RSX-11M/M-PLUS
I/O Drivers
Reference Manual

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RSX-11M Version 3.2
RSX-11M-PLUS Version 1.0

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CONTENTS

CONTENTS

CONTENTS

CONTENTS

CONTENTS

CONTENTS

CONTENTS

CONTENTS

CONTENTS

CONTENTS

CONTENTS

CONTENTS

CONTENTS

FIGURES

TABLES

CONTENTS

Page

TABLES (Cont.)

CONTENTS

Page

TABLES (Cont.)

CONTENTS

SUMMARY OF TECHNICAL CHANGES

This revision of the I/O Drivers Reference Manual contains changes and additions to document two operating systems: RSX-11M V3.2 and RSX-11M-PLUS V1.0. The following list contains a brief summary of technical changes for both operating systems:

- A new full-duplex terminal driver is available for RSX-11M systems. During SYSGEN, the RSX-11M user can select either the half-duplex terminal driver (available in previous RSX-11M systems) or the full-duplex terminal driver. Only the full-duplex terminal driver is available in RSX-11M-PLUS systems.

  Terminal driver support has been added for the following terminal devices:

  VT100
  LA120

- Disk driver support has been added for the following new disk devices:

  RHXX/RM02
  RL11/RL02
  RK611/RK07
  RX211/RX02

- DECtape II (TU58) driver support has been added.
- Magnetic tape driver support has been added for the TU77 and TS04.
- LPA11-K driver support has been expanded to accommodate systems with 22-bit addressing. While this allows the driver to run on any system in which RSX-11M/M-PLUS is installed, user tasks previously written to run on earlier versions of RSX-11M may not run with the current LPA11-K driver without modification (see Section 21.7).
- PCL11 Parallel Communication Link transmitter and receiver driver support has been added for RSX-11M-PLUS systems. (PCL11 driver support is not available in RSX-11M systems.)
- UNIBUS switch (DT03/DT07) driver support is provided for RSX-11M-PLUS systems. (UNIBUS switch driver support is not available in RSX-11M systems.)
- Virtual terminal driver support is provided for RSX-11M-PLUS systems. (Virtual terminals are not supported in RSX-11M systems.)

NOTE

The following devices are not supported in RSX-11M-PLUS systems:

Synchronous and asynchronous line interfaces:

DA11-B	
DL11-E	(modem support is provided in the full-duplex terminal driver)
DP11	
DQ11	
DU11	

Analog-to-digital converters:

AFC11
AD01-D

UDC11 universal digital controller

Laboratory peripheral systems:

AR11
LPS11

Industrial control subsystems:

ICS/ICR	local and remote subsystems
DSS/DRS	digital input and output subsystems

Graphics subsystems:

VT11
VS60

Terminal support is provided via the full-duplex terminal driver only; the half-duplex terminal driver is not supported

PREFACE

MANUAL OBJECTIVES

The purpose of this manual is to provide all information necessary to interface directly with the I/O device drivers supplied as part of the RSX-11M/M-PLUS system.

INTENDED AUDIENCE

This manual is intended for use by experienced RSX-11M/M-PLUS programmers who want to take advantage of the time and/or space savings which result from direct use of the I/O drivers. Readers are expected to be familiar with the information contained in the RSX-11M/M-PLUS Executive Reference Manual, and to have some experience using the Task Builder and either MACRO-11 or FORTRAN programs and to be familiar with the manuals describing their use.

STRUCTURE OF THE DOCUMENT

Chapter 1 provides an overview of RSX-11M input/output operations. It is somewhat tutorial in its approach in introducing the reader to the use of logical unit numbers, directive parameter blocks, event flags, macro calls, etc. The discussions include the standard I/O functions common to a variety of devices, and summarizes standard error and status conditions relating to completion of I/O requests.

Chapters 2 through 23 describe the use of all device drivers supported by RSX-11M and/or RSX-11M-PLUS; refer to the preceding Summary Of Technical Changes to determine which drivers are supported in your operating system. Descriptions by chapter are as follows:

Chapter	Device Drivers
2	Full-duplex terminal communications line interface
3	Half-duplex terminal communications line interface
4	Virtual terminal driver
5	Disks
6	DECtape

Chapter	Device Drivers
7	DECtape II
8	Magnetic tape
9	Cassette
10	Line printers
11	Card reader
12	Message-oriented communications line interfaces
13	PCL11 parallel communications link transmitter and receiver
14	Analog-to-digital converters
15	Universal digital controller
16	Laboratory peripheral systems
17	Paper tape reader/punch
18	Industrial control subsystems
19	The null device
20	Graphics display terminals
21	LPA11-K laboratory peripheral accelerator
22	K-series laboratory peripherals
23	UNIBUS switch

Each of these chapters is structured in similar fashion and focuses on the following basic elements:

- Description of the device, including information on physical characteristics such as speed, capacity, access, and usage
- Summary of standard functions supported by the devices and descriptions of device-specific functions
- Discussion of special characters, carriage control codes, and functional characteristics, if relevant
- Summary of error and status conditions returned on acceptance or rejection of I/O requests
- Description of programming hints for users of the device under RSX-11M

Appendixes A through C provide quick reference material on I/O functions and status codes and an example of RSX-11M I/O operations. These include the following:

Appendix	Contents
A	Summary of I/O functions by device
B	I/O function and status codes
C	Programming example

ASSOCIATED DOCUMENTS

Other manuals closely allied to the purposes of this document are described briefly in the RSX-11M/RSX-11S Documentation Directory and the RSX-11M-PLUS Documentation Directory. Each Documentation Directory defines the intended readership of each manual in the RSX-11M/RSX-11S or RSX-11M-PLUS set and provides a brief synopsis of each manual's contents.

CONVENTIONS USED IN THIS MANUAL

There are a number of conventions and assumptions used in this manual to present syntax and program coding examples. These are described in the following list.

1. Brackets ([]) in syntactic models enclose optional parameters.

   The following example illustrates this format:

   ```
   ASTX$S  [err]
   ```

2. Braces ({ }) in syntactic models indicate that one of the items must be selected, as in the following:

   $$\text{CALL}\left\{\begin{matrix}\text{DOM}\\ \text{DOMW}\end{matrix}\right\}\text{<inm,icont,idata,[idx],[isb],[lun]>}$$

3. An ellipsis (...) in a syntactic model or coding example indicates that parameters have been omitted. As used in this manual, an ellipsis in a QIO macro call indicates omission of standard QIO parameters described in Section 1.5.1. This is illustrated below:

   ```
   QIO$C  IO.RLV,...,<stadd,size>
   ```

4. Consecutive commas in a coding example indicate null arguments. The following illustrates this usage:

   ```
   QIO$C  IO.ATT,6,,,,AST01
   ```

5. Commas indicating null trailing optional arguments may be omitted, as in the following:

   ```
   QIO$C  IO.KIL,9.
   ```

6. Certain parameters are required but ignored by RSX-11M or RSX-11M-PLUS; this is necessary to maintain compatibility with RSX-11D. For example, in the following, the priority specification (fourth parameter) is ignored:

```
QIO$C  IO.WLB,8.,EV,,IOSB,ASTX,<IOBUF,NBUF>
```

7. With the exception of MACRO-11 coding examples, all numbers in the text of this manual are assumed to be decimal; octal radix is explicitly declared as in the following:

   An illegal logical block number has been specified for DECtape. The number exceeds 577 (1101 octal).

   In MACRO-11 coding examples, all numbers are assumed to be octal; decimal radix is explicitly designated by following the number with a decimal point, as in the following example:

```
QIO$C  IO.RDB,14.,,,IOSB,,<IOBUF,80.>
```

8. In FORTRAN subroutine models, parameters which begin with the letters i through n indicate integer variables, as in the following example:

```
CALL DRS (ibuf,ilen,imode,irate,iefn,imask,isb,
          [nbuf],[istart],[istop])
```

   In general, where both i and n prefixes are used in a call, the i form indicates the name of an array and the n form specifies the size of the array.

   All integer arrays and variables are assumed to occupy one storage word per variable (i.e., INTEGER*2) and all real arrays and variables are assumed to occupy two storage words per variable (i.e., REAL*4).

CHAPTER 1

RSX-11M/M-PLUS INPUT/OUTPUT

1.1 OVERVIEW OF RSX-11M I/O

The RSX-11M/M-PLUS Real-Time Executives support a wide variety of PDP-11 input and output devices, including disks, DECtapes, magnetic tapes, tape cassettes, line printers, card readers, and such laboratory and industrial devices as analog-to-digital converters, universal digital controllers, and laboratory peripheral systems. Drivers for these devices are supplied by Digital Equipment Corporation as part of the system software. This manual describes all of the device drivers supported by the system and the characteristics, functions, error conditions, and programming hints associated with each. Devices not described in this manual can be added to basic system configurations, but users must develop and maintain their own drivers for these devices. (See the RSX-11M Guide to Writing an I/O Driver, including update No 1, or the RSX-11M-PLUS Guide to Writing an I/O Driver, depending upon the system you are using.)

Input/output operations under RSX-11M are extremely flexible and are as device- and function-independent as possible. Programs issue I/O requests to logical units which have been previously associated with particular physical device units. Each program or task is able to establish its own correspondence between physical device units and logical unit numbers (LUNs). I/O requests are queued as issued; they are subsequently processed according to the relative priority of the tasks which issued them. I/O requests (for appropriate devices) can be issued from tasks by means of either the File Control Services or Record Management Services, or can be interfaced directly to an I/O driver by means of the Queue I/O (QIO) system directive.

All of the I/O services described in this manual are requested by the user in the form of QIO system directives. A function code included in the QIO directive indicates the particular input or output operation to be performed. I/O functions can be used to request such operations as:

- attaching or detaching a physical device unit for a task's exclusive use
- reading or writing a logical or virtual block of data
- canceling a task's I/O requests

A wide variety of device-specific input/output operations (e.g., reading DECtape in reverse, rewinding cassette tape) can also be specified via QIO directives.

1.2 PHYSICAL, LOGICAL, AND VIRTUAL I/O

There are three possible modes in which an I/O transfer can take place. These are physical, logical, and virtual.

Physical I/O concerns reading and writing data in the actual physical units accepted by the hardware (e.g., sectors on a disk). For most devices, physical I/O is identical to logical I/O. For example, the RK05 disk has sectors of 256 words, the same size as RSX-11M logical blocks for all disks. Thus, in this case, a logical block maps directly into a physical block. For other devices, the mapping is not one to one. The RF11 disk, for example, is word-addressable; however no physical I/O may be done with the RF11. Data is always written in 256-word logical blocks. Another example is the RX01 flexible disk. Data for the RX01 is recorded in physical sectors of 64 words each. Therefore, logical blocks for the RX01 are made up of four physical sectors.

Logical I/O concerns reading and writing data in blocks that are convenient for the operating system. In most cases, logical blocks map directly into physical blocks. For block-structured devices (e.g., disks), logical blocks are numbered beginning at zero (0). For nonblock-structured devices (e.g., terminals), logical blocks are not addressable.

Virtual I/O concerns reading and writing data to open files. In this case, the executive maps virtual blocks into logical blocks. For file-structured devices (disks or DECtapes) virtual blocks are the same size as logical blocks and are numbered starting from one (1) and are relative to the file rather than to the device. For nonfile-structured devices, the mapping from virtual block to logical block is direct.

1.3 RSX-11M DEVICES

The devices listed below are supported by both RSX-11M and RSX-11M-PLUS, except as indicated. Drivers are supplied for each of these devices, and I/O operations for them are described in detail in subsequent chapters of this manual.

1. A variety of terminals, including the following:

   - ASR/KSR-33 and ASR/KSR-35 Teletypes[1]
   - LA30 DECwriters (serial and parallel)
   - LA36 DECwriter II
   - LA120 DECwriter III
   - LA180S DECprinter
   - VT05B Alphanumeric Display Terminal
   - VT50 Alphanumeric Display Terminal
   - VT50H Alphanumeric Display Terminal
   - VT52 Alphanumeric Display Terminal

[1] Teletype is a registered trademark of the Teletype Corporation.

- VT55 Graphics Display Terminal
- VT61 Alphanumeric Display Terminal
- VT100 Alphanumeric Display Terminal
- RT02 Data Entry Terminal
- RT02-C Badge Reader and Data Entry Terminal

These terminals are supported on the following asynchronous line interfaces:

- DJ11 Asynchronous Communication Line Interface Multiplexer
- DH11 and DH11-DM11-BB Asynchronous Communication Line Interface Multiplexer
- DL11-A, DL11-B, DL11-C, DL11-D, DL11-E and DL11-W Asynchronous Communication Line Interfaces
- DZ11 Asynchronous Communication Line Interface Multiplexer

2. A variety of disks, including the following:

   - RF11/RS11 Fixed-Head Disk
   - RS03 Fixed-Head Disk
   - RS04 Fixed-Head Disk
   - RP11/RP02 or RP03 Pack Disks
   - RM02, RM03 Pack Disk
   - RP04, RP05, RP06 Pack Disks
   - RK11/RK05 or RK05F Cartridge Disks
   - RL11/RL01 or RL02 Cartridge Disk
   - RK611/RK06 or RK07 Cartridge Disk
   - RX11/RX01 Flexible Disk
   - RX211/RX02 Flexible Disk

3. TC11/TU56 DECtape

4. TU58 DECtape II

5. Three types of magnetic tape:

   - RH11 or RH70/TM02 or TM03/TE16, TU16, TU45 or TU77 Magnetic Tape Controller/Formatter/Drive
   - TM11/TE10, TU10 or TS03 Magnetic Tape Controller/Drive
   - TS11/TS04 Magnetic Tape Controller/Drive

6. TA11 Tape Cassette

7. A variety of line printers:

   - LP11 Line Printers
   - LS11 Line Printer
   - LV11 Line Printer
   - LA180 Line Printer

8. CR11 Card Reader

9. Synchronous and asynchronous line interfaces:

   - DA11-B Asynchronous Communication Line Interface (RSX-11M support only)
   - DL11-E Asynchronous Communication Line Interface (RSX-11M support only)
   - DMC11 Synchronous Communication Line Interface
   - DP11 Synchronous Communication Line Interface (RSX-11M support only)
   - DQ11 Synchronous Communication Line Interface (RSX-11M support only)
   - DU11 Synchronous Communication Line Interface (RSX-11M support only)
   - DUP11 Synchronous Communication Line Interface

10. Two analog-to-digital converters:

    - AFC11 Analog-to-Digital Converter (RSX-11M support only)
    - AD01-D Analog-to-Digital Converter (RSX-11M support only)

11. UDC11 Universal Digital Controller (RSX-11M support only)

12. Laboratory peripheral systems:

    - AR11 Laboratory Peripheral System (RSX-11M support only)
    - LPS11 Laboratory Peripheral System (RSX-11M support only)

13. Paper tape devices:

    - PC11 Paper Tape Reader/Punch
    - PR11 Paper Tape Reader

14. Industrial control subsystems:

    - ICS/ICR Local and Remote Subsystems (RSX-11M support only)
    - DSS/DRS Digital Input and Output Subsystems (RSX-11M support only)

15. The "Null Device," a software construct that facilitates eliminating unwanted output

16. Two graphics subsystems:
    - VT11 Graphics Display System (RSX-11M support only)
    - VS60 Graphics Display System (RSX-11M support only)
17. Laboratory Peripheral Accelerator:
    - LPA11-K
18. K-series laboratory peripherals:
    - AA11-K Digital-to-analog Converter and Display
    - AD11-K Analog-to-Digial Converter
    - AM11-K Multiple Gain Multiplexer
    - DR11-K Digital I/O Interface
    - KW11-K Programmable Real Time Clock
19. PCL11 Parallel Communications Link (RSX-11M-PLUS support only)
20. UNIBUS switch:
    - DT07 (RSX-11M-PLUS support only)
21. Virtual Terminals (RSX-11M-PLUS support only)

1.4 LOGICAL UNITS

This section describes the construction of the logical unit table and the use of logical unit numbers.

1.4.1 Logical Unit Number

A logical unit number or LUN is a number which is associated with a physical device unit during RSX-11M/M-PLUS I/O operations. For example, LUN 1 might be associated with one of the terminals in the system, LUNs 2, 3, 4, and 5 with DECtape drives, and LUNs 6, 7, and 8 with disk units. The association is a dynamic one; each task running in the system can establish its own correspondence between LUNs and physical device units, and can change any LUN/physical-device-unit association at almost any time. The flexibility of this association contributes heavily to system device independence.

A logical unit number is simply a short name used to represent a logical-unit/physical-device-unit association. Once the association has been made, the LUN provides a direct and efficient mapping to the physical device unit, and eliminates the necessity to search the device tables whenever the system encounters a reference to a physical device unit.

The user should remember that, although a LUN/physical-device-unit association can be changed at any time, reassignment of a LUN at run time causes pending I/O requests for the previous LUN assignment to be cancelled. It is the user's responsibility to verify that all outstanding I/O requests for a LUN have been serviced before that LUN is associated with another physical device unit.

1.4.2 Logical Unit Table

There is one logical unit table (LUT) for each task running in a system. This table is a variable-length block contained in the task header. Each LUT contains sufficient 2-word entries for the number of logical units specified by the user at task build time by the "UNITS=" option.

Each entry or slot contains a pointer to the physical device unit currently associated with that LUN. Whenever a user issues an I/O request, the system matches the appropriate physical device unit to the LUN specified in the call by indexing into the logical unit table by the number supplied as the LUN. Thus, if the call specifies 6 as the LUN, the system accesses the sixth 2-word entry in the LUT and associates the I/O request with the physical device unit to which the entry points. The number of LUN assignments valid for a task ranges from zero to 255, but cannot be greater than the number of LUNs specified at task build time.

Figure 1-1 illustrates a typical logical unit table.

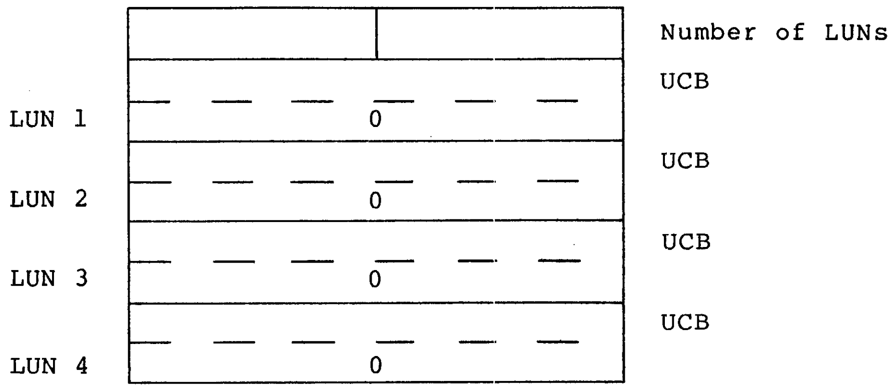

Figure 1-1 Logical Unit Table

Word 1 of each active (assigned) 2-word entry in the logical unit table points to the unit control block (UCB) of the physical device unit with which the LUN is associated. This linkage may be indirect - that is, the user may force redirection of references from one unit to another unit via the MCR command, REDIRECT. Word 2 of each entry is reserved for mountable devices.

1.4.3 Changing LUN Assignments

Logical unit numbers have no significance until they are associated with a physical device unit by means of one of the methods described below:

1. At task build time, the user can specify an ASG keyword option, which associates a physical device unit with a logical unit number referenced in the task being built.

2. The user or system operator can issue a REASSIGN command to MCR; this command reassigns a LUN to another physical device unit and thus changes the LUN-physical device unit correspondence. Note that this reassignment has no effect on the in-core image of a task.

3. At run time, a task can dynamically change a LUN assignment by issuing the Assign LUN system directive, which changes the association of a LUN with a physical device unit during task execution.

1.5 ISSUING AN I/O REQUEST

User tasks perform I/O in the RSX-11M/M-PLUS system by submitting requests for I/O service in the form of QIO or QIO And Wait system directives. See the RSX-11M/M-PLUS Executive Reference Manual for a complete description of system directives.

In RSX-11M/M-PLUS, as in most multiprogramming systems, tasks do not normally access physical device units directly. Instead, they utilize input/output services provided by the Executive, since it can effectively multiplex the use of physical device units over many users. The Executive routes I/O requests to the appropriate device driver and queues them according to the priority of the requesting task. I/O operations proceed concurrently with other activities in an RSX-11M/M-PLUS system.

Before a request is queued, it must pass a battery of acceptance tests administered by the Executive. If the request fails it is rejected; this rejection is signalled by the setting of the C-bit when the statement following the QIO is executed. It is good programming practice to check for directive rejection by following the QIO directive with a BCS instruction.

After an I/O request has been queued, the system does not wait for the operation to complete. If at any time the user task which issued the QIO request cannot proceed until the I/O operation has completed, it should specify an event flag (see sections 1.5.1 and 1.5.2) in the QIO request and should issue a Waitfor system directive which specifies the same event flag at the point where synchronization must occur. The task then waits for completion of I/O by waiting for the specified event flag to be set.

The QIOW directive, QIO And Wait, is a more economical way to achieve this synchronization. QIOW automatically waits until I/O has completed before returning control to the task. Thus, the additional Waitfor directive is not necessary.

Each QIO or QIOW directive must supply sufficient information to identify and queue the I/O request. The user may also want to include locations to receive error or status codes and to specify the address of an asynchronous system trap service routine. Certain types of I/O operations require the specification of device-dependent information as well. Typical QIO parameters are the following:

- I/O function to be performed
- Logical unit number associated with the physical device unit to be accessed
- Optional event flag number for synchronizing I/O completion processing (required for QIOW)
- Optional address of the I/O status block to which information indicating successful or unsuccessful completion is returned
- Optional address of an asynchronous system trap service routine to be entered on completion of the I/O request

- Optional device- and function-dependent parameters specifying such items as the starting address of a data buffer, the size of the buffer, and a block number

A set of system macros which facilitate the issuing of QIO directives is supplied with the RSX-11M/M-PLUS system. These macros, which reside in the System Macro Library (LB:[1,1]RSXMAC.SML), must be made available to the source program by means of the MACRO-11 Assembler directive .MCALL. The function of .MCALL is described in Section 1.7.3. Several of the first six parameters in the QIO directive are optional, but space for these parameters must be reserved.

During expansion of a QIO macro, a value of zero is defaulted for all null (omitted) parameters. Inclusion of the device- and function-dependent parameters depends on the physical device unit and function specified. If the user wanted to specify only an I/O function code, a LUN, and an address for an asynchronous system trap service routine, the following might be issued:

```
QIO$C   IO.ATT,6,,,,ASTOX
```

where IO.ATT is the I/O function code for attach, 6 is the LUN, ASTOX is the AST address, and commas indicate null arguments for the event flag number, the request priority, and the address of the I/O status block. No additional device- or function-dependent parameters are required for an attach function. The C form of the QIO$ macro is used here and in most of the examples included in Chapter 1. Section 1.7 describes the three legal forms of the macro.

For convenience, any comma may be omitted if no parameters appear to the right of it. The command above could therefore be issued as follows, if the asynchronous system trap was not desired.

```
QIO$C  IO.ATT,6
```

All extra commas have been dropped. If, however, a parameter appears to the right of any place-holding comma, that comma must be retained.

1.5.1 QIO Macro Format

The arguments for a specific QIO macro call may be different for each I/O device accessed and for each I/O function requested. The general format of the call is, however, common to all devices and is as follows:

```
QIO$C  fnc,lun,[efn],[pri],[isb],[ast][,<p1,p2,...,p6>]
```

where brackets ([]) enclose optional or function-dependent parameters. If function-dependent parameters <p1,...,p6> are required, these parameters must be enclosed within angle brackets (<>). The following paragraphs summarize the use of each QIO parameter. Section 1.7 discusses different forms of the QIO$ macro itself.

The **fnc** parameter is a symbolic name representing the I/O function to be performed. This name is of the form:

```
IO.xxx
```

where xxx identifies the particular I/O operation. For example, a QIO request to attach the physical device unit associated with a LUN specifies the function code:

```
IO.ATT
```

A QIO request to cancel (or kill) all I/O requests for a specified LUN begins in the following way:

```
        QIO$C  IO.KIL,...
```

The fnc parameter specified in the QIO request is stored internally as a function code in the high-order byte and modifier bits in the low-order byte of a single word. The function code is in the range zero through 31 and is a binary value supplied by the system to match the symbolic name specified in the QIO request. The correspondence between global symbolic names and function codes is defined in the system object module library, which is automatically searched by the Task Builder. Local symbolic definitions may also be obtained via the FILIO$ and SPCIO$ macros which reside in the System Macro Library and are summarized in Appendix A. Several similar functions may have identical function codes, and may be distinguished only by their modifier bits. For example, the DECtape read logical forward and read logical reverse functions have the same function code. Only the modifier bits for these two operations are stored differently.

The **lun** parameter represents the logical unit number (LUN) of the associated physical device unit to be accessed by the I/O request. The association between the physical device unit and the LUN is specific to the task which issues the I/O request, and the LUN reference is usually device-independent. An attach request to the physical device unit associated with LUN 14 begins in the following way:

```
        QIO$C  IO.ATT,14.,...
```

Because each task has its own logical unit table (LUT) in which the physical device unit-LUN correspondences are established, the legality of a lun parameter is specific to the task which includes this parameter in a QIO request. In general, the LUN must be in the following range:

```
        0 < LUN < length of task's LUT (if nonzero)
```

The number of LUNs specified in the logical unit table of a particular task cannot exceed 255.

The **efn** parameter is a number representing the event flag to be associated with the I/O operation. It may optionally be included in a QIO or QIO And Wait request. The specified event flag is cleared when the I/O request is queued and is set when the I/O operation has completed. If the task has issued the QIO And Wait directive, execution is automatically suspended until the I/O completes. If a QIO directive has been issued (with no Waitfor directive), then task execution proceeds in parallel with the I/O. When the task continues to execute, it may test the event flag whenever it chooses by using the Read All Event Flags system directive (if group global event flags are not being used) or the Read Extended Flags system directive (for all event flags, including group-global event flags). If the user specifies an event flag number, this number must be in the range 1 through 96. If an event flag specification is not desired, efn can be omitted or can be supplied with a value of zero. Event flags 1 through 32 are local (specific to the issuing task); event flags 33 through 64 are global (shared by all tasks in the system). Event flags 65 through 96 are group-global event flags (shared by all tasks in the same user group). Flags 25 through 32 and 57 through 64 are reserved for use by system software. Within these bounds, the user can specify event flags as desired to synchronize I/O completion and task execution. Section 1.5.2 provides a more detailed explanation of event flags and significant events.

The optional **pri** parameter is supplied only to make RSX-11M/M-PLUS QIO requests compatible with RSX-11D. An RSX-11M I/O request automatically assumes the priority of the requesting task. Thus, it is recommended that a value of zero (or a null) be used for this parameter.

The optional **isb** parameter identifies the address of the I/O status block (I/O status double-word) associated with the I/O request. This block is a 2-word array in which a code representing the final status of the I/O request is returned on completion of the operation. This code is a binary value that corresponds to a symbolic name of the form IS.xxx (for successful returns) or IE.xxx (for error returns). The binary error code is returned to the low-order byte of the first word of the status block. It can be tested symbolically, by name. For example, the symbolic status IE.BAD is returned if a bad parameter is encountered. The following illustrates the examination of the I/O status block, IOST, to determine if a bad parameter has been detected.

```
        QIO$C   IO.ATT,14.,2,,IOST
        BCS     DIRERR
        WTSE$C  2
                .
                .
                .
        CMPB    #IS.SUC,IOST
        BNE     ERROR
```

The correspondence between global symbolic names and I/O completion codes is defined in the system object module library, which is automatically searched by TKB. Local symbolic definitions, which are summarized in Appendix B, may also be obtained via the IOERR$ macro which resides in the System Macro Library.

Certain device-dependent information is returned to the high-order byte of the first word of isb on completion of the I/O operation. If a read or write operation is successful, the second word is also significant. For example, in the case of a read function on a terminal, the number of bytes typed before a carriage return is returned in the second word of isb. If a magtape unit is the device and a write function is specified, this number represents the number of bytes actually transferred. The status block can be omitted from a QIO request if the user does not intend to test for successful completion of the request.

The optional **ast** parameter specifies the address of a service routine to be entered when an asynchronous system trap occurs. Section 1.5.3 discusses the use of asynchronous system traps, and Section 2.2.5 of the <u>RSX-11M/M-PLUS Executive Reference Manual</u> describes traps in detail. If the user wants to interrupt his task to execute special code on completion of an I/O request, an asynchronous system trap routine can be specified in the QIO request. When the specified I/O operation completes, control branches to this routine at the software priority of the requesting task. The asynchronous code beginning at address ast is then executed, much as an interrupt service routine would be. If the user does not want to perform asynchronous processing, the ast parameter can be omitted or a value of zero specified in the QIO macro call.

The additional QIO parameters, <p1,p2,...,p6>, are dependent on the particular function and device specified in the I/O request. Typical parameters may include I/O buffer address, I/O buffer length, etc. Between zero and six parameters can be included, depending on the particular I/O function. Rules for including these parameters and legal values are described in subsequent chapters of this manual.

1.5.2 Significant Events

"Significant event" is a term used in real-time systems to indicate a change in system status. In RSX-11M/M-PLUS, a significant event is declared when an I/O operation completes. This signals the system that a change in status has occurred and indicates that the Executive should review the eligibility of all tasks in the system to determine which task should run next. The use of significant events helps cooperating tasks in a real-time system to communicate with each other and thus allows these tasks to control their own sequence of execution dynamically.

Significant events are normally set by system directives, either directly or indirectly, by completion of a specified function. Event flags associated with tasks may be used to indicate which significant event has occurred. Of the 96 event flags available in RSX-11M/M-PLUS, the flags numbered 1 through 32 are local to an individual task and are set or reset only as a result of that task's operation. The event flags numbered 33 through 64 are common to all tasks. Flags 25 through 32 and 57 through 64 are reserved for system software use. The event flags numbered 65 through 96 are group-global event flags which are common to all tasks running under the same user group.

An example of the use of significant events follows. A task issues a QIO directive with an efn parameter specified. A Waitfor directive follows the QIO and specifies as an argument the same event flag number. The event flag is cleared when the I/O request is queued by the Executive, and the task is blocked when it executes the Waitfor directive until the event flag is set and a significant event is declared at the completion of the I/O request. The task resumes when the appropriate event flag is set, and execution resumes at the instruction following the Waitfor directive. During the time that the task is blocked, tasks with priorities lower than that of the blocked task have a chance to run, thus increasing throughput in the system.

1.5.3 System Traps

System traps are used to interrupt task execution and to cause a transfer of control to another memory location for special processing. Traps are handled by the Executive and are relevant only to the task in which they occur. To use a system trap, a task must contain a trap service routine which is automatically entered when the trap occurs.

There are two types of system traps - synchronous and asynchronous. Both are used to handle error or event conditions, but the two traps differ in their relation to the task which is running when they are detected. Synchronous traps signal error conditions within the executing task. If the same instruction sequence were repeated, the same synchronous trap would occur at the same place in the task. Asynchronous traps signal the completion of an external event such as an I/O operation. An asynchronous system trap (AST) usually occurs as the result of the initiation or completion of an external event rather than a program condition.

The Executive queues ASTs in a first-in-first-out queue for each task and monitors all asynchronous service routine operations. Because asynchronous traps may be the end result of I/O-related activity, they cannot be controlled directly by the task which receives them. However, the task may, under certain circumstances, block recognition of ASTs to prevent simultaneous access to a critical data region. When access to the critical data region has been completed, the queued

ASTs may again be honored. The DSAR$S (Disable AST Recognition) and ENAR$S (Enable AST Recognition) system directives provide the mechanism for accomplishing this. An example of an asynchronous trap condition is the completion of an I/O request. The timing of such an operation clearly cannot be predicted by the requesting task. If an AST service routine is not specified in an I/O request, a trap does not occur and normal task execution continues.

Asynchronous system traps associated with I/O requests enable the requesting task to be truly event-driven. The AST service routine contained in the initiating task is executed as soon as possible, consistent with the task's priority. The use of the AST routine to service I/O related events provides a response time which is considerably better than a polling mechanism, and provides for better overlap processing than the simple QIO and Waitfor sequence. Asynchronous system traps also provide an ideal mechanism for use in multiple buffering of I/O operations.

All ASTs are inserted in a first-in-first-out queue on a per task basis as they occur (i.e., the event which they are to signal has expired). They are effected one at a time whenever the task does not have ASTs disabled and is not already in the process of executing an AST service routine. The process of effecting an AST involves storing certain information on the task's stack, including the task's Waitfor mask word and address, the Directive Status Word (DSW), the PS, the PC and any trap dependent parameters. The task's general-purpose registers R0-R5 are not saved and thus it is the responsibility of the AST service routine to save and restore the registers it uses. After an AST is processed, the trap-dependent parameters (if any) must be removed from the task's stack and an AST Service Exit directive executed. The ASTX$S macro described in Section 1.7.6 of this manual is used to issue the AST Service Exit directive. On AST service exit, control is returned to another queued AST, to the executing task, or to another task which has been waiting to run. The _RSX-11M/M-PLUS Executive Reference Manual_ describes in detail the purpose of AST service routines and all system directives used to handle them.

1.6 DIRECTIVE PARAMETER BLOCKS

A directive parameter block (DPB) is a fixed-length area of contiguous memory which contains the arguments specified in a system directive macro call. The DPB for a QIO directive has a length of 12 words. It is generated as the result of the expansion of a QIO macro call. The first byte of the DPB contains the directive identification code (DIC) - always 1 for QIO. The second byte contains the size of the DPB in words - always 12 for RSX-11M/M-PLUS. During assembly of a user task containing QIO requests, the MACRO-11 Assembler generates a DPB for each I/O request specified in a QIO macro call. At run time, the Executive uses the arguments stored in each DPB to create, for each request, an I/O packet in system dynamic storage. The packet is entered by priority into a queue of I/O requests for the specified physical device unit. This queue is created and maintained by the Executive and is ordered by the priority of the tasks which issued the requests. The I/O drivers examine their respective queues for the I/O request with the highest priority capable of being executed. This request is dequeued (removed from the queue) and the I/O operation is performed. The process is then repeated until the queue is emptied of all requests.

After the I/O request has been completed, the Executive declares a significant event and may set an event flag, cause a branch to an asynchronous system trap service routine, and/or return the I/O status, depending on the arguments specified in the original QIO macro call. Figure 1-2 illustrates the layout of a sample DPB.

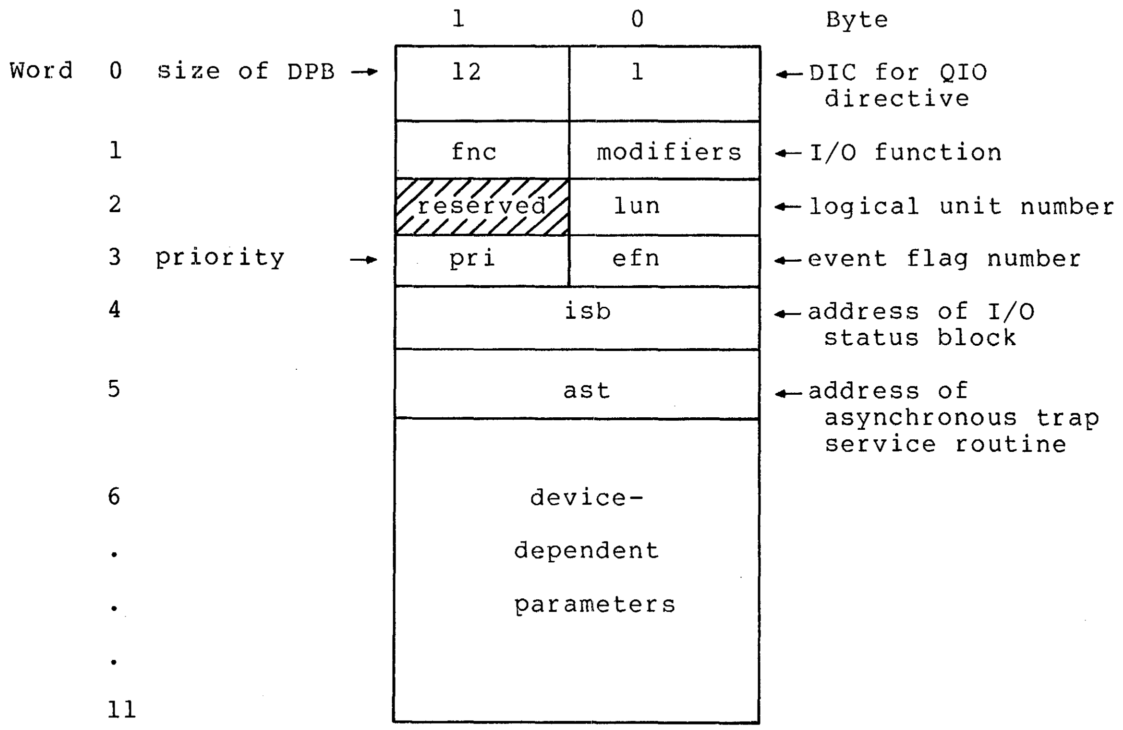

Figure 1-2 QIO Directive Parameter Block

1.7 I/O-RELATED MACROS

Several system macros are supplied with the RSX-11M/M-PLUS system to issue and return information about I/O requests. These macros reside in the System Macro Library and must be made available during assembly via the MACRO-11 assembler directive .MCALL.

Also supplied are FORTRAN-callable subroutines that perform the same functions as the system macros. See the RSX-11M/M-PLUS Executive Reference Manual for details.

There are three distinct forms of most of the system directive macros discussed in this section. The following list summarizes the forms of QIO$, but the characteristics of each form also apply to QIOW$, ALUN$, GLUN$, and other system directive macros described below.

1. QIO$ generates a directive parameter block for the I/O request at assembly time, but does not provide the instructions necessary to execute the request. This form of the request is actually executed using the DIR$ macro. It is useful if the DPB is to be used in several different places in the task and/or modified or referenced by the task at run time.

2. QIO$S generates a directive parameter block for the I/O request on the stack, and also generates code to execute the request. This is a useful form for reentrant, sharable code since the DPB is generated dynamically at execution time.

3. QIO$C generates a directive parameter block for the I/O request at assembly time, and also generates code to execute the request. The DPB is generated in a separate program section called $DPB$$. This approach incurs little system overhead and is useful when an I/O request is executed from only one place in the program.

Parameters for both the QIO$ and QIO$C forms of the macro must be valid expressions to be used in assembler data-generating directives such as .WORD and .BYTE. Parameters for the QIO$S form must be valid source operand address expressions to be used in assembler instructions such as MOV and MOVB. The following example references the same parameters in the three distinct forms of the macro call.

```
QIO$      IO.RLB,6,2,,,AST01,<RDBUF,80.>

QIO$C     IO.RLB,6,2,,,AST01,<RDBUF,80.>

QIO$S     #IO.RLB,#6,#2,,,#AST01,<#RDBUF,#80.>
```

Only the QIO$S form of the macro produces the DPB dynamically. The other two forms generate the DPB at assembly time. The characteristics and use of these different forms are described in greater detail in the <u>RSX-11M/M-PLUS Executive Reference Manual</u>.

The following Executive directives and assembler macros are described in this section:

1. QIO$, which is used to request an I/O operation and supply parameters for that request.

2. QIOW$, which is equivalent to QIO$ followed by WTSE$.

3. DIR$, which specifies the address of a directive parameter block as its argument, and generates code to execute the directive.

4. .MCALL, which is used to make available from the System Macro Library all macros referenced during task assembly.

5. ALUN$, which is used to associate a logical unit number with a physical device unit at run time.

6. GLUN$, which requests that the information about a physical device unit associated with a specified LUN be returned to a user-specified buffer.

7. ASTX$S, which is used to terminate execution of an asynchronous system trap (AST) service routine.

8. WTSE$, which instructs the system to block execution of the issuing task until a specified event flag is set.

1.7.1 The QIO$ Macro: Issuing an I/O Request

As described in Section 1.7, there are three distinct forms of the QIO$ macro. QIO$S generates a DPB for the I/O request on the stack, and also generates code to execute the request. QIO$C generates a DPB and code, but the DPB is generated in a separate program section. QIO$ generates only the DPB for the I/O request. This form of the macro call is used in conjunction with DIR$ (see Section 1.7.2) to execute an I/O request. In the following example, the DIR$ macro actually generates the code to execute the QIO$ directive. It provides no QIO parameters of its own, but references the QIO directive parameter block at address QIOREF by supplying this label as an argument.

```
QIOREF:  QIO$    IO.RLB,6,2,,,AST01,<BUFFER,80.>
         .                           ; CREATE QIO DPB
         .
         .
READ1:   DIR$    #QIOREF             ; ISSUE I/O REQUEST
         .
         .
         .
READ2:   DIR$    #QIOREF             ; ISSUE I/O REQUEST
```

1.7.2 The QIOW$ Macro: Issuing an I/O Request and Waiting for an Event Flag

The QIOW$ macro is equivalent to a QIO$ followed by a WTSE$. It is more economical to issue a QIO And Wait request than to use the two separate macros. An event flag (efn parameter) must be specified with QIOW$.

1.7.3 The DIR$ Macro: Executing a Directive

The DIR$ (execute directive) macro has been implemented to allow a task to reference a previously defined directive parameter block. It is issued in the form:

```
DIR$   [addr][,err]
```

where:

addr	is the address of a directive parameter block to be used in the directive. If addr is not included, the DPB itself or the address of the DPB is assumed to already be on the stack. This parameter must be a valid source operand for a MOV instruction generated by the DIR$ macro.
err	is an optional argument which specifies the address of an error routine to which control branches if the directive is rejected. The branch occurs via a JSR PC, err if the C-bit is set, indicating rejection of the QIO directive.

