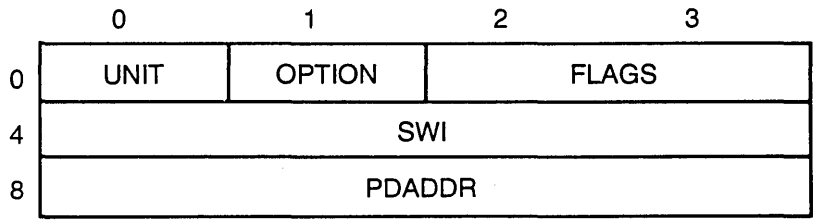


Figure 10-1. Printer Driver SELECT Parameter Block

Table 10-1. Printer Driver SELECT Parameter Block Fields

Field	Description
UNIT	Unit number of printer being enabled
OPTION	User-defined option
FLAGS	User flags field
SWI	Address of optional Software Interrupt Routine; this value is 0 if there is no SWI.
PDADDR	Process descriptor address of process attempting to open this device. This is not necessarily the process calling this entry point and therefore not the PDADDR used with the FLAGEVENT and FLAGSET driver services. Find the PDADDR of the process calling FLAGEVENT in the RLR field of the Driver Header. If an address is specified and it is a User Address, this is the PDADDR that must be used with the MAPU driver service.

The Miscellaneous RM calls SELECT to enable a specific printer unit for printing. A printer is selected before writing to it (if not previously selected), or if another unit was selected since last writing to this printer.

10.2.2 FLUSH--Disable Printer

Parameter: Address of FLUSH parameter block

Return Code:

E_SUCCESS	Printer is deselected
IO_ERROR	Printer not deselected

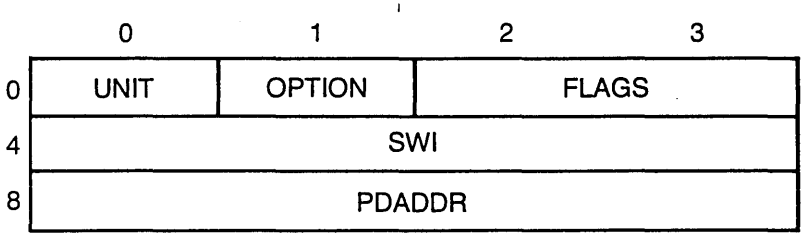


Figure 10-2. Printer Driver FLUSH Parameter Block

Table 10-2. Printer Driver in FLUSH Parameter Block Fields

Field	Description
UNIT	Unit number of printer to be disabled
OPTION	User-defined option
FLAGS	User flags field
SWI	Address of optional Software Interrupt Routine; this value is 0 if there is no SWI.
PDADDR	Process descriptor address of process attempting to write to this device. This is not necessarily the process calling this entry point and therefore not the PDADDR used with the FLAGEVENT and FLAGSET driver services. Find the PDADDR of the process calling FLAGEVENT in the RLR field of the Driver Header. If a User Address is specified, this is the PDADDR that must be used with the MAPU driver service.

The Miscellaneous Resource Manager calls FLUSH before writing to another unit connected to the same driver or before uninstalling the driver. If you are using a port driver to perform the actual printer I/O, the printer driver must call the FLUSH function in the sub-driver (port driver) to place it in a quiescent state.

Because writes are not allowed past the point of invoking FLUSH without first calling SELECT, any buffers not yet sent to the printer should be sent before FLUSH actually disables the unit.

10.2.3 WRITE--Write data to printer

Parameter: Address of WRITE parameter block

Return Code:

emask	Event mask for calling process to wait for printer to be ready for more characters
IO_ERROR	Unable to write to printer

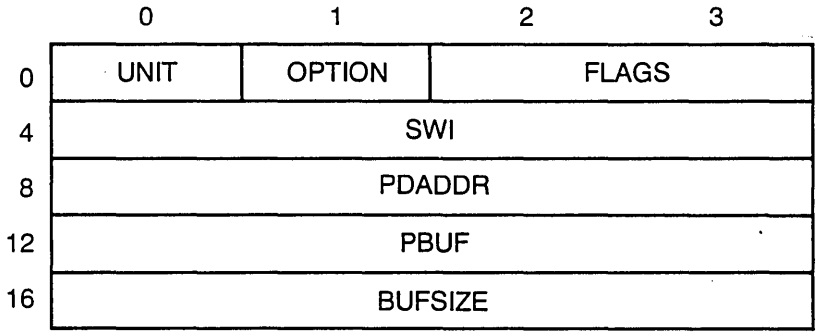


Figure 10-3. Printer Driver WRITE Parameter Block

Table 10-3. Printer Driver WRITE Parameter Block Fields

Field	Description
UNIT	Unit number of printer being written to
OPTION	User-defined option
FLAGS	User flags field
SWI	Address of optional Software Interrupt Routine; this value is 0 if there is no SWI.
PDADDR	Process descriptor address of process attempting to write to this device. This is not necessarily the process calling this entry point and therefore not the PDADDR used with the FLAGEVENT and FLAGSET driver services. Find the PDADDR of the process calling FLAGEVENT in the RLR field of the Driver Header. If an address is specified and it is a User Address, this is the PDADDR that must be used with the MAPU driver service.
PBUF	Pointer to buffer that holds characters to be written
BUFSIZE	Size of buffer indicated in PBUF

The Miscellaneous RM calls WRITE to output characters to a selected printer. As implemented in the FlexOS example driver, WRITE uses the POLLEVENT driver service to wait until the printer is ready, then outputs the character. The printer driver checks the status of the selected unit before calling POLLEVENT.

WRITE should first call FLAGCLR to make certain that the flag the driver obtained during its initialization is clear. It should pass the flag and the address of any SWIs to the FLAGEVENT driver service. FLAGEVENT returns an event mask that WRITE eventually passes back to the calling process on completion of the event.

WRITE latches a character to the output port for transmission to the printer. WRITE then calls POLLEVENT for an event mask with which to WAIT for the printer to become ready. POLLEVENT requires the address of status routine as a parameter. The status routine should return a non-zero WORD value if the unit is ready to receive a character; zero indicates that the unit is not ready. Your status routine should contain any delays required for carriage returns, form feeds, and any other device-related operations.

After all the characters have been written, WRITE must call FLAGSET and then return to the calling process the event mask obtained from FLAGVENT. Even though the event has already been completed (as signaled by FLAGSET), the call cannot be synchronous because POLLEVENT permits other tasks to run while the printer is busy.

See Section 5.1 for a description of the FlexOS flag system driver services. POLLEVENT is described in Section 5.3.

For an interrupt-driven printer, use the SETVEC driver service to establish an Interrupt Service Routine (ISR). Guidelines for using ISRs are presented in Section 5.7.

10.2.4 GET--Provide unit-specific information

Parameter: Address of GET parameter block

Return Code:

E_SUCCESS	Write to buffer completed - no error
E_xxx	Driver specific error code

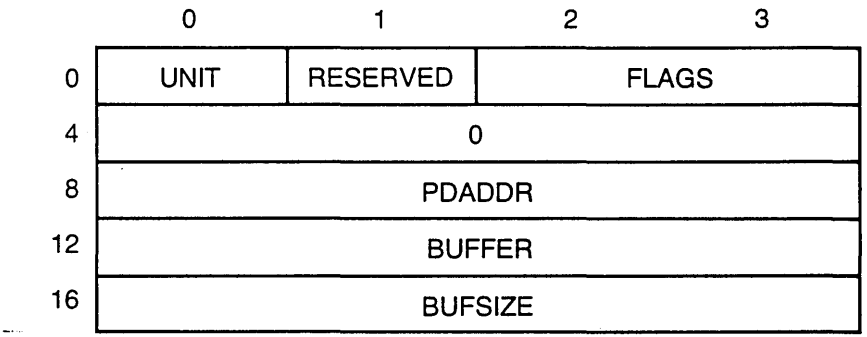


Figure 10-4. Printer Driver GET Parameter Block

Table 10-4. Printer Driver GET Parameter Block Fields

Field	Description
UNIT	Printer driver unit number
FLAGS	Bit map of flags: Bits 0-7: Can be defined by driver Bits 8-14: Reserved Bit 15: 1 = User Address 0 = System Address
PDADDR	Process descriptor address of the process that initiated the GET request. If the buffer address is a User Address and the asynchronous portion of the driver is required to access the buffer, this parameter is used to call the MAPU driver service.
BUFFER	Address of buffer in which to write information from the driver's GET/SET Table. See Figure 10-5, below.
BUFSIZ	Size of buffer. This field determines the amount of information returned from the driver's GET/SET Table.

The Miscellaneous Resource Manager calls the GET entry point to place information from the printer driver's GET/SET Table into the buffer at the address specified. The BUFSIZ parameter is passed to limit the amount of information to be obtained. If the buffer's size is less than the size of the table, only those fields that fit into the buffer are written there.

The GET and SET routines are not expected to return an event mask. The calling process should not return until the operation is complete. If the asynchronous portion of the driver is required to fulfill an I/O event in order to obtain the information, the GET and SET routines must perform their own WAIT and RETURN SVCs through the Supervisor interface described in Section 6.

Many of the GET/SET Table values cannot be determined until they are placed in the table by SET. GET/SET Table values are set by one process for use by another. For example, a parent process can configure a unit to print labels and then pass information about the width and length of the labels to its subprocesses through the appropriate table entries. The GET and SET SVCs can only be called if the printer driver unit is OPEN.

The format of the printer driver GET/SET Table is shown in Figure 10-5.

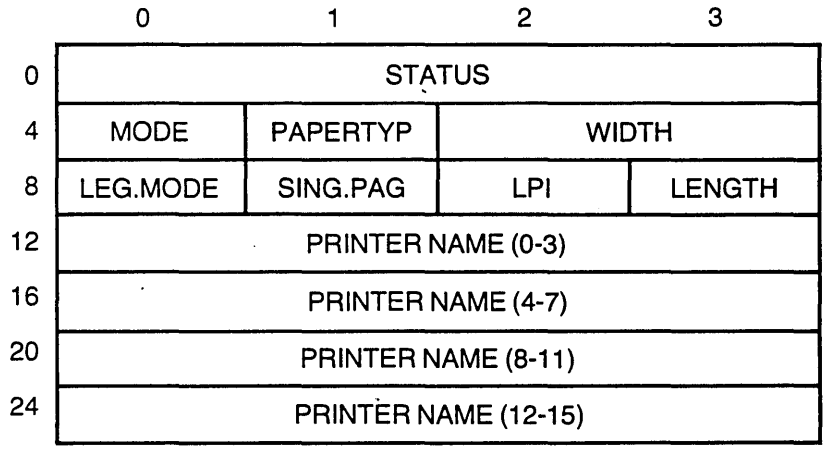


Figure 10-5. Printer Driver GET/SET Table

Table 10-5. Printer Driver GET/SET Table Fields

Field	Description
STATUS	Bit map of printer error codes--see Table 10-6
MODE	Current printer mode. This field specifies the printer typeface. This code may be replaced for other printer types, indicating the wheel-type on letter-quality printers, for example. The bit map for this field is the same for the LEG.MODE field (least significant bit is right-most): 0 boldface 1 graphics 2 italic 3 subscript 4 superscript 5 condensed 6 elongated 7 letter quality
PAPERTYP	This field indicates the type of paper currenly in use on the printer: 0 wide paper 1 letterhead 2 labels
WIDTH	Paper width, in columns, or dots if in graphics mode
LENGTH	Paper length, in lines
LEG.MODE	Printing modes supported by this printer (see MODE)
SING.PAGE	Set to non-zero if using a single-page-feed mechanism
LPI	Number of lines-per-inch
PRINTER NAME	This 16-bit field contains the printer's brand and model in ASCII.

Table 10-6 lists the Printer Status flag bits (least significant bit rightmost) and their meanings when set.

Table 10-6. Printer Status Bit Map

Flag Bit	Meaning
0	Printer unit off line
1	Out of paper
2	Select error
3	Initialization error
4	Illegal mode requested
5	Framing error
6	Internal buffer full
7	Waiting for XON

10.2.5 SET--Change unit-specific information

Parameter: Address of SET parameter block

Return Code:

E_SUCCESS	Write completed - no error
E_xxx	Driver specific error code

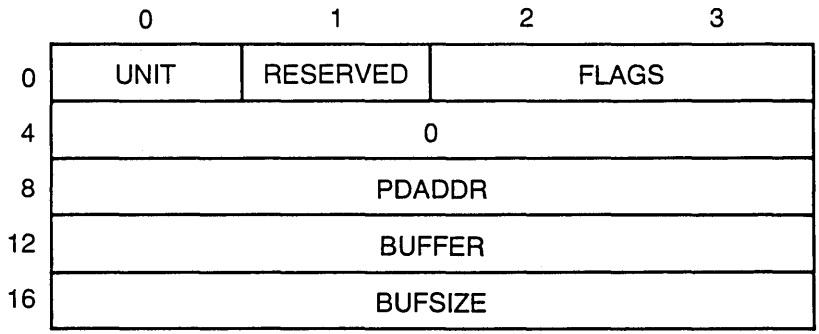


Figure 10-6. Printer Driver SET Parameter Block

Table 10-7. Printer Driver SET Parameter Block Fields

Field	Description
UNIT	Printer driver unit number
FLAGS	Bit map of flags Bits 0-14: Reserved Bit 15: 1 = User Address 0 = System Address
PDADDR	Process descriptor address of the process that initiated the SET call. This parameter is used to call the MAPU driver service if the buffer address is a User Address and the asynchronous portion of the driver is required to access the buffer.
BUFFER	Address of buffer containing information to be written to the driver's GET/SET Table. See Figure 10-5 above.
BUFSIZ	Size of buffer. This field determines the amount of information returned from the driver's GET/SET Table.

The Miscellaneous Resource Manager calls the SET entry point to set or modify unit-specific information in the printer driver's GET/SET Table. The buffer indicated in the SET parameter block contains the information to be set. A buffer size parameter is passed by the calling process to limit the amount of information to be written to the driver's GET/SET Table.

See the explanation of the printer driver's GET function for the description of the GET/SET Table.

End of Section 10

Special Drivers

This section describes the interface to special drivers. Special drivers interface to printers, plotters, ports and other devices not defined by FlexOS. Special drivers are managed by the Miscellaneous Resource Manager.

Special driver functions are available to application programs through standard Supervisor calls. The OPEN and CLOSE SVCs are mapped directly to the special driver's SELECT and FLUSH I/O functions. The READ, WRITE, GET, SET, and SPECIAL SVCs map directly to the corresponding entry points in the special driver's Driver Header.

In most cases, the Supervisor copies the user's parameter block into the System Area. The Supervisor and Miscellaneous Resource Manager then modify this copy of the user's parameter block before the special driver units are called with the address of the parameter block.

11.1 Special Driver Access

The Miscellaneous Resource Manager protects special drivers from user processes according to the level of access specified in the access flags parameter of the INSTALL SVC. INSTALL is described in the FlexOS Programmer's Guide. INSTALL's access flags are defined in the following table:

Table 11-1. Driver Access Flags

Flag	Description
Bit 0:	1 = SET allowed 0 = SET not allowed If flag bit 0 is 1, users can get the SET privilege to modify the driver's GET/SET table. If this bit is 0, the resource manager returns an error to users requesting the SET privilege at OPEN (the driver's SELECT function is not called).
Bit 1:	Reserved (must be set to 0)
Bit 2:	1 = WRITE allowed 0 = WRITE not allowed If flag bit 2 is 1, users can get the WRITE privilege to the device. If bit 2 is 0, the resource manager returns an error to users requesting the WRITE privilege at OPEN (the driver's SELECT function is not called).
Bit 3:	1 = READ allowed 0 = READ not allowed If flag bit 3 is 1, user can get the READ privilege to the device. If bit 3 is 0, the resource manager returns an error to users requesting the READ privilege at OPEN (the driver's SELECT function is not called).

Table 11-1. (Continued)

Flag	Description
Bit 4:	1 = Shared access allowed 0 = Exclusive access only If flag bit 4 is 1, multiple processes may have the same unit of the special driver OPEN at the same time. If bit 4 is 0, only one process may have the unit OPEN at any particular time. To enforce exclusive access, and indicate that the driver is synchronized at the unit level, you should set the Unit Level Interface Flag in the Driver Header (Bit 1) to 1. See Section 4.2, "Driver Header."
Bit 5:	1 = Removable driver 0 = Permanent driver If flag bit 5 is 1, the INSTALL SVC is allowed to remove the driver unit. The Miscellaneous Resource Manager does not allow the unit to be removed if it is currently OPEN or if another driver is using the unit as a sub-driver.
Bit 6:	1 = DEVLOCKs allowed 0 = DEVLOCKs not allowed The DEVLOCK SVC allows a process to temporarily restrict access to a driver it has opened. The process can restrict access to itself or processes within the same process family. DEVLOCK also allows the process to prevent the driver from being locked by other processes. This option is effective only if flag bit 4 is 1 (shared access allowed).