1.7.4 The .MCALL Directive: Retrieving System Macros

.MCALL is a MACRO-11 assembler directive which is used to retrieve macros from the System Macro Library (LB:[1,1]RSXMAC.SML) for use during assembly. It must be included in every user task which invokes system macros. .MCALL is usually placed at the beginning of a user task source module and specifies, as arguments in the call, all system macros which must be made available from the library.

The following example illustrates the use of this directive:

```
        .MCALL  QIO$,QIO$S,DIR$,WTSE$S      ; MAKE MACROS AVAILABLE
            .
            .
            .
ATTACH: QIO$S   #IO.ATT,#6,,,IOSB,#AST02    ; ATTACH DEVICE
            .
            .
            .
QIOREF: QIO$    IO.RLB,6,,,IOSB,AST01,...   ; CREATE ONLY QIO DPB
            .
            .
            .
READ1:  DIR$    #QIOREF,DIRERR              ; ISSUE I/O REQUEST
            .
            .
            .
```

As many macro references as can fit on a line can be included in a single .MCALL directive. There is no limit to the number of .MCALL directives that can be specified.

1.7.5 The ALUN$ Macro: Assigning a LUN

The Assign LUN macro is used to associate a logical unit number with a physical device unit at run time. All three forms of the macro call may be used. Assign LUN does not request I/O for the physical device unit, nor does it attach the unit for exclusive use by the issuing task. It simply establishes a LUN-physical device unit relationship, so that when the task requests I/O for that particular LUN, the associated physical device unit is referenced. The macro is issued from a MACRO-11 program in the following way:

```
ALUN$   lun,dev,unt
```

where:

lun	is the logical unit number to be associated with the specified physical device unit.
dev	is the device name of the physical device or a logical device name assigned to a physical device (see MCR ASN command).
unt	is the unit number of that device specified above.

For example, to associate LUN 10 with terminal unit 2, the following macro call could be issued by the task:

```
ALUN$C  10.,TT,2
```

A unit number of 0 represents unit 0 for multi-unit devices such as disk, DECtape, or terminals; it indicates the single available unit for devices without multiple units, such as card readers and line printers.

Logical devices are SYSGEN options that allow the user to assign logical names to physical devices by means of the MCR command ASN. See the RSX-11M/M-PLUS MCR Operations Manual for a full description.

The example included below illustrates the use of the three forms of the ALUN$ macro.

```
;
; DATA DEFINITIONS
;

ASSIGN: ALUN$    10.,TT,2        ; GENERATE DPB
        .
        .
        .

;
; EXECUTABLE SECTION
;

        DIR$     #ASSIGN         ; EXECUTE DIRECTIVE
        .
        .
        .
        ALUN$C   10.,TT,2        ; GENERATE DPB IN SEPARATE PROGRAM
        .                        ; SECTION, THEN GENERATE CODE TO
        .                        ; EXECUTE THE DIRECTIVE
        .
        ALUN$S   #10.,#"TI,#0    ; GENERATE DPB ON STACK, THEN
                                 ; EXECUTE DIRECTIVE
```

1.7.5.1 **Physical Device Names** - The following list contains physical device names, listed alphabetically, that may be included as dev parameters:

Name	Device
AD	AD01-D Analog-to-Digital Converter (not supported in RSX-11M-PLUS systems)
AF	AFC11 Analog-to-Digital Converter (not supported in RSX-11M-PLUS systems)
AR	AR11 Laboratory Peripheral System (not supported in RSX-11M-PLUS systems)
BS	DT03/DT07 UNIBUS Switch (supported in RSX-11M-PLUS systems, only)
CD	CD11 Card Reader
CP	Central Processor Unit (CPU) in a multiprocessor system (supported in RSX-11M-PLUS systems, only)
CR	CR11/CM11 Card Reader
CT	TA11/TU60 Tape Cassette
DB	RP04, RP05, RP06 Pack Disk
DD	TU58 DECtape II

Name	Device
DF	RF11/RS11 Fixed-Head Disk
DK	RK11/RK05 Cartridge Disk
DL	RL11/RL01/RL02 Cartridge Disk
DM	RK611/RK06 and RK711/RK07 Cartridge Disk
DP	RP11/RP02/RP03 Pack Disk
DR	RM02/RM03 Pack Disk
DS	RS03 and RS04 Fixed-Head Disks
DT	TC11/TU56 DECtape
DX	RX11/RX01 Flexible Disk
DY	RX211/RX02 Flexible Disk
GR	VT11/VS60 Graphics Systems (not supported in RSX-11M-PLUS systems)
IC	ICS/ICR Industrial Control Local and Remote Subsystems (not supported in RSX-11M-PLUS systems)
IS	DSS/DRS Digital Input and Output Subsystems (not supported in RSX-11M-PLUS systems)
LA	LPA11-K Laboratory Peripheral Accelerator
LP	LA180/LP11/LS11/LV11 Line Printers
LS	LPS11 Laboratory Peripheral System (not supported in RSX-11M-PLUS systems)
MM	TU16/TE16/TU45/TU77/TM02/TM03 Magnetic Tape
MS	TS11/TS04 Magnetic Tape
MT	TM11/TU10/TU11 or TS03 Magnetic Tape
NL	The Null Device
PP	PC11 Paper Tape Punch
PR	PC11 or PR11 Paper Tape Reader
RX	PCL11-A/PCL11-B Receiver Port (supported in RSX-11M-PLUS systems, only)
TT	Terminals (regardless of interface)
TX	PCL11-A/PCL11-B Transmitter Port (supported in RSX-11M-PLUS systems, only)
UD	UDC11 Universal Digital Controller (not supported in RSX-11M-PLUS systems)
XB	DA11-B Parallel Unibus Link (not supported in RSX-11M-PLUS systems)

Name	Device
XL	DL11-E Asynchronous Communication Line Interface (not supported in RSX-11M-PLUS systems)
XM	DMC11 Synchronous Communication Line Interface
XP	DP11 Synchronous Communication Line Interface (not supported in RSX-11M-PLUS systems)
XQ	DQ11 Synchronous Communication Line Interface (not supported in RSX-11M-PLUS systems)
XU	DU11 Synchronous Communication Line Interface (not supported in RSX-11M-PLUS systems)
XW	DUP11 Synchronous Communication Line Interface
YH	DH11 Asynchronous Communications Line Multiplexer
YL	DL11-A/DL11-B/DL11-C/DL11-D/DL11-E Asynchronous Communications Line Interface (DL11-B, DL11-E, DP11, DQ11, and DU11 are not supported in RSX-11M-PLUS systems)
YZ	DZ11 Asynchronous Communications Line Multiplexer
ZA-ZZ	Reserved for customer use (not used by DIGITAL)

1.7.5.2 **Pseudo-Device Names** - A pseudo-device is a logical device which can normally be redirected by the operator to another physical device unit at any time, without requiring changes in programs which reference the pseudo-device. Dynamic redirection of a physical device unit affects all tasks in the system; reassignment by means of the MCR REASSIGN command affects only one task. The following pseudo-devices are supported, as indicated:

Code	Device
CL	Console listing, normally the line printer.
CO	Console output, normally the main operator's console.
LB	System library device, normally the device from which the system was bootstrapped. For example, LB: is the device which tasks such as TKB and MAC access for default library files.
NL	Null device.
NT	Network.
RD	Online reconfiguration pseudo device.
SP	Spooling scratch disk device.
SY	User default device. On non-multiuser systems, SY: is normally the disk from which the system was bootstrapped. On multiuser systems, SY: is normally the default login device.

Code	Device
TI	Pseudo-input terminal; the terminal from which a task was requested. The pseudo-device TI cannot be redirected, since such redirection would have to be handled on a per-task rather than a system-wide basis (i.e., change the TI device for one task without affecting the TI assignments for other tasks).
VT	Virtual terminal. Used by some RSX-11M-PLUS offspring tasks as TI: for command and data I/O. (Supported in RSX-11M-PLUS systems, only).

1.7.6 **The GLUN$ Macro: Retrieving LUN Information**

The Get LUN Information macro requests that information about a LUN-physical device unit association be returned in a 6-word buffer specified by the issuing task. Upon successful completion of the directive processing, the buffer contains the information listed in Table 1-1, as appropriate for the specific device. All three forms of the macro call may be used. It is issued from a MACRO-11 program in the following way:

```
GLUN$   lun,buf
```

where:

lun is the logical unit number associated with the physical device unit for which information is requested.

buf is the 6-word buffer to which information is returned.

For example, to request information on the disk unit associated with LUN 8, the following call is issued:

```
GLUN$C   8.,IOBUF
```

Table 1-1
Get LUN Information

Numerical Offset			Symbolic Offset			Contents
Word	Byte	Bit	Word	Byte	Bit	
0			G.LUNA			Name of device associated with LUN (ASCII bytes)
1	0			G.LUNU		Unit number of associated device
	1			G.LUFB		Driver flag value. Returned as 200 octal if the driver is resident, or as 0 if a loadable driver is not in the system

(continued on next page)

Table 1-1 (Cont.)
Get LUN Information

Numerical Offset			Symbolic Offset			Contents
Word	Byte	Bit	Word	Byte	Bit	
2			G.LUCW[1]			First device characteristics word:
		0	(U.CW1)		(DV.REC)	Unit record-oriented device (e.g., card reader, line printer) (1 = yes)
		1			(DV.CCL)	Cariage-control device (e.g., line printer, terminal) (1 = yes)
		2			(DV.TTY)	Terminal device (1 = yes)
		3			(DV.DIR)	Directory device (e.g., DECtape, disk) (1 = yes)
		4			(DV.SDI)	Single directory device (e.g., ANSI-standard magtape) (1 = yes)
		5			(DV.SQD)	Sequential device (e.g., ANSI-standard magtape) (1 = yes)
		6				Reserved
		7			(DV.UMD)	User-mode diagnostics supported (1 = yes)
		8			(DV.MBC)	Massbus device (1 = yes)
		9			(DV.SWL)	Unit software write-locked (1 = yes)
		10			(DV.ISP)	Input spooled device (1 = yes)
		11			(DV.OSP)	Output spooled device (1 = yes)
		12			(DV.PSE)	Pseudo-device (1 = yes)
		13			(DV.COM)	Device mountable as a communications channel for Digital network support (e.g., DP11, DU11) (1 = yes)
		14			(DV.F11)	Device mountable as a FILES-11 device (e.g., disk or DECtape) (1 = yes)
		15			(DV.MNT)	Device mountable (logical OR of bits 13 and 14) (1 = yes)
3			G.LUCW+02			Second device characteristics word:
			(U.CW2)		(U2.xxx)	Device-specific information

(continued on next page)

Table 1-1 (Cont.)
Get LUN Information

Numerical Offset			Symbolic Offset			Contents
Word	Byte	Bit	Word	Byte	Bit	
4			G.LUCW+04			Third device characteristics word:
			(U.CW3)		(U3.xxx)	Device-specific information[2]
5			G.LUCW+06			Fourth device characteristics word:
			(U.CW4)			Default buffer size (e.g., for disks, and line length for terminals).

[1] The following word and bit symbols shown in parenthesis are symbols used in defining and referencing corresponding items in the device Unit Control Block (UCB)

[2]. For mass storage devices, such as disks, DECtape, and DECtape II, this is the maximum logical block number. For the proper use of the RX211/RX02 flexible disk, it is important to be able to test the fourth device characteristics word to determine media density mode.

The example included below illustrates the use of the three forms of the GLUN$ macro.

```
;
; DATA DEFINITIONS
;

GETLUN: GLUN$   6,DSKBUF        ; GENERATE DPB
        .
        .
        .

;
; EXECUTABLE SECTION
;

        DIR$    #GETLUN         ; EXECUTE DIRECTIVE
        .
        .
        .
        GLUN$C  6,DSKBUF        ; GENERATE DPB IN SEPARATE PROGRAM
        .                       ; SECTION, THEN GENERATE CODE TO
        .                       ; EXECUTE THE DIRECTIVE
        .
        GLUN$S  #6,#DSKBUF      ; GENERATE DPB ON STACK, THEN
                                ; EXECUTE DIRECTIVE
```

1.7.7 The ASTX$S Macro: Terminating AST Service

The AST Service Exit macro is used to terminate execution of an asynchronous system trap (AST) service routine. All forms of the macro are provided. However, the S-form is preferred because it requires less space and executes at least as fast as the ASTX$ or ASTX$C forms of the macro. The macro is issued in the following way:

```
          ASTX$S  [err]
```

where: err is an optional argument which specifies the address of an error routine to which control branches if the directive is rejected.

On completion of the operation specified in this macro call, if another AST is queued and asynchronous system traps have not been disabled, then the next AST is immediately entered. Otherwise, the task's state before the AST was entered is restored (it is the AST service routine's responsibility to save and restore the registers it uses).

1.7.8 The WTSE$ Macro: Waiting for an Event Flag

The Wait For Single Event Flag macro instructs the system to suspend execution of the issuing task until the event flag specified in the macro call is set. This macro is extremely useful in synchronizing activity on completion of an I/O operation. All three forms of the macro call may be used. It is issued as follows:

```
          WTSE$   efn
```

where: efn is the event flag number

WTSE$ causes the task to be blocked from execution until the specified event flag is set. Frequently, an efn parameter is also included in a QIO$ macro call, and the event flag is set on completion of the I/O operation specified in that call. The following example illustrates task blocking until the setting of the specified event flag occurs. This example also illustrates the use of the three forms of the macro call.

```
;
; DATA DEFINITIONS
;
WAIT:   WTSE$   5               ; GENERATE DPB
IOSB:   .BLKW   2               ; I/O STATUS BLOCK
        .
        .
        .
;
; EXECUTABLE SECTION
;
        ALUN$S  #14.,#"MM       ; ASSIGN LUN 14 TO MAGTAPE UNIT ZERO
        QIO$C   IO.ATT,14.,5    ; ATTACH DEVICE
        DIR$    #WAIT           ; EXECUTE WAITFOR DIRECTIVE
        .
        .
        .
        QIO$S   #IO.RLB,#14.,#2,,#IOSB,,<#BUF,#80.>
        .                       ; READ RECORD, USE EFN2
        .
        .
```

```
WTSE$S  #2              ; WAIT FOR READ TO COMPLETE
.
.
.
QIO$C   IO.WLB,14.,3,,IOSB,,<BUF,80.>
.                       ; WRITE RECORD, USE EFN3
.
.
WTSE$C  3               ; WAIT FOR WRITE TO COMPLETE
.
.
.
QIO$C   IO.DET,14.      ; DETACH DEVICE
.
.
.
```

1.8 STANDARD I/O FUNCTIONS

The number of input/output operations that can be specified by means of the QIO directive is large. A particular operation can be requested by including the appropriate function code as the first parameter of a QIO macro call. Certain functions are standard. These functions are almost totally device-independent and can thus be requested for nearly every device described in this manual. Others are device-dependent and are specific to the operation of only one or two I/O devices. This section summarizes the function codes and characteristics of the following device-independent I/O operations:

- attach to an I/O device
- detach from an I/O device
- cancel I/O requests
- read a logical block
- read a virtual block
- write a logical block
- write a virtual block

For certain physical device units discussed in this manual, a standard I/O function may be described as being a NOP. This means that no operation is performed as a result of specifying the function, and an I/O status code of IS.SUC is returned in the I/O status block specified in the QIO macro call.

In the following descriptions and in formats shown in subsequent chapters, the five QIO directive parameters lun, efn, pri, isb, and ast are represented by the ellipsis (...) (see Section 1.5.1).

1.8.1 IO.ATT: Attaching to an I/O Device

The function code IO.ATT is specified by a user task when that task requires exclusive use of an I/O device. This function code is included as the first parameter of a QIO macro call in the following way:

```
QIO$C   IO.ATT,...
```

Successful completion of an IO.ATT request causes the specified physical device unit to be dedicated for exclusive use by the issuing task. This enables the task to process input or output in an unbroken stream and is especially useful on sequential, nonfile-oriented devices such as terminals, card readers, and line printers. An attached physical device unit remains under control of the issuing task until it is explicitly detached by that task. To detach the device the task can specify any LUN previously assigned to the attached device.

While a physical device unit is attached, the I/O driver for that unit dequeues only I/O requests issued by the task that issued the attach. Thus, a request to attach a device unit already attached by another task will not be processed until the attachment is broken and no higher priority request exists for the unit. A LUN that is associated with an attached physical device unit may not be reassigned by means of an Assign LUN directive except when at least one LUN is still assigned to the attached device.

If the task which issued an attach function exits or is aborted before it issues a corresponding detach, the Executive automatically detaches the physical device unit.

1.8.2 **IO.DET: Detaching from an I/O Device**

The function code IO.DET is used to detach a physical device unit which has been previously attached by means of an IO.ATT request for exclusive use of the issuing task. This function code is included as the first parameter of a QIO macro call in the following way:

```
          QIO$C   IO.DET,...
```

The LUN specifications of both IO.ATT and IO.DET must be the same, as in the following example, which also illustrates the use of "S" forms of several macro calls.

```
        .MCALL  ALUN$S,QIO$S
        ALUN$S  #14.,#"CR       ; ASSOCIATE CARD READER WITH LUN 14
        .
        .
        .
        QIO$S   #IO.ATT,#14.    ; ATTACH CARD READER
        .
        .
        .
LOOP:   QIO$S   #IO.RLB,#14.,... ; READ CARD
        .
        .
        .
        QIO$S   #IO.DET,#14.    ; DETACH CARD READER
```

1.8.3 **IO.KIL: Canceling I/O Requests**

The function IO.KIL is issued by a task to cancel all of that task's I/O requests for a particular physical device unit.

For I/O requests waiting for service - that is, in the I/O driver's queue - a status code of IE.ABO is returned in the I/O status block. An event flag is set, if specified. But any asynchronous system trap (AST) service routine that may have been specified is not initiated.

For I/O requests being processed by an I/O driver - other than the disk or DECtape drivers - the IE.ABO status code is returned. Other status information (byte count, etc.) is also returned in the I/O status block. An AST, if specified, is activated.

For disk, DECtape, or DECtape II I/O requests being processed when an IO.KIL is issued, the IO.KIL acts as a NOP. The request is allowed to complete, except in the case in which a DECtape transfer is blocked by a select error. Because disk and DECtape operate quickly, IO.KIL simply causes the return of IS.SUC in the I/O status block.

This function code is included as the first parameter of a QIO macro in the following way:

```
QIO$C   IO.KIL,...
```

IO.KIL is useful in such special cases as canceling an I/O request on a physical device unit from which a response is overdue (e.g., a read on a paper-tape reader).

1.8.4 IO.RLB: Reading a Logical Block

The function code IO.RLB is specified by a task to read a block of data from the physical device unit specified in the macro call. This function code is included as the first parameter of a QIO macro in the following way:

```
QIO$C   IO.RLB,...,<stadd,size,pn>
```

where:	stadd	is the starting address of the data buffer.
	size	is the data buffer size in bytes.
	pn	represents one to four optional parameters, used to specify such additional information as block numbers for certain devices.

1.8.5 IO.RVB: Reading a Virtual Block

The function code IO.RVB is used to read a virtual block of data from the physical device unit specified in the macro call. A "virtual" block indicates a relative block position within a file and is identical to a "logical" block for such sequential, record-oriented devices as terminals and card readers. For these sequential, record-oriented devices, IO.RVB is converted to IO.RLB before being issued.

NOTE

Any subfunction bits specified in the IO.RVB request (see Sections 2.3.1 and 3.3.1) are stripped off in this conversion.

It is recommended that all tasks use virtual rather than logical reads. However, if a virtual read is issued for a file-structured device (disk, DECtape, or DECtape II), the user must ensure that a file is open on the specified physical device unit. This function code is included as the first parameter of a QIO macro call in the following way:

```
          QIO$C   IO.RVB,...,<stadd,size,pn>
```

where:

stadd	is the starting address of the data buffer.
size	is the data buffer size in bytes.
pn	represents one to four optional parameters, used to specify such additional information as block numbers for certain devices.

1.8.6 **IO.WLB: Writing a Logical Block**

The function code IO.WLB is specified by a task to write a block of data to the physical device unit specified in the macro call. This function code is included as the first parameter of a QIO macro call in the following way:

```
          QIO$C   IO.WLB,...,<stadd,size,pn>
```

where:

stadd	is the starting address of the data buffer.
size	is the data buffer in bytes.
pn	represents one to four optional parameters, used to specify such additional information as block numbers or format control characters for certain devices.

1.8.7 **IO.WVB: Writing a Virtual Block**

The function code IO.WVB is used to write a virtual block of data to a physical device unit. A "virtual" block indicates a block position relative to the start of a file. For sequential, record-oriented devices such as terminals and line printers, the function IO.WVB is converted to IO.WLB.

NOTE

Any subfunction bits specified in the IO.WVB request (see Sections 2.3.1 and 3.3.1) are stripped off in this conversion.

It is recommended that all tasks use virtual rather than logical writes. However, if a virtual write is issued for a file-structured device (disk, DECtape, or DECtape II), the user must ensure that a file is open on the specified physical device unit. This function code is included as the first parameter of a QIO macro call in the following way:

```
          QIO$C   IO.WVB,...,<stadd,size,pn>
```

where:

stadd	is the starting address of the data buffer.
size	is the data buffer size in bytes.
pn	represents one to four optional parameters, used to specify such additional information as block numbers or format control characters for certain devices.

1.9 I/O COMPLETION

When an I/O request has been completed, either successfully or unsuccessfully, one or more actions may be taken by the Executive. Selection of return conditions depends on the parameters included in the QIO macro call. There are three major returns:

1. A significant event is declared on completion of an I/O operation. If an efn parameter was included in the I/O request, the corresponding event flag is set.

2. If an isb parameter was specified in the QIO macro call, a code identifying the type of success or failure is returned in the low-order byte of the first word of the I/O status block at the location represented by isb.

   This status return code is of the form IS.xxx (success) or IE.xxx (error). For example, if the device accessed by the I/O request is not ready, a status code of IE.DNR is returned in isb. The section below (Return Codes) summarizes general codes returned by most of the drivers described in this manual.

   If the isb parameter was omitted, the requesting task cannot determine whether the I/O request was successfully completed. A carry clear return from the directive itself simply means that the directive was accepted and the I/O request was queued, not that the actual input/output operation was successfully performed.

3. If an ast parameter was specified in the QIO macro call, a branch to the asynchronous system trap (AST) service routine which begins at the location identified by ast occurs on completion of the I/O operation. See Section 1.5.3 for a detailed description of AST service routines.

1.10 RETURN CODES

There are two kinds of status conditions recognized and handled by RSX-11M/M-PLUS when they occur in I/O requests:

- Directive conditions, which indicate the acceptance or rejection of the QIO directive itself

- I/O status conditions, which indicate the success or failure of the I/O operation

Directive conditions relevant to I/O operations may indicate any of the following:

- directive acceptance
- invalid buffer specification
- invalid efn parameter
- invalid lun parameter
- invalid DIC number or DPB size
- unassigned LUN
- insufficient memory

A code indicating the acceptance or rejection of a directive is returned to the directive status word at symbolic location $DSW. This location can be tested to determine the type of directive condition.

I/O conditions indicate the success or failure of the I/O operation specified in the QIO directive. I/O driver errors include such conditions as device not ready, privilege violation, file already open, or write-locked device. If an isb parameter is included in the QIO directive, identifying the address of a 2-word I/O status block, an I/O status code is returned in the low-order byte of the first word of this block on completion of the I/O operation. This code is a binary value which corresponds to a symbolic name of the form IS.xxx or IE.xxx. The low-order byte of the word can be tested symbolically, by name, to determine the type of status return. The correspondence between global symbolic names and directive and I/O completion status codes is defined in the system object module library. Local symbolic definitions may also be obtained via the DRERR$ and IOERR$ macros which reside in the System Macro Library and are summarized in Appendix B.

Binary values of status codes always have the following meaning:

Code	Meaning
Positive (greater than zero)	Successful completion
Zero	Operation still pending
Negative	Unsuccessful completion

A pending operation means that the I/O request is still in the queue of requests for the respective driver, or the driver has not yet completely serviced the request.

1.10.1 Directive Conditions

Table 1-2 summarizes the directive conditions which may be encountered in QIO directives. The acceptance condition is first, followed by error codes indicating various reasons for rejection, in alphabetical order.

Table 1-2
Directive Conditions

Code	Reason
IS.SUC	Directive accepted The first six parameters of the QIO directive were valid, and sufficient dynamic memory was available to allocate an I/O packet. The directive is accepted.
IE.ADP	Invalid address The I/O status block or the QIO DPB was outside of the issuing task's address space or was not aligned on a word boundary.
IE.IEF	Invalid event flag number The efn specification in a QIO directive was less than zero or greater than 96.
IE.ILU	Invalid logical unit number The lun specification in a QIO directive was invalid for the issuing task. For example, there were only five logical unit numbers associated with the task, and the value specified for lun was greater than five.
IE.SDP	Invalid DIC number or DPB size The directive identification code (DIC) or the size of the directive parameter block (DPB) was incorrect; the legal range for a DIC is from 1 through 127, and all DIC values must be odd. Each individual directive requires a DPB of a certain size. If the size is not correct for the particular directive, this code is returned. The size of the QIO DPB is always 12 words.
IE.ULN	Unassigned LUN The logical unit number in the QIO directive was not associated with a physical device unit. The user may recover from this error by issuing a valid Assign LUN directive and then reissuing the rejected directive.
IE.UPN	Insufficient dynamic memory There was not enough dynamic memory to allocate an I/O packet for the I/O request. The user can try again later by blocking the task with a Waitfor Significant Event directive. Note that Waitfor Significant Event is the only effective way for the issuing task to block its execution, since other directives that could be used for this purpose themselves require dynamic memory for their execution (e.g., Mark Time).

1.10.2 I/O Status Conditions

The following list summarizes status codes which may be returned in the I/O status block specified in the QIO directive on completion of the I/O request. The I/O status block is a 2-word block with the following format:

- The low-order byte of the first word receives a status code of the form IS.xxx or IE.xxx on completion of the I/O operation.
- The high-order byte of the first word is usually device-dependent; in cases where the user might find information in this byte helpful, this manual identifies that information.
- The second word contains the number of bytes transferred or processed if the operation is successful and involves reading or writing.

If the isb parameter of the QIO directive is omitted, this information is not returned.

The following illustrates a sample 2-word I/O status block on completion of a terminal read operation:

	1	0	Byte
Word 0	0	-10	
1	Number of bytes read		

where -10 is the status code for IE.EOF (end of file). If this code is returned, it indicates that input was terminated by typing CTRL/Z, which is the end-of-file termination sequence on a terminal.

To test for a particular error condition, the user generally compares the low-order byte of the first word of the I/O status block with a symbolic value as in the following:

```
          CMPB     #IE.DNR,IOSB
```

However, to test for certain types of successful completion of the I/O operation, the entire word value must be compared. For example, if a carriage return terminated a line of input from the terminal, a successful completion code of IS.CR is returned in the I/O status block. If an Escape (or Altmode) character was the terminator, a code of IS.ESC is returned. To check for these codes, the user should first test the low-order byte of the first word of the block for IS.SUC and then test the full word for IS.CC, IS.CR, IS.ESC, or IS.ESQ. (Other success codes which must be read in this manner are listed in Appendix B, Section B.1.2.)

Note that both of the following comparisons will test equal since the low-order byte in both cases is +1.

```
     CMP      #IS.CR,IOSB

     CMPB     #IS.SUC,IOSB
```

In the case of a successful completion where the carriage return is the terminal indicator (IS.CR), the following illustrates the status block:

	1	0	Byte
Word 0	15	+1	
1	Number of bytes read (excluding the CR)		

where 15 is the octal code for carriage return and +1 is the status code for successful completion.

The codes described in Table 1-3 are general status codes which apply to the majority of devices presented in subsequent chapters. Error codes specific to only one or two drivers are described only in relation to the devices for which they are returned. The list below describes successful and pending codes first, then error codes in alphabetical order.

Table 1-3
I/O Status Conditions

Code	Reason
IS.SUC	Successful completion The I/O operation specified in the QIO directive was completed successfully. The second word of the I/O status block can be examined to determine the number of bytes processed, if the operation involved reading or writing.
IS.PND	I/O request pending The I/O operation specified in the QIO directive has not yet been executed. The I/O status block is filled with zeros.
IE.ABO	Operation aborted The specified I/O operation was cancelled via IO.KIL while in progress or while still in the I/O queue.
IE.ALN	File already open The task attempted to open a file on the physical device unit associated with the specified LUN, but a file has already been opened by the issuing task on that LUN.

(continued on next page)

Table 1-3 (Cont.)
I/O Status Conditions

Code	Reason
IE.BAD	Bad parameter An illegal specification was supplied for one or more of the device-dependent QIO parameters (words 6-11). For example, a bad channel number or gain code was specified in an analog-to-digital converter I/O operation.
IE.BBE	Bad block on device One or more bad blocks were found by executing the BAD utility. Data cannot be written on bad blocks.
IE.BLK	Illegal block number An illegal block number was specified for a file-structured physical device unit. This code is returned, for example, if block 4800 is specified for an RK05 disk, on which legal block numbers extend from zero through 4799.
IE.BYT	Byte-aligned buffer specified. Byte alignment was specified for a buffer, but only word (or double-word) alignment is legal for the physical device unit. For example, a disk function requiring word alignment was requested, but the buffer was aligned on a byte boundary. Alternately, the length of a buffer was not an appropriate multiple of bytes. For example, all RP03 disk transfers must be an even multiple of four bytes.
IE.DAA	Device already attached The physical device unit specified in an IO.ATT function was already attached to the issuing task. This code indicates that the issuing task has already attached the desired physical device unit, not that the unit was attached by another task.
IE.DNA	Device not attached The physical device unit specified in an IO.DET function was not attached to the issuing task. This code has no bearing on the attachment status with respect to other tasks.

(continued on next page)

Table 1-3 (Cont.)
I/O Status Conditions

Code	Reason
IE.DNR	Device not ready The physical device unit specified in the QIO directive was not ready to perform the desired I/O operation. This code is often returned as the result of an interrupt timeout, that is, a "reasonable" amount of time has passed, and the physical device unit has not responded.
IE.EOF	End-of-file encountered An end-of-file mark, record, or control character was recognized on the input device.
IE.FHE	Fatal hardware error Controller is physically unable to reach the location where input/output is to be performed on the device. The operation cannot be completed.
IE.IFC	Illegal function A function code was specified in an I/O request that was illegal for the specified physical device unit. This code is returned if the task attempts to execute an illegal function or if, for example, a read function is requested on an output-only device, such as the line printer.
IE.NLN	File not open The task attempted to close a file on the physical device unit associated with the specified LUN, but no file was currently open on that LUN.
IE.NOD	Insufficient buffer space Dynamic storage space has been depleted, and there was insufficient buffer space available to allocate a secondary control block. For example, if a task attempts to open a file, buffer space for the window and file control block must be supplied by the Executive. This code is returned when there is not enough space for such an operation.
IE.OFL	Device off-line The physical device unit associated with the LUN specified in the QIO directive was not on-line. When the system was booted, a device check indicated that this physical device unit was not in the configuration.

(continued on next page)

Table 1-3 (Cont.)
I/O Status Conditions

Code	Reason
IE.OVR	Illegal read overlay request A read overlay was requested and the physical device unit specified in the QIO directive was not the physical device unit from which the task was installed. The read overlay function can only be executed on the physical device unit from which the task image containing the overlays was installed.
IE.PRI	Privilege violation The task which issued a request was not privileged to execute that request. For example, for the UDC11 and LPS11, a checkpointable task attempted to connect to interrupts or to execute a synchronous sampling function.
IE.SPC	Illegal address space The buffer requested for a read or write request was partially or totally outside the address space of the issuing task. Alternately a byte count of zero was specified.
IE.VER	Unrecoverable error After the system's standard number of retries have been attempted upon encountering an error, the operation still could not be completed. This code is returned in the case of parity, CRC, or similar errors.
IE.WCK	Write check error An error was detected during the check (read) following a write operation.
IE.WLK	Write-locked device The task attempted to write on a write-locked physical device unit.

1.11 POWERFAIL RECOVERY PROCEDURES FOR DISKS AND DECTAPE

Powerfail recovery recommendations for various devices are included in the following chapters, as appropriate, to assist the user in restoring device operation after a power failure. For disks and DECtape, it is recommended that power recovery ASTs be used. The AST service routine should provide a sufficient time delay, prior to returning for normal I/O operations, that will allow the disk to attain normal operating speed before actually attempting read and write operations.

If QIOs are being used for disk or DECtape I/O operations during powerfail recovery, an IE.DNR error status may be returned if the device is not up to operating speed when the request is issued. When this error is returned, it is recommended that the user task wait a sufficient time for the device to attain operating speed, and attempt the I/O operation again prior to reporting an error. For example, an RK05 disk may require approximately 1 minute to attain operating speed after a power failure.

CHAPTER 2

FULL-DUPLEX TERMINAL DRIVER

2.1 INTRODUCTION

Two terminal drivers are available as SYSGEN options for use in RSX-11M systems:

1. A compact, half-duplex terminal driver for use with a wide variety of terminals, containing all basic features required for RSX-11M terminal support. (This terminal driver is not available on RSX-11M-PLUS systems.) This terminal driver is described in Chapter 3.

2. A full-duplex terminal driver, as described in this chapter, containing all features of the half-duplex terminal driver, plus the following:

   - Full duplex operation
   - Type-ahead buffering
   - Eight-bit characters
   - Detection of hard receive errors
   - Increased byte transfer length (8128 bytes)
   - Additional terminal characteristics
   - Additional terminal types
   - Optional time-out on solicited and/or unsolicited input
   - Device-independent cursor control
   - Redisplay of prompt buffer upon CTRL-R or CTRL-U
   - Automatic XOFF character generation upon completion of a read (except when in the full-duplex mode), if requested
   - Added hardware support

Note that either terminal driver can be selected during RSX-11M V3.2 SYSGEN. RSX-11M-PLUS systems use the full-duplex terminal driver only.

Throughout the remainder of this chapter, references made to MCR can generally be applied to other command line intepreters (for example, DCL). In addition, the prompt displayed on a terminal in response to invoking a command line interpreter will be appropriate for the specific command line interpreter in use. For example, when MCR is invoked, the MCR prompt is displayed as follows:

```
MCR>
```

Terminal driver support is provided for a variety of terminal devices, as listed in Table 2-1. Subsequent sections describe each device in greater detail.

Table 2-1
Supported Terminal Devices

Model	Columns	Lines/ screen[1]	Character set	Baud range	Upper & lower case?	
					Send	Receive
ASR-33/35	72		64	110		
KSR-33/35	72		64	110		
LA30-P	80		64	300		
LA30-S	80		64	110-300		
LA36	132		64-96	110-300	yes	yes[2]
LA120	132		96	50-9600	yes	yes
LA180S	132		96	300-9600		yes
RT02	64	1	64	110-1200		
RT02-C	64	1	64	110-1200		
VT05B	72	20	64	110-2400	yes	
VT50	80	12	64	110-9600		
VT50H	80	12	64	110-9600		
VT52	80	24	96	110-9600	yes	yes
VT55	80	24	96	110-9600	yes	yes
VT61	80	24	96	110-9600	yes	yes
VT100	80-132	24	96	50-9600	yes	yes

[1] Applies only to video terminals.

[2] Only for 96-character terminal. The terminal driver supports the terminal interfaces summarized in Table 2-2. These interfaces are described in greater detail in Section 2.9. Programming is identical for all interfaces.

Table 2-2
Standard Terminal Interfaces

Model	Type
DH11	16-line multiplexer[1]
DH11-DM11-BB	16-line multiplexer with modem control[2]
DJ11	16-line multiplexer
DL11-A/B/C/D/E/W	Single-line interfaces[3]
DZ11	8-line multiplexer with modem control[2]

1 Direct memory access (DMA) is supported in the full-duplex terminal driver only.

2 Full-duplex control only. For example, in the USA, a Bell 103A-type modem.

3 DLV11 support with modem control is provided in the full-duplex terminal driver only.

Terminal input lines can have a maximum length of 8128 (8K minus 64) bytes. Extra characters of an input line that exceed the maximum line length generally become an unsolicited input line.

2.1.1 ASR-33/35 Teletypes [4]

The ASR-33 and ASR-35 Teletypes are asynchronous, hard-copy terminals. No paper-tape reader or punch capability is supported.

2.1.2 KSR-33/35 Teletypes [4]

The KSR-33 and KSR-35 Teletypes are asynchronous, hard-copy terminals.

2.1.3 LA30 DECwriters

The LA30 DECwriter is an asynchronous, hard-copy terminal that is capable of producing an original and one copy. The LA30-P is a parallel model and the LA30-S is a serial model.

2.1.4 LA36 DECwriter

The LA36 DECwriter is an asynchronous terminal that produces hard copy and operates in serial mode. It has an impact printer capable of generating multipart and special preprinted forms. The LA36 can receive and transmit both upper-case and lower-case characters.

[4] Teletype is a registered trademark of the Teletype Corporation.

2.1.5 LA120 DECwriter

The LA120 DECwriter is a hard-copy upper- and lower-case terminal, capable of printing multipart forms at speeds up to 180 characters-per-second. Serial communications speed is selected from 14 baud rates ranging from 50 to 9600 bps; split transmit and receive baud rates are supported by the terminal driver. Hardware features allow bidirectional printing for maximum printing speed, and user-selected features, including font size, line spacing, tabs, margins, and forms control. These functions can also be set-up by the system by issuing appropriate ANSI-standard escape sequences.

2.1.6 LA180S DECprinter

The LA180S DECprinter is a serial version of the LA180. It is a print-only device (it has no keyboard) that can generate multipart forms. The LA180S can print upper-case and lower-case letters.

2.1.7 RT02 Alphanumeric Display Terminal and RT02-C Badge Reader/ Alphanumeric Display Terminal

The RT02 is a compact, alphanumeric display terminal designed for applications in which source data is primarily numeric. A shift key permits the entry of 30 discrete characters, including upper-case alphabetic characters. The RT02 can, however, receive and display 64 characters.

The RT02-C model also contains a badge reader. This option provides a reliable method of identifying and controlling access to the PDP-11 or to a secure facility. Furthermore, data in a format corresponding to that of a badge (22-column fixed data) can be entered quickly.

2.1.8 VT05B Alphanumeric Display Terminal

The VT05B is an alphanumeric display terminal that consists of a CRT display and a self-contained keyboard. From a programming point of view, it is equivalent to other terminals, except that the VT05B offers direct cursor addressing.

2.1.9 VT50 Alphanumeric Display Terminal

The VT50 is an alphanumeric display terminal that consists of a CRT display and a keyboard. It is similar to the VT05B in operation, but does not offer direct cursor addressing.

2.1.10 VT50H Alphanumeric Display Terminal

The VT50H is an alphanumeric display terminal with CRT display, keyboard, and numeric pad. It offers direct cursor addressing. (The VT50H's direct cursor addressing is not compatible with that of the VT05B.)

2.1.11 VT52 Alphanumeric Display Terminal

The VT52 is an upper-and-lower-case alphanumeric terminal with numeric pad and direct cursor addressing. (The VT52's direct cursor addressing is compatible with that of the VT50H, not with that of the VT05B.) The VT52 can be configured with a built-in thermal printer.

2.1.12 VT55 Graphics Display Terminal

The VT55 is similar to the VT52 in its operation as an alphanumeric terminal. The VT55 offers graphics display features that are not supported by RSX-11M, although the system allows a knowledgeable task to access the explicitly special features of the VT55.

2.1.13 VT61 Alphanumeric Display Terminal

The VT61 is an "intelligent" upper-and-lower-case alphanumeric terminal with an integral microprocessor. It offers two 128-member character sets and numerous built-in functions for editing and forms preparation as well as a block-transfer mode. (None of these special features is supported by RSX-11M.)

2.1.14 VT100 DECscope

The VT100 DECscope is an upper- and lower-case alphanumeric keyboard/video display terminal. It is capable of displaying 24 lines of 80 to 132 characters (each line). Serial communications speed is selected from baud rates ranging from 50 to 9600 bps. Hardware features allow user selection of display characteristics and functions including smooth scroll, reverse video, etc. These functions can also be set-up by the system by issuing appropriate ANSI-standard escape sequences.

2.2 GET LUN INFORMATION MACRO

Word 2 of the buffer filled by the Get LUN Information system directive (the first characteristics word) contains the following information for terminals. A setting of 1 indicates that the described characteristic is true for terminals.

Bit	Setting	Meaning
0	1	Record-oriented device
1	1	Carriage-control device
2	1	Terminal device
3	0	File structured device
4	0	Single-directory device

Bit	Setting	Meaning
5	0	Sequential device
6	0	Reserved
7	0	User-mode diagnostics supported
8	0	Massbus device
9	0	Unit software write-locked
10	0	Input spooled device
11	0	Output spooled device
12	0	Pseudo device
13	0	Device mountable as a communications channel
14	0	Device mountable as a FILES-11 volume
15	0	Device mountable

Words 3 and 4 of the buffer are undefined. Word 5 indicates the default buffer size (the width of the terminal carriage or display screen).

2.3 QIO MACRO

Table 2-3 lists the standard and device-specific functions of the QIO macro that are valid for terminals. Some device-specific functions are options that may be selected during SYSGEN.

Two device-specific functions, SF.SMC and SF.GMC, have nonstandard function names. These names are retained for compatibility with RSX-11D.

Table 2-3
Standard and Device-Specific QIO Functions for Terminals

Format	Function
STANDARD FUNCTIONS:	
QIO$C IO.ATT,...	Attach device.
QIO$C IO.DET,...	Detach device.
QIO$C IO.KIL,...	Cancel I/O requests.