Table 11-1. (Continued)

Flag	Description
Bit 7:	1 = Shared access only 0 = Exclusive access allowed If flag bit 7 is 1, the Miscellaneous Resource Manager does not allow an exclusive OPEN of this device.
Bits 8-12:	Reserved
Bit 13:	1 = Force case to media default 0 = Do not force case to media default
Bit 14:	Used in interpreting the driver load file name given in the INSTALL SVC.
Bit 15:	Reserved

The Miscellaneous Resource Manager also restricts special driver access according to the OPEN SVC flags specified by the current process. For example, if a process opens the driver for exclusive access (OPEN flag bit 4 = 0), the Miscellaneous Resource Manager does not allow any other process to open the driver unless the driver has been INSTALLed for shared access (INSTALL flag bit 7 set to 1).

When a unit of a special driver is installed as a sub-driver, its higher-level driver can access any of its entry points. The higher-level driver must assume the responsiblities of controlling access to the special driver unit, acting, in effect, as the sub-driver's Resource Manager.

A controlling driver has the option of accepting or not accepting a special sub-driver's INSTALL options. The special driver unit attached as a sub-driver responds at its discretion to calls from the controlling driver.

11.2 Special Driver I/O Functions

This section describes the special driver I/O functions available to the Miscellaneous Resource Manager through entry points in the special driver's Driver Header. See 4.4 for a description of the INIT, SUBDRIVE, and UNINIT driver installation functions.

The READ and WRITE entry points are responsible for initiating the appropriate I/O request and calling the FLAGEVENT driver service to return an event mask (emask) to the calling process. The asynchronous portion of the special driver must complete the request by moving the appropriate data to or from the specified buffer. The asynchronous portion of the driver must then call the FLAGSET driver service to satisfy the outstanding request and return a completion code. See Section 5.1, "Flag System."

Each special driver is responsible for a single, well-defined table of information, the GET/SET Table. The GET and SET entry points read and write information in the table. The format of the GET/SET Table is dependent upon the special driver type. Any process can call a special driver's GET function at any time (through the LOOKUP SVC) without opening the driver. A user process can only call a special driver's SET function when the driver unit is open.

11.2.1 SELECT--Open a special driver unit for I/O

Parameter: Address of SELECT Parameter Block

Return Code:

E_SUCCESS	Successful operation
E_xxxxxxx	Special driver-specific error code. The OPEN is denied and this error code is returned to the user.

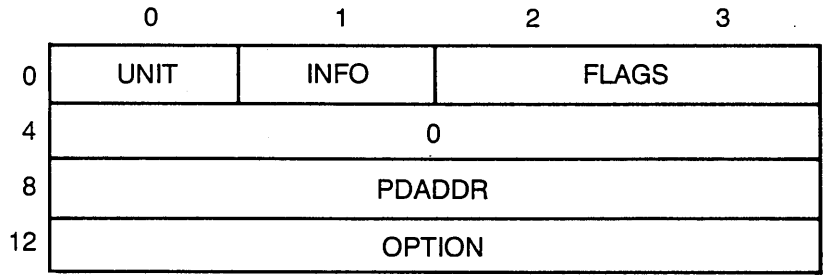


Figure 11-1. SELECT Parameter Block

Table 11-2. SELECT Parameter Block Fields

Field	Description
UNIT	Driver unit number
INFO	Unit information provided to the special driver by the Miscellaneous RM. 0 - This is the first OPEN 1 - This is a subsequent OPEN The Miscellaneous Resource Manager indicates if another process has the driver unit open (1) or if this is the first open (0) since either INSTALL or CLOSE (FLUSH).
FLAGS	OPEN call's flag field contents
PDADDR	Process descriptor address of process making OPEN call
OPTION	Contains the OPEN call's option field value in low 8 bits.

The SELECT function is called by the Miscellaneous RM to open the specified unit. The name field in the OPEN parameter block is translated by the Supervisor to identify which driver unit to open. The information passed to your SELECT function is the OPEN call's flags and option fields. These fields are passed unmodified. The flag's field options are listed in Table 11-3.

Table 11-3. SELECT Flags

Flag	Description
Bit 0:	1 = Delete file/set attributes 0 = No delete/set
Bit 1:	1 = Execute access 0 = No execute access
Bit 2:	1 = Write access 0 = No write access
Bit 3:	1 = Read access 0 = No read access
Bit 4:	1 = Shared access 0 = Exclusive access
Bit 5:	1 = Allow shared reads if shared 0 = Allow shared R/W if shared
Bit 6:	1 = Shared file pointer 0 = Unique file pointer
Bit 7:	1 = Reduced access accepted 0 = Return error on reduced access
Bits 8–12:	Reserved, must be 0
Bit 13:	1 = Force case to media default 0 = Do not affect name case
Bit 14:	1 = Literal name 0 = Prefix substitution allowed
Bit 15:	Reserved, must be 0

11.2.2 FLUSH--Close the specified special driver unit

Parameter: Address of FLUSH parameter block

Return Code:

E_SUCCESS	No hardware errors
E_xxxxxxx	Special driver specific error code

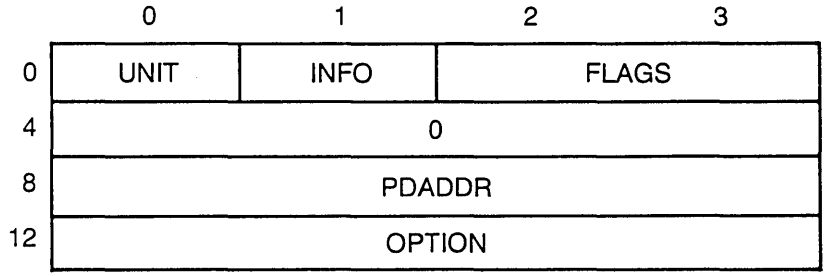


Figure 11-2. FLUSH Parameter Block

Table 11-4. FLUSH Parameter Block Fields

Field	Description
UNIT	Driver unit number
INFO	Close information provided by the Miscellaneous RM: 0 - This is the last CLOSE 1 - This is not the last CLOSE The Miscellaneous RM indicates if another process has the driver unit open (1) or if this is the last CLOSE. When last CLOSE is indicated, the driver unit is required to make itself quiescent.
FLAGS	Contents of CLOSE call's flag field: Bit 0: 1 = Partial close (flush only) 0 = Full close Bit 1: 1 = Do not close on error 0 = Close on error Bits 2-15 can be user parameters to the special driver's FLUSH function.
PDADDR	Process descriptor address of process making CLOSE call
OPTION	Contents of option field in the CLOSE parameter block

The Miscellaneous Resource Manager calls the FLUSH entry point when a process attempts to CLOSE a special driver unit it had previously opened. When the last CLOSE is indicated, the FLUSH routine must make the device quiescent. If your driver called has a sub-driver, you must call the sub-driver's FLUSH function.

The Miscellaneous Resource Manager passes the flags and option fields to FLUSH unmodified from the CLOSE SVC parameter block. When the partial close option is specified, the FLUSH function should only flush any buffers, but not actually close, the unit.

11.2.3 READ--Initiate request for data

Parameter: Address of READ Parameter Block

Return Code:

emask — Event mask as returned by FLAGEVENT. If an error occurs before the READ function can call FLAGEVENT to return the event mask, READ must call FLAGEVENT and then FLAGSET to return the error code. The error code must be returned to the calling process before READ returns to the Miscellaneous Resource Manager with an event mask.

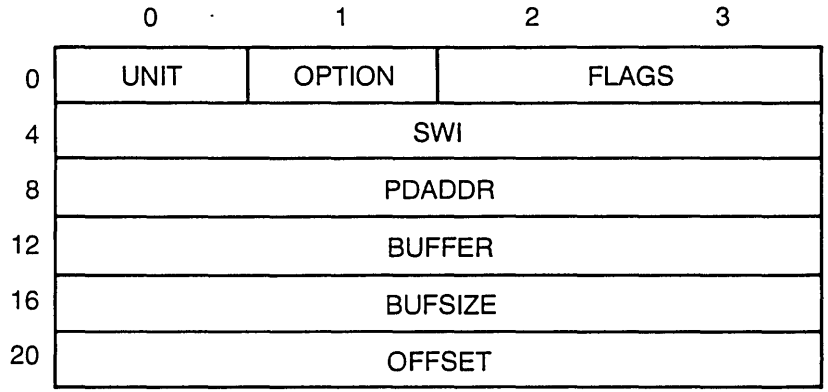


Figure 11-3. READ Parameter Block

Table 11-5. READ Parameter Block Fields

Field	Description
UNIT	Driver unit number
OPTION	Option field from the READ SVC
FLAGS	Flags field from the READ SVC. Bit 15 is turned on by the Miscellaneous Resource Manager if the buffer field is a User Address. All other flag bits are passed unchanged. Bit 15: 1 = Buffer is User Address 0 = Buffer is System Address
SWI	User-supplied software interrupt. The SWI is passed as a parameter to the FLAGEVENT driver service.
PDADDR	Process descriptor address of process that initiated the READ request. If the specified address is a User Address, this is the PDADDR that must be used for the MAPU function.
BUFFER	Data buffer address specified in READ call; the Supervisor checks the range before calling the READ function.
BUFSIZE	Size of buffer passed from READ SVC
OFFSET	Position in file relative to point indicated by value of bits 8 and 9 in READ SVC's flags field

The Miscellaneous Resource Manager calls the READ entry point when a process performs the READ SVC on a SELECTed special driver unit. The resource manager converts the READ SVC's file number into the READ parameter block's UNIT and PDADDR values. Most of the remaining parameter block contents are direct copies from the READ call's entries. The exception is flag bit 15, which the Miscellaneous RM sets to indicate whether the buffer provided is in User (1) or System (0) space. The buffer can be in System space when another driver calls the special driver unit with local buffers.

The offset field is used at the discretion of the special driver.

READ must initiate an I/O request, call the FLAGEVENT driver service, and return with an event mask. The special driver's asynchronous portion must complete the request by placing the appropriate data into the specified buffer. The driver then calls FLAGSET to clear the event from the system and return a completion code.

If an error occurs before READ can call FLAGEVENT, READ must call FLAGEVENT and then call the FLAGSET driver service to return the error code to the original calling process before returning to the Miscellaneous Resource Manager with the event mask. FLAGSET can be called from the synchronous portion of the driver's code.

11.2.4 WRITE--Initiate output of data

Parameter: Address of WRITE parameter block

Return Code:

emask — Event mask returned by the FLAGEVENT driver service. If an error occurs before FLAGEVENT is called, WRITE must first call FLAGEVENT and then call the FLAGSET driver service to return the error code before returning to the Miscellaneous Resource Manager with the event mask.

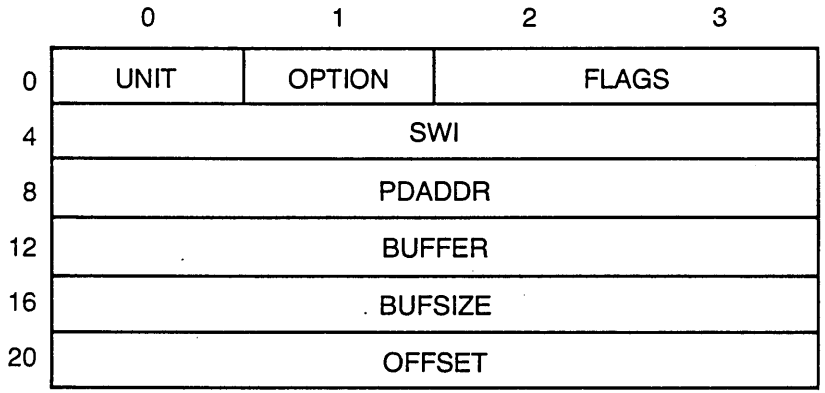


Figure 11-4. WRITE Parameter Block

Table 11-6. WRITE Parameter Block Fields

Field	Description
UNIT	Driver unit number
OPTION	User option field
FLAGS	Flags field as passed from WRITE SVC. The Miscellaneous Resource Manager turns on bit 15 if the buffer field is a User Address. Bit 15: 1 = Buffer is User Address 0 = Buffer is System Address
SWI	User-supplied software interrupt to be passed as a parameter to the FLAGEVENT driver service
PDADDR	Process descriptor address of process that initiated the WRITE request. If the specified address is a User Address, this is the PDADDR that must be used for the MAPU driver service.
BUFFER	Data buffer address specified in WRITE call; the Supervisor checks the range before calling the WRITE function.
BUFSIZE	Bufsiz field as passed from WRITE call; indicates number of bytes to write.
OFFSET	Position in file relative to point indicated by value of bits 8 and 9 in the flags field

The Miscellaneous Resource Manager calls the WRITE entry point when a process performs the WRITE SVC on a SELECTed special driver unit. The resource manager converts the WRITE SVC's file number into the WRITE parameter block's UNIT and PDADDR values. Most of the remaining parameter block contents are direct copies from the WRITE call's entries. The exception is flag bit 15, which the Miscellaneous RM sets to indicate whether the buffer provided is in User (1) or System (0) space. The buffer can be in System space when another driver calls the special driver unit with local buffers.

The offset field is used at the discretion of the special driver. WRITE must call the FLAGSET driver service upon completion to satisfy the outstanding event and return a completion code.

11.2.5 SPECIAL Entry Point

Parameter: Address of SPECIAL Parameter Block

Return Code:

emask Event mask returned by the FLAGEVENT driver service

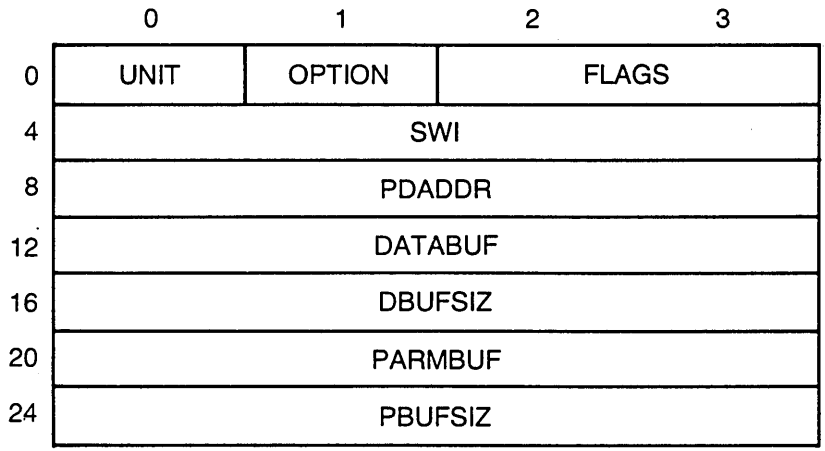


Figure 11-5. SPECIAL Parameter Block

Table 11-7. SPECIAL Parameter Block Fields

Field	Description
UNIT	Driver unit number
OPTION	Contents of the SPECIAL SVC's func field. The value of bits 7 and 6 indicate the data flow direction of the data and parameter buffers as follows: bit 7--parmbuf: 1 = write buffer, 0 = read buffer bit 6--databuf: 1 = write buffer, 0 = read buffer If no data or parameters are being provided, the corresponding bit is set to 0. The remainder of the bits indicate the SPECIAL function number.
FLAGS	Flags field as passed from the SPECIAL SVC. The Miscellaneous Resource Manager sets bit 15 if parameters came directly from User Memory. Bits 0-14: special driver-type specific Bit 15: 1 = User Address 0 = System Address
SWI	User-supplied software interrupt, passed as a parameter to the FLAGEVENT driver service.
PDADDR	Process descriptor address of process that initiated the SPECIAL request. If the specified address is a User Address, this is the PDADDR that must be used for the MAPU driver service.

Table 11-7. (Continued)

Field	Description
DATABUF	Value from SPECIAL call's databuf parameter. If DBUFSIZ is zero, this value is data; if DBUFSIZ is non-zero, this value is an address of a data buffer. The FlexOS Programmer's Guide instructs the programmer never to put an address in the data buffer.
DBUFSIZ	Size in bytes of data buffer; if zero, the DATABUF value is data rather than an address.
PARMBUF	Value from SPECIAL call's parmbuf parameter. If PBUFSIZ is zero, this value is data; if PBUFSIZ is non-zero, this value is an address of a data buffer. The FlexOS Programmer's Guide instructs the programmer never to put an address in the parameter buffer.
PBUFSIZ	Size in bytes of parameter buffer; if zero, the PARMBUF is data rather than an address.

The Miscellaneous Resource Manager calls the SPECIAL entry point when a user process calls the SPECIAL SVC on a previously SELECTed special driver unit.