(continued on next page)

Table 2-3 (Cont.)
Standard and Device-Specific QIO Functions for Terminals

Format	Function
STANDARD FUNCTIONS: (Cont.)	
QIO$C IO.RLB,...,<stadd,size[,tmo]>	Read logical block (read typed input into buffer).
QIO$C IO.RVB,...,<stadd,size[,tmo]>	Read virtual block (read typed input into buffer).
QIO$C IO.WLB,...,<stadd,size,vfc>	Write logical block (print buffer contents).
QIO$C IO.WVB,...,<stadd,size,vfc>	Write virtual block (print buffer contents).
DEVICE-SPECIFIC FUNCTIONS:	
[1]QIO$C IO.ATA,...,<ast,[parameter2][,ast2]>	Attach device, specify unsolicited-input-character AST.
QIO$C IO.CCO,...,<stadd,size,vfc>	Cancel CTRL/O (if in effect), then write logical block.
[1]QIO$C SF.GMC,...,<stadd,size>	Get multiple characteristics.
[1]QIO$C IO.GTS,...,<stadd,size>	Get terminal support.
QIO$C IO.RAL,...,<stadd,size[,tmo]>	Read logical block, pass all bits.
QIO$C IO.RNE,...,<stadd,size[,tmo]>	Read logical block, do not echo.
[1]QIO$C IO.RPR,...,<stadd,size, [tmo],pradd,prsize,vfc>	Read logical block after prompt.
QIO$C IO.RST,...,<stadd,size[,tmo]>	Read logical block ended by special terminators.
QIO$C IO.RTT,...,<stadd,size, [tmo],table>	Read logical block ended by specified special terminator.
[1]QIO$C SF.SMC,...,<stadd,size>	Set multiple characteristics.

[1] SYSGEN options in RSX-11M.

(continued on next page)

Table 2-3 (Cont.)
Standard and Device-Specific QIO Functions for Terminals

Format	Function
DEVICE-SPECIFIC FUNCTIONS: (Cont.)	
QIO$C IO.WAL,...,<stadd,size,vfc>	Write logical block, pass all bits.
[1]QIO$C IO.WBT,...,<stadd,size,vfc>	Write logical block, break through any I/O conditions at terminal.

where:	ast	is the entry point for an unsolicited-input-character AST.
	parameter 2	is a number that can be used to identify this terminal as the input source upon entry to an unsolicited character AST routine.
	ast2	is the entry point for an unsolicited CTRL/C AST.
	pradd	is the starting address of the byte buffer where the prompt is stored.
	prsize	is the size of the pradd prompt buffer in bytes. The specified size must be greater than zero and less than or equal to 8128. The buffer must be within the task's address space.
	size	is the size of the stadd data buffer in bytes. The specified size must be greater than zero and less than or equal to 8128. The buffer must be within the task's address space. For SF.GMC, IO.GTS, and SF.SMC functions, size must be an even value.
	stadd	is the starting address of the data buffer. The address must be word-aligned for SF.GMC, IO.GTS, and SF.SMC; otherwise stadd may be on a byte boundary.
	table	is the address of the 16-word special terminator table.
	tmo	is an optional timeout count in ten-second intervals for the full-duplex terminal driver. If zero is specified, no timeout can occur. Timeout is the maximum time allowed between two input characters before the read is aborted.
	vfc	is a character for vertical format control from Table 2-11 (see Section 2.7).

[1] SYSGEN options in RSX-11M.

2.3.1 Subfunction Bits

Most device-specified functions supported by terminal drivers described in this section are selected using "subfunction bits". One or more functions can be selected by ORing their relative bits in a QIO function. Table 2-4 contains a listing of device-specific QIO functions and relative subfunction bits that can be issued.

Each subfunction bit and subfunction selected when it is included in a QIO function is listed as follows:

Symbolic Name	Subfunction
TF.AST	unsolicited-input-character AST
TF.BIN	binary prompt
TF.CCO	cancel CTRL/O
TF.ESQ	recognize escape sequences
TF.NOT	unsolicited input AST notification; unsolicited characters are stored in the type-ahead buffer until they are read by the task
TF.RAL	read all bits
TF.RCU	restore cursor position
TF.RNE	read with no echo
TF.RST	read with special terminators
TF.TMO	read with timeout
TF.WAL	write all bits
TF.WBT	break-through write
TF.XCC	CTRL/C starts a command line interpreter command line (command line characters are not sent to the task)
TF.XOF	send XOFF

Table 2-4 lists subfunction bits that can be ORed with QIO functions to invoke device-specific functions. Additional details for using subfunction bits are included in Section 2.3.2.

If a task invokes a subfunction bit that is not supported on the system, the subfunction bit is ignored, but the QIO request is not rejected. For example, if break-through write (TF.WBT) is not selected, an IO.WBT or IO.WLB!TF.WBT function is interpreted as an IO.WLB function.

The following example is a QIO request using more than one subfunction bit: a nonechoed (TF.RNE) read, terminated by a special terminator character (TF.RST), followed by a prompt.

```
QIO$C IO.RPR!TF.RNE!TF.RST,...,<stadd,size,,pradd,prsize,vfc>
```

2.3.2 Device-Specific QIO Functions

Some device-specific functions described in this section are SYSGEN options. All except SF.GMC, IO.RPR, SF.SMC, IO.RTT, and IO.GTS can be issued by ORing a particular subfunction bit with another QIO function. These subfunction bits are specified in the following descriptions; subfunction bits are described in general in Section 2.3.1.

In addition to the device-specific QIO functions, this section also describes use of subfunction bits TF.ESQ, TF.BIN, and TF.XOF.

Table 2-4
Subfunction Bits

Function	Equivalent Subfunctions	Allowed Subfunction Bits													
		TF.AST	TF.BIN	TF.CCO	TF.ESQ	TF.NOT	TF.RAL	TF.RCU	TF.RNE	TF.RST	TF.TMO	TF.WAL	TF.WBT	TF.XCC	TF.XOF
STANDARD FUNCTIONS															
IO.ATT		X			X										
IO.DET															
IO.KIL															
IO.RLB							*		X	*	X				X
IO.RVB							**		**	**	**				**
IO.WLB				X				X				***	X		
IO.WVB				**				**				**	**		
DEVICE-SPECIFIC FUNCTIONS															
IO.ATA	IO.ATT!TF.AST				X	X								X	
IO.CCO	IO.WLB!TF.CCO											***	X		
SF.GMC															
IO.GTS															
IO.RAL	IO.RLB!TF.RAL								X	*	X				X
IO.RNE	IO.RLB!TF.RNE						*			*	X				X
IO.RPR			X				*		X	*	X				X
IO.RST	IO.RLB!TF.RST						*		X		X				X
IO.RTT							*		X		X				X
SF.SMC															
IO.WAL	IO.WLB!TF.WAL			***				***					***		
IO.WBT	IO.WLB!TF.WBT			X				X				***			

*Exercise great care when using Read All and Read with Special Terminators together. Obscure problems can result.

**These subfunctions are allowed but are not effective. They are stripped off when the read or write virtual operation is converted to a read or write logical operation.

***During a write-pass-all operation (IO.WAL or IO.WLB!TF.WAL) the terminal driver outputs characters without interpretation; it does not keep track of cursor position.

2.3.2.1 **IO.ATA** - IO.ATA is a variation of the Attach function. The use of this function is eased by the addition of TF.NOT and TF.XCC subfunction bits, described later in this section. IO.ATA specifies asynchronous system traps (ASTs) to process unsolicited input characters. When called as follows:

```
QIO$C   IO.ATA,...,<[ast],[parameter2][,ast2]>
```

NOTE

A minimum of one AST parameter (ast or ast2) is required.

This function attaches the terminal and identifies "ast" and "ast2" as entry points for an unsolicited-input-character AST. Control passes to ast whenever an unsolicited character (other than CTRL/Q, CTRL/S, CTRL/X or CTRL/O) is input. If the ast2 parameter is specified, an unsolicited CTRL/C character will result in entering the AST specified in that parameter. If ast2 is not specified, an unsolicited CTRL/C will result in entering the AST specified in the ast parameter.

Unless the TF.XCC subfunction is specified, CTRL/C is trapped by the task and does not reach MCR. Thus, any task that uses IO.ATA without the TF.XCC subfunction should recognize some input sequence as a request to terminate; otherwise, MCR can not be invoked to abort the task in case of difficulty.

Note that either ast2 or TF.XCC can be used, but not both in the same QIO request. If both are specified in the request, an IE.SPC error is returned.

Upon entry to the AST routines, the unsolicited character and parameter 2 are in the top word on the stack as shown below. That word must be removed from the stack before exiting the AST.

SP+10	Event flag mask word
SP+06	PS of task prior to AST
SP+04	PC of task prior to AST
SP+02	Task's directive status word
SP+00	Unsolicited character in low byte; parameter 2, in the high byte, is a user-specified value that can be used to identify individual terminals in a multiterminal environment

The processing of unsolicited input ASTs is eased through the use of TF.NOT and TF.XCC subfunction bits. When TF.XCC is included in the IO.ATA function, all characters (except CTRL/C) are handled in the manner previously described. CTRL/C marks the beginning of a command line interpreter (CLI) line that will be processed by a CLI task (for example, MCR); none of the characters, including the CTRL/C, are sent to the task issuing the function.

When unsolicited terminal input (except CTRL/C) is received by the full-duplex terminal driver and the TF.NOT subfunction is used, the resulting AST serves only as notification of unsolicited terminal input; the terminal driver does not pass the character to the task. Upon entry to the AST service routine, the high byte of the first word on the stack identifies the terminal causing the AST (parameter 2). After the AST has been effected, the AST becomes "disarmed" until a read request is issued by the task. If multiple characters are received before the read request is issued, they are stored in the type-ahead buffer. Once the read request is received, the contents of the type-ahead buffer, including the character causing the AST, is returned to the task; the AST is then "armed" again for new unsolicited input characters. Thus, the use of the TF.NOT subfunction allows a task to monitor more than one terminal for unsolicited input without the need to continuously read each terminal for possible unsolicited input. Note that the TF.NOT subfunction cannot be used with the CTRL/C AST; an unsolicited CTRL/C character flushes the typeahead buffer.

See the <u>RSX-11M/11M-PLUS Executive Reference Manual</u> for further details on ASTs.

IO.ATA is equivalent to IO.ATT ORed with the subfunction bit TF.AST.

2.3.2.2 **IO.ATT!TF.ESQ** - The task issuing this function attaches a terminal and notifies the driver that it recognizes escape sequences input from that terminal. Escape sequences are recognized only for solicited input. (See Section 2.6 for a discussion of escape sequences.)

If the terminal has not been declared capable of generating escape sequences, IO.ATT!TF.ESQ has no effect other than attaching the terminal. No escape sequences are returned to the task because any

ESC sent by the terminal acts as a line terminator. The SF.SMC function or the MCR SET /ESCSEQ command are used to declare the terminal capable of generating escape sequences (see Table 2-5 and Section 2.3.2.12).

2.3.2.3 **IO.CCO** - This write function directs the driver to write to the terminal regardless of a CTRL/O condition that may be in effect. If CTRL/O is in effect, it is cancelled before the write is done.

IO.CCO is equivalent to IO.WLB!TF.CCO.

2.3.2.4 **SF.GMC** - The Get Multiple Characteristics function returns terminal characteristics information, as follows:

```
     QIO$C SF.GMC,...,<stadd,size>
```

where stadd is the starting address of a data buffer of length "size" bytes. Each word in the buffer has the form:

```
     .BYTE   characteristic-name
     .BYTE   0
```

where characteristic-name is one of the bit names given in Table 2-5. The value returned in the high byte of each byte-pair is 1 if the characteristic is true for the terminal and 0 if it is not true.

For the TC.TTP characteristic (terminal type), one of the values shown in Table 2-6 is returned in the high byte.

Table 2-5
Full-Duplex Terminal Driver-Terminal Characteristics for SF.GMC and SF.SMC Functions

Bit Name	Octal Value	Meaning (if asserted)	Corresponding MCR Command
TC.ACR	24	Wrap-around mode	SET /WRAP=TTnn:
TC.BIN	65	Binary input mode (read-pass-all) no characters are interpreted as control characters.	SET /RPA=TTnn:
TC.CTS	72	Suspend output to terminal 0 = resume 1 = suspend	--
TC.DLU	41	Dial-up line	SET /REMOTE=TTnn:
TC.ESQ	35	Input escape sequence recognition	SET /ESCSEQ=TTnn:
TC.FDX	64	Full-duplex mode	SET /FDX=TTnn:
TC.HFF	17	Hardware form-feed capability (If 0, form-feeds are simulated using TC.LPP.)	SET /FORMFEED=TTnn:

(continued on next page)

Table 2-5 (Cont.)
Full-Duplex Terminal Driver-Terminal Characteristics for SF.GMC and SF.SMC Functions

Bit Name	Octal Value	Meaning (if asserted)	Corresponding MCR Command
TC.HFL	13	Number of fill characters to insert after a carriage return (0-7=x) (Use a value of 7 for the LA30-S.)	SET /HFILL=TTnn:x
TC.HHT	21	Horizontal tab capability (if 0, horizontal tabs are simulated using spaces.)	SET /HHT=TTnn:
TC.HLD[1]	44	Hold screen mode	SET /HOLD=TTnn:
TC.ISL	6	Subline on interface (=0-15) (Read only)	--
TC.LPP	2	Page length (1-255.=x)	SET /LINES=TTnn:x
TC.NEC	47	Echo suppressed	SET /ECHO=TTnn:
TC.PRI	51	Terminal is privileged (Read only)	SET /PRIV=TTnn:
TC.RAT	7	Type-ahead buffer: 0 = 1-character type-ahead 1 = 36. character type-ahead	SET /TYPEAHEAD=TTnn:
TC.RSP[2]	3	Receiver speed (bits-per-second)	SET /SPEED=TTnn:rcv:xmit
TC.SCP	12	Terminal is a scope (CRT)	SET /CRT=TTnn:
TC.SLV	50	Terminal is a slave If set to 0 (SET /NOSLAVE=TTnn:), the terminal's type-ahead buffer is cleared	SET /SLAVE=TTnn:
TC.SMR	25	Upper-case conversion disabled	SET /LOWER=TTnn:
TC.TBF	71	Type-ahead buffer count read, or flush	--

TC.TTP	10	Terminal type (=0-255.=x)	SET /X=TTnn:
			SET /TERM=TTnn:x

TC.VFL	14	Send 4 fill characters after line feed	SET /VFILL=TTnn:
TC.WID[3]	1	Page width (=1-255.=x)	SET /BUF=TTnn:x
TC.XSP[2]	4	Transmitter speed (bits-per-second)	SET /SPEED=TTnn:rcv:xmit
TC.8BC	67	Pass 8 bits on input, even if not binary input mode (TC.BIN)	SET /EBC=TTnn:

[1] Effective for VT5x, VT61, and VT100, only.

[2,3] See next page.

[2] TC.RSP, TCXSP, and corresponding MCR SET /SPEED command values for terminal receiver and transmitter speeds are listed below:

NOTE

The MCR SET /SPEED command requires parameters for both receiver (rcv) and transmitter (xmit) baud rates, as follows:

```
SET /SPEED=TTnn:rcv:xmit
```

TC.RSP or TC.XSP value	Actual baud rate (in bps) and valid MCR SET /SPEED values
S.0	(disabled)
S.50	50 (Baudot codes are not supported)
S.75	75
S.110	110
S.134	134
S.150	150
S.200	200
S.300	300
S.600	600
S.1200	1200
S.1800	1800
S.2000	2000
S.2400	2400
S.3600	3600
S.4800	4800
S.7200	7200
S.9600	9600
S.EXTA (DH11 external speed A)	--
S.EXTB (DH11 external speed B)	--

NOTE

Speed can be set only on DH11 and DZ11 controllers. DZ11 transmitter and receiver speeds must be equal (no split baud rates permitted).

[3] Unsolicited input that fills the buffer before a terminator is received is likely invalid. When this happens, the driver discards the input by simulating a CTRL/U and echoing ^U.

The TC.TPP characteristic, when read by the terminal driver, sets implicit values for terminal characteristics TC.LPP, TC.WID, TC.HFF, TC,HHT, TC.VFL, and TC.SCP as shown in Table 2-6. These values can be changed (overridden) by subsequent Set Multiple Characteristics requests. In addition, TC.TPP is used by the terminal driver to determine cursor positioning commands, as appropriate.

Table 2-6
Bit TC.TTP (Terminal Type) Values Set by SF.SMC
and Returned by SF.GMC

Octal Value	Symbolic	Terminal Type	Implicit Characteristics						
			TC.LPP	TC.WID	TC.HFF	TC.HHT	TC.HFL	TC.VFL	TC.SCP
0	T.UNKO	Unknown							
1	T.AS33	ASR33	66	72			1		
2	T.KS33	KSR33	66	72			1		
3	T.AS35	ASR35	66	72			1		
4	T.L30S	LA30S	66	80			7		
5	T.L30P	LA30P	66	80					
6	T.LA36	LA36	66	132					
7	T.VT05	VT05	20	72		1		1	1
10	T.VT50	VT50	12	80		1			1
11	T.VT52	VT52	24	80		1			1
12	T.VT55	VT55	24	80		1			1
13	T.VT61	VT61	24	80		1			1
14	T.L180	LA180S	66	132	1				
15	T.V100	VT100	24	80		1			1
16	T.L120	LA120	66	132	1				

NOTES

- Octal values 0-177 are reserved by DIGITAL. Values 200-377 are available for customer use to define non-DIGITAL terminals.
- Implicit characteristics are shown as supported by the driver. Values not shown are not automatically set by the driver. An "unknown" terminal type has no implicit characteristics.

The TC.CTS characteristic returns the present suspend (CTRL/S), resume (CTRL/Q), or suppress (CTRL/O) state set via the SF.SMC function. Values returned are as follows:

Value Returned	State
0	Resume (CTRL/Q)
1	Suspend (CTRL/S)
2	Suppress (CTRL/O)
3	Both suppress and suspend

When a value of 0 is used with the SF.SMC function, the suspend state is cleared; a value of 1 selects the suspend state.

The TC.TBF characteristic returns the number of unprocessed characters in the type-ahead buffer for the specified terminal. This allows tasks to determine if any characters were typed that did not require AST processing. In addition, the value returned can be used to read the exact number of characters typed, rather than a typical value of 80. or 132. characters for the terminal.

NOTES

1. It is necessary that the task attach the terminal to receive characters from the type-ahead buffer.

2. The capacity of the type-ahead buffer is 36. characters, maximum.

3. Using TC.TBF in an SF.SMC function will flush the type-ahead buffer.

2.3.2.5 **IO.GTS** - This function is a Get Terminal Support request that returns information to a four-word buffer specifying which SYSGEN-option features are part of the terminal driver. Only two of these words are currently defined. Table 2-7 gives details for these words. The IO.GTS function is a SYSGEN option. If IO.GTS is issued on a system without IO.GTS support, IE.IFC is returned in the I/O status block.

Table 2-7
Information Returned by Get Terminal Support (IO.GTS) QIO

Bit	Octal Value	Mnemonic	Meaning When Set to 1
Word 0 of Buffer:			
0	1	F1.ACR	Automatic CR/LF on long lines
1	2	[1]F1.BTW	Break-through write
2	4	F1.BUF	Checkpointing during terminal input
3	10	[1]F1.UIA	Unsolicited-input-character AST
4	20	F1.CCO	Cancel CTRL/O before writing
5	40	[1]F1.ESQ	Recognize escape sequences in solicited input
6	100	F1.HLD	Hold-screen mode
7	200	[1]F1.LWC	Lower-to-upper-case conversion
8	400	F1.RNE	Read with no echo
9	1000	[1]F1.RPR	Read after prompting
10	2000	F1.RST	Read with special terminators
11	4000	[1]F1.RUB	CRT rubout
12	10000	F1.SYN	CTRL/R terminal synchronization
13	20000	F1.TRW	Read all and write all
14	40000	F1.UTB	Input characters buffered in task's address space
15	100000	F1.VBF	Variable-length terminal buffers
Word 1 of Buffer:			
0	1	[1]F2.SCH	Set characteristics QIO (SF.SMC)
1	2	[1]F2.GCH	Get characteristics QIO (SF.GMC)
2	4	F2.DCH	Dump/restore characteristics
3	10	F2.DKL	Historical IAS/RSX-11D IO.KIL
4	20	F2.ALT	Altmode is echoed
5	40	F2.SFF	Formfeed can be simulated
6	100	[1]F2.CUP	Cursor positioning

[1] SYSGEN options on RSX-11M systems

The various symbols used by the IO.GTS, SF.GMC, and SF.SMC functions are defined in a system module, TTSYM. These symbols include: F1.xxx and F2.xxx (Table 2-7); T.xxxx (Table 2-6); TC.xxx (Table 2-5); and the SE.xxx error returns described in Table 2-8, Section 2.4. These symbols may be defined locally within a code module by using:

```
     .MCALL   TTSYM$
       .
       .
       .
     TTSYM$
```

Symbols that are not defined locally are automatically defined by the Task Builder.

Octal values shown for the symbols are subject to change. Therefore, it is recommended that only the symbolic names be used.

2.3.2.6 **IO.RAL** - The Read All function causes the driver to pass all bits to the requesting task. The driver does not intercept control characters or mask out the "parity" (high-order) bit. For example, CTRL/C, CTRL/Q, CTRL/S, CTRL/O, and CTRL/Z are passed to the program and are not interpreted by the driver.

NOTE

IO.RAL echoes the characters that are read. The terminal driver in Version 2 of RSX-11M did not echo a Read All. To read all bits without echoing, use IO.RAL!TF.RNE.

IO.RAL is equivalent to IO.RLB ORed with the subfunction bit TF.RAL. The IO.RAL function can be terminated only by a full character count (input buffer full).

2.3.2.7 **IO.RNE** - The IO.RNE function reads terminal input characters without echoing the characters back to the terminal for immediate display. This feature can be used when typing sensitive information (for example, a password or combination) or when reading a badge with the RT02-C terminal.

(Note that the no-echo mode can also be selected via the SF.SMC function; see Table 2-5, bit TC.NEC.)

CTRL/R is ignored while an IO.RNE is in progress.

The IO.RNE function is equivalent to IO.RLB ORed with the subfunction bit TF.RNE.

2.3.2.8 **IO.RPR** - The IO.RPR Read After Prompt functions as an IO.WLB (to write a prompt to the terminal) followed by IO.RLB. However, IO.RPR differs from this combination of functions as follows:

- System overhead is lower with the IO.RPR because only one QIO is processed.

- When using the IO.RPR function, there is no "window" during which a response to the prompt may be ignored. Such a window occurs if IO.WAL/IO.RLB is used, because no read may be posted at the time the response is received.
- If the issuing task is checkpointable, it can be checkpointed during both the prompt and the read requested by the IO.RPR.
- A CTRL/O that may be in effect prior to issuing the IO.RPR is cancelled before the prompt is written.

Subfunction bits may be ORed with IO.RPR to write the prompt as a Write All (TF.BIN) and to send XOFF after the read (TF.XOF). In addition, read subfunction bits TF.RAL, TF.RNE, and TF.RST can be used with IO.RPR.

NOTE

If an IO.RPR function is in progress when the driver receives a CTRL/R or CTRL/U, the prompt is redisplayed.

2.3.2.9 **IO.RPR!TF.BIN** - This function results in a read after a "binary" prompt; that is, a prompt is written by the driver with no character interpretation (as if it were issued as an IO.WAL).

2.3.2.10 **IO.RPR!TF.XOF** - This function causes the driver to send an XOFF to the terminal after its prompt-and-read. The XOFF or CTRL/S may have the effect of inhibiting input from the terminal, if the terminal recognizes XOFF for this purpose. TF.XOF is ignored when full-duplex I/O is in use.

2.3.2.11 **IO.RST** - This function is similar to an IO.RLB, except certain special characters terminate the read. These characters are in the ranges 0-037 and 175-177. The driver does not interpret the terminating character, with certain exceptions.[1] For example, a horizontal TAB (011) is not expanded, a RUBOUT (or DEL, 177) does not erase, and a CTRL/C does not produce an MCR prompt.

Upon successful completion of an IO.RST request that was not terminated by filling the input buffer, the first word of the I/O status block contains the terminating character in the high byte and the IS.SUC status code in the low byte. The second word contains the number of bytes contained in a buffer. The terminating character is not put in the buffer.

IO.RST is equivalent to IO.RLB!TF.RST.

---

[1] If upper-lower-case conversion is disabled, characters 175 and 176 do not act as terminators. CTRL/O, CTRL/Q, and CTRL/S (017, 021, and 023, respectively) are not special terminators. The driver interprets them as output control characters in a normal manner.

2.3.2.12 **SF.SMC** - This function enables a task to set and reset the characteristics of a terminal. Set Multiple Characteristics is the inverse function of SF.GMC. Like SF.GMC, it is called in the following way:

```
     QIO$C SF.SMC,...,<stadd,size>
```

where stadd is the starting address of a buffer of length "size" bytes. Each word in the buffer has the form:

```
     .BYTE characteristic-name
     .BYTE value
```

where "characteristic-name" is one of the symbolic bit names given in Table 2-5, and "value" is either 0 (to clear a given characteristic) or 1 (to set a characteristic). Table 2-5 notes the restrictions that apply to these characteristics.

If the "characteristic-name" is TC.TTP (terminal type), "value" can have any of the values listed in Table 2-6.

A nonprivileged task can only issue an SF.SMC request for its own terminal (TI:). A privileged task can issue SF.SMC to any terminal.

Terminal output can be suspended or resumed (simulated CTRL/S and CTRL/Q, respectively) by specifying an appropriate value for TC.CTS. A value of 0 resumes output and a value of 1 suspends output.

Specifying any value for TC.TBF flushes (clears) the type-ahead buffer (forces the type-ahead buffer count to 0).

2.3.2.13 **IO.RTT** - This QIO function reads characters in a manner like the IO.RLB function, except a user-specified character terminates the read operation. The specified character's code can range from 0-377. It is user-designated by setting the appropriate bit in a 16-word table that corresponds to the desired character. Multiple characters can be specified by setting their corresponding bits.

The 16-word table starts at the address specified by the table parameter. The first word contains bits that represent the first 16 ASCII character codes (0-17); similarly, the second word contains bits that represent the next 16 character codes (20-37), and so-on, through the sixteenth word, bit 15, which represents character code 377. For example, to specify the % symbol (code 045) as a read terminator character, set bit 05 in the third word, since the third word of the table contains bits representing character codes 40-57.

If the CTRL/S (023), CTRL/Q (021), and/or any characters whose codes are greater than 177 is/are desired as the terminator character(s), the terminal must be set to read-pass-all operation (TC.BIN=1), or read-pass 8-bits (TC.8BC), as listed in Table 2-5.

The optional timeout count parameter can be included, as desired.

2.3.2.14 **IO.WAL** - The Write All function causes the driver to pass all output from the buffer without interpretation. It does not intercept control characters. Long lines are not wrapped around if input/output wrap-around has been selected.

IO.WAL is equivalent to the IO.WLB!TF.WAL function.

2.3.2.15 **IO.WBT** - IO.WBT function instructs the driver to write the buffer regardless of the I/O status of the receiving terminal. If an IO.WBT function is issued on a system that does not support IO.WBT, it is treated as an IO.WLB function.

- If another write function is currently in progress, it finishes the current request and the IO.WBT is the next write issued. The effect of this is that IO.WBT functions can be stopped by a CTRL/S. Therefore, it may be desirable for tasks to timeout on IO.WBT operations.
- If a read is currently posted, the IO.WBT proceeds, and an automatic CTRL/R is performed to redisplay any input that was received before the break-through write was effected (if the terminal is not in the full-duplex mode).
- CTRL/O, if in effect, is cancelled.
- An escape sequence that was interrupted is rubbed out.

An IO.WBT function cannot break through another IO.WBT that is in progress.

Break-through write may only be issued by a privileged task. The privileged MCR command BRO (broadcast) uses IO.WBT.

2.4 STATUS RETURNS

Table 2-8 lists error and status conditions that are returned by the terminal driver to the I/O status block.

Most RSX-11M error and status codes returned are byte values. For example, the value for IS.SUC is 1. However, IS.CC, IS.CR, IS.ESC, and IS.ESQ are word values. When any of these codes are returned, the low byte indicates successful completion, and the high byte shows what type of completion occurred.

To test for one of these word-value return codes, first test the low byte of the first word of the I/O status block for the value IS.SUC. Then, test the full word for IS.CC, IS.CR, IS.ESC, or IS.ESQ. (If the full word tests equal to IS.SUC, then its high byte is zero, indicating byte-count termination of the read.)

The "error" return IE.EOF may be considered a successful read since characters returned to the task's buffer can be terminated by a CTRL/Z character.

The SE.xxx codes are returned by the SF.GMC and SF.SMC functions as described in Sections 2.3.2.4 and 2.3.2.12. When any of these codes are returned, the low byte in the first word in the I/O status block will contain IE.ABO. The second IOSB word contains an offset (starting from 0) to the byte in error in the QIO's stadd buffer.

Table 2-8
Terminal Status Returns

Code	Reason
IE.EOF	Successful completion on a read with end-of-file The line of input read from the terminal was terminated with the end-of-file character CTRL/Z. The second word of the I/O status block contains the number of bytes read before CTRL/Z was seen. The input buffer contains those bytes.
IS.SUC	Successful completion The operation specified in the QIO directive was completed successfully. If the operation involved reading or writing, you can examine the second word of the I/O status block to determine the number of bytes processed. The input buffer contains those bytes.
IS.CC	Successful completion on a read The line of input read from the terminal was terminated by a CTRL/C. The input buffer contains the bytes read.
IS.CR	Successful completion on a read The line of input read from the terminal was terminated by a carriage return. The input buffer contains the bytes read.
IS.ESC	Successful completion on a read The line of input read from the terminal was terminated by an Altmode character. The input buffer contains the bytes read.
IS.ESQ	Successful completion on a read The line of input read from the terminal was terminated by an escape sequence. The input buffer contains the bytes read and the escape sequence.
IS.PND	I/O request pending The operation specified in the QIO directive has not yet been executed. The I/O status block is filled with zeros.
IS.TMO	Successful completion on a read The line of input read from the terminal was terminated by a time-out (TF.TMO was set and the specified time interval was exceeded). The input buffer contains the bytes read.

(continued on next page)

Table 2-8 (Cont.)
Terminal Status Returns

Code	Reason
IE.ABO	Operation aborted The specified I/O operation was cancelled by IO.KIL while in progress or while in the I/O queue. The second word of the I/O status block indicates the number of bytes that were put in the buffer before the kill was effected.
IE.BAD	Bad parameter. The size of the buffer exceeds 8128 bytes.
IE.BCC	Framing error A framing error was hardware detected and returned by the controller. All characters up to (but not including) the erroneous character are in the buffer. This condition can result by pressing the BREAK key on some terminals, or by hardware problems.
IE.DAA	Device already attached. The physical device-unit specified in an IO.ATT function was already attached by the issuing task. This code indicates that the issuing task has already attached the desired physical device-unit, not that the unit was attached by another task. If the attach specified TF.AST or TF.ESQ, these subfunction bits have no effect.
IE.DAO	Data overrun error A data overrun error was hardware-detected and returned by the controller. All characters up to (but not including) the erroneous character are in the buffer. This error occurs when a hardware failure or incompatibility causes characters to be received by the controller faster than they can be processed (that is, an incorrect serial I/O baud rate or format exists).
IE.DNA	Device not attached The physical device-unit specified in an IO.DET function was not attached by the issuing task. This code has no bearing on the attachment status of other tasks.

(continued on next page)

Table 2-8 (Cont.)
Terminal Status Returns

Code	Reason
IE.DNR	Device not ready The physical device-unit specified in the QIO directive was not ready to perform the desired I/O operation. This code is returned to indicate one of the following conditions: ● A timeout occurred on the physical device-unit (that is, an interrupt was lost). ● an attempt was made to perform a function on a remote DH11 or DZ11 line without carrier present.
IE.IES	Invalid escape sequence An escape sequence was started but escape-sequence syntax was violated before the sequence was completed. (See Section 2.6.4.) The character causing the violation is the last character in the buffer.
IE.IFC	Illegal function A function code specified in an I/O request was illegal for terminals; or, the function code specified was a SYSGEN option not selected for this system.
IE.NOD	Buffer allocation failure System dynamic storage has been depleted resulting in insufficient space available to allocate an intermediate buffer for an input request or an AST block for an attach request.
IE.OFL	Device off-line The physical device-unit associated with the LUN specified in the QIO directive was not online. When the system was booted, a device check indicated that this physical device-unit was not in the configuration. In RSX-11M-PLUS systems, the physical device-unit could have been configured offline.
IE.PES	Partial escape sequence An escape sequence was started, but read-buffer space was exhausted before the sequence was completed. See Section 2.6.4.3.

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Table 2-8 (Cont.)
Terminal Status Returns

Code	Reason
IE.PRI	Privilege violation In a multiuser system, a nonprivileged task issued an IO.WBT, directed an SF.SMC to a terminal other than TI:, or it attempted to set its privilege bit.
IE.SPC	Illegal address space The buffer specified for a read or write request was partially or totally outside the address space of the issuing task, a byte count of zero was specified, or an odd or 0 AST address was specified.
IE.VER	Character parity error A parity error was hardware-detected and returned by the controller. All characters up to (but not including) the erroneous character are in the buffer.
SE.NIH	A terminal characteristic other than those in Table 2-5 was named in an SF.GMC or SF.SMC request, or a task attempted to assert TC.PRI.
SE.FIX	An attempt was made to change a fixed characteristic in a SF.SMC subfunction request (for example, an attempt was made to change the unit number).
SE.VAL	The new value specified in an SF.SMC request for the TC.TTP terminal characteristic was not one of those listed in Table 2-6.
SE.NSC	An attempt was made to change a non-settable characteristic. This error can occur when an attempt is made to make a local-only line a remote line when the controller does not support remote lines, or when no remote line support was specified during SYSGEN.
SE.SPD	The new speed specified in an SF.SMC subfunction request was not valid for the controller associated with the specified terminal.

2.5 CONTROL CHARACTERS AND SPECIAL KEYS

This section describes the meanings of special terminal control characters and keys for RSX-11M. Note that the driver does not recognize control characters and special keys during a Read All request (IO.RAL) and recognizes only some of them during a Read with Special Terminators (IO.RST).

2.5.1 Control Characters

A control character is input from a terminal by holding the control key (CTRL) down while typing one other key. Three of the control characters described in Table 2-9, CTRL/R, CTRL/U, and CTRL/Z, are echoed on the terminal as ^R, ^U, and ^Z respectively.

Table 2-9
Terminal Control Characters

Character	Meaning
CTRL/C	Typing CTRL/C causes unsolicited input on that terminal to be directed to a control line interpreter task, such as MCR. (Command line interpreters are invoked and display a prompt in a manner similar to MCR; therefore, for the purposes of this discussion, it is assumed that MCR is the command line interpreter in use, although the terminal driver will respond to other command line interpreters in a similar manner.) The "MCR>" prompt is echoed when the terminal driver is ready to accept an unsolicited MCR command line for input. When the unsolicited input is terminated, the command line is passed to MCR. If the last character typed on the terminal was a CTRL/S (suspend output), CTRL/C restarts suspended output and directs subsequent input to MCR. If the hold-screen mode SYSGEN option has been selected and the terminal is a VT5x or VT61 in hold-screen mode, typing a CTRL/C removes the terminal from hold-screen mode. CTRL/C characters can also be directed to a task if the task has attached a terminal and has specified an unsolicited-input-character AST (see Section 2.3.2.1). CTRL/C characters are also passed to a task if an IO.RAL or IO.RST function is effected. NOTE If the terminal driver receives a CTRL/C character during a read operation (except during a Read-Pass-All operation or a Read With Special Terminators operation), the read operation is terminated, the typeahead buffer is cleared and an IS.CC status code is returned to the task.
CTRL/I	CTRL/I or TAB characters initiate a horizontal tab, and the terminal spaces to the next tab stop. Tabs at every eighth character position are simulated by the terminal driver.

(continued on next page)

Table 2-9 (Cont.)
Terminal Control Characters

Character	Meaning
CTRL/J	CTRL/J is equivalent to a LINE FEED character.
CTRL/K	CTRL/K initiates a vertical tab, and the terminal tabs to the next vertical tab stop. For a CRT terminal, 4 LINE FEEDs are output.
CTRL/L	CTRL/L initiates a formfeed. If the terminal has hardware formfeed support, the driver echos ^L. Otherwise, the driver simulates the formfeed by outputting enough LINE FEED characters to advance the next character position to the top of the next page. If a CRT terminal is in use, 4 LINE FEEDs are output.
CTRL/M	CTRL/M is equivalent to a carriage RETURN character (see Section 2.5.2).
CTRL/O	CTRL/O suppresses terminal output. For attached terminals, CTRL/O remains in effect (output is suppressed) until one of the following occurs: ● The terminal is detached ● Another CTRL/O character is typed ● An IO.CCO or IO.WBT function is issued ● Input is entered For unattached terminals, CTRL/O suppresses output for only the current output buffer (typically one line).
CTRL/Q	CTRL/Q resumes terminal output previously suspended by means of CTRL/S.
CTRL/S	CTRL/S suspends terminal output. (Output can be resumed by typing CTRL/Q or CTRL/C.)
CTRL/R	CTRL/R response is a terminal driver feature that can be selected during RSX-11M V3.2 SYSGEN. Typing CTRL/R results in a carriage return and line feed being echoed, followed by the incomplete (unprocessed) input line. Any tabs that were input are expanded and the effect of any rubouts is shown. On hardcopy terminals, CTRL/R allows verifying the effect of tabs and/or rubouts in an input line. CTRL/R is also useful for CRT terminals when the CRT rubout SYSGEN option has been selected (see Section 2.8). For example, after rubbing out the left-most character on the second displayed line of a wrapped input line, the cursor does not move to the right of the first displayed line. In this case, CTRL/R brings the input line and the cursor back together again.

(continued on next page)

Table 2-9 (Cont.)
Terminal Control Characters

Character	Meaning
CTRL/U	Typing CTRL/U before typing a line terminator deletes previously typed characters back to the beginning of the line. The system echoes this character as ^U followed by a carriage return and a line feed.
CTRL/X	This character clears the typeahead buffer.
CTRL/Z	CTRL/Z indicates an end-of-file for the current terminal input. It signals MAC, PIP, TKB, and other system tasks, that terminal input is complete, allowing the task to exit. The system echoes this character as ^Z followed by a carriage return and a line feed.

2.5.2 **Special Keys**

The ESCape, carriage RETURN, and RUBOUT keys have special significance for terminal input, as described in Table 2-10. A line can be terminated by an ESCape (or Altmode), carriage RETURN, or CTRL/Z characters, or by completely filling the input buffer (that is, by, exhausting the byte count before a line terminator is typed). The standard buffer size for a terminal can be determined for a task by issuing a Get LUN Information system directive and examining Word 5 of the buffer. An operator can obtain the same information via the MCR SET /BUF=TI: command.

Table 2-10
Special Terminal Keys

Key	Meaning
ESCape	If escape sequences are not recognized, typing ESCape or Altmode signals the terminal driver that there is no further input on the current line. This line terminator allows further input on the same line, because the carriage or cursor is not returned to the first column position. If escape sequences are recognized, ESCape signals the beginning of an escape sequence. (See Section 2.6.)
RETURN	Typing RETURN terminates the current line and causes the carriage or cursor to return to the first column on the line.

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Table 2-10 (Cont.)
Special Terminal Keys

Key	Meaning
RUBOUT	Typing RUBOUT deletes the last character typed on an input line. Only characters typed since the last line terminator may be deleted. Several characters can be deleted in sequence by typing successive RUBOUTs. For example, on a printing terminal, the first RUBOUT echoes a backslash (\) followed by the character that has been deleted, even if the terminal is in the noecho mode. Subsequent RUBOUTs cause only the deleted character to be echoed. The next character typed that is not a RUBOUT causes another backslash to be printed, followed by the new character. The non-RUBOUT character will not be echoed if the terminal is in the noecho mode; however, a backslash is echoed in response to the first non-RUBOUT character. The following example illustrates rubbing out ABC and then typing CBA: ABC\CBA\CBA The second backslash is not displayed if a line terminator is typed after rubbing out the characters on a line, as in the following example: ABC\CBA At SYSGEN time, the "CRT rubout" feature can be selected. This feature applies to a terminal only after a SET MCR directive has been issued: SET /CRT=TI: If the CRT rubout feature was selected, RUBOUT causes the last typed character (if any) to be removed from the incomplete input line and a backspace-space-backspace sequence of characters for that terminal are echoed. If the last typed character was a tab, enough backspaces are issued to move the cursor to the character position before the tab was typed. If a long input line was split, or "wrapped," by the automatic-carriage-return option, and a RUBOUT erases the last character of a previous line, the cursor is not moved to the previous line. CTRL/R must be used to resynchronize the current display with the contents of the incomplete input line.

2.6 ESCAPE SEQUENCES

Escape sequences are strings of two or more characters beginning with an ESC (033) character. In RSX-11M systems, escape sequence support described in this section in a SYSGEN option. Some terminals generate an escape sequence when a special key is pressed (for example, the FCN key on the VT61). On any terminal, an escape sequence may be generated manually by typing ESCape followed by the appropriate characters.

Escape sequences provide a way to pass input to a task without interpretation by the operating system. This could be done via a number of one-character Read All functions, but escape sequences allow them to be read with IO.RLB requests.

2.6.1 Definition

The format of an escape sequence as defined in American National Standard X 3.41-- 1974 and used in the VT100 is:

- ESC ... F

Where:

1. ESC is the introducer control character (33(8)) that is named escape.

2. ... are the intermediate bit combinations that may or may not be present. I characters are bit combination 40(8) to 57(8) inclusive in both 7- and 8-bit environments.