If an error occurs before FLAGEVENT is called, the SPECIAL function must call FLAGEVENT and then call FLAGSET to return the error code to the original calling process before returning to the Miscellaneous Resource Manager with the event mask. FLAGSET can be called from the synchronous portion of the special driver.

See the description of the SPECIAL SVC in the FlexOS Programmer's Guide for rules on defining the SPECIAL driver function parameter block.

11.2.6 GET--Provide unit-specific information

Parameter: Address of GET parameter block

Return Code:

E_SUCCESS	Operation completed - no error
E_xxxxxxx	Driver type-specific error code

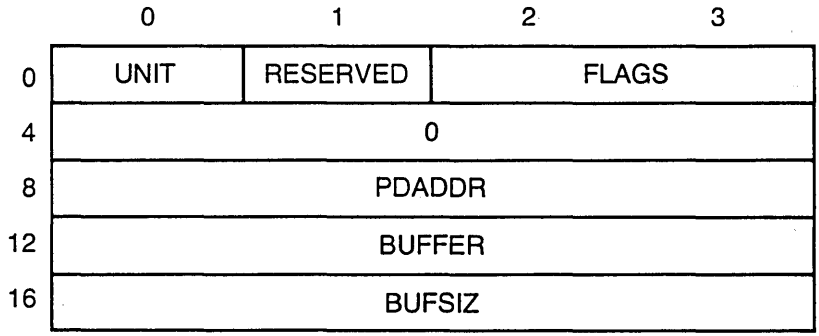


Figure 11-6. GET Parameter Block

Table 11-8. GET Parameter Block Fields

Field	Description
UNIT	Driver unit number
FLAGS	Bit map of flags Bits 0-7: Defined by driver Bits 8-14: Reserved Bit 15: 1 = User Address 0 = System Address
PDADDR	Process descriptor address of the process that initiated the GET request. If the buffer address is a User Address and the asynchronous portion of the driver is required to access the buffer, use this as the pdaddr value in your MAPU driver service call
BUFFER	Address of buffer
BUFSIZE	Size of buffer. This field determines the amount of information wanted.

You must define a single table structure for each type of special driver. The first field of this structure must be a 32-bit value that indicates the structure's size. When a user process calls the GET SVC, the special driver must return the requested information in a specified buffer in the defined table format. The GET and SET SVCs can be called only if the special driver unit is OPEN.

The Miscellaneous Resource Manager calls the GET entry point to place information from the special driver's GET/SET Table into the buffer at the address specified. The buffer size parameter is passed to indicate the amount of information requested. If the buffer size is less than the table size, fill in only those fields that fit completely.

The GET entry point is not expected to return an event mask. The calling process should not return until the operation is complete. If the asynchronous portion of the driver is required to fulfill an I/O event in order to obtain the information, the GET routine must perform its own WAIT and RETURN SVCs to complete the event. Drivers access SVCs through the Supervisor interface defined in Section 6, "Supervisor Interface."

11.2.7 SET--Change unit-specific information

Parameter: Address of SET Parameter Block

Return Code:

E_SUCCESS	Operation completed
E_xxx	Driver type-specific error code

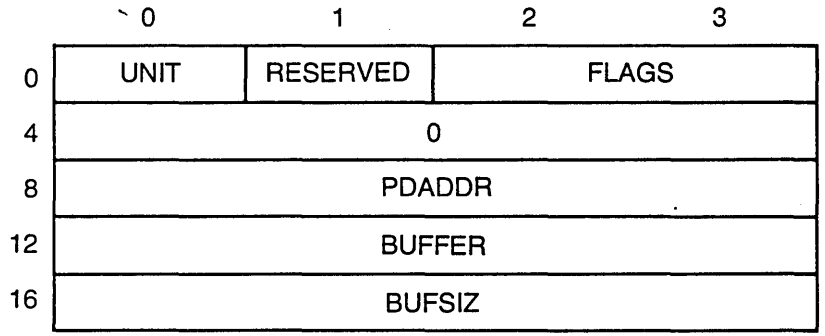


Figure 11-7. SET Parameter Block

Table 11-9. SET Parameter Block Fields

Field	Description
UNIT	Driver unit number
FLAGS	Bit map of flags Bits 0-7: Defined by driver Bits 8-14: Reserved Bit 15: 1 = User Address 0 = System Address
PDADDR	Process descriptor address of the process that initiated the SET SVC. If the buffer address is a User Address and the asynchronous portion of the driver is required to access the buffer, use this as the pdaddr value in your MAPU driver service call.
BUFFER	Address of buffer
BUFSIZ	Size of buffer; indicates the amount of information to set.

You must define a single table structure for each type of special driver. The first field of this structure must be a 32-bit value that indicates the structure's size. The GET and SET SVCs can be called only if the special driver unit is OPEN.

The Miscellaneous Resource Manager calls the SET entry point to modify information in the special driver's GET/SET table. The format of the table is specific to the type of special driver. The buffer indicated in the SET parameter block contains the information to be set. A buffer size parameter is passed to limit the amount of information being SET. If the size of the buffer is less than the size of the table, only those fields that fit within the buffer are SET.

SET is not expected to return an event mask. The calling process should not return until the operation is complete. If the asynchronous portion of the driver is required to fulfill an I/O event in order to change the state of the information, SET must perform its own WAIT and RETURN SVCs to complete the event.

End of Section 11

System Boot

This section outlines the steps required to cold boot a system. It describes boot and data disk formats and the FlexOS layout in memory. The section explains how to construct a loader and concludes with a description of the SYS utility, which transfers the loader to a disk's boot track.

Utilities used to generate a system that are specific to a given microprocessor are described in chip-specific supplements. These supplements are distributed with FlexOS.

12.1 Boot Overview

The boot procedure usually involves the following three steps:

1. A ROM reads the disk boot loader contained in the boot record, starting at track 0, sector 0 of the boot drive, then transfers control to it.
2. The disk boot loader reads the system image into memory starting at the first data cluster and continuing for n clusters, where n is the size of the operating system in clusters.
3. The disk boot loader then transfers control to the initialization routine in the operating system.

The boot loader reads the code into memory at the address specified by the code-load base address. The loader reads operating system data into memory at the address specified by the data-load base address. The loader then transfers control to the code-load base address, which should be the address of or a jump to the operating system initialization routines. Code-load and data-load base addresses are defined in Table 12-1, below.

The operating system initialization routines must perform any hardware and software initialization required by the operating system.

12.1.1 Data Disk Layout

The FlexOS disk layout is identical to the PC DOS disk layout, illustrated in Figure 12-1, below. The boot record, FAT, and root directory are all of variable size.

Figure 12-1. FlexOS Disk Layout

12.1.2 Boot Disk Layout

The FlexOS boot disk is a data disk which contains the operating system as illustrated above. The system file must be recorded under the file name FLEXOS.SYS, beginning at the disk's first data cluster and continuing for as many consecutive clusters as are required to store the complete operating system. Record the FLEXOS.SYS file with the System, Hidden, and Read-Only attributes.

12.2 Boot Record Format

The boot record (see Figure 12-2 below) contains the code needed to load FlexOS from disk into memory. It is a minimum of one physical sector in length. The boot record also contains information about where to load the various parts of the operating system and the sizes of each part. Table 12-1 defines the fields in the boot record.