3. F is the final character. F characters are bit combinations 60(8) to 176(8) inclusive in escape sequences in both 7- and 8-bit environments.

4. The occurrence of characters in the inclusive ranges 0(8) to 37(8) is technically an error condition whose recovery is to execute immediately the function specified by the character and then continue with the escape sequence execution. The execeptions are: If the character ESC occurs, the current escape sequence is aborted, and a new one commences, beginning with the ESC just recieved. If the character CAN (30(8)) or the character SUB (32(8)) occurs, the current escape sequence is aborted, as is the case with any control character.

There are five exceptions to this general definition; these exceptions are discussed in Section 2.6.5.

2.6.2 Prerequisites

Two prerequisites must be satisfied before escape sequences can be received by a task.

First, the task must "ask" for them by issuing an IO.ATT function and invoking the subfunction bit TF.ESQ.

Second, the terminal must be declared capable of generating escape sequences. This may be done with an MCR SET command:

```
SET /ESCSEQ=TI:
```

An alternative way to tell the driver that the terminal can generate escape sequences is by issuing the Set Multiple Characteristics request. (See Section 2.3.2.12).

If either of these prerequisites is not satisfied, the ESC character is treated as a line terminator.

If both prerequisites are satisfied, CTRL/SHIFT/O (037) may be used as an Altmode character.[1] This character does not act as an Altmode from a terminal that cannot generate escape sequences.

2.6.3 Characteristics

Escape sequences always act as line terminators. That is, an input buffer may contain other characters that are not part of an escape sequence, but an escape sequence always comprises the last characters in the buffer.

Escape sequences are not echoed. However, if a non-CRT rubout sequence is in progress, it is closed with a backslash when an escape sequence is begun.

Escape sequences are not recognized in unsolicited input streams. Neither are they recognized in a Read with Special Terminators (subfunction bit TF.RST) nor in a Read All (subfunction bit TF.RAL).

2.6.4 Escape Sequence Syntax Violations

A violation of the syntax defined in Section 2.6.1 causes the driver to abandon the escape sequence and to return an error (IE.IES).

2.6.4.1 **DEL or RUBOUT (177)** - The character DEL or RUBOUT is not legal within an escape sequence. Typing it at any point within an escape sequence causes the entire sequence to be abandoned and deleted from the input buffer. Thus, use DEL or RUBOUT to abandon an escape sequence, if desired, once you have begun it.

2.6.4.2 **Control Characters (0-037)** - The reception of any character in the range 0 to 037 (with four exceptions -- see footnote[2]) is a syntax violation that terminates the read with an error (IE.IES).

---

[1] An Altmode is a line terminator that does not cause the cursor to advance to a new line. On terminals that cannot generate escape sequences, the ESCape key acts as an Altmode. Characters 175 and 176 also function as Altmodes if the terminal has not been declared lower-case (MCR command SET /LOWER).

[2] Four control characters are allowed: CTRL/Q, CTRL/S, CTRL/X, and CTRL/O. These characters are handled normally by the operating system even when an escape sequence is in progress. For example, entering:

```
     ESC CTRL/S A
```

gives:

IOSB	IS.ESQ
	2

with the additional effect of turning off the output stream.

2.6.4.3 **Full Buffer** - A syntax error results when an escape sequence is terminated by running out of read-buffer space, rather than by receipt of a final character. The error IE.PES is returned. For example, after a task issues an IO.RLB with a buffer length of 2, and you type:

```
ESC !  A
```

the buffer contains "ESC !", and the I/O status block contains:

IOSB	
	IE.PES
	2

The "A" is treated as unsolicited input.

2.6.5 Exceptions to Escape-Sequence Syntax

Five "final characters" that normally terminate an escape sequence are treated as special cases by the terminal driver for use with certain terminals:

```
ESC ?...
ESC O...
ESC P...
ESC Y...
ESC [...
```

Refer to documentation supplied with the specific terminal(s) in use for correct use of escape sequences.

2.7 VERTICAL FORMAT CONTROL

Table 2-11 is a summary of all characters used for vertical format control on the terminal. Any one of these characters can be specified as the value of the vfc parameter in IO.WLB, IO.WVB, IO.WBT, IO.CCO, or IO.RPR functions.

2.8 AUTOMATIC CARRIAGE RETURN

Individual terminals can be set for wraparound, as desired, using the MCR SET command:

```
>SET /WRAP=TTxx:
```

Once wrap around has been selected, the column at which wrap around occurs can be selected using the MCR SET command:

```
>SET /BUF=TI:n
>
```

The SET /BUF command can also be used without an argument to display the current buffer width for a terminal:

```
>SET /BUF=TI:
BUF=TI:00072.
>
```

Table 2-11
Vertical Format Control Characters

Octal Value	Character	Meaning
040	blank	SINGLE SPACE - Output 1 line feed, print the contents of the buffer, and output a carriage return. Normally, printing immediately follows the previously printed line.
060	0	DOUBLE SPACE - Output 2 line feeds, print the contents of the buffer, and output a carriage return. Normally, the buffer contents are printed two lines below the previously printed line.
061	1	PAGE EJECT - If the terminal supports FORM FEEDs, output a form feed, print the contents of the buffer, and output a carriage return. If the terminal does not support FORM FEEDs, the driver simulates the FORM FEED character by either outputting 4 line feeds to a crt terminal, or by outputting enough line feeds to advance the paper to the top of the next page on a printing terminal.
053	+	OVERPRINT - Print the contents of the buffer and output a carriage return, normally overprinting the previous line.
044	$	PROMPTING OUTPUT - Output 1 line feed and print the contents of the buffer. This mode of output is intended for use with a terminal on which a prompting message is output, and input is then read on the same line.
000	null	INTERNAL VERTICAL FORMAT - Print the buffer contents without addition of vertical format control characters. In this mode, more than one line of guaranteed contiguous output can be printed for each I/O request.

All other vertical format control characters are interpreted as blanks (040).

A task can determine the buffer width by issuing a Get LUN Information directive and examining word 5 returned in the buffer.

After the SET has been done, typing beyond the buffer width results in a carriage return and line feed being output before the next character is echoed. Although only one line only was input, it is displayed on two terminal lines.

It is possible to lose track of where you are in the input buffer if wraparound is enabled for your terminal. For example, while deleting text on a wrapped line, the cursor will not back up to the previous line. In order to resynchronize the cursor with the contents of the incomplete input buffer, type CTRL/R (if this SYSGEN option has been selected).

2.9 FEATURES AVAILABLE BY RSX-11M SYSGEN OPTION

A number of terminal-driver features are available as RSX-11M SYSGEN options. (See the RSX-11M System Generation and Management Guide). Features previously discussed that are not repeated in this section include:

- Some device-specific QIO functions (see Section 2.3.2)
- Special keys: CTRL/R -- Write incomplete input buffer (see Section 2.5.1)

  CRT rubout (see Section 2.5.2)
- Escape sequences (see Section 2.6)

The only remaining features selected at SYSGEN time are terminal-independent cursor control (described in Section 2.15), private buffer pool size and hard receive error detection, described in the following sections.

2.9.1 Private Buffer Pool Size

The private buffer pool is contained within the full-duplex terminal driver. The size of the whole driver is established during SYSGEN by the VMR command to load the driver as follows:

```
     LOA TT:/SIZE=nnn
```

The private buffer pool occupies all of the space from the top of the actual driver code up to nnn. The argument nnn is expressed in octal words, and the maximum value is 20000, corresponding to 8K words. Depending on driver options selected, the code requires from 2.5 to 3.5k words. Thus, the maximum buffer pool size is from 4.5k to 5.5k words.

Alternatively, on a processor that has separate I- and D-space mapping registers, it is possible to allocate the private pool together with all driver data in a separate common block called TTCOM. This block can range up to 8k words, allowing the private buffer pool to be almost as large. When this is desired, answer Y to the following two SYSGEN questions:

```
>* DO YOU WANT KERNEL DATA SPACE SUPPORT?  [Y/N]:
>* DO YOU WANT A SEPARATE TERMINAL BUFFER POOL?  [Y/N]:
```

2.9.2 Hard Receive Error Detection

All terminal interfaces supported by the full-duplex terminal driver are capable of detecting and flagging hard receive errors. Hard receive errors include framing errors, enable character parity error, and data overrun error.

NOTE

The driver does not enable parity generation and checking on DH11 and DZ11 interfaces.

If the hard receive error detection SYSGEN option (T$$RED) is selected, the driver handles hard receive errors as follows:

1. If a read request is being processed and the character can be processed immediately, the read request is terminated with one of the following error codes returned in the status block:

Error Code	Hard Receive Error
IE.BCC	framing error
IE.DAO	data overrun
IE.VER	character parity error

2. If a command line is being input for a command line interpreter task and the character can be processed immediately, a CTRL/U is simulated, ^U is echoed, and the input is terminated. No command line is sent to the task.

3. If the character would normally cause an AST if no error was detected, the character is ignored and no AST occurs.

4. If the character cannot be processed immediately, it is stored in the typeahead buffer. A flag is set for the line, indicating that the last character in the typeahead buffer has no error, disabling further storage in the typeahead buffer. When the character is retrieved from the buffer, the appropriate action previously described is taken and the flag is cleared. Any characters received in the meantime are discarded with a bell echoed for each character.

If the T$$RED option is not selected, hard receive errors are ignored.

2.10 TASK BUFFERING OF RECEIVED CHARACTERS

When task-buffering received characters, characters read from the terminal are sent directly to the task's buffer. Thus, there is no need to allocate a terminal driver buffer.

Task buffering of received characters does not necessarily reduce system overhead. For example, in a mapped system each character must be mapped to the task's buffer. However, if terminal driver buffering was used, the mapping is only done once for all characters to be transferred.

Task buffering is overridden during checkpointing. If a task is checkpointable, a driver buffer is allocated and the task is made eligible for checkpointing by any task, regardless of priority, while the read operation is in progress. (Checkpointing only occurs in this situation when there is another task that can be made active.) Since checkpointability is controlled by the task, the user retains control over this operation.

2.11 TYPEAHEAD BUFFERING

Characters received by the terminal driver are either processed immediately or stored in the typeahead buffer. The typeahead buffer allows characters to be temporarily stored and retrieved FIFO. The typeahead buffer is used as follows:

1. **Store in buffer:**

   An input character is stored in the typeahead buffer if one or more of the following conditions are true:

   - The driver is not ready to accept the character (fork process pending or in progress)
   - There is at least one character presently in the typeahead buffer
   - The character input requires echo and the output line to the terminal is presently busy outputting a character
   - No read request is in progress, no unsolicited input AST is specified, and the terminal is either attached or slaved.

   NOTE

   Depending on the terminal mode and the presence of a read function, read subfunctions and an unsolicited input AST, the CTRL-C, CTRL-O, CTRL-Q, CTRL-S, and CTRL-X characters may be processed immediately and not stored in the typeahead buffer.

   A character is not echoed when it is stored in the buffer. Echoing a character is deferred until it is retrieved from the buffer since the read mode (for example, read-without-echo) is not known by the driver until then.

2. **Retrieve from buffer:**

   When the driver becomes ready to process input, or when a task issues a read request, an attempt is made to retrieve a character from the buffer. If this attempt is successful, the character is processed and echoed, if required. The driver then loops, retrieving and processing characters until either the buffer is empty, the driver becomes unable to process another character, or a read request is finished with the terminal attached or slaved.

3. **Flush the buffer:**

   The buffer is flushed (cleared) when:

   1. CTRL-C is received
   2. CTRL-X is received
   3. the terminal becomes detached
   4. the terminal becomes non-slaved

   Exceptions: CTRL-C and CTRL-X do not flush the buffer if read-pass-all or read-with-special-terminators is in effect.

If the buffer becomes full, each character that cannot be entered causes a BELL character to be echoed to the terminal.

If a character is input and echo is required, but the transmitter section is busy with an output request, the input character is held in the type-ahead buffer, until output (transmitter) completion occurs.

2.12 FULL-DUPLEX OPERATION

When a terminal line is in the full-duplex mode, the full-duplex driver attempts to simultaneously service one read request and one write request. The Attach, Detach and Set Multiple Characteristics functions are only performed with the line in an idle state (not executing a read or a write request).

2.13 PRIVATE BUFFER POOL

The driver has a private buffer pool for intermediate input and output buffers, typeahead buffers and UCB extensions. Whenever the driver needs dynamic memory, it first attempts to allocate a buffer in the private pool. If this fails, a second attempt is made in the system pool. If the allocation in the system pool fails during command line input, a CTRL/U is simulated and echoed.

Command line interpreter task buffers are handled in a special way. When unsolicited input begins, a buffer is allocated, as previously described, for the command line (a string of characters, followed by an appropriate terminator character). When the input is completed, the contents of the buffer is sent directly to the command line interpreter task if the buffer was allocated in the system pool. However, if the buffer was allocated in the driver's private pool, it must first be moved into a buffer in the system pool to provide access for the task.

2.14 INTERMEDIATE INPUT AND OUTPUT BUFFERING

Input buffering for checkpointable tasks with checkpointing enabled is provided in the private pool. As each buffer becomes full, a new buffer is automatically allocated and linked to the previous buffer. The Executive then transfers characters from these buffers to the task buffer and the terminal driver deallocates the buffers once the transfer has been completed.

If the driver fails to allocate the first input buffer, the characters are transferred directly into the task buffer. If the first buffer is successfully allocated, but a subsequent buffer allocation fails, the input request terminates with the error code IE.NOD. In this case, the I/O status block contains the number of characters actually transferred to the task buffer. The task may then update the buffer pointer and byte count and reissue a read request to receive the rest of the data. The typeahead buffer ensures that no input data is lost.

All terminal output is buffered. As many buffers as required are allocated by the terminal driver and linked to a list. If not enough buffers can be obtained for all output data, the transfer is done as a number of partial transfers, using available buffers for each partial transfer. This is transparent to the requesting task. If no buffers can be allocated, the request terminates with the error code IE.NOD.

The unconditional output buffering serves three purposes.

1. It reduces time spent at system state

2. It enables long DMA transfers for DH11 controllers

3. It enables task checkpointing during the transfer to the terminal (if all output fits in one buffer list)

2.15 TERMINAL-INDEPENDENT CURSOR CONTROL

Terminal-independent cursor control capability is provided at SYSGEN time if the assembly parameter T$$CUP is defined. The terminal driver responds to task I/O requests for cursor positioning without the task requiring information about the type of terminal in use. I/O functions associated with cursor positioning are described as follows.

Cursor position is specified in the vfc parameter of the IO.WLB or IO.RPR function. The parameter is interpreted simply as a vfc parameter if the high byte of the parameter is zero. However, if the parameter is used to define cursor position, the high byte must be nonzero, the low byte is interpreted as column number (x-coordinate) and the high byte is interpreted as line number (y-coordinate). Home position, the upper left corner of the display, is defined as 1,1. Depending upon terminal type, the driver outputs appropriate cursor positioning commands appropriate for the terminal in use that will move the cursor to the specified position. If the most significant bit of the line number is set, the driver clears the display before positioning the cursor.

When defining cursor position in an IO.WLB function, the TF.RCU subfunction can be used to save the current cursor position. When included in this manner, IF.RCU causes the driver to first save the current cursor position, then position the cursor and output the specified buffer, and, finally, restore the cursor to the original (saved) position once the output transfer has been completed.

2.16 TERMINAL INTERFACES

This section summarizes the characteristics of the four types of standard communication-line interfaces supported by RSX-11M. Refer to the Terminals and Communications Handbook for additional details.

2.16.1 DH11 Asynchronous Serial Line Multiplexer

The DH11 multiplexer interfaces up to 16 asynchronous serial communications lines for terminal use. The DH11 supports programmable baud rates. Input and output baud rates may differ; the input rate may be set to 0 baud, thus effectively turning off the terminal. The DM11-BB option may be included to provide modem control for dial-in lines. These lines must be interfaced by means of a full duplex modem (for example, in the United States, a Bell 103A or equivalent modem).

2.16.2 DJ11 Asynchronous Serial Line Multiplexer

The DJ11 multiplexer interfaces as many as 16 asynchronous serial lines to the PDP-11 for local terminal communications. The DJ11 does not provide a dial-in capability. Baud rates are jumper-selectable.

2.16.3 DL11 Asynchronous Serial Line Interface

The DL11 supports a single asynchronous serial line and handles communication between the PDP-11 and a terminal. A number of standard baud rates are available to DL11 users.

2.16.4 DZ11 Asynchronous Serial Line Multiplexer

The DZ11 multiplexer interfaces up to eight asynchronous serial communication lines for use with terminals. It supports programmable baud rates; however, transmit and receive baud rates must be the same. The DZ11 can control a full duplex modem in auto-answer mode.

2.17 PROGRAMMING HINTS

2.17.1 ESCape Code Conversion

If escape sequences are recognized, the character code 037 will terminate input and a status code IS.ESC is returned. In addition, character codes will terminate input and return the IS.ESC status if upper to lower-case conversion is not enabled.

2.17.2 RT02-C Control Function

Because the screen of an RT02C Badge Reader and Data Entry Terminal holds only one line of information, special care must be taken when sending a control character (for example, vertical tab) to the RT02-C. Use the IO.WAL (Write All) function for this purpose.

It is recommended that read without echoing be used when reading a badge with the RT02-C. Use IO.RAL or IO.RNE functions followed by the IO.WAL function to echo the information for display.

2.17.3 Use of IO.WVB Instead of IO.WLB

The use IO.WVB instead of IO.WLB is recommended when writing to a terminal. If the write actually goes to a terminal, the Executive converts the IO.WVB to an IO.WLB request. However, if the LUN has been redirected to an inappropriate device (for example, a disk), the use of an IO.WVB function will be rejected because a file is not open on the LUN. This prevents privileged tasks from overwriting block zero of the disk.

Note that any subfunction bits specified in the IO.WVB request (for example, TF.CCO, TF.WAL, or TF.WBT) are stripped when the IO.WVB is converted to an IO.WLB.

2.17.4 Remote DL11-E, DH11, and DZ11 Lines

All remote DH11 lines in a system are answered at the same baud rate. All remote DZ11 lines are also answered at the same rate, which may differ from the DH11 rate. These rates are specified at SYSGEN time.

Before a remote line is answered, the driver clears certain terminal characteristics (see Table 2-5) that may have been set by an MCR SET command, or by an SF.SMC function. The characteristics cleared are: TC.SCP, TC.ESQ, TC.HLD, TC.SMR, TC.NEC, TC.FDX, TC.HFF, TC.HHT, TC.VFL, TC.HFL, and TC.TTP. (Clearing TC.TTP means that a terminal type of "unknown" will be returned in an SF.GMC request.) Buffer size is set to 72.

A DZ11 remote line must be declared to be remote before the terminal driver will correctly handle the modem.

2.17.5 Side Effects of Setting Characteristics

Certain terminal characteristics that a task may set or that an operator may set using MCR commands may have undesirable side effects. In particular, these characteristics include the hold-screen mode and the lower/upper-case conversion disable mode. Their effects are described as follows.

TC.HLD -- Unexpected behavior can result from a terminal in the hold-screen mode if its reception rate is much greater than its transmission rate. (The DH11 supports split baud rates.) When in the hold-screen mode, the terminal automatically sends a CTRL/S during reception of an output stream when the screen is nearly full. Output is resumed -- another screen-full -- when you type SHIFT/SCROLL (the terminal generates CTRL/Q). Thus, no output is lost as a result of scrolling off the screen before you can read it. However, if the terminal's transmission rate is far below its reception rate, some unread output may scroll out of sight before the CTRL/S can be transmitted.

Note that some terminals and interfaces are hardware-buffered. This can cause obscure timing problems for tasks that attempt to invoke the hold-screen mode.

TC.SMR -- If this characteristic is asserted (lower/upper-case conversion is disabled), octal characters 175 and 176 are interpreted as "right brace (})" and "tilde (~)" respectively. If TC.SMR is not asserted, these characters are interpreted as an Altmode (that is, they function as line terminators that do not advance the cursor to a new line).

2.17.6 Modem Support

The terminal driver provides terminal support for modem control. A communications line can be set to remote or local operation via the TC.DLU caracteristic bit. MCR supports this bit with the SET /REMOTE and SET /LOCAL commands.

If a communication link is established when a line is set to local, the line is properly hung up. If carrier is lost, the driver waits 2 seconds for carrier to return, otherwise, the line is hung up. If a ring interrupt occurs during this time, the line is immediately hung up.

CHAPTER 3

HALF-DUPLEX TERMINAL DRIVER

3.1 INTRODUCTION

The half-duplex terminal driver provides support for a variety of terminal devices under RSX-11M. (This terminal driver is not supported on RSX-11M-PLUS systems.) The half-duplex terminal driver is generally used in RSX-11M systems where small driver size is essential, and the additional functional capability provided by the larger full-duplex terminal driver (described in Chapter 2) is not required. Table 3-1 summarizes the terminals supported, and subsequent sections describe these devices in greater detail.

Table 3-1
Supported Terminal Devices

Model	Columns	Lines/ screen[1]	Character set	Baud range	Upper & lower case? Send	Receive
ASR-33/35	72		64	110		
KSR-33/35	72		64	110		
LA30-P	80		64	300		
LA30-S	80		64	110-300		
LA36	80-132		64-96	110-300	yes	yes[2]
LA120	132		96	50-9600	yes	yes
LA180S	132		96	300-9600		yes
RT02	64	1	64	110-1200		
RT02-C	64	1	64	110-1200		
VT05B	72	20	64	110-2400	yes	

1 Applies only to video terminals.

2 Only for 96-character terminal. The terminal driver supports the terminal interfaces summarized in Table 3-2. These interfaces are described in greater detail in Section 3.9. Programming is identical for all.

(continued on next page)

Table 3-1 (Cont.)
Supported Terminal Devices

Model	Columns	Lines/ screen[1]	Character set	Baud range	Upper & lower case?	
					Send	Receive
VT50	80	12	64	110-9600		
VT50H	80	12	64	110-9600		
VT52	80	24	96	110-9600	yes	yes
VT55	80	24	96	110-9600	yes	yes
VT61	80	24	96	110-9600	yes	yes
VT100	80-132	24	96	50-9600	yes	yes

1 Applies only to video terminals.

Table 3-2
Standard Terminal Interfaces

Model	Type
DH11	16-line multiplexer[1]
DH11-DM11-BB	16-line multiplexer with modem control[2]
DJ11	16-line multiplexer
DL11-A/B/C/D/W	Single-line interfaces
DZ11	8-line multiplexer with modem control[2]

1 Direct memory access (DMA) not supported.

2 Full-duplex control only. For example, in the USA, a Bell 103A-type modem.

Terminal input lines can have a maximum length of 255 bytes (the maximum is set in the system generation, or SYSGEN, dialog). The extra characters of an input line that exceeds the maximum length generally become an unsolicited input line.

3.1.1 **ASR-33/35 Teletypes** [3]

The ASR-33 and ASR-35 Teletypes are asynchronous, hard-copy terminals. No paper-tape reader or punch capability is supported.

3.1.2 **KSR-33/35 Teletypes** [3]

The KSR-33 and KSR-35 Teletypes are asynchronous, hard-copy terminals.

3 Teletype is a registered trademark of the Teletype Corporation.

3.1.3 LA30 DECwriters

The LA30 DECwriter is an asynchronous, hard-copy terminal that is capable of producing an original and one copy. The LA30-P is a parallel model and the LA30-S is a serial model.

3.1.4 LA36 DECwriter

The LA36 DECwriter is an asynchronous terminal that produces hard copy and operates in serial mode. It has an impact printer capable of generating multipart and special preprinted forms. The LA36 can receive and transmit both upper-case and lower-case characters.

3.1.5 LA120 DECwriter

The LA120 DECwriter is a hard-copy upper- and lower-case terminal, capable of printing multipart forms at speeds up to 180 characters-per-second. Serial communications speed is selected from 14 baud rates ranging from 50 to 9600 bps. Hardware features allow bidirectional printing for maximum printing speed, and user-selected features, including font size, line spacing, tabs, margins, and forms control. These functions can also be set-up by user tasks that issue appropriate ANSI-standard escape sequences.

3.1.6 LA180S DECprinter

The LA180S DECprinter is a serial version of the LA180. It is a print-only device (it has no keyboard) that can generate multipart forms. The LA180S can print upper-case and lower-case letters.

3.1.7 RT02 Alphanumeric Display Terminal and RT02-C Badge Reader/ Alphanumeric Display Terminal

The RT02 is a compact, alphanumeric display terminal designed for applications in which source data is primarily numeric. A shift key permits the entry of 30 discrete characters, including upper-case alphabetic characters. The RT02 can, however, receive and display 64 characters.

The RT02-C model also contains a badge reader. This option provides a reliable method of identifying and controlling access to the PDP-11 or to a secure facility. Furthermore, data in a format corresponding to that of a badge (22-column fixed data) can be entered quickly.

3.1.8 VT05B Alphanumeric Display Terminal

The VT05B is an alphanumeric display terminal that consists of a CRT display and a self-contained keyboard. From a programming point of view, it is equivalent to other terminals, except that the VT05B offers direct cursor addressing.

3.1.9 VT50 Alphanumeric Display Terminal

The VT50 is an alphanumeric display terminal that consists of a CRT display and a keyboard. It is similar to the VT05B in operation, but does not offer direct cursor addressing.

3.1.10 VT50H Alphanumeric Display Terminal

The VT50H is an alphanumeric display terminal with CRT display, keyboard, and numeric pad. It offers direct cursor addressing. (The VT50H's direct cursor addressing is not compatible with that of the VT05B.)

3.1.11 VT52 Alphanumeric Display Terminal

The VT52 is an upper-and-lower-case alphanumeric terminal with numeric pad and direct cursor addressing. (The VT52's direct cursor addressing is compatible with that of the VT50H, not with that of the VT05B.) The VT52 can be configured with a built-in thermal printer.

3.1.12 VT55 Graphics Display Terminal

The VT55 is similar to the VT52 in its operation as an alphanumeric terminal. The VT55 offers graphics display features that are not supported by RSX-11M, although the system allows a knowledgeable task to access the explicitly special features of the VT55.

3.1.13 VT61 Alphanumeric Display Terminal

The VT61 is an "intelligent" upper-and-lower-case alphanumeric terminal with an integral microprocessor. It offers two 128-member character sets and numerous built-in functions for editing and forms preparation as well as a block-transfer mode. (None of these special features is supported by RSX-11M.)

3.1.14 VT100 DECscope

The VT100 DECscope is an upper- and lower-case alphanumeric keyboard/video display terminal. It is capable of displaying 24 lines of 80 characters (each line). Serial communications speed is selected from baud rates ranging from 50 to 9600 bps. Hardware features allow user selection of display characteristics and functions including smooth scroll, reverse video, etc. These functions can also be set-up by user tasks that issue appropriate ANSI-standard escape sequences.

3.2 GET LUN INFORMATION MACRO

Word 2 of the buffer filled by the Get LUN Information system directive (the first characteristics word) contains the following information for terminals. A setting of 1 indicates that the described characteristic is true for terminals.

Bit	Setting	Meaning
0	1	Record-oriented device
1	1	Carriage-control device
2	1	Terminal device
3	0	File structured device
4	0	Single-directory device
5	0	Sequential device
6	0	Reserved
7	0	User-mode diagnostics supported
8	0	Massbus device
9	0	Unit software write-locked
10	0	Input spooled device
11	0	Output spooled device
12	0	Pseudo device
13	0	Device mountable as a communications channel
14	0	Device mountable as a FILES-11 volume
15	0	Device mountable

Words 3 and 4 are undefined. Word 5 indicates the default buffer size for the device: for terminals the width of the terminal carriage or display screen.

3.3 QIO MACRO

Table 3-3 lists the standard and device-specific functions of the QIO macro that are valid for terminals. All device-specific functions are options that may be selected at system generation.

Two device-specific functions, SF.SMC and SF.GMC, have nonstandard function names. These names are for compatibility with IAS.

Table 3-3
Standard and Device-Specific QIO Functions for Terminals

Format	Function
<u>STANDARD FUNCTIONS:</u>	
QIO$C IO.ATT,...	Attach device.
QIO$C IO.DET,...	Detach device.
QIO$C IO.KIL,...	Cancel I/O requests.
QIO$C IO.RLB,...,<stadd,size>	Read logical block (read typed input into buffer).
QIO$C IO.RVB,...,<stadd,size>	Read virtual block (read typed input into buffer).
QIO$C IO.WLB,...,<stadd,size,vfc>	Write logical block (print buffer contents).
QIO$C IO.WVB,...,<stadd,size,vfc>	Write virtual block (print buffer contents).
<u>DEVICE-SPECIFIC FUNCTIONS (ALL SYSGEN OPTIONS):</u>	
QIO$C IO.ATA,...,<ast>	Attach device, specify unsolicited-input-character AST.
QIO$C IO.CCO,...,<stadd,size,vfc>	Cancel CTRL/O (if in effect), then write logical block.
QIO$C SF.GMC,...,<stadd,size>	Get multiple characteristics.
QIO$C IO.GTS,...,<stadd,size>	Get terminal support.
QIO$C IO.RAL,...,<stadd,size>	Read logical block, pass all bits.
QIO$C IO.RNE,...,<stadd,size>	Read logical block, do not echo.
QIO$C IO.RPR,...,<stadd,size, [tmo],pradd,prsize,vfc>	Read logical block after prompt.
QIO$C IO.RST,...,<stadd,size>	Read logical block ended by special terminators.
QIO$C SF.SMC,...,<stadd,size>	Set multiple characteristics.
QIO$C IO.WAL,...,<stadd,size>	Write logical block, pass all bits.
QIO$C IO.WBT,...,<stadd,size,vfc>	Write logical block, break through most I/O conditions at terminal.

where:	ast	is the entry point for an unsolicited-input-character AST.
	pradd	is the starting address of the byte buffer where the prompt is stored. The buffer must be within the task's address space.

prsize	is the size of the pradd prompt buffer in bytes. If the system supports variable length reads, the buffer size must be greater than zero and less than or equal to 255. If the system does not support variable length reads, the specified size must be greater than zero and less than or equal to 80.
size	is the size of the stadd data buffer in bytes (must be greater than zero). If the function is a read and the system supports variable length reads, size must be less than or equal to 255. Otherwise, size must be less than or equal to 80. The buffer must be within the task's address space. For SF.GMC, IO.GTS, and SF.SMC, size must be an even number less than 4065 (decimal). If the function is a write, size can be up to 32K bytes.
stadd	is the starting address of the data buffer. The address must be word-aligned for SF.GMC, IO.GTS, and SF.SMC; otherwise stadd may be on a byte boundary.
tmo	is an optional timeout count, included for IAS compatibility. If supplied, it is ignored.
vfc	is a character for vertical format control from Table 3-11 (see Section 3.7).

3.3.1 Subfunction Bits

Most of the device-specific functions supported by the terminal driver are implemented by way of "subfunction bits." That is, these functions can be invoked by ORing a named bit with some other function. Table 3-4 shows the relationship of the 10 subfunction bits to the standard and device-specific functions.

The 10 subfunction bits, and their octal values, are:

TF.AST	unsolicited-input-character AST	10
TF.BIN	binary prompt	2
TF.CCO	cancel CTRL/O	40
TF.ESQ	recognize escape sequences	20
TF.RAL	read all bits	10
TF.RNE	read with no echo	20
TF.RST	read with special terminators	1
TF.WAL	write all bits	10
TF.WBT	break-through write	100
TF.XOF	send XOFF	100

The subfunction bits are defined in the system module TTSYM (discussed further in Section 3.3.2.5). The octal values of these entities are subject to change; therefore, we recommend that you always use the symbolic names. As Table 3-4 shows, 7 of the 10 subfunction bits can be ORed with standard QIO functions to invoke device-specific functions. The remaining three subfunction bits (TF.BIN, TF.ESQ, and TF.XOF) can be ORed with Attach and Read After Prompt QIO's to provide added features, as described in Section 3.3.2.

Of the 10 subfunction bits, 3 can be used with Read QIO functions, 3 with Write functions, 2 with Attach functions, and 5 with Read After Prompt. The breakdown is:

Read	TF.RAL, TF.RNE, TF.RST
Write	TF.CCO, TF.WAL, TF.WBT
Attach	TF.AST, TF.ESQ
Read After Prompt	TF.BIN, TF.XOF, TF.RAL, TF.RNE, TF.RST

If a task invokes a subfunction bit that is not supported on the system, the subfunction bit is ignored, not rejected. For example, if Read with Special Terminators is not selected, either IO.RST or IO.RLB!TF.RST is interpreted as IO.RLB.

The following example shows a QIO request using more than one subfunction bit: a nonechoed read, which may be concluded by a special terminator, after a prompt.

```
QIO$C IO.RPR!TF.RNE!TF.RST,...,<stadd,size,,pradd,prsize,vfc>
```

Table 3-4
Subfunction Bits

Function	Equivalent with subfunction bits	Allowed Subfunction Bits									
		TF.AST	TF.BIN	TF.CCO	TF.ESQ	TF.RAL	TF.RNE	TF.RST	TF.WAL	TF.WBT	TF.XOF
STANDARD FUNCTIONS:											
IO.ATT		X			X						
IO.DET											
IO.KIL											
IO.RLB						1	X	1			
IO.RVB						2	2	2			
IO.WLB				X					X	X	
IO.WVB				2					2	2	
DEVICE-SPECIFIC FUNCTIONS:											
IO.ATA	IO.ATT!TF.AST				X						
IO.CCO	IO.WLB!TF.CCO								X	X	
SF.GMC											
IO.GTS											
IO.RAL	IO.RLB!TF.RAL						X	1			
IO.RNE	IO.RLB!TF.RNE					1		1			
IO.RPR			X			1	X	1			X
IO.RST	IO.RLB!TF.RST					1	X				
SF.SMC											
IO.WAL	IO.WLB!TF.WAL			X						X	
IO.WBT	IO.WLB!TF.WBT			X					X		

[1] Exercise great care when using Read All and Read with Special Terminators together. Obscure problems can result.

[2] These subfunction bits are allowed but are not effective. They are stripped off when the read or write virtual is converted to a read or write logical.

3.3.2 Details on Device-Specific QIO Functions

All the device-specific functions described in this section are SYSGEN options. All except SF.GMC, IO.RPR, SF.SMC, and IO.GTS can be issued by ORing a particular subfunction bit with another QIO function. These subfunction bits are specified in the text; subfunction bits are described in general in Section 3.3.1.

In addition to the 11 device-specific QIO functions, this section also gives details on the features provided by the 3 subfunction bits TF.ESQ, TF.BIN, and TF.XOF.

3.3.2.1 **IO.ATA** - IO.ATA is a variation of the Attach directive. It specifies an asynchronous system trap (AST) to process an unsolicited input character. When called as follows:

```
     QIO$C   IO.ATA,...,<ast>
```

this function attaches the terminal and identifies "ast" as the entry point for an unsolicited-input-character AST. Control passes to this address whenever any unsolicited character (other than CTRL/Q, CTRL/S, or CTRL/O) is input. Note that little checking is done on the specific AST address. A bad address is frequently detected only when the Executive tries to transfer control to it and the task crashes.

In particular, CTRL/C is trapped by the task and does not reach MCR. Thus, any task that uses IO.ATA should recognize some input sequence as a request to terminate, because MCR can not be invoked to abort the task in case of difficulty.

Note that this mechanism is intended to get a single character into the system -- not a series of characters. Since the driver must become a fork process in order to declare an AST, a second character can arrive before the driver can queue an AST for the first character. The buffer for unsolicited input characters, however, is one byte long. Therefore, the terminal driver ignores the second character. This circumstance can occur because of fast input on a busy system or because output is in progress when the characters are received. The implications of this are that neither type-ahead nor full-duplex operations can be simulated perfectly using unsolicited character ASTs.

At entry, the unsolicited character is the low-order byte of the top word on the stack. Before exiting the AST, be sure to pop that word off the stack; otherwise the task will crash. In all other respects the AST environment is standard:

SP+10	Event flag mask word
SP+06	PS of task prior to AST
SP+04	PC of task prior to AST
SP+02	Task's directive status word
SP+00	Unsolicited character in low byte

See the RSX-11M/M-PLUS Executive Reference Manual for further details on ASTs. See Section 3.10.10 for hints on ASTs in a multiterminal environment.

IO.ATA is equivalent to IO.ATT ORed with the subfunction bit TF.AST.

3.3.2.2 **IO.ATT!TF.ESQ** - The task issuing this directive attaches a terminal and notifies the driver that it recognizes escape sequences input from that terminal. Escape sequences are recognized only for solicited input. See Section 3.6 for a discussion of escape sequences.

If the terminal has not been declared capable of generating escape sequences, IO.ATT!TF.ESQ has no effect beyond attaching the terminal. No escape sequences are returned to the task, because any ESC sent by the terminal acts as a line terminator. The SF.SMC QIO or the MCR SET /ESCSEQ command are used to declare the terminal capable of generating escape sequences (see Table 3-5 and Section 3.3.2.12).

3.3.2.3 **IO.CCO** - This write function directs the driver to write to the terminal regardless of a CTRL/O condition that may be in effect. If CTRL/O is in effect, it is cancelled before the write is done.

IO.CCO is equivalent to IO.WLB!TF.CCO.

3.3.2.4 **SF.GMC** - The Get Multiple Characteristics function returns information on terminal characteristics. Get Multiple Characteristics is used in the following way:

```
QIO$C SF.GMC,...,<stadd,size>
```

where stadd is the starting address of a data buffer of length "size" bytes. Each word in the buffer has the form:

```
.BYTE   characteristic-name
.BYTE   0
```

where characteristic-name is one of the eight bit names given in Table 3-5. The QIO function returns a value in the high-order byte of each byte-pair: 1 if the characteristic is true for the terminal, 0 if not true.

For the TC.TTP characteristic (terminal type), one of three values is returned in the high-order byte, as shown in Table 3-6.

Table 3-5
Terminal Characteristics for SF.GMC and SF.SMC Requests

Bit Name	Octal Value	Meaning (If Asserted): Terminal ...	Corresponding MCR Command
TC.ESQ	35	...can generate escape sequences	SET /ESCSEQ=TI:
TC.HLD[1]	44	...is in hold-screen mode	SET /HOLD=TI:
TC.NEC	47	...is in no-echo mode	SET /NOECHO=TI:
TC.PRI[2]	51	...is privileged	SET /PRIV=TTnn:
TC.SCP	12	...is a scope (CRT)	SET /CRT=TI:
TC.SLV	50	...is slaved	SET /SLAVE=TTnn:
TC.SMR	25	Upper-case conversion disabled	SET /LOWER=TI:
TC.TTP	10	Terminal type	SET /LA30S=TI:
			SET /VT05B=TI:
TC.HFF	17	...handle hardware form feeds	SET /HHF=TI:
TC.RSP[3]	3	Receiver speed	SET /SPEED=TI:rcv:xmit
TC.XSP[3]	4	Transmitter speed	(as above)

1 Effective for VT5x, VT61 only.

2 Cannot be changed by a task; must use MCR command.

3 Recognized only by the SF.SMC function.

Table 3-6
Bit TC.TTP (Terminal Type): Values Set by SF.SMC and Returned by SF.GMC

Octal Value	Symbolic	Meaning
0	T.UNK0	Terminal type is unknown
4	T.L30S	Terminal is an LA30
7	T.VT05	Terminal is a VT05B

3.3.2.5 **IO.GTS** - The Get Terminal Support QIO returns a four-word buffer of information specifying which SYSGEN-option features are part of the terminal driver. Of these four words, two are currently defined. Table 3-7 gives details on these two words. The IO.GTS QIO is itself a SYSGEN option. If IO.GTS is issued on a minimum system (one with no terminal-driver SYSGEN options), IE.IFC is returned in the I/O status block.

Table 3-7
Information Returned by Get Terminal Support (IO.GTS) QIO

Bit	Value	Mnemonic	Meaning When Set to 1
Word 0 of Buffer:			
0	1	F1.ACR	Automatic CR/LF on long lines
1	2	F1.BTW	Break-through write
2	4	F1.BUF	Checkpointing during terminal input
3	10	F1.UIA	Unsolicited-input-character AST
4	20	F1.CCO	Cancel CTRL/O before writing
5	40	F1.ESQ	Recognize escape sequences in solicited input
6	100	F1.HLD	Hold-screen mode
7	200	F1.LWC	Lower-to-upper-case conversion
8	400	F1.RNE	Read with no echo
9	1000	F1.RPR	Read after prompting
10	2000	F1.RST	Read with special terminators
11	4000	F1.RUB	CRT rubout
12	10000	F1.SYN	CTRL/R terminal synchronization
13	20000	F1.TRW	Read all and write all
14	40000	F1.UTB	Input characters buffered in task's address space
15	100000	F1.VBF	Variable-length terminal buffers
Word 1 of Buffer:			
0	1	F2.SCH	Set characteristics QIO (SF.SMC)
1	2	F2.GCH	Get characteristics QIO (SF.GMC)

The various symbols used by the IO.GTS, SF.GMC, and SF.SMC QIO's are defined in a system module, TTSYM. These symbols include: F1.xxx and F2.xxx (Table 3-7); T.xxxx (Table 3-6); TC.xxx (Table 3-5); and the SE.xxx error returns described in Table 3-8, Section 3.4. These symbols may be defined locally within a code module by using:

```
     .MCALL   TTSYM$
       .
       .
       .
     TTSYM$
```

If the symbols are not defined locally, they are automatically defined by the Task Builder.

The octal values of these symbols are subject to change. Therefore, we recommend that you always use the symbolic names.

3.3.2.6 **IO.RAL** - The Read All function causes the driver to pass all bits to the requesting task. The driver does not intercept control characters or mask out the "parity" (high-order) bit. This means, for example, that CTRL/C, CTRL/Q, CTRL/S, CTRL/O, and CTRL/Z are passed to the program and are not interpreted by the driver.

NOTE

IO.RAL echoes the characters that are read. To read all bits without echoing, use IO.RAL!TF.RNE.

IO.RAL is equivalent to IO.RLB ORed with the subfunction bit TF.RAL. The only way to terminate an IO.RAL function is by a character count (i.e., filling the input buffer).

3.3.2.7 **IO.RNE** - IO.RNE causes the driver to read a line from the terminal without echoing the characters that are input. This feature is useful when typing sensitive information, for example a password or combination. IO.RNE is also used to read a badge with the RT02-C.

(Another way to suppress echoing of input is to set the terminal to no-echo mode via the SF.SMC QIO or the MCR SET /NOECHO command. See Table 3-5, bit TC.NEC.)

CTRL/R, if selected as a SYSGEN option, is ignored while an IO.RNE is in progress.

IO.RNE is equivalent to IO.RLB ORed with the subfunction bit TF.RNE.

3.3.2.8 **IO.RPR** - The QIO function IO.RPR (Read After Prompt) has the same effect as IO.WLB (to write a prompt to the terminal) followed by IO.RLB. However, IO.RPR differs in four ways from this combination of QIO's. With IO.RPR:

- System overhead is lower because only one QIO is processed.
- There is no "window" during which a response to the prompt may be ignored. Such a window occurs if IO.WAL/IO.RLB is used, because no read may be posted at the time the response is received.
- If the issuing task is checkpointable, it is checkpointed during both the prompt and the read.
- A CTRL/O that may be in effect is cancelled before the prompt is written.

The third user-specified argument to IO.RPR, tmo, is required for compatibility with IAS. If supplied, it is ignored.

Subfunction bits may be ORed with IO.RPR to write the prompt as a Write All (TF.BIN) and to send XOFF after the read (TF.XOF). See the next two sections. In addition, the three Read subfunction bits (TF.RAL, TF.RNE, TF.RST) can be used with IO.RPR.

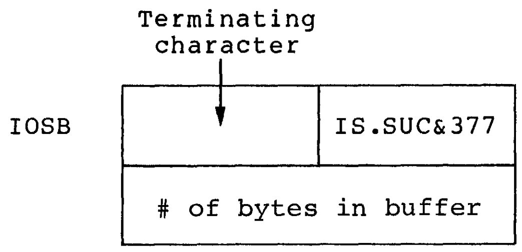
3.3.2.9 **IO.RPR!TF.BIN** - This QIO function results in a read after a "binary" prompt, that is, a prompt that is written by the driver with no character interpretation (as if it were issued as an IO.WAL).

3.3.2.10 **IO.RPR!TF.XOF** - This QIO function causes the driver to send an XOFF to the terminal after its prompt-and-read. The XOFF, or CTRL/S, may have the effect of inhibiting input from the terminal, if the terminal recognizes XOFF for this purpose.

3.3.2.11 **IO.RST** - This QIO function acts like IO.RLB, except that certain special characters terminate the read. These characters are in the ranges 0-37 octal and 175-177 octal. The driver does not interpret the terminating character, with certain exceptions.[1] For example, a horizontal TAB (11 octal) is not expanded, a RUBOUT (or DEL, 177 octal) does not erase, and a CTRL/C does not get MCR's attention.

[1] If upper-lower-case conversion is disabled (see remarks in Section 3.10.9), the character 175 octal echoes as right-brace and 176 octal as tilde, and these characters do not act as terminators. The three characters CTRL/O, CTRL/Q, and CTRL/S (17, 21, and 23 octal, respectively) are not special terminators. The driver interprets them as output effectors.

Upon successful completion of an IO.RST request that was not terminated by filling the input buffer, the I/O status block looks like:



The terminating character is not in the buffer.

IO.RST is equivalent to IO.RLB!TF.RST.

3.3.2.12 **SF.SMC** - This QIO function allows a task to set and reset the characteristics of a terminal. Set Multiple Characteristics is the inverse of SF.GMC. Like SF.GMC, it is called in the following way:

```
QIO$C SF.SMC,...,<stadd,size>
```

where stadd is the starting address of a buffer of length "size" bytes. Each word in the buffer has the form:

```
.BYTE characteristic-name
.BYTE value
```

where "characteristic-name" is one of the symbolic bit names given in Table 3-5, and "value" is either 0 (to clear a given characteristic) or 1 (to set a characteristic). Table 3-5 notes the restrictions that apply to these characteristics.

If "characteristic-name" is TC.TTP (terminal type), then "value" can have any of the values listed in Table 3-6.

A nonprivileged task can only issue an SF.SMC request to affect its own terminal, TI0:. A privileged task can issue SF.SMC to any terminal.

3.3.2.13 **IO.WAL** - The Write All function causes the driver to pass all output from the buffer without interpretation. It does not intercept control characters. Lines are neither wrapped around (if input/output wrap-around has been selected) nor truncated (if wrap-around is not selected).

IO.WAL is equivalent to IO.WLB!TF.WAL.

3.3.2.14 **IO.WBT** - IO.WBT instructs the driver to write the buffer regardless of the I/O status of the receiving terminal. If an IO.WBT is issued on a system that does not support IO.WBT, it is treated as an IO.WLB.

- If another write is in progress, it finishes and the IO.WBT is the next write issued. The effect of this is that IO.WBTs can be stopped by a CTRL/S. Therefore, tasks may still want to timeout on IO.WBT.
- If a read is posted, the IO.WBT proceeds anyway, and an automatic CTRL/R is performed to redisplay any input that was received before the break-through write.
- CTRL/S and/or CTRL/O, if in effect, are cancelled.
- Characters input during a break-through write are ignored.

An IO.WBT cannot break through another IO.WBT that is in progress or if a prompt is being written by IO.RPR. In either case, the low-order byte of the first word of the I/O status block contains IE.RSU&377. The task receiving this error need only reissue the write.

Break-through write may only be issued by a privileged task. However, the task does not have to be mapped to the Executive (Task Builder options /PR:4 or /PR:5). A task can use IO.WBT if it is built with the /PR:0 switch specified. The privileged MCR command BRO (broadcast) uses IO.WBT.

3.4 STATUS RETURNS

Table 3-8 lists error and status conditions that are returned by the terminal driver.

Upon successful completion of a read, the I/O status block contains data of this sort:

	1	0	Byte
Word 0	ret	+1	
1	Number of bytes read		

where:			
ret = 0	means		read terminated by buffer full (byte count satisfied);
ret = 15	means	IS.CR:	read terminated by carriage return;
ret = 33	means	IS.ESC:	read terminated by an Altmode;
ret = 233	means	IS.ESQ:	read terminated by an escape sequence.
+1	is	IS.SUC:	the return code for successful completion.

Most RSX-11M return codes are byte values: for example, IS.SUC = 1 is a byte value. By contrast, the three return codes IS.CR, IS.ESC, and IS.ESQ are word values. The low-order byte indicates successful completion, and the high-order byte is required to show what type of completion occurred.

To test for one of these word-value return codes, first test the low-order byte of the first word of the IOSB for the value IS.SUC. Then test the full word for IS.CR, IS.ESC, or IS.ESQ. (If the full word tests equal to IS.SUC, then its high-order byte is zero, indicating byte-count termination of the read.)

The "error" return IE.EOF may be considered to indicate a successful read, because characters can be returned to the task's buffer.

The three errors in Table 3-8 with SE.xxx codes are returned by the SF.GMC and SF.SMC QIO's. They are characterized by IE.ABO&377 in the low-order byte of the first IOSB word. The high-order byte contains the error code. The second IOSB word contains an offset (starting from 0) to the byte in error in the QIO's stadd buffer.

Table 3-8
Terminal Status Returns

Code	Reason
IE.EOF	Successful completion on a read with end-of-file The line of input read from the terminal was terminated with the end-of-file character CTRL/Z. The second word of the I/O status block contains the number of bytes read before CTRL/Z was seen. The input buffer contains those bytes.
IS.SUC	Successful completion The operation specified in the QIO directive was completed successfully. If the operation involved reading or writing, you can examine the second word of the I/O status block to determine the number of bytes processed. The input buffer contains those bytes.
IS.CR	Successful completion on a read The line of input read from the terminal was terminated by a carriage return. The input buffer contains the bytes read.
IS.ESC	Successful completion on a read The line of input read from the terminal was terminated by an Altmode character. The input buffer contains the bytes read.
IS.ESQ	Successful completion on a read The line of input read from the terminal was terminated by an escape sequence. The input buffer contains the bytes read and the escape sequence.
IS.PND	I/O request pending The operation specified in the QIO directive has not yet been executed. The I/O status block is filled with zeros.

(continued on next page)

Table 3-8 (Cont.)
Terminal Status Returns

Code	Reason
IE.ABO	Operation aborted The specified I/O operation was cancelled by IO.KIL while in progress or while in the I/O queue. The second word of the IOSB shows how many bytes were processed before the kill took effect.
IE.BAD	Bad parameter. The size of the prompt in a read-after-prompt QIO is too big (i.e., greater than 255 bytes on systems supporting variable-length buffers or greater than 80 on systems that do not).
IE.DAA	Device already attached. The physical device-unit specified in an IO.ATT function was already attached by the issuing task. This code indicates that the issuing task has already attached the desired physical device-unit, not that the unit was attached by another task. If the attach specified TF.AST or TF.ESQ, these subfunction bits have no effect.
IE.DNA	Device not attached The physical device-unit specified in an IO.DET function was not attached by the issuing task. This code has no bearing on the attachment status of other tasks.
IE.DNR	Device not ready The physical device-unit specified in the QIO directive was not ready to perform the desired I/O operation. This code is returned to indicate one of the following conditions: ● A timeout occurred on the physical device-unit (that is, an interrupt was lost). ● An attempt was made to perform a function on a remote DH11 or DZ11 line without carrier present. (The line is hung up.)
IE.IES	Invalid escape sequence An escape sequence was started but escape-sequence syntax was violated before the sequence was completed. See Section 3.6.4.

(continued on next page)

Table 3-8 (Cont.)
Terminal Status Returns

Code	Reason
IE.IFC	Illegal function A function code specified in an I/O request was illegal for terminals; or, the function code specified was a SYSGEN option not selected for this system.
IE.NOD	Buffer allocation failure System dynamic storage has been depleted, and there was insufficient space available to allocate an intermediate buffer for an input request.
IE.OFL	Device off-line The physical device-unit associated with the LUN specified in the QIO directive was not online. When the system was booted, a device check indicated that this physical device-unit was not in the configuration.
IE.PES	Partial escape sequence An escape sequence was started, but read-buffer space was exhausted before the sequence was completed. See Section 3.6.4.3.
IE.PRI	Privilege violation In a multiuser system, a nonprivileged task either issued an IO.WBT, or directed an SF.SMC to a terminal other than its own TI0:.
IE.RSU	Resource in use The prompt of an IO.RPR, or a break-through write, was in progress when an IO.WBT was issued. Reissue the IO.WBT later.
IE.SPC	Illegal address space The buffer specified for a read or write request was partially or totally outside the address space of the issuing task. Alternately, a byte count of zero was specified.
SE.BIN	The new value specified for a terminal characteristic in an SF.SMC request was not 0 or 1. (Characteristics other than TC.TTP -- see Table 3-5.)
SE.NIH	A terminal characteristic other than those in Table 3-5 was named in an SF.GMC or SF.SMC request; or, a task attempted to assert TC.PRI.
SE.VAL	The new value specified in an SF.SMC request for the TC.TTP terminal characteristic was not one of those listed in Table 3-6, or the baud rate (speed) specified is not valid.

3.5 CONTROL CHARACTERS AND SPECIAL KEYS

This section describes the meanings of special terminal control characters and keys for RSX-11M. Note that the driver does not recognize control characters and special keys during a Read All request (IO.RAL) and recognizes only some of them during a Read with Special Terminators (IO.RST).

3.5.1 Control Characters

A control character is input from a terminal by holding the control key (CTRL) down while typing one other key. Two of the control characters described in Table 3-9, CTRL/U and CTRL/Z, are echoed on the terminal as ^U and ^Z respectively. Other control characters are recognized by the terminal driver, but are not printing characters and therefore are not echoed.

Table 3-9
Terminal Control Characters

Character	Meaning
CTRL/C	Typing CTRL/C repeatedly is the way to get a terminal's attention. Normally, typing CTRL/C causes unsolicited input on that terminal to be directed to the Monitor Control Routine (MCR). "MCR>" echoes when the terminal is ready to accept unsolicited input. When the unsolicited input completes, it is passed to MCR. If the last item typed on the terminal was CTRL/S (suspend output), then CTRL/C restarts suspended output and directs subsequent input to MCR. If the hold-screen mode option has been selected at SYSGEN, and if the terminal is a VT5x or VT61 in hold-screen mode, then typing a string of CTRL/Cs eventually removes the terminal from hold-screen mode. Not all CTRL/C's act to get MCR's attention. CTRL/Cs are directed to a task if the task has attached a terminal and has specified an unsolicited-input-character AST. See the discussion on unsolicited-input-character ASTs, Section 3.3.2.1. CTRL/C's also go to a task if an IO.RAL (Read All) or IO.RST (Read with Special Terminators) is posted.
CTRL/I	Typing CTRL/I or TAB initiates a horizontal tab, and the terminal spaces to the next tab stop. Tabs at every eighth character position are simulated by the terminal driver.
CTRL/J	Typing CTRL/J is equivalent to typing the LINE FEED key on the terminal.
CTRL/K	Typing CTRL/K initiates a vertical tab, and the terminal performs four line feeds.

(continued on next page)

Table 3-9 (Cont.)
Terminal Control Characters

Character	Meaning
CTRL/L	Typing CTRL/L initiates a form feed, and the terminal performs eight line feeds. Paging is not performed.
CTRL/M	Typing CTRL/M is equivalent to typing the carriage RETURN key on the terminal (see Section 3.5.2).
CTRL/O	Typing CTRL/O suppresses output being sent to a terminal by the current I/O request. For attached terminals, CTRL/O remains in effect, and output continues to be suppressed until any of the following occurs: ● The terminal is detached ● Input is entered ● Another CTRL/O character is typed ● An IO.CCO, IO.WBT, or IO.RPR is processed For unattached terminals, CTRL/O suppresses output for only the current output buffer (generally one line).
CTRL/Q	(SYSGEN option.) Typing CTRL/Q resumes terminal output previously suspended by means of CTRL/S.
CTRL/R	(SYSGEN option.) Typing CTRL/R on a terminal results in the echo of CR/LF followed by the incomplete (unprocessed) input line. Any tabs that were input are expanded and the effect of any rubouts is shown. On hardcopy terminals, CTRL/R allows you to verify the effect of tabs and/or rubouts in an input line. CTRL/R is also useful for CRT terminals when the automatic-cariage-return and CRT rubout SYSGEN options have been selected (see Section 3.8). For example, after rubbing out the leftmost character on the second displayed line of a wrapped input line, you will find that the cursor does not move to the right of the first displayed line. In this case, CTRL/R brings the input line and the cursor back together again.
CTRL/S	(SYSGEN option.) Typing CTRL/S causes terminal output to be suspended. Output is resumed by typing CTRL/Q or CTRL/C.
CTRL/U	Typing CTRL/U before typing a line terminator causes previously typed characters to be deleted back to the beginning of the line. The system echoes this character as ^U followed by a carriage return and a line feed. This allows you to retype the line.
CTRL/Z	Typing CTRL/Z indicates an end-of-file for the current terminal input. It signals MAC, PIP, TKB, and other system tasks that terminal input is complete and the task should exit. The system echoes this character as ^Z followed by a carriage return and a line feed.

3.5.2 Special Keys

The ESCape, carriage RETURN, and RUBOUT keys have special significance for terminal input, as described in Table 3-10. A line can be terminated by an ESCape (or Altmode) character, by a carriage RETURN, by CTRL/Z, or by completely filling the input buffer (that is, by exhausting the byte count before a line terminator is typed). The standard buffer size for a terminal can be determined by issuing a GET LUN INFORMATION system directive and examining Word 5 of the information buffer. Another way is to type the MCR command "SET /BUF=TI:".

Table 3-10
Special Terminal Keys

Key	Meaning
ESCape	If escape sequences are not recognized, typing ESCape or Altmode signals the terminal driver that there is no further input on the current line. This line terminator allows further input on the same line, because the carriage or cursor is not returned to the first column position. If escape sequences are recognized, ESCape signals the beginning of an escape sequence. See Section 3.6.
RETURN	Typing RETURN terminates the current line and causes the carriage or cursor to return to the first column on the line.

RUBOUT	Typing RUBOUT deletes the last character typed on an input line. Only characters typed since the last line terminator may be deleted. Several characters can be deleted in sequence by typing successive RUBOUTs.
	
	The first RUBOUT echoes as a backslash (\\), followed by the character that has been deleted. Subsequent RUBOUTs cause only the deleted character to be echoed. The next character typed that is not a RUBOUT causes another backslash, followed by the new character, to be echoed. The following example illustrates rubbing out ABC and then typing CBA:
	
	`ABC\CBA\CBA`
	
	The second backslash is not displayed if a line terminator is typed after rubbing out the characters on a line, as in the following:
	
	`ABC\CBA`
	
	(SYSGEN option.) At SYSGEN time you may elect to support a "CRT rubout" feature. This feature applies to a terminal only after a SET MCR directive has been issued:
	
	`SET /CRT=TI:`

(continued on next page)

Table 3-10 (Cont.)
Special Terminal Keys

(Note: see Section 3.3.2.12 for another way this SET can be accomplished, via the SF.SMC QIO function.) When a RUBOUT is struck, the last typed character (if any) is removed from the incomplete input line and backspace-space-backspace is echoed. If the last typed character was a tab, enough backspaces are issued to move the cursor to the character position before the tab was typed. If a long input line was split, or "wrapped," by the automatic-carriage-return option, and a RUBOUT erases the last character of a previous line, the cursor is not moved to the previous line. CTRL/R must be used to resynchronize the display with the contents of the incomplete input line.

3.6 ESCAPE SEQUENCES

Escape sequences are strings of two or more characters beginning with 33 octal. Some terminals generate an escape sequence when a special key is pressed (for example, the PF1 key on the VT100). On any terminal, an escape sequence may be generated manually by typing ESCape and the appropriate following characters.

Escape sequences provide a way to pass input to a task without interpretation by the operating system. This could be done with a number of one-character Read All's, but escape sequences allow a neater way to accomplish it (they can be read with ordinary IO.RLB's).

Most DIGITAL software currently does not employ escape sequences. The specifics provided here are for the benefit of users who wish to take advantage of escape sequences in their own tasks.

3.6.1 Definition

An escape sequence is defined as follows:

```
     ESC [int] ... [int] fin
```

where:

ESC	is the result of pressing the ESCape key, a byte (character) of 33 octal.
int	is an "intermediate character" in the range 40 to 57 octal. This range includes the character "space" and 15 punctuation marks. An escape sequence may contain any number of intermediate characters, or none.
fin	is a "final character" in the range 60 to 176 octal. This range includes upper- and lower-case letters, numbers, and 13 punctuation marks.

There are four exceptions to this general definition; these exceptions are discussed in Section 3.6.5.

3.6.2 Prerequisites

Two prerequisites must be satisfied before escape sequences can be received by a task.

First, the task must "ask" for them by issuing an IO.ATT and invoking the subfunction bit TF.ESQ.

Second, the terminal must be declared capable of generating escape sequences. This may be done with an MCR SET command:

```
     SET /ESCSEQ=TI:
```

An alternative way to tell the driver that the terminal can generate escape sequences is by issuing the Set Multiple Characteristics QIO. See Section 3.3.2.13.

If either of these prerequisites is not satisfied, the ESC character is treated as a line terminator. If both prerequisites are satisfied, then an additional feature results. CTRL/SHIFT/O (37 octal) may be used as an Altmode.[1] This character does not act as an Altmode from a terminal that cannot generate escape sequences.

3.6.3 Characteristics

Escape sequences always act as line terminators. That is, an input buffer may contain other characters that are not part of an escape sequence, but an escape sequence always comprises the last characters in the buffer.

Escape sequences are not echoed. However, if a non-CRT rubout sequence is in progress, it is closed with a backslash when an escape sequence is begun.

Escape sequences are not recognized in unsolicited input streams. Neither are they recognized in a Read with Special Terminators (subfunction bit TF.RST) nor in a Read All (subfunction bit TF.RAL).

3.6.4 Escape Sequence Syntax Violations

A violation of the syntax defined in Section 3.6.1 causes the driver to abandon the escape sequence and to return an error (IE.IES).

[1] An Altmode is a line terminator that does not cause the cursor to advance to a new line. On terminals that cannot generate escape sequences, the ESCape key acts as an Altmode. So do the characters 175 and 176 octal, if the terminal has not been declared lower-case (MCR command SET /LOWER). If the terminal is lower-case, then these characters represent right-brace and tilde, respectively.

3.6.4.1 **DEL or RUBOUT (177 Octal)** - The character DEL or RUBOUT is not legal within an escape sequence. Typing it at any point within an escape sequence causes the entire sequence to be abandoned and deleted from the input buffer. Thus, use DEL or RUBOUT to abandon an escape sequence, if desired, once you have begun it. For example, if you enter:

```
AB ESC " DEL CR
```

the buffer contains "AB" and the I/O status block looks like:

IOSB	IS.CR
	2

3.6.4.2 **Control Characters (0-37 Octal)** - The reception of any character in the range 0 to 37 octal (with four exceptions -- see footnote[1]) is a syntax violation that terminates the read with an error (IE.IES). For example, entering:

```
ESC ! CTRL/SHIFT/O
```

results in a buffer that contains these three characters and an I/O status block that looks like:

IOSB	IE.IES
	3

[1] Four control characters are allowed: CTRL/Q, CTRL/S, CTRL/C, and CTRL/O. These characters are handled normally by the operating system even when an escape sequence is in progress. For example, entering:

```
ESC CTRL/S A
```

gives:

IOSB	IS.ESQ
	2

with the side effect of turning off the output stream.

3.6.4.3 **Full Buffer** - A syntax error results when an escape sequence is terminated by running out of read-buffer space, rather than by receipt of a final character. The error IE.PES is returned. For example, after a task issues an IO.RLB QIO with a buffer length of two, and you type:

```
ESC ! A
```

the buffer contains "ESC !", and the I/O status block contains:

IOSB	IE.PES
	2

The "A" is treated as unsolicited input.

3.6.5 Exceptions to Escape-Sequence Syntax

Four "final characters" that normally would terminate an escape sequence are treated as special cases by the terminal driver. These special cases exist for historical compatibility reasons. Three of these characters are: ; (73 octal), ? (77 octal), and O (117 octal). The syntax for escape sequences that contain these four characters as intermediates is:

```
ESC ; [int] ... [int] fin

ESC ? [int] ... [int] fin

ESC O [int] ... [int] finl
```

```
where:  int    =>   40-57   octal;
        fin    =>   60-176  octal; and
        finl   =>  100-176  octal.
```

The fourth exception to the general syntax given in section 3.6.1 involves the "final character" Y (131 octal). Historically (for example, in the VT52), ESC Y has been used to signal the cursor position. It is followed by two numbers signifying column and row positions:

```
ESC Y colpos rowpos
```

where colpos and rowpos are both characters in the range 40-176 octal. They represent bias-40 numbers: colpos = 40 corresponds to column 0, etc.

3.7 VERTICAL FORMAT CONTROL

Table 3-11 summarizes the meanings of all characters used for vertical format control on the terminal. Any one of these characters can be specified as the value of the vfc parameter in the functions IO.WLB, IO.WVB, IO.WBT, IO.CCO, or IO.RPR.

Table 3-11
Vertical Format Control Characters

Octal Value	Character	Meaning
40	blank	SINGLE SPACE - Output a line feed, print the contents of the buffer, and output a carriage return. Normally, printing immediately follows the previously printed line.
60	0	DOUBLE SPACE - Output two line feeds, print the contents of the buffer, and output a carriage return. Normally, the buffer contents are printed two lines below the previously printed line.
61	1	PAGE EJECT - Output eight line feeds (or, if the terminal is an LA180S, output a form feed), print the contents of the buffer, and output a carriage return.
53	+	OVERPRINT - Print the contents of the buffer and output a carriage return, normally overprinting the previous line.
44	$	PROMPTING OUTPUT - Output a line feed and print the contents of the buffer. This mode of output is intended for use with a terminal on which a prompting message is output, and input is then read on the same line.
00	null	INTERNAL VERTICAL FORMAT - Print the buffer contents without addition of vertical format control characters. In this mode, more than one line of guaranteed contiguous output can be printed for each I/O request.

All other vertical format control characters are interpreted as blanks (octal 40).

3.8 FEATURES AVAILABLE BY SYSGEN OPTION

A number of terminal-driver features are available as options at the time the RSX-11M system is generated (see the RSX-11M System Generation and Management Guide or RSX-11S System Generation and Installation Guide, as appropriate). Some have been mentioned previously in the text; these are:

- All the device-specific QIO functions
- Special keys
  CTRL/S -- Suspend output
  CTRL/Q -- Resume suspended output
  CTRL/R -- Write incomplete input buffer
  CRT rubout
- Escape sequences

Other features that you may select at SYSGEN time are described in the following sections.

3.8.1 Automatic Carriage Return

By SYSGEN option, all terminals in a system may be set to "wrap around," on input and output, after a specified number of columns. If this option is selected, the number of characters per line is determined on a terminal-by-terminal basis. An MCR SET command is used to specify the wrap-around column, n:

```
    >SET /BUF=TI:n
    >
```

(Note that n is an octal number by default. Type an explicit decimal point to enter a decimal number.) After SYSGEN and before this SET has been done for a given terminal, the default column width is 72 (decimal).

The SET /BUF command used without an argument is an enquiry that returns the current buffer width for a terminal:

```
    >SET /BUF=TI:
    BUF=TI0:00072.
    >
```

A task can determine the buffer width by issuing a Get LUN Information directive and examining word 5.

After the SET has been done, typing the n+1st character results in a CR/LF being output before the n+1st character is echoed (at the leftmost character position of the next line). There is still only one input line, but it is displayed on two lines on the terminal.

Output also wraps around after column n. This is undesirable for some applications. To disable wraparound, set the buffer to some number greater than the terminal's column width. Output -- and input too -- beyond the column width will then overprint at the right margin. Wraparound is also disabled when executing the IO.WAL function (see Section 3.10.11), because the driver does not keep track of the cursor's position.

It is possible to lose track of where you are in the input buffer if both the automatic carriage return and the CRT rubout features have been selected at SYSGEN. If, while rubbing out text on a wrapped line, you rub out the first character on that line, the cursor will not back up to the previous line. In order to resynchronize the cursor with the contents of the incomplete input buffer, type CTRL/R (if this option has been selected).

It is also possible to cause wraparound to malfunction. This can occur when more than 255. characters are output without an intervening carriage return. This condition is possible because the driver maintains a byte location with the current cursor position; thus, counts greater than 255. are truncated, and the cursor count will be invalid until the next carriage return is received.

3.8.2 Variable-Length Buffering

If this user-transparent SYSGEN option is selected, up to 255 (decimal) characters may be read from a terminal. The terminal driver allocates an Executive buffer the same size as the read request.

If the variable-length option is not chosen, any number of characters may be read from a terminal, but a maximum of 80 are transferred to the task issuing the read request. An Executive buffer of 80 characters is always allocated.

Note that, whether variable-length buffering is selected or not, a maximum of 80 characters may be directed to MCR as unsolicited input.

3.8.3 Task Buffering of Received Characters

This user-transparent SYSGEN option causes characters read from the terminal to be sent directly to the reading task's buffer. With this option, no Executive buffer need be allocated, and the completed input line need not be transferred to the task's buffer. This option, however, does not necessarily reduce system overhead. In a mapped system, each character must be mapped to the task's buffer. If Executive buffering was used, the mapping is done once and then all the characters are transferred.

Task buffering may be overridden by checkpointing. If a task is checkpointable, an Executive buffer is allocated in the normal way and the task is made eligible for checkpointing by any task, regardless of priority, while the read proceeds. (Checkpointing only occurs when there is another task that can be made active.) Since checkpointability is a dynamic quality controlled by the task, the user retains control over the resource tradeoff.

3.8.4 LA30-P Support

This option provides a 1-byte software buffer for terminal input from an LA30-P. Because LA30-P's communicate with RSX-11M by a single-buffered hardware interface, the echoing of an input character may block the reception of the next input character. This is because a character is normally discarded by the terminal driver if it is received before the echo of the previous character completes. The SYSGEN option for LA30-P support (transparent to the user) will buffer the second character in the software.

This option should not be chosen at SYSGEN if there are no LA30-P's in the system.

3.9 TERMINAL INTERFACES

This section summarizes the characteristics of the four types of standard communication-line interfaces supported by RSX-11M. All four interfaces support parity, but RSX-11M does not.

3.9.1 DH11 Asynchronous Serial Line Multiplexer

The DH11 multiplexer interfaces up to 16 asynchronous serial communications lines for terminal use. The DH11 supports programmable baud rates. Input and output baud rates may differ; the input rate may be set to 0 baud, thus effectively turning off the terminal. The DM11-BB option may be included to provide modem control for dialin lines. These lines must be interfaced by means of a full duplex modem (for example, in the United States, a Bell 103A or equivalent modem).

The direct memory access (DMA) capability of the DH11 is not supported by the RSX-11M terminal driver.

3.9.2 DJ11 Asynchronous Serial Line Multiplexer

The DJ11 multiplexer interfaces as many as 16 asynchronous serial lines to the PDP-11 for local terminal communications. The DJ11 does not provide a dialin capability but supports jumper-selectable baud rates.

3.9.3 DL11 Asynchronous Serial Line Interface

The DL11 supports a single asynchronous serial line and handles communication between the PDP-11 and a terminal. A number of standard baud rates are available to DL11 users. Four versions of the DL11 interface are supported by RSX-11M for terminal use: DL11-A, DL11-B, DL11-C, and DL11-D. The DL11-E is supported by the full-duplex terminal driver described in Chapter 2 and by the message-oriented communication drivers described in Chapter 11.

3.9.4 DZ11 Asynchronous Serial Line Multiplexer

The DZ11 multiplexer interfaces up to eight asynchronous serial communication lines for use with terminals. It supports programmable baud rates; however, input and output speeds must be the same. The DZ11 can control a full duplex modem in auto-answer mode.

3.10 PROGRAMMING HINTS

This section contains information relevant to users of the terminal driver.

3.10.1 Terminal Line Truncation

If automatic carriage return has not been selected at SYSGEN, and if the number of characters to be printed exceeds the line length of the physical device-unit, then the terminal driver discards the excess characters until it receives one that instructs it to return to horizontal position 1. You can determine when this will happen by examining word 5 of the information buffer returned by the Get LUN Information system directive, or by typing "SET /BUF=TI:".

3.10.2 ESCape Code Conversion

If escape sequences are not recognized, an ESCape or Altmode character code of 33, 175, or 176 is converted internally to 33 before it is returned to the user on input.

3.10.3 RT02-C Control Function

Because the screen of an RT02C Badge Reader and Data Entry Terminal holds only one line of information, special care must be taken when sending a control character (for example, vertical tab) to the RT02-C. Use IO.WAL (Write All).

It is advisable to read without echoing when reading a badge with the RT02-C. Use IO.RAL or IO.RNE, and then write the received information.

3.10.4 Checkpointing During Terminal Input

If checkpointing during terminal input was selected as a SYSGEN option, a checkpointable task is stopped (and therefore eligible to be checkpointed) when trying to read. Therefore, a stratagem such as issuing a read followed by a mark-time does not work. The intent might be to time-out the read if input is not received in a reasonable length of time. But the mark-time is not issued until the read completes.

You can circumvent this behavior by disabling checkpointing for the read. This is not a desirable solution because it forces a task to remain in memory during the entire read. This defeats the purpose of selecting the checkpoint-during-terminal-input option.

3.10.5 Time Required for IO.KIL

An IO.KIL request may take up to one second to succeed. This is because an internal mark-time mechanism is used to generate a software interrupt to get into a clean state. The I/O may reach a state in which the kill can complete within this time (for instance, if a hardware interrupt is received). If not, the request is killed after one second.

3.10.6 Use of IO.WVB

We recommend that you routinely use IO.WVB, instead of IO.WLB, when writing to a terminal. If the write actually goes to a terminal, the Executive converts your IO.WVB into IO.WLB. However, if the LUN has been redirected to some inappropriate device -- a disk, for example -- your use of an IO.WVB will be rejected because a file is not open on the LUN. This prevents privileged tasks from overwriting block zero of the disk (the boot block).

Note that any subfunction bits specified in the IO.WVB request (for example, TF.CCO, TF.WAL, or TF.WBT) are stripped off when the QIO is converted to an IO.WLB.

3.10.7 Remote DH11 and DZ11 Lines

All remote DH11 lines in a system are answered at the same baud rate. All remote DZ11 lines are also answered at the same rate, which may differ from the DH11 rate. These rates are specified at system generation.

Before a remote DH11 or DZ11 line is answered, the driver clears certain of the terminal characteristics (see Table 3-5) that may have been set by an MCR SET command or by an SF.SMC QIO. The characteristics cleared are: TC.SCP, TC.ESQ, TC.HLD, TC.SMR, and TC.TTP. (Clearing TC.TTP means that a terminal type of "unknown" is returned to an SF.GMC request.) Also, buffer size is set to 73.

A DZ11 remote line must be declared to be remote before the terminal driver will correctly handle the modem. This is done with the MCR command SET /REMOTE=TI:.

NOTE

Because of the few modem signals that the DZ11 handles and the lack of interrupt support provided for those signals, the DZ11 may not adequately handle telephone exchange requirements in all countries.

3.10.8 High-Order Bit on Output

Setting the high-order bit of an output byte causes it to be transmitted but not interpreted by the driver.

3.10.9 Side Effects of Setting Characteristics

Some of the characteristics that a task may set, or that you may set from a terminal, have side effects that should be noted.

TC.HLD -- unexpected behavior can result from a terminal in hold-screen mode if its reception rate is much greater than its transmission rate. (The DH11 supports split baud rates.) In hold-screen mode the terminal sends a CTRL/S during reception of an output stream, when the screen is nearly full. Output is resumed -- another screen-full -- when you type SHIFT/SCROLL (the terminal generates CTRL/Q). Thus, no output is lost as a result of scrolling off the screen before you can read it. However, if the terminal's transmission rate is far below its reception rate, some unread output may scroll out of sight before the CTRL/S can be transmitted.

A related point to note is that some terminals and interfaces are hardware-buffered. This fact can cause obscure timing problems for tasks that try to implement hold-screen mode.

TC.SMR -- If this characteristic is asserted (that is, if lower/upper-case conversion is disabled by, for example, SET /LOWER=TI:), the two characters 175 and 176 octal are interpreted as [(right-brace) and (tilde), respectively. If TC.SMR is not asserted, these two characters act as Altmodes. That is, they act as line terminators that do not advance the cursor to a new line. Altmodes are not echoed.

3.10.10 Unsolicited-Input-Character AST's for Tasks Attaching Several Terminals

For a task that attaches several terminals (for example, a reentrant language processor), the handling of unsolicited input requires special care. When the terminal driver passes an unsolicited input character to a task, it does not pass any information about which of several terminals generated the character. The task must ascertain this for itself.

One solution is for the task to name uniquely the AST entry points for each attached terminal. Each separate AST then identifies its terminal before branching to a common routine that processes the unsolicited character. For example:

```
ATT1:  QIO$C IO.ATA,...,<UIC1>
       BR CONT
ATT2:  QIO$C IO.ATA,...,<UIC2>
       BR CONT
         .
         .
         .
UIC1:  MOV #1,-(SP)
       BR UIC
UIC2:  MOV #2,-(SP)
       BR UIC
         .
         .
         .
UIC:   MOV (SP)+,INDEX
         .
         .
         .
```

3.10.11 Direct Cursor Control

The terminal driver generally examines the output stream in order to keep track of the cursor's horizontal position (so that output can be wrapped around or discarded). Therefore, tasks that want to use direct cursor control should use IO.WALs. This prevents the terminal driver from inserting CR/LFs (that the task considers spurious) into the output stream. FORTRAN WRITE statements become IO.WVBs, which are interpreted by the driver. To prevent this, a FORTRAN task can use the CALL QIO routine or can issue carriage returns at frequent intervals (to make the driver think the cursor is always well to the left of the rightmost column and therefore no CR/LFs need be emitted to keep the cursor on the screen).

3.10.12 DL11 Receiver Interrupt Enable

For hardware reasons, a DL11 is susceptible to losing receiver interrupt enable in its Receiver Status Register. The disabling of the receiver interrupt bit causes the terminal to print output requests but not to respond to input (e.g., the terminal does not echo input characters). The terminal driver has no mechanism for recognizing the disabling. Therefore, it cannot recover. The bit must be reset with an MCR OPEN command, or the console switch register, or a periodically rescheduled task.

3.10.13 Loadable Driver Restrictions

Checkpointing during terminal input, variable length terminal buffer support, and escape sequence support require the presence of conditionally assembled Executive support. If a loadable terminal driver supports one of these features and the Executive does not (or vice versa), the best that can happen is an undefined global when the terminal driver is built. At worst, the system is corrupted.

CHAPTER 4

VIRTUAL TERMINAL DRIVER

4.1 INTRODUCTION

The virtual terminal driver supports offspring task use of virtual terminals in RSX-11M-PLUS systems. Virtual terminals are not physical hardware devices; they are actually implemented in software through the use of data structures created by the RSX-11M-PLUS Executive. Virtual terminals are created by the Executive when requested by parent tasks via the Create Virtual Terminal directive. Virtual terminals are useful in batch processing and other processing environments to provide non-interactive terminal I/O support for offspring tasks, eliminating the need for operator intervention.

Offspring task(s) "spawned" by or "connected" to the parent task that created the virtual terminal can perform terminal I/O operations with the virtual terminal in the same manner as with physical terminals. Virtual terminals differ from physical terminals in that they receive input from or output to a program (the parent task), rather than from a keyboard or to a display (or printer), respectively.

4.2 GET LUN INFORMATION MACRO

Word 2 of the buffer filled by the Get LUN Information system directive (the first characteristics word) contains the following information for virtual terminals. A setting of 1 indicates that the described characteristic is true for virtual terminals.

Bit	Setting	Meaning
0	1	Record-oriented device
1	1	Carriage-control device
2	1	Terminal device
3	0	File-structured device
4	0	Single-directory device
5	0	Sequential device
6	0	Reserved
7	0	User-mode diagnositcs supported
8	0	Massbus device

Bit	Setting	Meaning
9	0	Unit software write-locked
10	0	Input spooled device
11	0	Output spooled device
12	0	Pseudo device
13	0	Device mountable as a communications channel
14	0	Device mountable as a FILES-11 volume
15	0	Device mountable

Words 3 and 4 are undefined. Word 5 specifies the maximum byte count (that is, maximum buffer size) to which offspring requests will be truncated; this value is specified by the parent task in the Create Virtual Terminal system directive as described in the RSX-11M/M-PLUS Executive Reference Manual.

4.3 QIO MACRO

Table 4-1 lists the standard and device-specific functions of the QIO macro that are valid for virtual terminals.

Table 4-1
Standard and Device-Specific QIO Functions for Virtual Terminals

Format	Function
STANDARD FUNCTIONS:	
QIO$C IO.ATT,...	Attach device
QIO$C IO.DET,...	Detach device
QIO$C IO.KIL,...	Cancel I/O request
QIO$C IO.RLB,...,<stadd,size>	Read logical block
QIO$C IO.RVB,...,<stadd,size>	Read virtual block (effects IO.RLB)
QIO$C IO.WLB,...,<stadd,size,stat>	Write logical block
QIO$C IO.WVB,...,<stadd,size,stat>	Write virtual block (effects IO.WLB)
DEVICE-SPECIFIC FUNCTION:	
QIO$C IO.STC,...,<cb,sw2,sw1>	Set terminal characteristics (enable/disable intermediate I/O buffering, or return I/O completion status to offspring task)

Where:

size	is the size of the data buffer in bytes (must be greater than zero). The buffer must be located within the addressing space of the parent or offspring task issuing the I/O request.
stadd	is the starting address of the data buffer.
stat	is the I/O completion status code, specified by the parent task, that is issued by the virtual terminal driver in response to an offspring task's read request upon successful completion.
cb	defines characteristic bits to become set, selecting the following virtual terminal functions:

cb Value	Bits Set	Function
0	none	Enable intermediate buffering in the Executive pool
1	0	Return the specified virtual terminal I/O completion status to the requesting offspring task
2	1	Disable intermediate buffering

sw1	is the I/O completion code for I/O completion status.

NOTE

The sw2 and sw1 parameters are valid in the IO.STC function only when cb=1.

4.3.1 Standard QIO Functions

4.3.1.1 IO.ATT

IO.ATT -- This I/O function can be issued by offspring task tasks to attach the virtual terminal. (It is illegal for parent tasks to issue IO.ATT). Attaching a virtual terminal prevents other offspring tasks from executing I/O operations with the virtual terminal. However, parent task I/O requests are always serviced when issued.

4.3.1.2 IO.DET

IO.DET -- This I/O function can be issued by offspring tasks to detach the virtual terminal, making it available for use by other offspring tasks connected to the same parent task. (It is illegal for parent tasks to issue IO.DET.)

4.3.1.3 **IO.KIL** -- Parent and offspring tasks can issue IO.KIL to cancel I/O requests. An offspring task issuing IO.KIL can result in IE.ABO being returned to the parent task.

4.3.1.4 **IO.RLB, IO.RVB, IO.WLB, IO.WVB** -- These read and write functions execute requested I/O operations with virtual terminals in the same manner as with terminals described in Chapter 2, except as follows:

1. The virtual terminal driver ignores, but does not reject, offspring task IO.WLB and IO.WVB requests containing the vfc parameter used by terminal drivers described in Chapter 2.