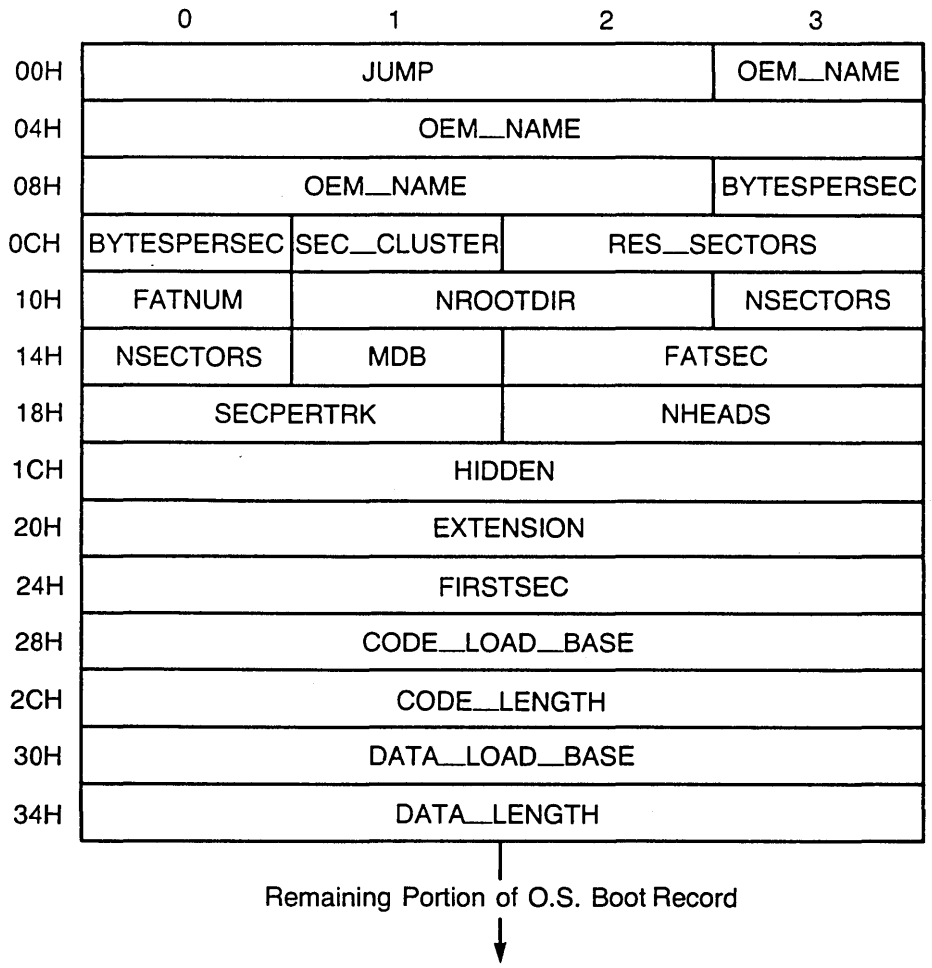


Figure 12-2. Boot Record

Table 12-1. Boot Record Fields

Field	Description
JUMP	A jump instruction to transfer control to an operating system's loader. See your chip-specific supplement for the description of the jump instruction.
OEM_NAME	The OEM name and version number identifying the boot record's operating system
BYTESPERSEC	Number of bytes per sector
SEC_CLUSTER	Number of sectors per file allocation unit (cluster) in a partition. This value must be a power of two.
RES_SECTOR	Number of sectors reserved by the operating system, starting at logical sector 0
FATNUM	Number of FATs in a partition
NROOTDIR	Maximum number of root directory entries in a partition
NSECTORS	Total number of sectors in a partition, including boot sector, directories, and reserved sectors. If this field contains zero, the EXTENSION field (see below) contains the total number of sectors.
MDB	Media Descriptor Byte. Describes the disk medium in terms of number of sides, number of sectors per track, and whether the medium is fixed or removable. Possible values for the MDB are defined in Table 8-5.
FATSEC	Number of sectors occupied by one FAT
SECPERTRK	Number of sectors per track in a partition
NHEADS	Number of heads in partition

Table 12-1. (Continued)

Field	Description
HIDDEN	Total number of sectors preceding a partition, including sectors occupied by the Master Boot Record.
EXTENSION	If NSECTORS contains zero, EXTENSION contains the total number of sectors in a partition. The EXTENSION field is used for partitions whose number of sectors is greater than can be stored in the one-word NSECTORS field.
FIRSTSEC	First sector of data area
CODE_LOAD_BASE	Address at which operating system code is to be loaded
CODE_LENGTH	Length, in bytes, of code segment
DATA_LOAD_BASE	Address at which operating system data is to be loaded
DATA_LENGTH	Length, in bytes, of data segment

The FORMAT utility fills in the fields from BYTESPERSEC through FIRSTSEC. The SYS utility (see Section 12.5) fills in the code and data load addresses and segment lengths.

12.3 Boot Loader Outline

Take the following steps in constructing a boot loader. The field names referenced below are defined in Table 12-1 above.

1. Calculate the number of physical sectors of code to read by dividing the value in the CODE_LENGTH field by the number of bytes in a physical sector. Add one physical sector if the division produces a remainder.

2. Read the operating system code into memory at the location specified by the CODE_LOAD_BASE field. The read always begins at the first sector of the first data cluster on the disk.

3. If the operating system code does not end on a physical sector boundary, the remainder of the sector is data. The data portion of the sector needs to be moved to the location in memory specified by the DATA_LOAD_BASE field.

4. Calculate the number of physical sectors of data to read by dividing the value in DATA_LENGTH, minus any data already read, by the number of bytes in a physical sector. Add one physical sector if the division produces a remainder.

5. Read the operating system data into memory at the location specified by the DATA_LOAD_BASE field plus the length of the data already read. The read begins at the next sector following the code reads.

If the operating system code and data are to be contiguous in memory, you can optimize the boot loader so that it performs one read that includes both the code and the data sectors.

12.4 The FlexOS Memory Image

Figure 12-3 shows the FlexOS memory image.

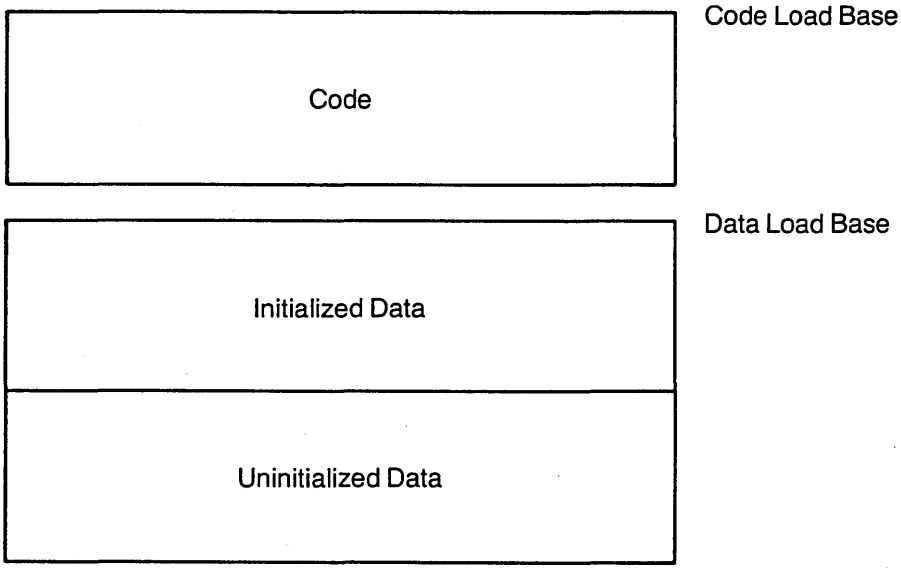


Figure 12-3. The FlexOS Memory Image

12.5 The SYS Utility

SYS transfers the operating system from the default to the specified drive or places the operating system onto the specified drive from a file. SYS modifies the destination drive's boot record to reflect the correct operating system Code Load Base, Code Length, Data Load Base, and Data Length fields.

SYS has the following syntax:

SYS d:

or

SYS d: d:filename.ext

The operating system image is placed in contiguous data clusters beginning at the first data cluster, Cluster 2. The first directory entry on the boot disk is FLEXOS.SYS. This file is recorded with the System, Hidden, and Read-Only attributes.

The header record on the specified input file is removed by SYS prior to placing the image on the disk. The information contained in the header record is used to update the proper fields in the disk's boot record.

End of Section 12

The FlexOS Standard Input and Output Character Sets

This appendix presents the characters sets supported by the FlexOS standard keyboard and standard console. The character sets are presented in the following order:

- 16-bit input characters (A.1)
- 8-bit input characters (A.2)
- 16-bit output characters (A.3)
- 8-bit output characters (A.4)

A.1 16-bit Input Character Set

This section defines the 16-bit character set supported by the FlexOS standard keyboard. The low order byte of a 16-bit input character is reserved for data. The high order byte can have the following values:

Table A-1. High-order Byte Values

Byte Value	Character Set
00H	ASCII character set. Includes DRI-standard US, Japanese, and European 8-bit character sets.
01H-7FH	Defined in Figure A-1, below.
80H-FCH	15-bit foreign language character sets, including KANJI.

When the high order byte of a 16-bit character is in the range from 01H to 7FH, the byte is defined as follows.