2. The virtual terminal driver returns I/O completion status to the offspring task in response to successful completion of the offspring task's IO.RLB or IO.RVB request; however, the actual I/O completion status values returned are specified for data transfers in the third parameter word of the parent task's IO.WLB or IO.WVB response, or in the second and third parameters of the parent task's IO.STC function response when no data transfer is desired.

4.3.2 Device-Specific QIO Function (IO.STC)

The IO.STC function can be issued by parent tasks to enable/disable offspring task I/O buffering in the Executive pool, or to force an appropriate I/O completion status for an offspring task read I/O request when no data transfer is desired. Both of these applications for the IO.STC function are described as follows.

Parent tasks can use IO.STC to enable (or disable) intermediate buffering in the Executive pool. Intermediate buffering, when enabled, is performed on offspring task virtual terminal read and write requests when the offspring task:

1. is checkpointable

2. is not executing an AST routine

3. ASTs are enabled

4. is not already at the stopped state.

Thus, offspring tasks can be stopped for virtual terminal I/O and checkpointed in a manner similar to that when physical terminals are used. Whenever the virtual terminal driver determines that intermediate buffering should not be used, offspring tasks that issue terminal requests become locked in memory until I/O completion; transfers occur directly between parent task and offspring task buffers without intermediate buffering in the Executive pool.

In addition to the conditions that permit intermediate buffering (when specified), one additional condition can automatically disable intermediate parent task in the Create Virtual Terminal directive exceeds the maximum size specified at Sysgen time (512(10) maximum).

The second application for IO.STC is to allow the virtual terminal driver to return an appropriate I/O completion status in response to an offspring task read request. I/O status returned in this manner allows successful completion of the offspring task's request when the parent task determines that no data transfer is desired; this condition can occur, for example, when no data is available for input to the offspring task via the virtual terminal driver. When used in this manner, the IO.STC function must include three parameters <cb,sw2,sw1>, as follows:

cb	A value of 1 is specified to indicate that the I/O completion status return to the offspring task is desired.
sw2	This parameter is the second word returned in the I/O completion status indicating the number of bytes read upon successful completion of an offspring task's read request. However, since no data transfer actually occurs, the value specified is 0; the byte count of 0 specified in this function is legal (and desired) whereas a byte count of 0 in write operations is illegal (and will result in an error being returned to the parent task).
sw2	This parameter specifies the status code to be returned to the offspring task by the virtual terminal driver in the first word of the I/O completion status. This value is returned in the high byte and a value of +1 is returned in the low byte of the status word. Typical values and the status that each represent are listed as follows:

Code	Value	Completion Status Indicated
IS.SUC	+ 1	Successful completion
IS.CR	15	Read terminated by carriage return
IS.ESC	33	Read terminated by an Altmode
IS.ESQ	233	Read terminated by an escape sequence

4.4 STATUS RETURNS

The error and status conditions listed in Tables 4-2 and 4-3 are returned by the virtual terminal driver described in this chapter.

Table 4-2
Virtual Terminal Status Returns for Offspring Task Requests

Code	Reason
--	Successful completion of an offspring task read request results in an I/O completion status specified in a parent task QIO parameter being returned. Typically, the status information returned simulates a subset of I/O returns normally produced by the terminal drivers described in Chapter 2.
IS.SUC	Successful completion The operation specified in the QIO directive was completed successfully. The second word of the I/O status block indicates the number of bytes transferred on a write operation.
IE.IFC	Invalid function code The offspring task attempted a read or a write function and the parent task did not specify an AST address in its response to the requested I/O function, or the offspring task issued an IO.STC or other invalid function.
IE.ABO	Request terminated The offspring task issued IO.KIL or the parent task eliminated the virtual terminal unit.
IE.UPN	Insufficient dynamic storage The driver could not allocate an AST block to notify the parent task of an offspring task request, or the driver could not allocate an intermediate buffer in the Executive pool.

Table 4-3
Virtual Terminal Status Returns for Parent Task Requests

Code	Reason
IS.SUC	Successful completion The operation specified in the QIO directive was completed successfully. The second word of the I/O status block indicates the number of bytes transferred on a read or write operation.
IE.EOF	End of file encountered The IO.STC function was completed successfully.
IE.BAD	Bad parameters The parent task specified a buffer size that exceeded the system maximum specified at Sysgen time.
IE.DUN	Device not attachable An IO.ATT or IO.DET function was issued by the parent task.
IE.IFC	Invalid function code A read, write, or IO.STC function was issued without a pending offspring task request. This status can occur if the offspring task cancels a pending read or write request. This function code is also returned when IO.STC is issued to enable intermediate buffering on a virtual terminal unit whose buffer size, specified in the Create Virtual Terminal directive, exceeds the system maximum specified at Sysgen time.

CHAPTER 5

DISK DRIVERS

5.1 INTRODUCTION

The RSX-11M disk drivers support the disks summarized in Table 5-1. Subsequent sections describe these devices in greater detail.

All of the disks described in this chapter are accessed in essentially the same manner. Up to eight disks of each type (except RX01, RX02, RL01, and RL02) may be connected to their respective controllers. Disks and other file-structured media under RSX-11M are divided logically into a series of 256-word blocks.

5.1.1 RF11/RS11 Fixed-Head Disk

The RF11 controller/RS11 fixed-head disk provides random-access bulk storage. It features fast track-switching time and a redundant set of timing tracks. The RF11/RS11 is unique because the hardware can automatically perform a spiral read across disk platters.

5.1.2 RS03 Fixed-Head Disk

The RS03 (RH11-RH70 controller/RS03 fixed-head disk) is a fixed-head disk which offers speed and efficiency. With 64 tracks per platter, and recording on one surface, the RS03 has a capacity of 262,144 words.

5.1.3 RS04 Fixed-Head Disk

The RS04 (RH11-RH70 controller/RS04 fixed-head disk) is similar to the RS03 disk, and interfaces to the same controller; but provides twice the number of words per track by recording on both surfaces of the platter, and thus twice the capacity.

5.1.4 RP11/RP02 or RP03 Pack Disks

The RP11 controller/RP02 or RP03 pack disk consists of 20 data surfaces and a moving read/write head. The RP03 has twice as many cylinders, and thus, double the capacity of the RP02. Only an even number of words can be transferred in a read/write operation.

Table 5-1
Standard Disk Devices

Controller/ Drive	RPM	Secs	Trks	Cyls	Bytes/ Drive	Decimal Blocks
RF11/RS11	1800	--	1	128	524,288	1024
RHXX/RS03	3600	64[1]	1	64	524,288	1024
RHXX/RS04	3600	64[1]	1	64	1,048,576	2048
RP11E/RPR02	2400	10	20	200	20,480,000	40,000
RP11C/RP03	2400	10	20	400	40,960,000	80,000
RHXX/RM02	2400	32	5	823	67,420,160	131,680
RHXX/RM03	3600	32	5	823	67,420,160	131,680
RH11/RP04,RP05	3600	22	19	411	87,960,576	171,798
RH70/RP06	3600	22	19	815	174,423,040	340,670
RK11/RK05	1500	12	2	200	2,457,600	4800
RL11/RL01	2400	40[2]	2	256	5,242,880	10,240
RL11/RL02	2400	40[2]	2	512	10,485,760	20,480
RK611/RK06	2400	22	3	411	13,888,512	27,126
RK611/RK07	2400	22	3	815	27,810,800	53,790
RX11/RX01	360	26[3]	1	77	256,256	494
RX211/RX02	360	26[3]	1	77	512,512	988

[1] THE RS03 has 64 words per sector; the RS04 has 128 words per sector.

[2] The RL01 and RL02 each have 128 words per sector.

[3] The RX01 has 64 words per sector; the RX02 has 128 words per sector.

All of the disks described in this chapter are accessed in essentially the same manner. Up to eight disks of each type (except RX01, RX02, RL01, or RL02) may be connected to their respective controllers. Disks and other file-structured media under RSX-11M are divided logically into a series of 256-word blocks.

5.1.5 **RM02/RM03 Pack Disk**

The RM02/RM03 are MASSBUS disk drives and adapters that uses the existing MASSBUS controller. With a single-head per surface, they provide a 1.2 megabyte per second data transfer rate. The RM03 is used with the RH70 controller on PDP-11/70 systems. All other systems use the RM02 with the RH11 controller.

5.1.6 **RP04, RP05, RP06 Pack Disks**

The RP04 or RP05 (RH11-RH70 controller/RP04 or RP05 pack disk) pack disks consist of 19 data surfaces and a moving read/write head. Both offer large storage capacity with rapid access time. The RP06 pack disk has approximately twice the capacity of the RP04 or RP05.

5.1.7 **RK11/RK05 or RK05F Cartridge Disks**

The RK11 controller/RK05 DECpack cartridge disk is an economical storage system for medium-volume, random-access storage. The removable disk cartridge offers the flexibility of large off-line capacity with rapid transfers of files between on- and off-line units without necessitating copying operations. The RK05F has twice the storage capacity of the RK05 and has a fixed (non-removable) disk cartridge.

5.1.8 **RL11/RL01 or RL02 Cartridge Disk**

The RL01 is a low cost, single-head per surface disk with a burst data transfer rate of 512 kilobytes per second. The storage capacity of the RL02 is twice that of the RL01.

5.1.9 **RK611/RK06 or RK07 Cartridge Disk**

The RK611 controller/RK06 cartridge disk is a removable, random-access, bulk-storage system with three data surfaces. The storage capacity is 6,944,256 words per pack. The system, expandable to eight drives, is suitable for medium to large systems.

The RK611 controller/RK07 cartridge disk is generally similar to the RK611/RK06, except storage capacity is increased to approximately 13,905,400 words per pack. Both RK06 and RK07 disks can use the same RK611 controller; mixing RK06 and RK07 disks on the same controller is permitted.

5.1.10 **RX10/RX01 Flexible Disk**

The RX11 controller/RX01 flexible disk is an economical storage system for low-volume, random-access storage. Data is stored in 26 64-word sectors per track; there are 77 tracks per disk. Data may be accessed by physical sector or logical block. If logical or virtual block I/O is selected, the driver reads four physical sectors. These sectors are interleaved to optimize data transfer. The next logical sector that falls on a new track is skewed by six sectors to allow for track to track switch time. Physical block I/O provides no interleaving or skewing and provides access to all 2002 sectors on the disk. Logical or virtual I/O starts on track one and provides access to 494 logical blocks.

5.1.11 **RX211/RX02 Flexible Disk**

The RX211 controller/RX02 flexible disk is an economical storage system for low-volume, random-access storage. It is capable of operating in either an industry-standard single density mode (as stated for the RX11/RX01 flexible disk), or a double density mode (not industry standard). In the single density mode, each drive can store data exactly as stated in Section 5.1.10. In the double density mode, data is stored in 26 128-word sectors per track; there are 77 tracks per disk. The RX211/RX02 operating in the single density mode can read disks written by an RX11/RX01 flexible disk system. In addition, disks written by the RX211/RX02 operating in the single density mode can be read by the RX11/RX01 flexible disk system.

5.2 GET LUN INFORMATION MACRO

Word 2 of the buffer filled by the Get LUN Information system directive (the first characteristics word) contains the following information for disks. A bit setting of 1 indicates that the described characteristic is true for disks.

Bit	Setting	Meaning
0	0	Record-oriented device
1	0	Carriage-control device
2	0	Terminal device
3	1	File structured device
4	0	Single-directory device
5	0	Sequential device
6	0	Reserved
7	X	User-mode diagnostics supported (device dependent)
8	X	Massbus device device dependent (can be set for Massbus devices using the RH70 controller)
9	0	Unit software write-locked
10	0	Input spooled device
11	0	Output spooled device
12	0	Pseudo device
13	0	Device mountable as a communications channel
14	1	Device mountable as a FILES-11 volume
15	1	Device mountable

Words 3 and 4 of the buffer contain the maximum logical block number. Word 5 indicates the default buffer size, which is 512 bytes for all disks.

5.3 QIO MACRO

This section summarizes the standard, and device-specific QIO functions for disk drivers.

5.3.1 Standard QIO Functions

Table 5-2 lists the standard functions of the QIO macro that are valid for disks.

Table 5-2
Standard QIO Functions for Disks

Format	Function
QIO$C IO.ATT,...	Attach device [1]
QIO$C IO.DET,...	Detach device
QIO$C IO.KIL,...	Kill I/O [2]
QIO$C IO.RLB,...,<stadd,size,,blkh,blkl>	Read logical block
QIO$C IO.RVB,...,<stadd,size,,blkh,blkl>	Read virtual block
QIO$C IO.WLB,...,<stadd,size,,blkh,blkl>	Write logical block
QIO$C IO.WLC,...,<stadd,size,,blkh,blkl>	Write logical block followed by write check[3]
QIO$C IO.WVB,...,<stadd,size,,blkh,blkl>	Write virtual block

[1] In RSX-11M systems, only unmounted volumes may be attached; in RSX-11M-PLUS systems, only volumes mounted foreign may be attached. Any other attempt to attach a mounted volume will result in an IE.PRI status being returned in the I/O status doubleword.

[2] In-progress disk operations are allowed to complete when IO.KIL is received, because they take such a short time. I/O requests that are queued when IO.KIL is received are killed immediately. An IE.ABO status is returned in the I/O status doubleword.

[3] Not supported on RX01 or RX02 flexible disks.

where:	stadd	is the starting address of the data buffer (must be on a word boundary).
	size	is the data buffer size in bytes (must be even, greater than zero, and, for the RP02 and RP03, also a multiple of four bytes).
	blkh/blkl	are block high and block low, combining to form a double-precision number that indicates the actual logical/virtual block address on the disk where the transfer starts; blkh represents the high eight bits of the address, and blkl the low 16 bits.

IO.RVB and IO.WVB are associated with file operations (see the IAS/RSX-11 I/O Operations Reference Manual). For these functions to be executed, a file must be open on the specified LUN if the volume associated with the LUN is mounted. Otherwise, the virtual I/O request is converted to a logical I/O request using the specified block numbers.

NOTE

When writing a new file using QIOs, the task must explicitly issue .EXTND File Control System library routine calls as necessary to reserve enough blocks for the file, or the file must be initially created with enough blocks allocated for the file. In addition, the task must put an appropriate value in the FDB for the end-of-file block number (F.EFBK) before closing the file. (Refer to the .EXTND routine description in the IAS/RSX-11 I/O Operations Reference Manual.)

Each disk driver supports the subfunction bit IQ.X: inhibit retry attempts for error recovery. The subfunction bit is used by ORing it into the desired QIO; for example:

```
     QIO$C IO.WLB!IQ.X,...,<stadd,size,,blkh,blkl>
```

The IQ.X subfunction permits user-specified retry algorithms for applications in which data reliability must be high.

The overlapped seek drivers for RSX-11M-PLUS support subfunction bit IQ.Q: queue the request immediately without doing a seek (that is, use implied seeks).

5.3.2 Device-Specific QIO Functions

The device-specific functions of the QIO macro are valid for the RX01 only; they are shown in Table 5-3.

Table 5-3
Device-Specific Functions for the RX01, RX02, RL01, and RL02 Disk Drivers

Format	Function
QIO$C IO.RPB,...,<stadd,size,,,pbn>	Read physical block
QIO$C IO.SEC,...	Sense diskette characteristics (RX02 only)
QIO$C IO.SMD,...,<density,,>	Set media density (RX02 only)
QIO$C IO.WDD,...,<stadd,size,,,pbn>	Write physical block (with deleted data mark) (RX01 and RX02 only)
QIO$C IO.WPB,...,<stadd,size,,,pbn>	Write physical block

where:	stadd	is the starting address of the data buffer (must be on a word boundary).
	size	is the data buffer size in bytes must be even and greater than zero).
	pbn	is the physical block number where the transfer starts (no validation will occur).
	density	is the media density as follows: 0 = single (RX01-compatible) density 2 = double density

5.4 STATUS RETURNS

The error and status conditions listed in Table 5-4 are returned by the disk drivers described in this chapter.

Table 5-4
Disk Status Returns

Code	Reason
IS.SUC	Successful completion The operation specified in the QIO directive was completed successfully. The second word of the I/O status block can be examined to determine the number of bytes processed, if the operation involved reading or writing.
IS.PND	I/O request pending The operation specified in the QIO directive has not yet been executed. The I/O status block is filled with zeros.
IS.RDD	Deleted data mark read A deleted record was encountered while executing an IO.RPB function. The second word of the I/O status block can be examined to determine the number of bytes processed (RX01 and RX02 only).
IE.ABO	Request aborted An I/O request was queued (not yet acted upon by the driver) when an IO.KIL was issued.
IE.ALN	File already open The task attempted to open a file on the physical device unit associated with specified LUN, but a file has already been opened by the issuing task on that LUN.

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Table 5-4 (Cont.)
Disk Status Returns

Code	Reason
IE.BLK	Illegal block number An illegal logical block number was specified. This code would be returned, for example, if block 4800 were specified for an RK05 disk, on which legal block numbers extend from zero through 4799. IE.BLK would also be returned if an attempt was made to write on the last track of an RK06 disk. (See Section 5.5.)
IE.BBE	Bad block error The disk sector (block) being read was marked as a bad block in the header word.
IE.BYT	Byte-aligned buffer specified Byte alignment was specified for a buffer, but only word alignment is legal for disk. Alternatively, the length of a buffer is not an appropriate number of bytes. For example, all RP03 and RP02 disk transfers must be multiples of four bytes.
IE.DNR	Device not ready The physical device unit specified in the QIO directive was not ready to perform the desired I/O operation.
IE.FHE	Fatal hardware error The controller is physically unable to reach the location where input/output operation is to be performed. The operation cannot be completed.
IE.IFC	Illegal function A function code was specified in an I/O request that is illegal for disks.
IE.NLN	File not open The task attempted to close a file on the physical device unit associated with the specified LUN, but no file was currently open on that LUN.
IE.NOD	Insufficient buffer space Dynamic storage space has been depleted, and there was insufficient buffer space available to allocate a secondary control block. For example, if a task attempts to open a file, buffer space for the window and file control block must be supplied by the Executive. This code is returned when there is not enough space for this operation.

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Table 5-4 (Cont.)
Disk Status Returns

Code	Reason
IE.OFL	Device off-line The physical device unit associated with the LUN specified in the QIO directive was not on-line. When the system was booted, a device check indicated that this physical device unit was not in the configuration.
IE.OVR	Illegal read overlay request A read overlay was requested, and the physical device unit specified in the QIO directive was not the physical device unit from which the task was installed. The read overlay function can only be executed on the physical device unit from which the task image containing the overlays was installed.
IE.PRI	Privilege violation The task which issued the request was not privileged to execute that request. For disk, this code is returned if a nonprivileged task attempts to read or write a mounted volume directly (i.e., using IO.RLB or IO.WLB). Also, this code is returned if any task attempts to attach a mounted volume.
IE.SPC	Illegal address space The buffer specified for a read or write request was partially or totally outside the address space of the issuing task. Alternately, a byte count of zero was specified.
IE.VER	Unrecoverable error After the system's standard number of retries has been attempted upon encountering an error, the operation still could not be completed. For disk, unrecoverable errors are usually parity errors.
IE.WCK	Write check error An error was detected during the write check portion of an operation.
IE.WLK	Write-locked device The task attempted to write on a disk that was physically write-locked.

When a disk I/O error condition is detected, an error is usually not returned immediately. Instead, RSX-11M attempts to recover from most errors by retrying the function as many as eight times. Unrecoverable errors are generally parity, timing, or other errors caused by a hardware malfunction.

5.5 PROGRAMMING HINTS

For the RK611 controller/RK06 or RK07 disk, the RL11 controller/RL01 or RL02 disk, RM02 disk and RM03 disk, the driver write-protects the last track of the cartridge. This track contains the factory-recorded bad-sector file.

CHAPTER 6

DECTAPE DRIVER

6.1 INTRODUCTION

The RSX-11M DECtape driver supports the TC11-G dual DECtape controller with up to three additional dual DECtape transports. The TC11-G is a dual-unit, bidirectional, magnetic-tape transport system for auxiliary data storage. DECtape is formatted to store data at fixed positions on the tape, rather than at unknown or variable positions as on coventional magnetic tape. The system uses redundant recording of the mark, timing, and data tracks to increase reliability. Each reel contains 578 logical blocks. As with disk, each of these blocks can be accessed separately, and each contains 256 words.

6.2 GET LUN INFORMATION MACRO

Word 2 of the buffer filled by the Get LUN Information system directive (the first characterics word) contains the following information for DECtapes. A bit setting of 1 indicates that the described characteristic is true for DECtapes.

Bit	Setting	Meaning
0	0	Record-oriented device
1	0	Carriage-control device
2	0	Terminal device
3	1	File structured device
4	0	Single-directory device
5	0	Sequential device
6	0	Reserved
7	0	User-mode diagnostics supported
8	0	Massbus device
9	0	Unit software write-locked
10	0	Input spooled device
11	0	Output spooled device
12	0	Pseudo device

Bit	Setting	Meaning
13	0	Device mountable as a communications channel
14	1	Device mountable as a FILES-11 volume
15	1	Device mountable

Words 3 and 4 of the buffer contain the maximum LBN. Word 5 indicates the default buffer size, 512 bytes, for DECtape.

6.3 QIO MACRO

This section summarizes standard and device-specific QIO functions for the DECtape driver.

6.3.1 Standard QIO Functions

Table 6-1 lists the standard functions of the QIO macro that are valid for DECtape.

Table 6-1
Standard QIO Functions for DECtape

Format	Function
QIO$C IO.ATT,...	Attach device [1]
QIO$C IO.DET,...	Detach device
QIO$C IO.KIL,...	Kill I/O [2]
QIO$C IO.RLB,...,<stadd,size,,,lbn>	Read logical block (forward)
QIO$C IO.RVB,...,<stadd,size,,,lbn>	Read virtual block (forward)
QIO$C IO.WLB,...,<stadd,size,,,lbn>	Write logical block (forward)
QIO$C IO.WVB,...,<stadd,size,,,lbn>	Write virtual block (forward)

[1] Only unmounted volumes may be attached. An attempt to attach a mounted volume will result in an IE.PRI status being returned in the I/O status doubleword.

[2] In-progress DECtape operations are allowed to complete when IO.KIL is received, unless the unit is not ready, because they take such a short time. I/O requests that are queued when IO.KIL is received are killed. An IE.ABO status is returned in the I/O status doubleword.

where:	stadd	is the starting address of the data buffer (must be on a word boundary).
	size	is the data buffer size in bytes (must be even and greater than zero).
	lbn	is the logical block number on the DECtape where the transfer starts (must be in the range 0-577).

IO.RVB and IO.WVB are associated with file operations (see the <u>IAS/RSX-11 I/O Operations Reference Manual</u>). For these functions to be executed, a file must be open on the specified LUN if the volume associated with the LUN is mounted. Otherwise, the virtual I/O request is converted to a logical I/O request using the specified block numbers.

6.3.2 Device-Specific QIO Functions

The device-specific functions of the QIO macro that are valid for DECtape are shown in Table 6-2.

Table 6-2
Device-Specific Functions for DECtape

Format	Function
QIO$C IO.RLV,...,<stadd,size,,,lbn>	Read logical block (reverse)
QIO$C IO.WLV,...,<stadd,size,,,lbn>	Write logical block (reverse)

Where:	stadd	is the starting address of the data buffer (must be on a word boundary).
	size	is the data buffer size in bytes (must be even and greater than zero).
	lbn	is the logical block number on the DECtape where the transfer starts (must be in the range 0-577).

6.4 STATUS RETURNS

The error and status conditions listed in Table 6-3 are returned by the DECtape driver described in this chapter.

Table 6-3
DECtape Status Returns

Code	Reason
IS.SUC	Successful completion The operation specified in the QIO directive was completed successfully. The second word of the I/O status block can be examined to determine the number of bytes processed, if the operation involved reading or writing.
IS.PND	I/O request pending The operation specified in the QIO directive has not yet been executed. The I/O status block is filled with zeros.
IE.ABO	Request aborted An I/O request was queued (not yet acted upon by the driver) when an IO.KIL was issued.
IE.ALN	File already open The task attempted to open a file on the physical device unit associated with the specified LUN, but a file has already been opened by the issuing task on that LUN.
IE.BLK	Illegal block number. An illegal logical block number was specified for DECtape. The number exceeds 577 (1101 octal).
IE.BYT	Byte-aligned buffer specified. Byte alignment was specified for a buffer, but only word alignment is legal for DECtape. Alternately, the length of the buffer is not an even number of bytes.
IE.DNR	Device not ready The physical device unit specified in the QIO directive was not ready to perform the desired I/O operation.
IE.IFC	Illegal function A function code was specified in an I/O request that is illegal for DECtape.

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Table 6-3 (Cont.)
DECtape Status Returns

Code	Reason
IE.NLN	File not open The task attempted to close a file on the physical device unit associated with the specified LUN, but no file was currently open on that LUN.
IE.NOD	Insufficient buffer space Dynamic storage space has been depleted, and there was insufficient buffer space available to allocate a secondary control block. For example, if a task attempts to open a file, buffer space for the window and file control block must be supplied by the Executive. This code is returned when there is not enough space for this operation.
IE.OFL	Device off-line The physical device unit associated with the LUN specified in the QIO directive was not on-line. When the system was booted, a device check indicated that this physical device unit was not in the configuration.
IE.OVR	Illegal read overlay request A read overlay was requested and the physical device unit specified in the QIO directive was not the physical device unit from which the task was installed. The read overlay function can only be executed on the physical device unit from which the task image containing the overlays was installed.
IE.PRI	Privilege violation The task which issued the request was not privileged to execute that request. For DECtape, this code is returned when a nonprivileged task attempts to read or write a mounted volume directly (that is, IO.RLB, IO.RLV, IO.WLB, or IO.WLV). Also, this code is returned if any task attempts to attach a mounted volume.
IE.SPC	Illegal address space The buffer specified for a read or write request was partially or totally outside the address space of the issuing task. Alternately, a byte count of zero was specified.

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Table 6-3 (Cont.)
DECtape Status Returns

Code	Reason
IE.VER	Unrecoverable error After the system's standard number of retries has been attempted upon encountering an error, the operation still could not be completed. For DECtape, this code is returned to indicate any of the following conditions. ● A parity error was encountered. ● The task attempted a forward multi-block transfer past block 577 (1101 octal). ● The task attempted a backward multi-block transfer past block zero.
IE.WLK	Write-locked device The task attempted to write on a DECtape unit that was physically write-locked.

6.4.1 DECtape Recovery Procedures

When a DECtape I/O error condition is detected, RSX-11M attempts to recover from the condition by retrying the function as many as five times. Unrecoverable errors are generally parity, mark track, or other errors caused by a faulty recording medium or a hardware malfunction. An unrecoverable error condition also occurs when a read or write operation is performed past the last block of the DECtape on a forward operation, or the first block of the DECtape on a reverse operation.

In addition to the standard error conditions, an unrecoverable error is reported when the "rock count" exceeds eight. The rock count is the number of times the DECtape driver reverses the direction of the tape while looking for a block number. Assume that the block numbers on a portion of DECtape are 99, 96, and 101, where one bit was dropped from block number 100, making it 96. If an I/O request is received for block 100 and the tape is positioned at block 99, the driver starts searching forward for block 100. The first block to be encountered is 96 and because the driver is searching for block 100 in a forward direction and 96 is less than 100, the search continues forward. Block 101 is the next block, and because number 101 is greater than 100, the driver reverses the direction of the tape and starts to search backward. The next block number in this direction is 96 and direction is reversed again, because 100 is greater than 96. To prevent the DECtape from being hung in this position, continually rocking between block numbers 96 and 100, a maximum rock count of eight has been established.

6.4.2 Select Recovery

If the DECtape unit is in an off-line condition when the I/O function is performed, the message shown below is output on the operator's console.

```
*** DTn:  -- SELECT ERROR
```

where n is the unit number of the drive that is currently off-line. The user should respond by placing the unit to REMOTE. The driver retries the function, from the beginning, once every second. It displays the message once every 15 seconds until the appropriate DECtape unit is selected. A select error may also occur when there are two drives with the same unit number or when no drive has the appropriate unit number.

6.5 PROGRAMMING HINTS

This section contains information on important programming considerations relevant to users of the DECtape driver described in this chapter.

6.5.1 DECtape Transfers

If the transfer length on a write is less than 256 words, a partial block is transferred with zero fill for the rest of the physical block. If the transfer length on a read is less than 256 words, only the number of words specified is transferred. If the transfer length is greater than 256 words, more than one physical block is transferred.

6.5.2 Reverse Reading and Writing

The DECtape driver supports reverse reading and writing, because these functions speed up data transfers in some cases. A block should normally be read in the same direction in which it was written. If a block is read from a DECtape into memory in the opposite direction from that in which it was written, it is reversed in memory (e.g., word 255 becomes word 0, and 254 becomes word 1). If this occurs, the user must then reverse the data within memory.

6.5.3 Speed Considerations When Reversing Direction

It is possible to reverse direction at any time while reading or writing DECtape. However, the user should understand that reversing direction substantially slows down the movement of the tape. Because DECtape must be moving at a certain minimum speed before reading or writing can be performed, a tape block cannot be accessed immediately after reversing direction. Two blocks must be bypassed before a read or write function can be executed, to give the tape unit time to build up to normal access speed. Furthermore, when a request is issued to read or write in a certain direction, the tape first begins to move in that direction, then starts detecting block numbers. The following examples illustrate these principles.

If a DECtape is positioned at block number 12 and the driver receives a request to read block 10 forward, the tape starts to move forward, in the direction requested. When block number 14 is encountered, the driver reverses the direction of the tape, since 14 is greater than 10. The search continues backward, and block numbers 11 and 10 are encountered. Because the direction must be reversed and the driver requires two blocks to build up sufficient speed for reading, block number 9 and 8 are also bypassed in the backward direction. Then the direction is reversed and the driver encounters blocks 8 and 9 forward before reaching block number 10 and executing the read request.

6.5.4 Aborting a Task

If a task is aborted while waiting for a unit to be selected, the DECtape driver recognizes this fact within one second.

CHAPTER 7

DECTAPE II DRIVER

7.1 INTRODUCTION

The DECTAPE II (TU58) driver supports TU58 system hardware, providing low cost, block replacable mass storage.

7.1.1 TU58 Hardware

Each TU58 DECTAPE II system consists of one or two TU58 cartridge drives, one tape drive controller, and one DL11-type serial line interface. Each TU58 drive functions as a random access, block-formatted mass storage device. Each tape cartridge is capable of storing 512(10) blocks of 512(10) bytes each. Access time is 10 seconds, average. All I/O transfers (commands and data) are via the serial line interface at serial transmission rates of 9600 bps. All read and write check operations are performed by the controller hardware using a 16-bit checksum. The controller performs up to 8 attempts to read a block, as necessary, before aborting the read operation and returning a hard error; however, whenever more than one read attempt is required for a successful read, the driver is notified in order to report a soft error message to the error logger.

7.1.2 TU58 Driver

The TU58 driver communicates with the TU58 hardware via a serial line interface (DL11); no other interface is required. All data and command transfers between the PDP-11 system and the TU58 are via programmed I/O and interrupt-driven routines; NPRs are not supported.

7.2 GET LUN INFORMATION MACRO

Word 2 of the buffer filled by the Get LUN Information system directive (the first characteristics word) contains the following information for the TU58. A bit setting of 1 indicates that the described characteristic is true for this device.

Bit	Setting	Meaning
0	0	Record-oriented device
1	0	Carriage-control device
2	0	Terminal device
3	1	File-structured device
4	0	Single-directory device
5	0	Sequential device
6	0	Reserved
7	1	User-mode diagnostics supported
8	0	Massbus device
9	0	Unit software write-locked
10	0	Input spooled device
11	0	Output spooled device
12	0	Pseudo device
13	0	Device mountable as a communications channel
14	1	Device mountable as a FILES-11 volume
15	1	Device mountable

Words 3 and 4 of the buffer are a double precision number specifying the total number of blocks on the device; this value is 512(10) blocks. Word 5 indicates the default buffer size, which is 512(10) bytes.

7.3 QIO MACRO

This section summarizes standard and device-specific QIO functions for the TU58.

7.3.1 Standard QIO Functions

Table 7-1 lists the standard QIO system directive functions of the QIO macro that are valid for the TU58.

Table 7-1
Standard QIO Functions for the TU58

Format	Function
QIO$C IO.ATT,...	Attach device
QIO$C IO.DET,...	Detach device
QIO$C IO.KIL,...	Cancel I/O requests[1]
QIO$C IO.RLB,...,<stadd,size,,,lbn>	Read logical block
QIO$C IO.WLB,...,<stadd,size,,,lbn>	Write logical block

[1] In-progress operations are allowed to complete when IO.KIL is received. I/O requests that are queued when IO.KIL is received are killed.

where:		
	stadd	is the starting address of the data buffer (must be on a word boundary)
	size	is the data buffer size in bytes (must be even and greater than zero)
	lbn	is the logical block number on the cartridge tape where the data transfer starts (must be in the range of 0-777)

7.3.2 Device-Specific QIO Functions

The device-specific QIO system directive functions that are valid for the TU58 are shown in Table 7-2.

Table 7-2
Device-Specific QIO Functions for the TU58

Format	Function
QIO$C IO.WLC,...,<stadd,size,,,lbn>	Write logical block with check
QIO$C IO.RLC,...,<stadd,size,,,lbn>	Read logical block with check
QIO$C IO.BLS,...,<lbn>	Position tape
QIO$C IO.DGN,...	Run internal diagnostics

where:		
	stadd	is the starting address of the data buffer (must be on a word boundary)
	size	is the data buffer size in bytes (must be even and greater than zero)
	lbn	is the logical block number on the cartridge tape where the data transfer starts (must be in the range of 0-777)

Additional details for device-specific QIO functions are provided in the following paragraphs.

7.3.2.1 **IO.WLC** - The IO.WLC function writes the specified data onto the tape cartridge. A checksum verification is then performed by reading the data just written; data is not returned to the task issuing the function. An appropriate status, based on the checksum verification, is returned to the issuing task.

7.3.2.2 **IO.RLC** - The IO.RLC function reads the tape with an increased threshold in the TU58's data recovery circuit. This is done as a check to insure data read reliability.

7.3.2.3 **IO.BLS** - The IO.BLS function is used for diagnostic purposes to position the tape to the specified logical block number.

7.3.2.4 **IO.DGN** - The IO.DGN function is used for diagnostic purposes to execute the TU58's internal (firmware) diagnostics. Appropriate status information is returned to the issuing task via the I/O status block.

7.4 STATUS RETURNS

Table 7-3 lists the error and status conditions that are returned by the TU58 driver.

Table 7-3
TU58 Driver Status Returns

Code	Reason
IS.SUC	Successful completion The operation specified in the QIO directive was completed successfully. The second word of the I/O status block can be examined to determine the number of bytes processed, if the operation involved reading or writing.
IE.DNR	Device not ready The physical device unit specified in the QIO directive was not ready to perform the desired I/O operation.
IE.IFC	Illegal function A function code was specified in an I/O request that is illegal for the TU58.

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Table 7-3 (Cont.)
TU58 Driver Status Returns

Code	Reason
IE.FHE	Fatal hardware error
IE.TMO	Timeout error The TU58 failed to respond to a function within the normal time specified by the driver.
IE.VER	Unrecoverable error After the system's standard number of retries (8) has been attempted upon encountering an error, the operation still could not be successfully completed.
IE.WLK	Cartridge write-locked The task attempted to write on a tape cartridge that is physically write-locked.

CHAPTER 8

MAGNETIC TAPE DRIVERS

8.1 INTRODUCTION

RSX-11M and RSX-11M-PLUS support a variety of magnetic tape devices. Table 8-1 summarizes these devices and subsequent sections describe them in greater detail.

Table 8-1
Standard Magtape Devices

	TE10,TU10	TE16,TU16	TU45	TU77	TS03	TS04
Channels	9 (TE10) 7 or 9 (TU10)	9	9	9	9	9
Recording density (frames/inch)	For 7-channel: 200, 556, or 800 For 9-channel: 800	800 or 1600	800 or 1600	800 or 1600	800	1600
Tape speed (inches/second)	45	45	75	125	15	45
Maximum data Transfer rate (bytes/second)	36,000	For 800 bpi: 36,000 For 1600 bpi: 72,000	For 800 bpi: 60,000 For 1600 bpi: 120,000	For 800 bpi: 100,000 For 1600 bpi: 200,000	12,000	72,000
Recording method	NRZI	NRZI or Phase Encoding	NRZI or Phase Encoding	NRZI or Phase Encoding	NRZI	Phase Encoding

Programming for magtape is quite similar to programming for the magnetic tape cassette (see Chapter 9). Unlike cassette, however, magtape can handle variable-length records and allows the user to select a parity mode.

8.1.1 TE10/TU10/TS03 Magnetic Tape

The TE10/TU10/TS03 consists of a TM11 controller with a TE10, TU10 or TS03 transport. It is a low-cost, high performance system for serial storage of large volumes of data and programs in an industry-compatible format. All recording is non-return-to-zero, inverted (NRZI).

8.1.2 TE16/TU16/TU45/TU77 Magnetic Tape

The TE16/TU16/TU45/TU77 consist of an RH11/RH70 controller, a TM02 or TM03 formatter, and a TE16/TU16/TU45/TU77 transport. They are quite similar to the TE10/TU10 but are Massbus devices, with a common controller, a specialized formatter, and a drive. Recording is either 800 bpi NRZI or 1600 bpi phase-encoded (PE).

8.1.3 TS04 Magnetic Tape

The TS04 tape system consists of a TS11 controller and a TS04 integrated drive, controller, and formatter. The TS04 hardware is microprocessor-controlled for all operations, including I/O transfers, tape motion, (etc.), and comprehensive (internal) diagnostic test execution. Recording is 1600 bpi phase-encoded (PE).

8.2 GET LUN INFORMATION MACRO

Word 2 of the buffer filled by the Get LUN Information system directive (the first characteristics word) contains the following information for magtapes. A bit setting of 1 indicates that the described characteristic is true for magtapes.

Bit	Setting	Meaning
0	1	Record-oriented device
1	0	Carriage-control device
2	0	Terminal device
3	0	File structured device
4	0	Single-directory device
5	1	Sequential device
6	0	Reserved
7	0 or 1	User-mode diagnostics supported[1]
8	0 or 1	Massbus device (set only for TE16, TU16, TU45 or TU77 drives interfaced via an RH70 controller)[1]
9	0	Unit software write-locked
10	0	Input spooled device
11	0	Output spooled device
12	0	Pseudo device
13	0	Device mountable as a communications channel

[1] SYSGEN and device-dependent characteristic

Bit	Setting	Meaning
14	0 or 1	Device mountable as a FILES-11 volume[1]
15	0 or 1	Device mountable[1]

Words 3 and 4 of the buffer are undefined; word 5 indicates the default buffer size, for magtapes 512 bytes.

8.3 QIO MACRO

This section summarizes standard and device-specific QIO functions for the magtape drivers.

8.3.1 Standard QIO Functions

Table 8-2 lists the standard functions of the QIO macro that are valid for magtape.

Table 8-2
Standard QIO Functions for Magtape

Format	Function
QIO$C IO.ATT,...	Attach device
QIO$C IO.DET,...	Detach device
QIO$C IO.KIL,...	Cancel I/O requests
QIO$C IO.RLB,...,<stadd,size>	Read logical block (read tape into buffer)
QIO$C IO.RVB,...,<stadd,size>	Read virtual block (read tape into buffer)
QIO$C IO.WLB,...,<stadd,size>	Write logical block (write buffer contents to tape)
QIO$C IO.WVB,...,<stadd,size>	Write virtual block (write buffer contents to tape)

where:	stadd	is the starting address of the data buffer (must be on a word boundary).
	size	is the data buffer size in bytes. Size must be even, greater than zero, and, for a write, must be at least 14 bytes.

IO.KIL does not cancel an in progress request unless a select error has occurred.

[1] SYSGEN and device-dependent characteristic

8.3.2 Device-Specific QIO Functions

Table 8-3 lists the device-specific functions of the QIO macro that are valid for magtape. Additional details on certain functions appear below.

8.3.2.1 **IO.RLV** - A TE16, TU16, TS04, TU45, or TU77 in performing a read reverse, decrements its bus address register. The net effect is that data are not inverted in memory locations (as is the case for the DECtape driver). Thus, the data appear in the specified buffer in an identical fashion as with IO.RLB or IO.RVB.

8.3.2.2 **IO.RWD** - Completion of IO.RWD means that the rewind has been initiated. Additional operations on that controller may then be queued. However, a request for the same unit will be queued by the driver until load point (BOT) is reached.

8.3.2.3 **IO.RWU** - IO.RWU is normally used when operator intervention is required (e.g., to load a new tape). The operator must turn the unit back on-line manually before subsequent operations can proceed.

Table 8-3
Device-Specific QIO Functions for Magtape

Format	Function
QIO$C IO.EOF,...	Write end-of-file mark (tape mark)
QIO$C IO.ERS,...	Erase (TE16, TU16, TU45, TU77, TS04 only)
QIO$C IO.RLV,...,<stadd,size>	Read logical block reverse (TE16, TU16, TU45, TS04, and TU77 only).
QIO$C IO.RWD,...	Rewind unit
QIO$C IO.RWU,...	Rewind and turn unit off-line
QIO$C IO.SEC,...	Sense tape characteristics
QIO$C IO.SMO,...,<cb>	Mount tape and set tape characteristics (Unit must be READY, tape at LOAD POINT.)
QIO$C IO.SPB,...,<nbs>	Space blocks
QIO$C IO.SPF,...,<nes>	Space files
QIO$C IO.STC,...,<cb>	Set tape characteristics

where:		
	cb	represents the characteristic bits to set.
	nbs	is the number of blocks to space past (positive if forward, negative if reverse).
	nes	is the number of EOF marks to space past (positive if forward, negative if reverse).
	size	is the size of the stadd data buffer in bytes (must be an even number of bytes greater than zero).
	stadd	is the starting address of the data buffer (may be on a byte boundary).

8.3.2.4 **IO.ERS** - The TE16, TU16, TU45, TU77, or TS04 will erase 3-inches of (write blank) tape. Effectively, this provides an extended interrecord gap.

8.3.2.5 **IO.SEC** - This function returns the tape characteristics in the second I/O status word. The tape characteristic bits are defined as follows:

Bit	Meaning When Set	Can Be Set by IO.SMO and IO.STC
0	For TU10, 556 bpi density (seven-channel). For TE16, TU16, TU45, TU77, and TS04, reserved.	X
1	For TU10, 200 bpi density (seven-channel). For TE16, TU16, TU45, TU77, and TS04, reserved.	X
2	For TU10, core-dump mode (seven-channel, see below). For TE16, TU16, TS04, TU45 and Tu77, reserved.	X
3	Even parity (default is odd). (Not selectable for the TS04.)	X
4	Tape is past EOT.	
5	Last tape command encountered EOF (unless last command was backspace).	
6	Writing is prohibited.	X
7	Writing with extended inter-record gap is prohibited (i.e., no recovery is attempted after write error).	X

Bit	Meaning When Set	Can Be Set by IO.SMO and IO.STC
8	Select error on unit.	
9	Unit is rewinding.	
10	Tape is physically write-locked.	
11	For TE10, TU10, and TS03, reserved. For TE16, TU16, TU45, TU77, and TS04, 1600 bpi, density.	X
12	For TU10, drive is seven-channel. For TE16, TU16, TU45, TU77, and TS04, reserved.	
13	Tape is at load point (BOT).	
14	Tape is at end-of-volume (EOV).	
15	Tape is past EOV (reserved for driver; always 0 when read by user).	

In core-dump mode (TU10 only, 800 bpi density, and seven-channel), each eight-bit byte is written on two tape frames, four bits per frame. In other modes on seven-channel tape, only six low-order bits per byte are written.

For the TS04, 1600 bpi density is always selected (bit 11=1). Bit 11 cannot be modified by either the IO.SMO or IO.STC functions. For drives that use the TM03 controller, this bit can be either set or cleared; however, once the tape is moved from the load (beginning of tape) position (BOT) the device driver modifies this bit to reflect the actual density of the tape currently mounted.

The effect of these settings is illustrated in Figure 8-1 for the TE10 and TU10 and in Figure 8-2 for the TE16, TU16, TU45, and TU77.

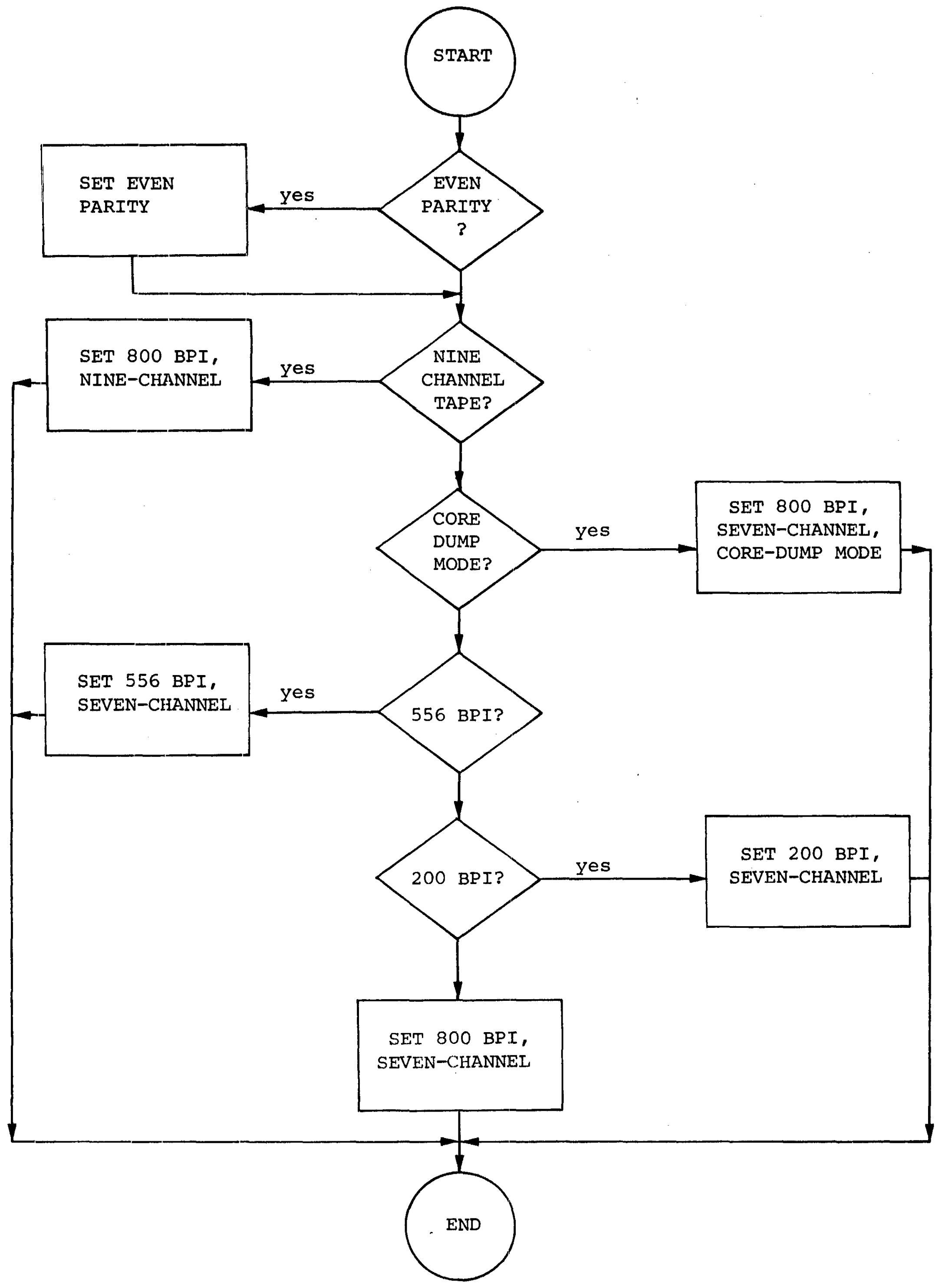
START
EVEN PARITY ?
yes
SET EVEN PARITY
NINE CHANNEL TAPE?
yes
SET 800 BPI, NINE-CHANNEL
CORE DUMP MODE?
yes
SET 800 BPI, SEVEN-CHANNEL, CORE-DUMP MODE
556 BPI?
yes
SET 556 BPI, SEVEN-CHANNEL
200 BPI?
yes
SET 200 BPI, SEVEN-CHANNEL
SET 800 BPI, SEVEN-CHANNEL
END

Figure 8-1 Determination of Tape Characteristics for the TE10/TU10

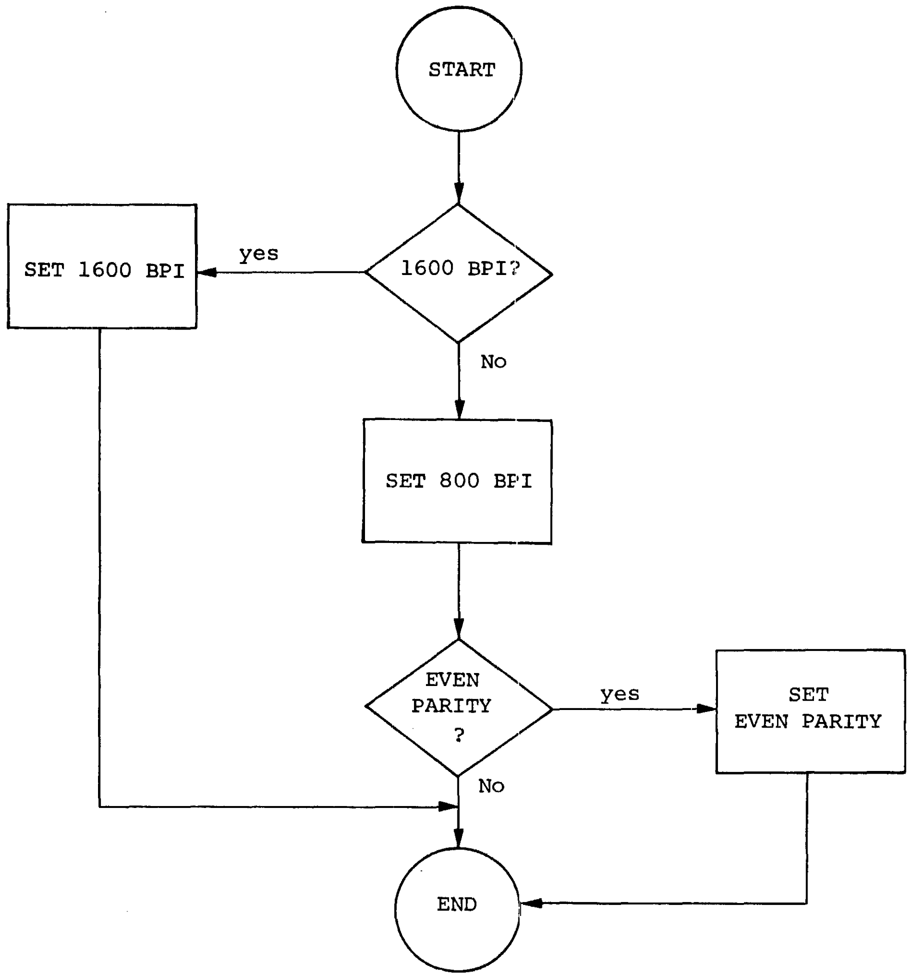

Figure 8-2 Determination of Tape Characteristics for the TE16/TU16/TU45/TU77

8.3.2.6 **IO.SMO** - This function can be used as a combination of the sense (IO.SEC) and set (IO.STC) tape characteristics functions. Unlike IO.STC, however, the IO.SMO function requires that the unit be READY and the tape be at load point (BOT). If either of these conditions is not met, the function returns an error status code of IE.FHE (refer to Table 8-4).

The IO.SMO function should be used to set the characteristics of a newly loaded tape. If the IE.FHE error code is returned, the tape has not been loaded properly on the drive.

8.4 STATUS RETURNS

The error and status conditions listed in Table 8-4 are returned by the magtape drivers described in this chapter.

Table 8-4
Magtape Status Returns

Code	Reason
IS.SUC	Successful completion The operation specified in the QIO directive was completed successfully. The second word of the I/O status block can be examined to determine 8 the number of bytes processed, if the operation involved reading or writing. This code is also returned if nbs equals zero in an IO.SPB function or if nes equals zero in an IO.SPF function.
IS.PND	I/O request pending The operation specified in the QIO directive has not yet been completed. The I/O status block is filled with zeros.
IE.ABO	Operation aborted The specified I/O operation was cancelled via IO.KIL while in progress or while still in the I/O queue.
IE.BBE	Bad block A bad block was encountered while reading or writing and the error persists after nine retries. The number of bytes transferred is returned in the second word of the I/O status block. For TM11, IE.BBE may also indicate that a bad tape error (BTE) has been encountered while reading or spacing.
IE.BYT	Byte-aligned buffer specified Byte alignment was specified for a buffer, while only word alignment is legal for the QIO. Alternatively, the length of a buffer is not an even number of bytes.
IE.DAA	Device already attached The physical device unit specified in an IO.ATT function was already attached by the issuing task. This code indicates that the issuing task has already attached the desired physical device unit, not that the unit was attached by another task.
IE.DAO	Data overrun On a read, a record exceeded the stated buffer size. The final portion of the buffer is checked for parity, but is not read into memory.

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Table 8-4 (Cont.)
Magtape Status Returns

Code	Reason
IE.DNA	Device not attached The physical device unit specified in an IO.DET function was not attached by the issuing task. This code has no bearing on the attachment status of other tasks.
IE.DNR	Device not ready The physical device unit specified in the QIO directive was not ready to perform the desired I/O operation. This code is returned to indicate one of the following conditions: ● A timeout occurred on the physical device unit (that is, an interrupt was lost). ● A vacuum failure occurred on the magtape drive. ● While trying to read or space, the driver detected blank tape. ● The LOAD switch on the physical drive was switched to the off position. ● The unit failed internal diagnostic tests (TS04 only) ● A tape position or hardware error occurred for which no recovery procedure is possible. (Also occurs if bit 7 in U.CW2, or IQ.X, becomes set.)
IE.EOF	End-of-file encountered An end-of-file (tapemark) was encountered.
IE.EOT	End-of-tape encountered The end-of-tape (physical end-of-volume) was encountered while the tape was moving in the forward direction. A ten-foot length of tape is provided past EOT to be used for writing data and markers, such as volume trailer labels. The IE.EOT code will continue to be returned in the I/O status block until the EOT marker is passed in the reverse direction. EOT is not returned on a read operation.
IE.EOV	End-of-volume encountered On a forward space function, the logical end-of-volume was encountered. An end-of-volume is two consecutive end-of-file marks (EOF), or a beginning-of-tape mark (BOT) followed by an EOF. The tape is normally left positioned between the two marks.

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Table 8-4 (Cont.)
Magtape Status Returns

Code	Reason
IE.FHE	Fatal hardware error Nonrecoverable hardware malfunction: e.g., magtape unit not READY and/or tape not at LOAD POINT when IO.SMO is issued.
IE.IFC	Illegal function An illegal function (or subfunction bit) was specified in a magtape I/O request. Refer also to Section 8.4.3.
IE.OFL	Device off-line The physical device unit associated with the LUN specified in the QIO directive was not on-line. When the system was booted, a device check indicated that this physical device unit was not in the configuration.
IE.SPC	Illegal address space The buffer specified for a read or write request was partially or totally outside the address space of the issuing task. For magtape, this code is also returned if a byte count of zero was specified or if the user attempted to write a block that was less than 14 bytes long.
IE.VER	Unrecoverable error After the system's standard number of retries has been attempted upon encountering an error, the operation still could not be completed. For magtape, this code is returned in the case of CRC or checksum errors or when a tape block could not be read.
IE.WLK	Write-locked device The task attempted to write on a magtape unit that was physically write-locked. Alternately, tape characteristic bit 6 was set by the software to write-lock the unit logically.

After read and write functions, the second I/O status word contains the number of bytes actually processed by the function. After spacing functions, it contains the number of blocks or files spaced over. The EOF mark counts as one block. If an EOF mark is encountered by a read operation, the second I/O status word will contain an octal 2.

8.4.1 Select Recovery

If a request fails because the desired unit is off-line, no drive has the desired unit number, or has its power off, the following message is output on the operator's console:

```
        *** MTn: -- SELECT ERROR
```

Where n is the unit number of the specified drive. The driver checks the unit for readiness and repeats the message every 15 seconds until the requesting task is aborted or the unit is made available. In the latter case, the driver then proceeds with the request.

8.4.2 Retry Procedures for Reads and Writes

If an error occurs during a read (e.g., vertical parity error), the recovery procedure depends on the type of magtape in use. A bad tape error on a TE10, TU10, or TS03 results in an immediate return of the error code IE.VER. All other read errors for these devices and the TE16, TU16, TU45, and TU77 are retried by backspacing one record and then rereading the record in question. If the error persists after nine retries, IE.VER is returned.

The TS04 attempts to recover from read errors by alternately reading reverse and forward (up to 16 attempts, maximum). During the next 8 attempts, the driver precedes each read attempt by positioning the tape under the clean heads. If the error persists after 24 retries have been executed, IE.VER is returned.

Write recovery is the same for all devices. When a write operation fails, the driver attempts to avoid the bad spot on the tape by means of an extended interrecord gap (IRG). This means that it backspaces, makes the IRG just before the record three inches longer, and then retries the write. If the error persists after nine retries, IE.VER is returned. The requesting task can use IO.STC to prohibit writing with an extended interrecord gap. In this case, the tape is backspaced and the write is retried.

8.4.3 Powerfail Recovery for Magnetic Tapes

If a power failure and/or loss of vacuum occurs on a magnetic tape drive, tape position is lost. (Note that an initial system boot simulates a recovery from a power failure.) Additionally, on auto-load drives, the tape will be positioned at BOT when the unit is turned online.

To prevent accidental destruction of data currently on tape, the driver maintains a powerfail status indicator. When this indicator is set, the driver disallows any data transfer or tape motion commands until a rewind (IO.RWD), rewind unload (IO.RWU), or mount and set characteristics (IO.SMO) function is issued. These functions clear the powerfail indicator and allow all tape functions to be issued. It is also possible to issue the set and sense characteristics functions (IO.STC and IO.SEC) while the powerfail indicator is set. These functions, however, will not clear the bit.

All functions other than those just described are considered illegal and cause the return of the IE.IFC (illegal function) error code to the requesting task. In situations where a tape is currently a mounted volume, the tape should be dismounted and then remounted before use. In doing this, the rewind command will be issued, thereby clearing the powerfail indicator.

8.5 PROGRAMMING HINTS

This section contains information on important programming considerations relevant to users of magtape drivers described in this chapter.

8.5.1 Block Size

Each block must contain an even number of bytes, at least 14 for a write and at most 65,534. It is more reasonable, however, to work with a block size of approximately 2,048 bytes.

8.5.2 Importance of Resetting Tape Characteristics

A task that uses magtape should always set the tape characteristics to the proper value before beginning I/O operations. The task cannot be certain in what state a previous task left these characteristics. It is also possible that an operator might have changed the magtape unit selection. If the selection switch is changed, the new physical device unit may not correspond to the characteristics of the unit described by the respective unit control block.

8.5.3 Aborting a Task

If a task is aborted while waiting for a magtape unit to be selected, the magtape driver recognizes this fact within one second.

8.5.4 Writing an Even-Parity Zero-NRZI

If an even-parity zero were written normally, it would appear to the drive as blank tape. It is therefore converted to 20 (octal). If this conversion is undesirable, the user must ensure that no even-parity zeros are output on the tape.

8.5.5 Density Selection

The TM03 controller imposes the following density selection restriction: the user cannot mix recording densities on any volume associated with the controller.

Density for write operations is selected when the tape is at the load (BOT) position. Density for read operations is hardware - selected during the first read (away from BOT); after the first read, the IO.SEC function can be used to determine (sense) tape density.

CHAPTER 9

CASSETTE DRIVER

9.1 INTRODUCTION

RSX-11M supports the TA11 magnetic tape cassette (a TA11 controller with a TU60 dual transport). Programming for cassette is quite similar to programming for magtape (see Chapter 8). The TA11 system is a dual-drive, reel-to-reel unit designed to replace paper tape. Its two drives run nonsimultaneously, using Digital Proprietary Philips-type cassettes.

The maximum capacity of a cassette, in bytes, is 92,000 (minus 300 per file gap and 46 per interrecord gap). It can transfer data at speeds of up to 562 bytes per second. Recording density ranges from 350 to 700 bits ber inch, depending on tape postion.

9.2 GET LUN INFORMATION MACRO

Word 2 of the buffer filled by the Get LUN Information system directive (the first characteristics word) contains the following information for cassettes. A bit setting of 1 indicates that the described characteristic is true for cassettes.

Bit	Setting	Meaning
0	1	Record-oriented device
1	0	Carriage-control device
2	0	Terminal device
3	0	File structured device
4	0	Single-directory device
5	1	Sequential device
6	0	Reserved
7	0	User-mode diagnostics supported
8	0	Massbus device
9	0	Unit software write-locked
10	0	Input spooled device
11	0	Output spooled device

Bit	Setting	Meaning
12	0	Pseudo device
13	0	Device mountable as a communications channel
14	0	Device mountable as a FILES-11 volume
15	0	Device mountable

Words 3 and 4 of the buffer are undefined; word 5 indicates the default buffer size, for cassettes 128 bytes.

9.3 QIO MACRO

This section summarizes standard and device-specific QIO functions for the cassette driver.

9.3.1 Standard QIO Functions

Table 9-1 lists the standard functions of the QIO macro that are valid for cassette.

Table 9-1
Standard QIO Functions for Cassette

Format	Function
QIO$C IO.ATT,...	Attach device
QIO$C IO.DET,...	Detach device
QIO$C IO.KIL,...	Cancel I/O requests
QIO$C IO.RLB,...,<stadd,size>	Read logical block (read tape into buffer)
QIO$C IO.RVB,...,<stadd,size>	Read virtual block (read tape into buffer)
QIO$C IO.WLB,...,<stadd,size>	Write logical block (write buffer contents to tape)
QIO$C IO.WVB,...,<stadd,size>	Write virtual block (write buffer contents to tape)

where: stadd is the starting address of the data buffer (may be on a byte boundary).

size is the data buffer size in bytes (must be greater than zero).

IO.KIL does not affect in progress-requests.

9.3.2 Device-Specific QIO Functions

Table 9-2 lists the device-specific functions of the QIO macro that are valid for cassette. The section on programming hints below provides more detailed information about certain functions.

9.4 STATUS RETURNS

The error and status conditions listed in Table 9-3 are returned by the cassette driver described in this chapter.

Table 9-2
Device-Specific QIO Functions for Cassette

Format	Function
QIO$C IO.EOF,...	Write end-of-file gap
QIO$C IO.RWD,...	Rewind unit
QIO$C IO.SPB,...,<nbs>	Space blocks
QIO$C IO.SPF,...,<nes>	Space files

where: nbs is the number of blocks to space past (positive if forward, negative if reverse).

nes is the number of EOF gaps to space past (positive if forward, negative if reverse).

Table 9-3
Cassette Status Returns

Code	Reason
IS.SUC	Successful completion The operation specified in the QIO directive was completed successfully. The second word of the I/O status block can be examined to determine the number of bytes processed, if the operation involved reading or writing, or the number of blocks or files spaced, if the operation involved spacing blocks or files.
IS.PND	I/O request pending The operation specified in the QIO directive has not yet been executed. The I/O status block is filled with zeros.

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Table 9-3 (Cont.)
Cassette Status Returns

Code	Reason
IE.ABO	Operation aborted The specified I/O operation was cancelled via IO.KIL while still in the I/O queue.
IE.DAA	Device already attached The physical device unit specified in an IO.ATT function was already attached by the issuing task. This code indicates that the issuing task has already attached the desired physical device unit, not that the unit was attached by another task.
IE.DAO	Data overrun The driver was not able to sustain the data rate required by the TA11 controller.
IE.DNA	Device not attached The physical device unit specified by an IO.DET function was not attached by the issuing task. This code has no bearing on the attachment status of other tasks.
IE.DNR	Device not ready The physical device unit specified in the QIO directive was not ready to perform the desired I/O operation. This code is returned to indicate one of the following conditions: ● The cassette has not been physically inserted. ● The unit is off-line. ● A timeout occurred on the physical device unit (that is, an interrupt was lost).
IE.EOF	End-of-file encountered An end-of-file gap was recognized on the cassette tape. This code is returned if an EOF gap is encountered during a read or if the cassette is physically removed during an I/O operation.
IE.EOT	End-of-tape encountered While reading or writing, clear trailer at end-of-tape (EOT) was encountered. Unlike magtape, writing beyond EOT is not permitted on cassettes. This condition is always sensed on a write before it would be sensed on a read of the same section of tape. If IE.EOT is returned during a write, the cassette head has encountered EOT before finishing the writing of the last block. It is recommended that the user rewrite the block on another cassette in its entirety.

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Table 9-3 (Cont.)
Cassette Status Returns

Code	Reason
IE.IFC	Illegal function A function code was specified in an I/O request that is illegal for cassette.
IE.OFL	Device off-line The physical device unit associated with the LUN specified in the QIO directive was not on-line. When the system was booted, a device check indicated that this physical device unit was not in the configuration.
IE.SPC	Illegal address space The buffer specified for a read or write request was partially or totally outside the address space of the issuing task. Alternately, a byte count of zero was specified on a transfer.
IE.VER	Nonrecoverable error This code is returned when a block check error occurs (see Section 9.6.5). The cyclic redundancy check (CRC), a two-byte value located at the end of each block, is a checksum that is tested during all read operations to ensure that data is read correctly. This is returned if a read request did not specify exactly the number of bytes of data in the record on tape. If a nonrecoverable error is returned, the user may attempt recovery by spacing backward one block and retrying the read operation.
IE.WLK	Write-locked device The task attempted to write on a cassette unit that was physically write-locked. This code may be returned after an IO.WLB, IO.WVB, or IO.EOF function.

9.4.1 Cassette Recovery Procedures

If an error occurs during a read or write operation, the operation should be retried several times. The recommended maximum number of retries is nine for a read and three for a write because each retry involves backspacing, which does not always position the tape in the same place. More than three retries of a write operation may destroy previously written data. For example, to retry a write, it is best to space two blocks in reverse, then space one block forward. This insures the tape is in the proper position to rewrite the block that encountered the error.

After read and write functions, the second I/O status word contains the number of bytes actually processed by the function. After spacing functions, it contains the number of blocks or files actually spaced.

9.5 STRUCTURE OF CASSETTE TAPE

Figure 9-1 illustrates a general structure for cassette tape. A different structure can be employed if the user wishes.

Here the tape consists of blocks of data interspersed with sections of clear tape that serve as leader, trailer, interrecord gaps (IRGs), and end-of-file gaps.

The logical end-of-tape in this case consists of a sentinel label record, rather than the conventional group of end-of-file gaps. Each file must contain at least one block. The size of each block depends upon the number of bytes the user specifies when writing the block.

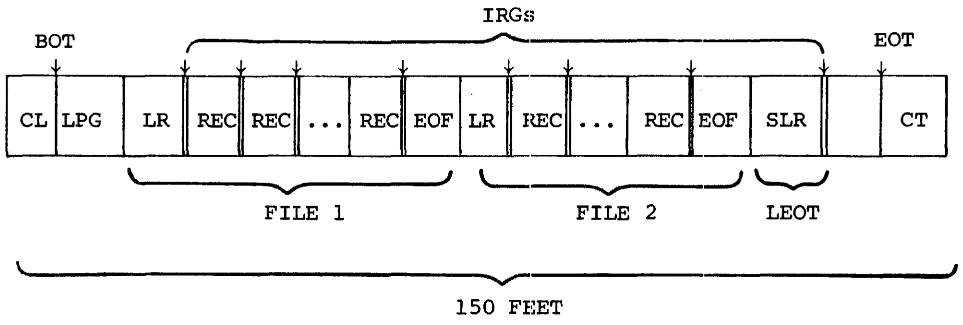

Figure 9-1 Structure of Cassette Tape

Abbreviation	Meaning
CL	Clear leader
BOT	Physical beginning-of-tape
LPG	Load point gap (blank tape written by driver before the first retrievable record)
LR	File label record
REC	Fixed-length record (data)
EOF	End-of-file gap
IRG	Interrecord gap
SLR	Sentinel label record
LEOT	Logical end-of-tape
EOT	Physical end-of-tape
CT	Clear trailer

9.6 PROGRAMMING HINTS

This section contains information on important programming considerations relevant to users of the cassette driver described in this chapter.

9.6.1 Importance of Rewinding

The first cassette operation performed on a tape must always be a rewind to ensure that the tape is positioned to a known place. When it is positioned in clear tape there is no way to determine whether it is in leader at the beginning-of-tape (BOT) or in trailer at the end-of-tape (EOT).

9.6.2 End-of-File and IO.SPF

The hardware senses end-of-file (EOF) as a timeout. When IO.SPF is issued in the forward direction (nes is positive), the tape is positioned two-thirds of the way from the beginning of the final file gap. In effect, this is all the way through the file gap. When IO.SPF is issued in the reverse direction (nes is negative), the tape is positioned one-third of the way from the beginning of the final file gap (i.e., two thirds of the way from the beginning of the last file spaced). Therefore to correctly position the tape for a read or write after issuing IO.SPF in reverse, the user should issue IO.SPB forward for one block, followed by IO.SPB in reverse for one block.

9.6.3 The Space Functions, IO.SPB and IO.SPF

IO.SPB always stops in an IRG, IO.SPF in an EOF gaps. Neither space function actually takes effect until data is encountered. For example, suppose the tape is positioned in clear leader at BOT and the user requests that one block be spaced forward. The drive passes over the remaining leader until it reaches data, passes one block, and stops in the IRG. Similarly, if the same command is issued when the tape is at BOT on a blank tape or a tape containing only EOF gaps, the function does not terminate until EOT.

9.6.4 Verification of Write Operations

Certain errors, such as cyclic redundancy check, are detected on read but not write operations. Therefore, to ensure reliability of recording, it is recommended that the user perform a read as verification of every write operation.

9.6.5 Block Length

The user must specify the exact number of bytes per block when requesting read or write operations. An attempt to read a block with an incorrect byte count causes an unrecoverable error (see Section 9.4) to occur.

9.6.6 Logical End-of-Tape

The conventional method of signaling logical end-of-tape by multiple EOF gaps is inadequate for cassettes. This is because multiple EOF gaps are not distinguishable from each other. For example, two sequential EOF gaps would be read as three instead of two. Also spacing functions, since they are triggered by encountering data, can not recognize multiple EOF gaps. Consequently, the use of a sentinel or key record to signal logical end-of-tape is recommended.

CHAPTER 10

LINE PRINTER DRIVER

10.1 INTRODUCTION

The RSX-11M line printer driver supports the line printers summarized in Table 10-1. Subsequent sections of this chapter describe these printers in greater detail.

Table 10-1
Standard Line Printer Devices

Model	Column Width	Character Set	Lines per Minute
LP11-F	80	64	170-1110
LP11-H	80	96	170-1110
LP11-J	132	64	170-1110
LP11-K	132	96	170-1110
LP11-R	132	64	1110
LP11-S	132	96	1110
LP11-V	132	64	300
LP11-W	132	96	300
LS11	132	62	60-200
LV11	132	96	500
LA180	132	96	150

10.1.1 LP11 Line Printer

The LP11 is a high-speed line printer available in a variety of models. The entire LP11 model line consists of impact printers, using one hammer per column and a revolving drum with upper-case and optional lower-case characters. The LP11-R and LP11-S are fully buffered models which operate at a standard speed of 1110 lines per minute. The other LP11 models have 20-character print buffers. These printers are therefore able to print at full speed if the printed line is no longer than 20 characters. Lines which exceed this maximum are printed at a slower rate. Forms with up to six parts may be used for multiple copies.

10.1.2 LS11 Line Printer

The LS11 is a medium-speed line printer. It has a 20-character print buffer, and lines of 20 characters or less are printed at a rate of 200 lines per minute. Longer lines are printed at a slower rate. RSX-11M does not support the LS11 expanded character set feature.

10.1.3 LV11 Line Printer

The LV11 is a fully-buffered, electrostatic printer-plotter which operates at a standard rate of 500 lines per minute. RSX-11M supports only the LV11 print capability, not the plotter mode.

10.1.4 LA180 DECprinter

The LA180 is a 180-character/sec, dot-matrix impact printer. It accepts multipart forms and pages of various lengths and widths.

10.2 GET LUN INFORMATION MACRO

Word 2 of the buffer filled by the Get LUN Information system directive (the first characteristics word) contains the following information for line printers. A bit setting of 1 indicates that the described characteristic is true for line printers.

Bit	Setting	Meaning
0	1	Record-oriented device
1	1	Carriage-control device
2	0	Terminal device
3	0	File structured device
4	0	Single-directory device
5	0	Sequential device
6	0	Reserved
7	0	User-mode diagnostics supported
8	0	Massbus device
9	0	Unit software write-locked
10	0	Input spooled device
11	0	Output spooled device
12	0	Pseudo device
13	0	Device mountable as a communications channel
14	0	Device mountable as a FILES-11 volume
15	0	Device mountable

Words 3 and 4 of the buffer are undefined; word 5 indicates the default size for the device, for line printers the width of the printer carriage (that is, 80 or 132).

10.3 QIO MACRO

Table 10-2 lists the standard functions of the QIO macro that are valid for line printers.

Table 10-2
Standard QIO Functions for Line Printers

Format	Function
QIO$C IO.ATT,...	Attach device
QIO$C IO.DET,...	Detach device
QIO$C IO.KIL,...	Cancel I/O requests
QIO$C IO.WLB,...,<stadd,size,vfc>	Write logical block (print buffer contents)
QIO$C IO.WVB,...,<stadd,size,vfc>	Write virtual block (print buffer contents)

where:	stadd	is the starting address of the data buffer (may be on a byte boundary).
	size	is the data buffer size in bytes (must be greater than zero).
	vfc	is a vertical format control character from Table 10-4.

IO.KIL does not cancel an in progress request unless the line printer is in an offline condition because of a power failure or a paper jam or because it is out of paper.

The line printer driver supports no device-specific functions.

10.4 STATUS RETURNS

Table 10-3 lists the error and status conditions that are returned by the line printer driver described in this chapter.

Table 10-3
Line Printer Status Returns

Code	Reason
IS.SUC	Successful completion The operation specified in the QIO directive was completed successfully. The second word of the I/O status block can be examined to determine the number of bytes processed, if the operation involved writing.
IS.PND	I/O request pending The operation specified in the QIO directive has not yet been executed. The I/O status block is filled with zeros.
IE.ABO	Operation aborted The specified I/O operation was cancelled while in progress or while in the I/O queue.
IE.DAA	Device already attached The physical device unit specified in an IO.ATT function was already attached by the issuing task. This code indicates that the issuing task has already attached the desired physical device unit, not that the unit was attached by another task.
IE.DNA	Device not attached The physical device unit specified an IO.DET function was not attached by the issuing task. This code has no bearing on the attachment status of other tasks.
IE.IFC	Illegal function A function code was specified in an I/O request that is illegal for line printers.
IE.OFL	Device off-line The physical device unit associated with the LUN specified in the QIO directive was not on-line. When the system was booted, a device check indicated that this physical device unit was not in the configuration.
IE.SPC	Illegal address space The buffer specified for a write request was partially or totally outside the address space of the issuing task. Alternately, a byte count of zero was specified.

10.4.1 Ready Recovery

If any of the following conditions occur:

- Paper jam
- Printer out of paper
- Printer turned off-line
- Power failure

the driver determines that the line printer is off-line, and the following message is output on the operator's console:

```
***LPn: -- NOT READY
```

where n is the unit number of the line printer that is not ready. The driver retries the function which encountered the error condition from the beginning, once every second. It displays the message every m seconds (m is defined at SYSGEN to be a value less than 256. The default is 15) until the line printer is readied. If a power failure occurs while printing a line, the entire line is reprinted from the beginning when power is restored.

10.5 VERTICAL FORMAT CONTROL

Table 10-4 summarizes the meaning of all characters used for vertical format control on the line printer. Any one of these characters can be specified as the vfc parameter in an IO.WLB or IO.WVB function.

Table 10-4
Vertical Format Control Characters

Octal Value	Character	Meaning
040	blank	SINGLE SPACE: output a line feed, print the contents of the buffer, and output a carriage return. Normally, printing immediately follows the previously printed line.
060	zero	DOUBLE SPACE: output two line feeds, print the contents of the buffer, and output a carriage return. Normally, the buffer contents are printed two lines below the previously printed line.
061	one	PAGE EJECT: output a form feed, print the contents of the buffer, and output a carriage return. Normally, the contents of the buffer are printed on the first line of the next page.
053	plus	OVERPRINT: print the contents of the buffer and perform a carriage return, normally overprinting the previous line.

(continued on next page)

Table 10-4 (Cont.)
Vertical Format Control Characters

Octal Value	Character	Meaning
044	dollar sign	PROMPTING OUTPUT: output a line feed and then print the contents of the buffer.
000	null	INTERNAL VERTICAL FORMAT: the buffer contents are printed without addition of vertical format control characters. In this mode, more than one line of guaranteed contiguous output can be printed per I/O request.

All other vertical format control characters are interpreted as blanks (octal 040).

10.6 PROGRAMMING HINTS

This section contains information on important programming considerations relevant to users of the line printer driver described in this chapter.

10.6.1 RUBOUT Character

The line printer driver discards the ASCII character code 177 during output, because a RUBOUT on the LS11 printer causes a RUBOUT of the hardware print buffer.

10.6.2 Print Line Truncation

If the number of characters to be printed exceeds the width of the print carriage, the driver discards excess characters until it receives one that instructs it to empty the buffer and return to horizontal position 1. The user can determine that truncation will occur by issuing a Get LUN Information system directive and examining word 5 of the information buffer. This word contains the width of the print carriage in bytes.

10.6.3 Aborting a Task

If a task is aborted while waiting for the line printer to be readied, the line printer driver recognizes this fact within one second.

CHAPTER 11

CARD READER DRIVER

11.1 INTRODUCTION

The RSX-11M card reader driver supports the CR11 card reader. This reader is a virtually jam-proof device which reads EIA standard 80-column punched cards at the rate of 300 per minute. The hopper can hold 600 cards. This device uses a vacuum picker which provides extreme tolerance to damaged cards and makes card wear insignificant. Cards are riffled in the hopper to prevent sticking. The reader uses a strong vacuum to deliver the bottom card. It has a very short card track, so only one card is in motion at a time.

11.2 GET LUN INFORMATION MACRO

Word 2 of the buffer filled by the Get LUN Information system directive (the first characteristics word) contains the following information for card readers. A bit setting of 1 indicates that the described characteristic is true for card readers.

Bit	Setting	Meaning
0	1	Record-oriented device
1	0	Carriage-control device
2	0	Terminal device
3	0	File structured device
4	0	Single-directory device
5	0	Sequential device
6	0	Reserved
7	0	User-mode diagnostics supported
8	0	Massbus device
9	0	Unit software write-locked
10	0	Input spooled device
11	0	Output spooled device
12	0	Pseudo device

Bit	Setting	Meaning
13	0	Device mountable as a communications channel
14	0	Device mountable as a FILES-11 volume
15	0	Device mountable

Words 3 and 4 of the buffer are undefined; word 5 indicates the default buffer size, which is 80 bytes for the card reader.

11.3 QIO MACRO

This section summarizes standard and device-specific QIO functions for the card reader driver.

11.3.1 Standard QIO Functions

Table 11-1 lists the standard functions of the QIO macro that are valid for the card reader.

Table 11-1
Standard QIO Functions for the Card Reader

Format	Function
QIO$C IO.ATT,...	Attach device
QIO$C IO.DET,...	Detach device
QIO$C IO.KIL,...	Cancel I/O requests
QIO$C IO.RLB,...,<stadd,size>	Read logical block (alphanumeric)
QIO$C IO.RVB,...,<stadd,size>	Read virtual block (alphanumeric)

where:	stadd	is the starting address of the data buffer (may be on a byte boundary).
	size	is the data buffer size in bytes (must be greater than zero).

IO.KIL does not cancel an in progress request unless the card reader is in an offline condition because of a pick, read, stack or hopper check, because of power failure, or because the RESET button has not been depressed.

11.3.2 Device-Specific QIO Function

The device-specific function of the QIO macro that is valid for the card reader is shown in Table 11-2.

Table 11-2
Device-Specific QIO Function for the Card Reader

Format	Function
QIO$C IO.RDB,...,<stadd,size>	Read logical block (binary)

where:

stadd	is the starting address of the data buffer (may be on a byte boundary).
size	is the data buffer size in bytes (must be greater than zero).

11.4 STATUS RETURNS

There are a wide variety of error conditions and recovery procedures related to the use of the card reader. This section describes the three major ways in which the system reports error conditions.

1. Lights and indicators on the card reader panel are turned on or off to indicate particular operational problems such as read, pick, stack or hopper checks. Switches are available to turn the reader power on and off and to allow the user to reset after correcting an error condition.

2. A message is output on the operator's console if operational checks or power problems occur.

3. An I/O completion code is returned in the low-order byte of the first word of the I/O status block specified in the QIO macro to indicate success or failure on completion of an I/O function.

The following subsections describe each of these returns in detail.

11.4.1 Card Input Errors and Recovery

The table included below describes all external lights and switches used to indicate to the operator that a hardware problem has occurred and must be corrected. There are two classes of hardware errors:

- Those requiring the operator to ready the reader and try the operation again.

- Those requiring the operator to remove the last card from the output stacker, to replace it in the input hopper, and to try the operation again.

In the first case, the card reader was unable to read the current card. In the second, the card was read incorrectly and must be physically removed from the output stacker. The card reader driver automatically restarts a read operation within one second after the cards have been replaced in the input hopper.

Table 11-3 summarizes the functions of lights and indicators on the front panel of the card reader. It discusses common operational errors which might be encountered while reading cards and recovery procedures associated with these error conditions.

Table 11-3
Card Reader Switches and Indicators

Indicator	Description	Action	Recovery
POWER switch	pushbutton indicator switch (alternate action: pressed for both ON and OFF)	Controls application of all power to the card reader. When indicator is off, depressing switch applies power to reader and causes associated indicator to light. When indicator is lit, depressing switch removes all power from reader and causes indicator to go out.	Card may have been read incorrectly; restore power if possible by depressing the POWER switch; insert the card again as the first card in the input hopper, and press the RESET switch; in some cases, it may be necessary to restart the program.
READ CHECK indicator	white light	When lit, this light indicates that the card just read may be torn on the leading or trailing edges, or that the card may have punches in column positions 0 or 81. Because READ CHECK indicates an error condition, whenever this indicator is lit, it causes the card reader to stop operation and extinguishes the RESET indicator.	Card was read incorrectly; duplicate if necessary, insert the card again as the first card in the input hopper and press the RESET switch.
PICK CHECK indicator	white light	When lit, this light indicates that the card reader failed to move a card into the read station after it received a READ COMMAND from the controller. Stops card reader operation and extinguishes RESET indicator.	Card could not be read; press the RESET switch to try again or remove the cards from the input hopper, smooth the leading edges, replace, and then press the RESET switch.