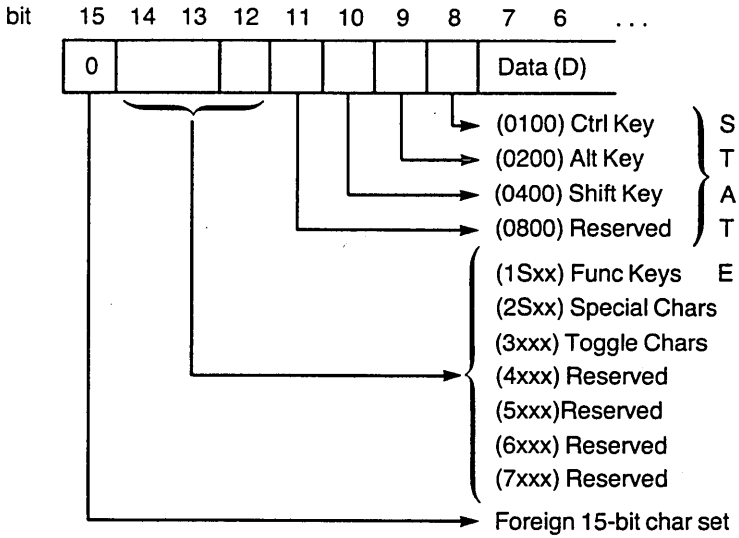


Figure A-1. High-order Byte Definitions for 01H to 7FH

Each defined bit field is described below. In the explanations, S refers to the state bits, bits 8-11.

- **STATE Bits:** The state bits indicate the status of the Ctrl, Alt, and Shift keys. When a state key is pressed along with another key, set the corresponding state bit or bits. If the ASCII standard specifies a code for the state and character key combination, the standard ASCII code should be generated without the state information. Examples of state bit use are:

  CTRL-C ==> 0003H
  SHIFT-p ==> P or 0050H
  CTRL-5 ==> 0135H
  CTRL-SHIFT-ALT-5 ==> 0735H

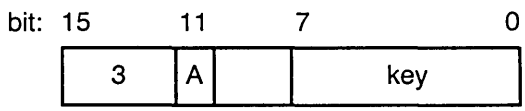
- **Func Keys:** Function key codes where you indicate the function key number in xx. Examples of function key codes are:

  FUNC 1 ==> 1001H
  CTRL-FUNC 1 ==> 1101H

- **Special Characters:** Special keys where the xx value should be generated for the key as follows:

Special Function		Cursor Movement		Numeric Keypad	
2S00	HELP	2S10	UP	2S30	ZERO
2S01	WINDOW	2S11	DOWN	2S31	ONE
2S02	NEXT	2S12	LEFT	2S32	TWO
2S03	PREVIOUS	2S13	RIGHT	2S33	THREE
2S04	PRINT SCREEN	2S14	PAGE UP	2S34	FOUR
2S05	BREAK	2S15	PAGE DOWN	2S35	FIVE
2S06	REDRAW (screen)	2S16	PAGE LEFT	2S36	SIX
2S07	BEGIN	2S17	PAGE RIGHT	2S37	SEVEN
2S08	END	2S18	HOME	2S38	EIGHT
2S09	INSERT	2S19	REVERSE TAB	2S39	NINE
2S0A	DELETE			2S3A	A
2S0B	SYSREQ			2S3B	B
				2S3C	C
				2S3D	D
				2S3E	E
				2S3F	F
				2S40	ENTER
				2S41	COMMA
				2S42	MINUS
				2S43	PERIOD
				2S44	PLUS
				2S45	DIVIDE
				2S46	MULTIPLY
				2S47	EQUAL

- **Toggle Characters:** Where your hardware supports toggle characters, generate the values for 3xxx according to the scheme:



where the fields are defined as follows:

A - action	0 - OFF 1 - ON
key	0x0 - Caps Lock 0x1 - Shift Lock 0x2 - Scroll Lock 0x3 - Num Lock 0x10 - Right Shift 0x11 - Left Shift 0x12 - Insert 0x13 - Control 0x14 - Alternate

Keys 0-3 should generate a character each time the user presses and releases the key.

Keys 10H-14H should generate a character when the user releases the key after pressing it along with another character

A.2 8-bit Input Character Set

The Console Resource Manager expects 16-bit keyboard input from the console driver. When the application specifies 8-bit character mode, the Console RM translates the 16-bit characters to 8-bit characters. The translation process may generate more characters than the console driver actually sends to the Console Resource Manager, as illustrated in Table A-2, below.

FlexOS supports the set of escape sequences only when the application is in 8-bit keyboard mode. Table A-4 lists the escape sequences supported.

Table A-2. Results of 16- to 8-bit Translation

16-bit Code	Result	Characters
00xxH	xxH	1
0100H-7FFFH	Converts to escape sequence except as follows (S=STATE bit values):	n
2S30	0x30H 0	1
2S31	0x31H 1	1
2S32	0x32H 2	1
2S33	0x33H 3	1
2S34	0x34H 4	1
2S35	0x35H 5	1
2S36	0x36H 6	1
2S37	0x37H 7	1
2S38	0x38H 8	1
2S39	0x39H 9	1
2S3A	0x41H A	1
2S3B	0x42H B	1
2S3C	0x43H C	1
2S3D	0x44H D	1
2S3E	0x45H E	1
2S3F	0x46H F	1
2S40	0x0DH RETURN or ENTER	1
2S41	0x2CH , (comma)	1
2S42	0x2DH - (minus)	1
2S43	0x2EH . (period)	1
2S44	0x2BH + (plus)	1
2S45	0x2FH / (divide)	1
2S46	0x2AH * (multiply)	1
2S47	0x3DH = (equal)	1
8000H-FCFCH	High byte, low byte	2

A.3 16-bit Output Character Set

The Console Resource Manager accepts 16-bit output characters through the WRITE SVC when in 16-bit screen mode. The 16-bit character codes provided are defined in Table A-3.

Table A-3. 16-bit Output Character Set

16-bit Value	Definition
00xxH	Same as 8-bit. Give these characters one character position on the screen. Characters in the range 80H-FFH are defined on a per-country basis.
8000H-FCFCH	16-bit language, such as KANJI. Give these characters two character positions on the screen. When modifying the FRAME, set the two character plane cells according to the key value and set the extension plane to indicate a two-cell character; that is, set bit 0 of both extension plane bytes to 1, set bit 1 of the first extention plane byte to 0, and set bit 1 of the second byte to 1.
01xxH-0FxxH	Alternate character sets. Implement these codes according to the following rules. Each character takes one character position. Typically, these characters are defined by the OEM extension field in a byte in a FRAME's extension plane. If an extension plane exists, the low byte is placed into the character plane while the low nibble of the high byte is placed into the low nibble of the extension plane.
1xxxH	Non-visible characters which take no space on the screen.
2xxxH	Editing functions. These functions are the equivalent of the escape sequences:

Table A-3. (Continued)

16-bit Value	Definition
2040	Enter Insert Character Mode
2041	Cursor Up
2042	Cursor Down
2043	Cursor Right
2044	Cursor Left
2045	Clear Display
2048	Cursor Home
2049	Reverse Index
204A	Erase to End of Page
204B	Erase to End of Line
204C	Insert Blank Line
204D	Delete Line
204E	Delete Character
204F	Exit Insert Character Mode
2064	Erase Beginning of Display
2065	Enable Cursor
2066	Disable Cursor
206A	Save Cursor Position
206B	Restore Cursor Position
206C	Erase Entire Line
206F	Erase Beginning of Line
2070	Enter Reverse Video Mode
2071	Exit Reverse Video Mode
2072	Enter Intensify Mode
2073	Enter Blink Mode
2074	Exit Blink Mode
2075	Exit Intensify Mode
2076	Wrap at End of Line
2077	Discard at End of Line

Table A-3. (Continued)

16-bit Value	Definition
3xxxH	Set cursor to xxx row (0 origin)
4xxxH	Set cursor to xxx column (0 origin)
50xxH	Set foreground color to color xx. Color codes are documented in the A.4, below.
51xxH	Set background color to color xx. Color codes are documented in the A.4, below.
52xxH-7xxxH	Non-visible characters. Take no space on screen.

A.4 8-bit Output Character Set

The Console Resource Manager converts the application's 8-bit output characters and escape sequences to 16-bit characters internally before calling the driver's WRITE function. The escape sequences are supported independently of the physical terminal type.

You can provide your own 8-to-16 bit conversion routine, accessible through the GET entry point in a console driver's Driver Header, to extend the character set. The extendability of the character set allows the implementation of SHIFT-JIS KANJI through the 8-bit character set in Japan. You might also modify the conversion routine to add escape sequences that switch to another character set.

You can support multiple country codes in the console driver. If you do, implement your selection routine in the driver's SET entry point using the value in the PCONSOLE table's COUNTRY field.

In the United States, FlexOS supports the IBM PC character set. In Japan, FlexOS uses the SHIFT-JIS character set. In Europe, the ISO standard ASCII character set is used.

While in 8-bit mode, the console's video attributes, such as cursor control, video blink, video intensity, and reverse video can be controlled through escape sequences sent through the WRITE SVC. The first character of an escape sequence is always the Escape character (ASCII character 27 or 1BH).

Table A-4, below, lists the escape sequences defined for FlexOS. This set of escape sequences is, with some exceptions, a superset of the set required by a VT-52 terminal. In the description below, <ESC> is followed by the function character. Blanks are used for clarity of presentation only.

Table A-4. FlexOS Escape Sequences for 8-bit Output

Function	Escape Sequence
Cursor Up	<ESC> A
Cursor Down	<ESC> B
Cursor Right	<ESC> C
Cursor Left	<ESC> D
Cursor Home	<ESC> H
Reverse Index	<ESC> I (upper case i)
Save Cursor Position	<ESC> j
Restore Cursor Position	<ESC> k
Set Cursor Position	<ESC> Y (r) (c) (r) = row + 32 (one character) (c) = col + 32 (one character) home = 0,0
Clear Display	<ESC> E
Erase to End of Page	<ESC> J
Erase to End of Line	<ESC> K
Erase Entire Line	<ESC> l (lower case L)
Erase Beginning of Display	<ESC> d
Erase Beginning of Line	<ESC> o
Insert Blank Line	<ESC> L
Delete Line	<ESC> M
Delete Character	<ESC> N

Table A-4. (Continued)

Function	Escape Sequence
Set Foreground Color	<ESC> b (c) where (c) = color (one character) 0 - Black 8 - Dark Gray 1 - Blue 9 - Light Blue 2 - Green 10 - Light Green 3 - Cyan 11 - Light Cyan 4 - Red 12 - Light Red 5 - Magenta 13 - Light Magenta 6 - Brown 14 - Yellow 7 - Light Gray 15 - White
Set Background Color	<ESC> c (c) where (c) = color (one character) 0 - Black 1 - Blue 2 - Green 3 - Cyan 4 - Red 5 - Magenta 6 - Brown 7 - Light Gray 8-15 are the same as 0-7 except the foreground blinks

Table A-4. (Continued)

Function	Escape Sequence
Enable Cursor	<ESC> e
Disable Cursor	<ESC> f
Enter Reverse Video Mode	<ESC> p
Exit Reverse Video Mode	<ESC> q
Enter Intensify Mode	<ESC> r
Exit Intensify Mode	<ESC> u
Enter Blink Mode	<ESC> s
Exit Blink Mode	<ESC> t
Enter Insert Mode	<ESC> @
Exit Insert Mode	<ESC> O
Wrap at End of Line	<ESC> v
Discard at End of Line	<ESC> w

End of Appendix A

Foreign Language Support

This appendix describes the FlexOS support for languages other than American English. FlexOS defines a console driver so an OEM can provide translation routines. In addition to this driver-level support, an OEM can translate or modify all messages displayed by FlexOS utilities.

Section B.1 describes provisions for foreign language support in a console driver. Section B.2 explains how to edit, recompile, and relink utility messages.

B.1 Console Driver Support

Support for foreign character sets exists in the console driver's SET and GET functions and in the extension plane of a FRAME. See Section 7, "Console Drivers," for a description of SET and GET and the FRAME data structure.

Through the SET function, a console driver can change the COUNTRY field in the PCONSOLE Table. The COUNTRY field contains a country code that determines which character set is being used. Applications can, through the GET and LOOKUP SVCs, obtain the country code from the PCONSOLE Table. Country codes are listed in Appendix C of the FlexOS Programmer's Guide.

Through the GET function, a console driver can provide the addresses of OEM-written character translation routines. The Console Resource Manager passes the address of the PCONSOLE Table to the GET function. The PCONSOLE Table has two 32-bit fields, CONVERT8 and CONVERT16, that can store pointers to translation routines. CONVERT8 can point to an 8-bit to 16-bit output translation routine. CONVERT16 can point to a 16-bit to 8-bit input translation routine. If these fields contain NULLPTR, the FlexOS standard conversion routines are called.

To support foreign language character sets, the console driver writer must implement an extension plane in his PFRAME. If the console driver supports virtual consoles, the extension plane must exist in the VFRAME also. FlexOS defines a byte in the extension plane to allow support for one-byte characters, two-byte characters, such as KANJI, or alternate character sets. See Section 7.2.1 for details.

B.2 Modifying Messages

Modifying the FlexOS messages consists of editing source message files, compiling those files, and linking the new object modules with a utility's code. The FlexOS utilities are written so code modules contain no messages and message modules contain only global symbols and messages.

The following message files are distributed with FlexOS:

- STDMSGS.C - contains all public messages, that is, all messages used by more than one utility. This file is provided as reference and is not used in the process of modifying messages.
- Set of files consisting of each message in STDMSGS.C in a separate file
- <utilityname>MSG.C - contains specific messages for a utility

Perform the following steps to create utilities that display modified messages.

1. Print STDMSGS.C, to use as a guide when editing individual message files.
2. Edit each of the public message files.
3. Edit the message file for each utility.

4. Run the batch file, CCMSGS.BAT. This file contains commands that do the following:

   - Compiles all public messages
   - For object files created by the Lattice C compiler, executes the COMB utility to change object files from Lattice format to a format usable by LINK-86 and LIB-86.
   - Runs LIB with the input file CCMSGS.INP using the I option. CCMSGS.INP contains a list of public symbols that LIB matches with corresponding message files to create a CCMSGS.L86 (CCMSGS.L68 for 68000-based systems), a library of standard object modules.

5. Run batch file, <utilityname>.BAT, for each utility. These files contain commands that do the following:

   - Compiles the <utility>MSG.C file containing a utility's messages
   - Runs LINK with a utility-specific input file, <utilityname>.INP. These input files contain a list of which code and message modules to link and a list of public symbols that LINK uses to extract appropriate messages from the CCMSGS file. LINK produces an executable file.

For 68000-based implementations that use SUBMIT rather than BATCH, SUBMIT files (file extension SUB) are provided.

The Window Manager and FORMAT utility distributed with FlexOS display text not contained in STDMSGS.C. Text strings for the Window Manager are stored in WMEXDATA.C (see Appendix C). Messages for FORMAT are stored in BOOT.A86 and HDBOOT.A86.

End of Appendix B

Modifying Windows

This appendix explains how you modify screen windows (virtual consoles) as set up by the FlexOS Window Manager.

You can modify the following window characteristics:

- size
- location on the screen
- attributes of windows, including borders
- fill characters
- number of windows to bring up at boot time
- startup command for each window
- text strings in window headers

A window can be as large as the limits of your physical console allow.

Distributed with FlexOS is the source code to the Window Manager, including two data files, WMEX.H and WMEXDATA.C.

WMEX.H contains the WNDWDESC structure, which describes a user window, and the WNDWSPEC structure, which describes a special window. A special window is a message or a status window. WMEXDATA.C contains data for both structures. WNDWDESC and WNDWSPEC are the only configurable window structures.

WNDWDESC describes a window's size, location, attributes, and fill characters. It also contains pointers to a text string for the window header and a pointer to the startup command line. WNDWSPEC contains pointers to text displayed in the message and status windows and stores the number of elements in a variety of different arrays of text strings.

In addition to configuration data, WMEXDATA.C contains the text strings pointed to in WNDWDESC and WNDWSPEC. You can translate, or otherwise modify these strings.

WMEX.H sets eight as the maximum number of user and special windows per physical console. Changing this number requires changing code in WMEX.H.

WMEXDATA.C defines eight windows: six user windows, a status window, and a message window.

In WMEXDATA.C, the variable WM0010, which stores the number of user windows at startup, is initialized to one. You can change this value to as many user windows as are defined in WMEX.H.

The variables WM0100, WM0110, and WM0120 in WMEXDATA.C define attributes and fill characters for the Desk Window. The Desk Window is the parent console for all user and special windows. Desk Window variables can also be modified.

In WNDWDESC, if you place a zero in the WD_RMAX (maximum number of rows) and WD_CMAX (maximum number of columns) fields, the Window Manager makes the window the size of the screen the Window Manager is running in. This is usually the size of the physical console.

In the WD_FLAGS field in WNDWDESC, you can change bits 0 (borders/no borders) and 1 (attributes/no attributes). Do not change bits 6 and 7.

End of Appendix C

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