(continued on next page)

Table 11-3 (Cont.)
Card Reader Switches and Indicators

Indicator	Description	Action	Recovery
STACK CHECK indicator	white light	When lit, this light indicates that the previous card was not properly seated in the output stacker and therefore may be badly mutilated. Stops card reader operation and extinguishes RESET indicator.	Card may have been read incorrectly and is not positioned properly in the output stacker; duplicate the card if it is damaged; insert the card again as the first card in the input hopper and press the RESET switch.
HOPPER CHECK indicator	white light	When lit, this light indicates that either the input hopper is empty or that the output stacker is full.	Card may have been read incorrectly; empty the stacker or fill the hopper; insert the card again as the fist card in the input hopper and press the RESET switch.
STOP switch	momentary pushbutton/ indicator switch (red light)	When depressed, immediately lights and drops the READY line, thereby extinguishing the RESET indicator. Card reader operation then stops as soon as the card currently in the read station has been read. This switch has no effect on the system power; it only stops the current operation.	
RESET switch	momentary pushbutton/ indicator switch (green light)	When depressed and released, clears all error flip-flops and initializes card reader logic. Associated RESET indicator lights to indicate that the READY signal is applied to the controller. The RESET indicator goes out whenever the STOP switch is depressed or whenever an error indicator lights (READ CHECK, PICK CHECK, STACK CHECK, or HOPPER CHECK).	

11.4.2 Ready and Card Reader Check Recovery

If any of the following conditions occurs:

- POWER failure
- Reset switch not pressed (reader offline)
- Timing error. (Two columns were read before the card reader driver input the first column from the card reader.)

the driver determines that the card reader is not ready, and the following message is output on the operator's console:

```
*** CRn: -- NOT READY
```

When a timing error occurs, the operator can proceed with normal card reader operation by:

1. Placing the card reader offline by pressing the STOP switch,
2. Removing the last card read and insert it where it will be the next card read, and
3. Placing the card reader online by pressing the RESET switch.

If any of the following conditions occurs:

- Pick error (PICK CHECK)
- Read error (READ CHECK)
- Output stacker error (STACK CHECK)
- Input hopper out of cards (HOPPER CHECK)
- Output stacker full (HOPPER CHECK)

the driver determines that a card reader check has occurred, and the following message is output on the operator's console:

```
*** CRn: -- READ FAILURE. CHECK HARDWARE STATUS
```

where n is the unit number of the card reader that is not ready. The operator should correct the error and press RESET: the driver attempts the function from the beginning, once every second. It displays the message once every m seconds (m is defined at SYSGEN as a value less than 256. The default is 15) until the card reader is readied. In all cases except pick error, the last card read should be reinserted in the input hopper, as described in Section 11.4.1.

11.4.3 I/O Status Conditions

The error and status conditions listed in Table 11-4 are returned by the card reader driver described in this chapter.

Table 11-4
Card Reader Status Returns

Code	Reason
IS.SUC	Successful completion The operation specified in the QIO directive was completed successfully. The second word of the I/O status block can be examined to determine the number of bytes processed, if the operation involved reading.
IS.PND	I/O request pending The operation specified in the QIO directive has not yet been executed. The I/O status block is filled with zeros.
IE.ABO	Operation aborted The specified I/O operation was cancelled while in progress or while still in the I/O queue.
IE.DAA	Device already attached The physical device unit specified in an IO.ATT function was already attached by the issuing task.
IE.DNA	Device not attached The physical device unit specified in an IO.DET function was not attached by the issuing task. This code has no bearing on the attachment status of other tasks.
IE.EOF	End-of-file encountered An end-of-file control card was recognized.
IE.IFC	Illegal function A function code was specified in an I/O request that is illegal for card readers.
IE.NOD	Buffer allocation failure Dynamic storage space has been depleted, and there was insufficient buffer space available to allocate a card buffer (that is, cards are read into a driver buffer, translated, and then moved to the user buffer).

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Table 11-4 (Cont.)
Card Reader Status Returns

Code	Reason
IE.OFL	Device off-line The physical device unit associated with the LUN specified in the QIO directive was not on-line. When the system was booted, a device check indicated that this physical device unit was not in the configuration.
IE.SPC	Illegal address space The buffer specified for a read request was partially or totally outside the address space of the issuing task. Alternately, a byte count of zero was specified.

11.5 FUNCTIONAL CAPABILITIES

The card reader driver can perform the following functions:

1. Read cards in DEC026 format and translate to ASCII.
2. Read cards in DEC029 format and translate to ASCII.
3. Read cards in binary format.

If the QIO macro specifies the IO.RLB or IO.RVB function, the driver interpets all data as alphanumeric (026 or 029 format). As explained below, control characters indicate whether 026 or 029 is desired. If the QIO macro specifies IO.RDB, the driver interprets all data, including 026 and 029 control characters, as binary.

11.5.1 Control Characters

Table 11-5 lists the multipunched cards that the card reader driver recognizes as control characters. They are never transferred to the user's buffer or included in the count of transferred bytes in alphanumeric mode. In binary mode, the only control card recognized is binary EOF.

Table 11-5
Card Reader Control Characters

Punches	Columns	Meaning
12-11-0-1-6-7-8-9	1	End-of-file (alphanumeric)
12-11-0-1-6-7-8-9	(all 8 punches in the first 8 columns)	End-of-file (binary)
12-2-4-8	1	026-coded cards follow
12-0-2-4-6-8	1	029-coded cards follow

DEC026 is the default translation mode when the system is bootstrapped. This mode remains in effect until explicitly changed by a control card indicating that DEC029 cards will follow. After encountering a DEC029 control card, the driver translates all cards in DEC029 format unless another DEC026 control card is encountered. This card overrides the 029 mode specification and indicates that subsequent cards are to be translated in 026 format. Control characters are addressed to the card reader itself, and remain in effect even when the reader is attached and subsequently detached.

The default condition can easily be changed from DEC026 to DEC029 by reading an 029 control card, and then saving the system with the MCR SAV command.

11.6 CARD READER DATA FORMATS

The card reader reads data in either alphanumeric or binary format.

11.6.1 Alphanumeric Format (026 and 0211)

Table 11-6 summarizes the translation from DEC026 or DEC029 card codes to ASCII.

11.6.2 Binary Format

In RSX-11M binary format, the data are not packed, but are transferred exactly as read, one card column per word. Because each word has 16 bits and each card column represents only 12, the data from the column are stored in the rightmost 12 bits of the word. The word's remaining four bits contain zeros.

11.7 PROGRAMMING HINTS

This section contains information on important programming considerations relevant to users of the card reader driver described in this chapter. Section 11.4 contains information on operational error-recovery procedures which might be important from a programming point of view.

11.7.1 Input Card Limitation

Only one card can be read with a single QIO macro call. A request to read more than 80 bytes or columns, the length of a single card, does not result in a multiple card transfer. Only 80 columns are processed. It is possible to read fewer than 80 columns of card input with a QIO read function. The user can specify that only the first 10 columns, for example, of each card are to be read.

11.7.2 Aborting a Task

If a task which is waiting for the card reader to be readied is aborted, the card reader driver recognizes this fact within one second.

Table 11-6
Translation from DEC026 or DEC029 to ASCII

Character	Non-Parity ASCII	DEC029	DEC026	Character	Non-Parity ASCII	DEC029	DEC026
	173	12 0	12 0	,	054	0 8 3	0 8 3
	175	11 0	11 0	-	055	11	11
SPACE	040	none	none	.	056	12 8 3	12 8 3
!	041	12 8 7	12 8 7	/	057	0 1	0 1
"	042	8 7	0 8 5	0	060	0	0
#	043	8 3	0 8 6	1	061	1	1
$	044	11 8 3	11 8 3	2	062	2	2
%	045	0 8 4	0 8 7	3	063	3	3
AND	046	12	11 8 7	4	064	4	4
'	047	8 5	8 6	5	065	5	5
(	050	12 8 5	0 8 4	6	066	6	6
)	051	11 8 5	12 8 4	7	067	7	7
*	052	11 8 4	11 8 4	8	070	8	8
+	053	12 8 6	12	9	071	9	9
:	072	8 2	11 8 2	M	115	11 4	11 4
;	073	11 8 6	0 8 2	N	116	11 5	11 5
<	074	12 8 4	12 8 6	O	117	11 6	11 6
=	075	8 6	8 3	P	120	11 7	11 7
>	076	0 8 6	11 8 6	Q	121	11 8	11 8
?	077	0 8 7	12 8 2	R	122	11 9	11 9
@	100	8 4	8 4	S	123	0 2	0 2
A	101	12 1	12 1	T	124	0 3	0 3
B	102	12 2	12 2	U	125	0 4	0 4
C	103	12 3	12 3	V	126	0 5	0 5
D	104	12 4	12 4	W	127	0 6	0 6
E	105	12 5	12 5	X	130	0 7	0 7
F	106	12 6	12 6	Y	131	0 8	0 8
G	107	12 7	12 7	Z	132	0 9	0 9
H	110	12 8	12 8	[	133	12 8 2	11 8 5
I	111	12 9	12 9	\	134	0 8 2	8 7
J	112	11 1	11 1	]	135	11 8 2	12 8 5
K	113	11 2	11 2	^ or ↑	136	11 8 7	8 5
L	114	11 3	11 3	_ or ←	137	0 8 5	8 2

CHAPTER 12

MESSAGE-ORIENTED COMMUNICATION DRIVERS

12.1 INTRODUCTION

RSX-11M supports a variety of communication line interfaces - synchronous and asynchronous, single-line and multiplexers, character-oriented and message-oriented. These are used for terminal communications, remote job entry, multicomputer interfaces, and laboratory and industrial control communications. Communications line interfaces can be roughly divided into two categories:

- Terminal (character-oriented) communications devices
- Multicomputer (message-oriented) communications devices

Chapter 1, 2 and 3 describe the character-oriented asynchronous communications line interfaces used primarily for terminal communications. The Terminals and Communications Handbook contains more detail on these devices. This chapter describes in some detail the RSX-11M message-oriented synchronous and asynchronous communication line interfaces. These are used most frequently in multicomputer communications.

Character-oriented communications devices include the DH11, DJ11, DL11-A, DL11-B/C/D, and DZ11 interfaces. These are asynchronous multiplexers and single-line interfaces used almost exclusively for terminal communications. Transfers on all of these interfaces are performed one character at a time. None of the interfaces in this category has a driver of its own (i.e., they are supported via the terminal driver), and none can be accessed directly as RSX-11M devices.

Message-oriented communications line interfaces are used primarily to link two separate but complementary computer systems. One system must serve as the transmitting device and the other as the receiving device. Devices in this category include the synchronous and asynchronous single-line interfaces summarized in Table 12-1.

The message-oriented communication line interfaces are used primarily to transfer large blocks of data.

Whereas the character-oriented interfaces can only be accessed indirectly through the terminal driver, the DA11-B, DL11-E, DMC11, DP11, DQ11, DU11, and DUP11 allow I/O requests to be queued directly for them. These devices have drivers of their own and can be accessed by means of the logical device names listed in Table 1-1. These names can be used in assigning LUNs via the Assign LUN system directive, at task build, or via the REASSIGN MCR command. The following subsections briefly discuss the message-oriented interfaces supported for RSX-11M.

Table 12-1
Message-Oriented Communication Interfaces

Model	Type	Rate (KBaud)	Duplex Half	Duplex Full	Data block (words)	Synch. Character
DA11-B[1]	Parallel	500	x		32K	no
DL11-E[2]	Serial, asynchronous	0.05-9.6	x	x	32K	programmable
DMC11	Serial, synchronous	19.2-1000	x	x	8K	no
DP11[1]	Serial, synchronous	2-19.2	x	x	32K	programmable
DQ11[1]	Serial, synchronous	2.4-1000	x	x	32K	programmable
DU11[1]	Serial, synchronous	0.05-9.6	x	x	32K	programmable
DUP11	Serial, synchronous	0.05-9.6	x	x	32K	programmable

[1] Support is not provided on RSX-11M-PLUS systems.

[2] DL11-E support is provided on RSX-11M-PLUS systems using the full-duplex terminal driver only.

12.1.1 **DA11-B Parallel Interface**

The DA11-B provides a bit-parallel, direct-memory-access interface between two PDP-11 computer systems. Data transfers are performed a word at a time and are made directly between the memories of the two systems. The maximum transfer rate is 500,000 baud, and is adjustable by the user to match the system configuration requirements. Being a parallel device, the DA11-B does not utilize sync characters. The interface is half-duplex and transfers data in blocks of up to 32K words.

The DA11-B requires two cooperating computers to effect a data transfer. In order to control the physical link between the computers, the device driver contains its own simple line protocol. This protocol requires one system to issue a receive QIO and the other to issue a transmit QIO before any data is actually transferred.

12.1.2 **DL11-E Asynchronous Line Interface**

The DL11-E is an asynchronous, serial-bit, single-line interface. It is a block-transfer device used for remote terminal and multicomputer communications. Baud rates are selectable between 50 and 9600, and full data-set control is supported.[3]

[3] Software support for data-set control consists of interlocking RTS and CTS for data transmission, and the setting of DTR (data terminal ready) to enable auto-answer modems to answer incoming calls. DTR is set when an IO.INL QIO (initialize) is issued.

12.1.3 DMC11 Synchronous Line Interface

The DMC11 provides a direct-memory-access interface between two PDP-11 computer systems using the DDCMP line protocol, thus delivering high throughput and reliability while simplifying programming. The DMC11 supports non-processor request (NPR) data transfers of up to 8K words at rates of 1,000,000 baud for local operation (over coaxial cable) and 19,200 baud for remote operation (using modems). Both full- and half-duplex modes are supported. The DMC11 also implements remote load detect, allowing it to reinitialize a halted computer system.

12.1.4 DP11 Synchronous Line Interface

The DP11 provides a program interrupt interface between a PDP-11 and a serial synchronous line. This interface facilitates the use of the PDP-11 in remote batch processing, remote data collection, and remote concentration applications. The modem control feature allows the DP11 to be used in switched or dedicated configurations.

On the DP11, baud rates are selectable between 2000 and 19,200. The programmer can select a specific sync character which is used to synchronize the transmitting and receiving systems.

12.1.5 DQ11 Synchronous Line Interface

The DQ11 provides a direct memory access interface between a PDP-11 and a serial synchronous line. The direct memory access characteristic of the DQ11 allows the device to operate at speeds higher than those of program interrupt devices, and with a lower interrupt overhead. Modem control of the DQ11 allows the device to be used in switched or dedicated configurations.

The DQ11 handles data rates from 2400 baud to 1,000,000 baud. The limiting rate is determined by the modem and data set interface level converters.

The DQ11 sync character is programmable in the same manner as the DP11 and the DU11. The maximum data block length transmitted is 65,536 characters.

12.1.6 DU11 Synchronous Line Interface

The DU11 synchronous line interface is a single-line communications device which provides a program-controlled interface between the PDP-11 and a serial synchronous line. The PDP-11 can be interfaced with a high-speed line to perform remote batch processing, remote data collection, and remote concentration applications. Modem control is a standard feature of the DU11 and allows the device to be used in switched or dedicated configurations. The DU11 transmits data at a maximum rate of 9600 baud; this rate is limited by modem and data set interface level converters.

The DU11 can be programmed to accept any user-defined sync character. The use of the sync character is the same for the DU11 and the DP11.

12.1.7 DUP11 Synchronous Line Interface

The DUP11 is identical to the DU11, except that it incorporates hardware to perform cyclic redundancy checking.

12.2 GET LUN INFORMATION MACRO

Word 2 of the buffer filled by the Get LUN Information system directive (the first characteristics word) contains the following information for message-oriented communication interfaces. A bit setting of 1 indicates that the described characteristic is true for the interfaces described in this chapter.

Bit	Setting	Meaning
0	0	Record-oriented device
1	0	Carriage-control device
2	0	Terminal device
3	0	File structured device
4	0	Single-directory device
5	0	Sequential device
6	0	Reserved
7	0	User-mode diagnostics supported
8	0	Massbus device
9	0	Unit software write-locked
10	0	Input spooled device
11	0	Output spooled device
12	0	Pseudo device
13	1	Device mountable as a communications channel
14	0	Device mountable as a FILES-11 volume
15	1	Device mountable

Words 3 and 4 are undefined, and word 5 has a special meaning for the DL11-E, DQ11, DP11, and the DU11 interfaces. Byte 0 of word 5 contains the number of sync characters to be transmitted before a synching message (for example, after line turn around in half-duplex operation), and byte 1 is used as a sync counter.

12.3 QIO MACRO

This section summarizes the standard and device-specific functions of the QIO macro that are valid for the communication interfaces described in this chapter.

12.3.1 Standard QIO Functions

Table 12-2 lists the standard functions of the QIO macro that are valid for the communication devices.

Table 12-2
Standard QIO Functions for Communication Interfaces

Format	Function
QIO$C IO.ATT,...	Attach device[1]
QIO$C IO.DET,...	Detach device
QIO$C IO.KIL,...	Cancel I/O requests
QIO$C IO.RLB,...,<stadd,size>	Read logical block (stripping sync)
QIO$C IO.WLB,...,<stadd,size>	Write logical block (preceded by syncs)

[1] Only unmounted channels may be attached. An attempt to attach a mounted channel will result in an IE.PRI status being returned in the I/O status doubleword.

where:	stadd	is the starting address of the data buffer (may be on a byte boundary).
	size	is the data buffer size in bytes (must be greater than zero).

12.3.2 Device-Specific QIO Functions

The specific functions of the QIO macro that are valid for the communication line interfaces are shown in Table 12-3.

Table 12-3
Device-Specific QIO Functions for Communication Interfaces

Format	Function
QIO$C IO.FDX	Set device to full-duplex mode. Not applicable to DA11-B.
QIO$C IO.HDX,...,<stat,mode>	Set device to half-duplex mode. Not applicable to DA11-B.
QIO$C IO.INL,...	Initialize device and set device characteristics
QIO$C IO.RNS,...,<stadd,size>	Read logical block, without stripping sync characters (transparent mode). Not applicable to DQ11. For DA11-B and DMC11, treated like IO.RLB.
QIO$C IO.SYN,...,<syn>	Specify sync character. Not applicable to DA11-B or DMC11.
QIO$C IO.TRM,...	Terminate communication, disconnecting from physical channel.
QIO$C IO.WNS,...,<stadd,size>	Write logical block without preceding sync characters (transparent mode). For DA11-B and DMC11, treated like IO.WLB.

where:

stadd	is the starting address of the data buffer (may be on a byte boundary).
size	is the data buffer size in bytes (must be greater than zero).
syn	is the sync character, expressed as an octal value.
stat	is the station assignment (primary or secondary).
mode	is the transmission mode (normal or maintenance).

The device-specific functions listed in Table 12-3 are described in greater detail below.

12.3.2.1 **IO.FDX** - The IO.FDX QIO function is used to set the mode on a DL11-E, DP11, DQ11, DU11, DUP11, or DMC11 unit to full-duplex. The IO.FDX function code can be combined (ORed) with the IO.SYN function code, if desired, to set the operational characteristics of the physical device unit.

12.3.2.2 **IO.HDX** - The IO.HDX QIO function is used to set the mode on a DL11-E, DP11, DQ11, DU11, DUP11, or DMC11 unit to half-duplex. The IO.HDX function code can be combined (ORed together) with the IO.SYN function code, if desired, to set the operational characteristics of the physical device unit.

Setting half-duplex on the DMC11 also involves setting the station assignment (primary/secondary) and may include selecting maintenance mode (MOP) as opposed to normal mode. The station assignment is included in optional QIO parameter p1. A zero indicates primary station and a non-zero indicates secondary station. The DMC11 works properly if both ends are primary stations or if there is one primary and one secondary station. It does not work if both ends are secondary stations. Optional QIO parameter p2 is used to select the mode. A zero selects normal mode and a non-zero selects MOP mode. A DMC11 in MOP mode cannot communicate with a DMC11 in normal mode.

12.3.2.3 **IO.INL and IO.TRM** - These two QIO functions have the same function code but different modifier bits. IO.INL is used to initialize a physical device unit for use as a communications link. It turns the device on-line, sets device characteristics, and ensures that the appropriate data terminal is ready. IO.TRM disconnects the device. If the device has a dial-up interface, it also hangs up the line.

12.3.2.4 **IO.RNS** - The IO.RNS QIO function is used to read a logical block of data, without stripping the sync characters which may precede the data. A similar function is IO.RLB, which is non-transparent, in that it causes sync characters preceding the data message to be stripped. IO.RLB is used at the start of a segmented data request, in which the block might have the following layout:

S	S	H	H	H	H	CS	CS	DATA	CS
1	2	3	4	5	6	7	8		

where: S is a sync character

H is a header character

CS is a validity check character

The programmer must strip sync characters from the beginning of a data block in this way. Stripping only at the beginning of a read allows a later character which happens to have the same binary value as a sync character to be read without stripping. IO.RLB is used to read a logical block with leading sync characters stripped; IO.RNS is used to read the block without stripping leading sync characters. Since the DA11-B is a parallel device and there are no sync characters, it treats the latter as if it were IO.RLB. Generally, IO.RLB should be used.

12.3.2.5 **IO.SYN** - This QIO function allows the programmer to specify the sync character to be recognized when an IO.RLB or IO.WLB function is performed. IO.SYN can be combined (ORed together) with IO.HDX or with IO.FDX to set the characteristics of the physical device unit.

12.3.2.6 **IO.WNS** - This QIO function causes a logical block to be written with no preceding sync characters. To ensure that the two systems involved in a communication are synchronized, two or more sync characters are transmitted by one system and received by the other before any other message can be sent. IO.WLB is used to write a block of data, preceded by sync characters; IO.WNS is used to perform a block transfer without sending sync characters first. Since the DA11-B is a parallel device and there are no sync characters, it treats the latter as if it were IO.WLB. Generally, IO.WLB should be used.

12.4 STATUS RETURNS

The error and status conditions listed in Table 12-4 are returned by the communication drivers described in this chapter.

Table 12-4
Communication Status Returns

Code	Reason
IS.SUC	Successful completion The operation specified in the QIO directive was completed successfully. The second word of the I/O status block can be examined to determine the number of bytes processed, if the operation involved reading or writing.
IS.PND	I/O request pending The operation specified in the QIO directive has not yet been executed. The I/O status block is filled with zeros.
IE.BCC	Block check error When the Cyclic Redundancy Check (CRC) option is present on the DQ11, a check character is appended to each message transmitted. The receiver of the messages recalculates the check character and compares it with the one transmitted. This error code is returned when the two check characters do not match, and represents a transmission error.
IE.CNR	Connection rejected (DMC11 only.) The DMC11 has detected that the device on the other end of the line has restarted itself. The user can recover by issuing IO.INL (initialize), and then reissuing the QIO in question.

(continued on next page)

Table 12-4 (Cont.)
Communication Status Returns

Code	Reason
IE.DAO	Data overrun Due to UNIBUS traffic or a modem problem, the DQ11 controller was unable to maintain the data rate required to prevent data loss (i.e., the receipt of another byte before processing of a previous byte was completed).
IE.DNR	Device not ready The physical device unit specified in the QIO directive was not ready to perform the desired I/O operation. This code is returned to indicate one of the following conditions: • The physical device unit could not be initialized (i.e., the circuit could not be completed). • The transmission of a character was not followed by an interrupt within the period of time selected as the device timeout period. This timeout occurs only when a transmission is in progress and the interrupt marking completion of a message does not occur. The appropriate response to this condition is to attempt to resynchronize the device by initializing and accepting the next request. A timeout does not occur on a read. If the receiving device is not ready, the transfer will not be initiated by the transmitting device. Once the transfer is initiated, however, it will complete either by satisfying the requested byte count or by timing out.
IE.IFC	Illegal function A function code was specified in an I/O request that is illegal for message-oriented communication devices.
IE.OFL	Device off-line The physical device unit associated with the LUN specified in the QIO directive was not on-line. When the system was booted, a device check indicated that this physical device unit was not in the configuration.
IE.SPC	Illegal address space The buffer specified for a read or write request was partially or totally outside the address space of the issuing task. Alternately, a byte count of zero was specified.

(continued on next page)

Table 12-4 (Cont.)
Communication Status Returns

Code	Reason
IE.VER	Nonrecoverable error (DA11-B only) The data transfer terminated before all of the data has been transmitted. The error code is returned on transmit when both systems attempt to transmit at the same time. This condition is detected by the device protocol. The error code is returned on receive when the transmit data count of the transmitting side does not equal the data count specified by the receive QIO.

12.5 PROGRAMMING HINTS

This section contains information on important programming considerations relevant to users of the message-oriented communication interfaces described in this chapter.

12.5.1 Transmission Validation

Because there is no way for the transmitting device to verify that the data block has successfully arrived at the receiving device unless the receiver responds, the transmitter assumes that any message which is clocked out on the line (without line or device outage) has been successfully transmitted. As soon as the receiver is able to satisfy a read request, it returns a successful status code (IS.SUC) in the I/O status block. Of course, only the task which receives the message can determine whether or not the message has actually been transmitted accurately.

The receiving device should be ready to receive data (with a read request) at the time the transmission is sent.

12.5.2 Redundancy Checking

By the nature of message-oriented communications, only the task which receives a communication can determine whether or not the message was received successfully. The transmitter simply transfers data, without validation of any kind. It is therefore the responsibility of the communicating tasks which use the device to check the accuracy of the transmission. A simple validity check is a checksum-type longitudinal redundancy check. A better approach to validating data is the use of a cyclic redundancy check (CRC). A CRC can be computed in software or with a hardware device, such as the KG-11 communications arithmetic option.

Both DQ11 and DUP11 incorporate hardware to compute a CRC. The DQ11 CRC hardware requires an extra system unit.

12.5.3 **Half-Duplex and Full-Duplex Considerations**

Because there is a single I/O request queue, only one QIO request can be performed at a time. It is therefore not possible, through QIOs, for a device to send and receive data at the same time. Also, since timeouts are not set for receive functions, a receive QIO is terminated only by receiving a message from the remote system, or by issuing an IO.KIL QIO for the device. Therefore, if no message is transmitted by the remote system, a receive will not terminate, and no further I/O can be performed on that device until the receive is killed by issuing an IO.KIL QIO.

Both half-duplex and full-duplex lines can be used with the DL11-E, DMC11, DP11, DQ11, DU11, and DUP11. The mode is settable by using IO.FDX for full-duplex and IO.HDX for half-duplex. In half-duplex mode, the modem signal RTS (Request To Send) is cleared after each "transmit message." In full-duplex, this signal is always left on. Using full-duplex mode eliminates modem delays in transmission, but requires full-duplex hardware and communication links.

Only half-duplex mode is available with the DA11-B because of the nature of the hardware.

The DMC11 Driver maintains both transmits and receives separately in its own internal queues. Thus, it is a full-duplex driver. There is no limit on the number of outstanding I/O requests that can be active at any given time. The DMC11 hardware, however, allows a maximum of only seven transmits and seven receives to be active at any time. The driver gives the first seven transmits (or receives) directly to the DMC11 and queues the eighth and subsequent transmits (or receives) internally until the DMC11 acknowledges a successful I/O request. When running on an 11/70, the driver gives only two transmits (or receives) to the DMC11 because each request requires a UNIBUS mapping register. The DMC11 driver is assigned five UMRs: 1 for base table(s), 2 for active transmits, and 2 for active receives.

12.5.4 **Low-Traffic Sync Character Considerations**

If message traffic on a line is low, each message sent from a communications device should be preceded by a sync train. This enables the controller to resynchronize if a message is "broken" (i.e., part or all of it is lost in transmission). Correspondingly, every message received by a communications device under low-traffic conditions, when messages are not contiguous (back-to-back), should be read via an IO.RLB (read, strip sync) function. This requires that the first character in the data message itself not have the binary value of the sync character.

12.5.5 **Vertical Parity Support**

Vertical parity is not supported by the DA11-B, DL11-E, DP11, DQ11, or DU11. Codes are assumed to be eight-bit only.

12.5.6 **Powerfail with DMC11**

The DMC11 currently cannot recover after a power failure. This is because the RAM in its internal microprocessor is erased when power fails. Any I/O requests outstanding at the time of a power failure will return IE.ABO. These requests must be reissued after initializing the DMC11 (IO.INL).

12.5.7 Importance of IO.INL

After the type of communication line has been determined, and after IO.SYN has specified the sync character, it is extremely important that IO.INL be issued before any transfers occur. This ensures that appropriate parameters are initialized and that the interface is properly conditioned. Note that IO.INL provides the only means of setting device characteristics, such as sync character. For this reason, IO.INL should always be used immediately prior to the first transfer over a newly-activated link.

Tasks sending messages to the DMC11 should begin by terminating and reinitializing the device (IO.TRM,IO.INL).[1] IO.INL must be issued after each IO.KIL (which effectively kills the DMC11), after powerfail, and upon receipt of any error code.

12.6 PROGRAMMING EXAMPLE

The following example illustrates the initialization, setting of device parameters, and transmission of a block of data on a message-oriented communication device.

```
        .MCALL  ALUN$S,QIO$S
        .       .
        .       .
        .       .
        ALUN$S  #1,#"XP,#0                    ; USE LUN1 FOR DP11
        QIO$S   #IO.HDX!IO.SYN,#1,,,,,<#226>  ; SET DEVICE PARAMETERS
        QIO$S   #IO.INL,#1                    ; PUT DEVICE ON LINE
        QIO$S   #IO.WLB,#1,,,#TXSTS,#TXAST,<#TXBUF,#100>; SEND A BLOCK
        .       .
        .       .
        .       .
TXAST:  CMPB    #IS.SUC&377,@(SP)+            ; WAS DATA CLOCKED OUT
                                              ; SUCCESSFULLY?
                                              ; IF SO, SET UP FOR NEXT
        BEQ     10$                           ; BLOCK
```

[1] Note that this will cause the error IE.CNR to be returned on any I/O outstanding on the other end of the line.

CHAPTER 13

PCL11 PARALLEL COMMUNICATIONS LINK DRIVERS

13.1 INTRODUCTION

PCL11 Parallel Communications Link hardware is supported on RSX-11M-PLUS systems via two drivers. One driver supports the transmitter function and the other driver supports the receiver function. The PCL11-B is a hardware interface that functions as a time division multiplexed (TDM) interface over which several PDP-11 computers can transfer data to each other. Each PCL11-B consists of a transmitter, receiver, and master section. The transmitter section can transfer parallel 16-bit words along the TDM bus to a receiver section of a separate PCL11-B on a different PDP-11 computer's UNIBUS. One of the PCL11-B units attached to the TDM bus must have its master section enabled to effect the data transfer.

13.1.1 PCL11-B Hardware

Each PCL11-B transmitter and receiver section has a unique TDM bus address (hardware-configured). When a master section is enabled, it places a transmitter address on the TDM bus for a period of time, called a timeslice. During the timeslice, the addressed transmitter can address the desired receiver section and transmit one word; the transmitter waits for the receiver to acknowledge the word or an indication that the word was not accepted. If the word is not accepted, it will normally retransmit the word on the next available timeslice. Thus, a message up to 32k words long can be transmitted to a receiver one word at a time during the time which other similar TDM transactions are multiplexed for other PCL11-B devices.

13.1.2 PCL11 Transmitter Driver

The PCL11 transmitter driver provides two basic functions. First, it must receive data sent by the attached task and store it in a silo buffer in the PCL11 hardware. Then, the driver passes proper receiver address and command information to the PCL11 transmitter hardware to effect the actual transfer over the TDM bus.

13.1.3 PCL11 Receiver Driver

The PCL11 receiver driver also performs two basic functions. First, it must remove data from the receiver silo and send it to the connected task. In addition, the receiver driver must ackowledge a transmitter when a data transmission is requested by that transmitter. Subsequent requests by other transmitters on the TDM bus are ignored until all message transactions with the current transmitter are completed.

13.2 GET LUN INFORMATION MACRO

Word 2 of the buffer filled by the Get LUN Information system directive (the first characteristics word) contains the following information for the PCL11 transmitter and receiver drivers. A setting of 1 indicates that the described characteristics is true for PCL11 transmitter and receiver drivers.

Bit	Setting	Meaning
0	1	Record-oriented device
1	0	Carriage-control device
2	0	Terminal device
3	0	File-structured device
4	0	Single-directory device
5	1	Sequential device
6	0	Reserved
7	0	User-mode diagnostic supported
8	0	Massbus device
9	0	Unit software write-locked
10	0	Input spooled device
11	0	Output spooled device
12	0	Pseudo device
13	0	Device mountable as a communications channel
14	0	Device mountable as a FILES-11 volume
15	0	Device mountable

Word 3 contains device driver-specific information, as follows:

Transmitter driver:

> The low byte of word 3 contains the number of transmit retries remaining after completing the current data transmit function if the current data transmit function attempt is not accepted by the addressed receiver. The high byte of word 3 is undefined.

Receiver driver:

> The low byte of word 3 contains the index of the current state of the receiver driver. These states are primarily used for diagnostic purposes and are defined as follows:

Index Value	Meaning
0	No task is connected
+2	Task connected but not triggered
+4	Task triggered and waiting for IO.RTF or IO.ATF function
+6	Task triggered and timed out while waiting for IO.RTF or IO.ATF function
-2	IO.ATF function in progress
-4	Task connected, not triggered, and has an IO.ATF function in progress
-6	An IO.RTF function is in progress

The high byte of word 3 is undefined.

Word 4 is undefined. Word 5 is the default buffer size in bytes. For the PCL11, this value is 64 bytes.

13.3 QIO MACRO -- PCL11 TRANSMITTER DRIVER FUNCTIONS

13.3.1 Standard QIO Functions

Table 13-1 lists the standard functions of the QIO macro that are valid for the PCL11 transmitter driver.

Table 13-1
Standard QIO Functions for PCL11 Transmitters

Format	Function
QIO$C IO.ATT,...	Attach device
QIO$C IO.DET,...	Detach device
QIO$C IO.KIL,...	Cancel I/O request

13.3.2 Device-Specific QIO Functions

Table 13-2 lists the device-specific functions of the QIO macro that are valid for the PCL11 transmitter driver.

Table 13-2
Device-Specific QIO Functions for PCL11 Transmitters

Format	Function
QIO$C IO.ATX,...,<stadd,size, flagwd,id,retries,retadd>	Attempt message transmission
QIO$C IO.SEC,...,	Sense master section status
QIO$C IO.STC,...,<stadd,size, [state],[mode],,retadd>	Set master section characteristics

Where:

stadd	is the starting address of a data buffer (its description and function is dependent upon the specific QIO function).
size	is the data buffer size in bytes (its description and function is dependent upon the specific QIO function).
flagwd	is the value of the flagword which is to precede the message being sent. The flags specify the desired receiver function as defined by the user's protocol.
id	is the identifier of the CPU to which the message is to be sent. This identifier is the desired receiver's TDM bus address. It appears in the high byte of the first word of the master section I/O status block. The identifier number is an octal value contained in the high byte of the parameter word. For example, receiver number 1 is specified as 400, receiver number 2 is specified as 1000, etc.
retries	is the number of retries that will be attempted, following the first attempt, that will be performed if the first attempt is unsuccessful, or upon detecting transmission errors or master down conditions, before returning error status to the calling task.
retadd	is the starting address of a 7-word buffer into which the contents of the 6 transmitter registers and the transmitter master/maintenance register are moved prior to returning to the calling task. Information describing the contents of these registers can be obtained by referring to the hardware documentation supplied with the PCL11 option.
state	is the desired state setting for the transmitter, as follows:

Parameter specified	State
SS.MAS	TDM bus master
SS.NEU	Neutral (default state)

mode is the desired mode setting for allocating transmitter timeslices on the TDM bus, as follows:

Parameter entered	Mode
MS.AUT	Auto addressing (default mode)
MS.ADS	Address silo

13.3.2.1 **IO.ATX** - This I/O function requests an attempt to transmit a message to a specified CPU. The message to be transmitted is contained in a data buffer starting at the address specified in the stadd parameter. This address must be on a word boundary. The data buffer size specified in the size parameter must be an even, positive value. The flagword parameter contains user-defined information that the receiving task will use in determining whether to accept or reject the message. The id parameter is the receiver TDM bus address. The task uses this address to direct a message to a specific CPU. Other parameters are as previously described.

13.3.2.2 **IO.SEC** - This I/O function is used to sense the master section status. Upon successful completion of this function, the I/O status block will contain a typical I/O status code (IS.SUC) return in the low byte of the first word, and current Transmitter Master/Maintenance Register (TMMR) contents in the second word, as follows:

	Status Code
Current TMMR Contents	

NOTE

The optional isb parameter (see Section 1.5.1) must be included in this QIO request.

13.3.2.3 **IO.STC** - This I/O function sets the master section operational characteristics. IO.STC can only be issued by a privileged task. Correct use of the function depends upon the current (or specified) operating state of the master section and proper use of parameters. Each parameter is used as described in the following paragraphs. Refer to all parameters in the sequence shown for a correct interpretation of parameter usage.

State -- The state parameter determines the overall function of this master section (and transmitter and receiver sections) in the PCL11 communications link as it relates to the TDM bus. The neutral state (SS.NEU) places the master section in an inactive state where the unit will send and receive messages in a normal manner, but the master section cannot control transmitter timeslice allocation on the TDM bus. The master state (SS.MAS) designates this unit as TDM bus master, enabling control of transmitter unit timeslice allotments on the TDM bus; only one master section on the TDM bus can be designated TDM bus master.

Mode -- The TDM bus master can allocate transmitter timeslices in one of two ways: auto address mode (MS.AUT) or address silo mode (MS.ADS). When operating in the auto address mode (MS.AUT), which is the default mode for the TDM bus master, equal timeslice allotments are given to each transmitter unit; transmitter unit addresses are sequentially put on the TDM bus in descending order, one address for each timeslice. When operating in the address silo mode, transmitter unit addresses are transmitted in a user-specified sequence, allowing up to 50% of the timeslices to be allocated to one transmitter unit, if desired.

The actual sequence of transmitter timeslice allocations for the address silo mode is set up in the user's task data buffer referenced by the stadd parameter. Certain constraints must be observed when specifying this information, as follows:

- Each entry in the buffer is a byte containing a transmitter unit address.

- At least 20 entries, but not more than 50 entries must be specified. If less than 20 entries are specified, the driver will repeat the entire sequence, as specified, in order to attain the required minimum of 20 addresses. If more than 50 addresses are specified, no change in timeslice allocation will be effected and an IE.VER error status will be returned to the task.

- Identical transmitter addresses in either adjacent bytes or in first and last bytes should be avoided. When identical addresses appear in adjacent bytes in this manner, the driver inserts invalid "pad" transmitter addresses between identical addresses, effectively resulting in no-operation timeslices.

- Transmitter addresses are decimal values ranging from 1 to 32 (inclusive) which correspond to addresses implemented on the actual transmitter unit hardware.

- The size parameter must correctly specify the number of address bytes contained in the buffer referenced by the stadd parameter.

13.4 PCL11 TRANSMITTER DRIVER STATUS RETURNS

Table 13-3 lists PCL11 transmitter driver return status codes and probable reasons.

Table 13-3
PCL11 Transmitter Driver Status Returns

Code	Reason
IS.SUC	Successful completion The QIO function was successfully completed. If an IO.ATX function was completed, the second status word contains the number of bytes transferred; the message was not truncated. If an IO.SEC function was completed, the second status word contains the current contents of the master section's TMMR.
IS.TNC	Successful transfer but message truncated The IO.ATX function was completed, but the message was truncated by the receiver (the receiver buffer is too small). The transmitter unit cannot determine how many words were actually received by the receiver unit; the second word of the I/O status block contains the length of the requested transfer, rather than the actual count of words successfully received in the receiver's buffer.
IE.BAD	Bad parameter specification A bad parameter specification was included in the IO.ATX function, or an invalid state parameter or TDM bus timeslice allocation addressing mode was specified in the IO.STC function. This error status is also returned when an IO.STC function, issued to a TDM bus master operating in the address silo mode, refers to a data buffer containing an illegal series of transmitter addresses. An illegal series of addresses occurs when the number of entries specified for the timeslice allocation, plus the required number of pad addresses, either exceeds 50 or is less than 0.
IE.DNR	Device not ready This error status return occurs in response to an IO.ATX function when one of the following occurs: • Power failure in this CPU • Device timeout (no response from the addressed receiver) • Receiver was too slow in accepting or rejecting the transfer request • The master section is inoperative. This error status is returned only after the number of retries specified in the IO.ATX function have been attempted without success.

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Table 13-3 (Cont.)
PCL11 Transmitter Driver Status Returns

Code	Reason
IE.VER	Unrecoverable error The IO.STC function state setting could not be achieved because the task is not privileged or another device is TDM bus master.
IE.SPC	Illegal user buffer The buffer address specified in the IO.ATF function is outside of the issuing task's address space.
IE.REJ	Transfer rejected The data transfer request specified in the IO.ATX function was rejected by the addressed receiver, based on the source CPU identifier of the task issuing the request, and flagword.
IE.FLG	Event flag already specified An event flag was previously specified in an IO.STC function.
IE.BBE	Transmission error This error status is returned only after the number of retries specified in the IO.ATX function have been attempted without a successful transmission. (Cycle redundancy check errors or parity errors have been detected on each attempt.)
IE.ABO	Request terminated This status is returned when a pending I/O function has been aborted in response to an IO.KIL function being issued by the task.
IE.IFC	Illegal function A function code was specified in an I/O request that is illegal for PCL11 transmitters.

13.5 QIO MACRO -- PCL11 RECEIVER DRIVER FUNCTIONS

13.5.1 Standard QIO Functions

Table 13-4 lists the standard function of the QIO macro that is valid for the PCL11 receiver driver.

Table 13-4
Standard QIO Functions for PCL11 Receivers

Format	Function
QIO$C IO.KIL,...	Cancel I/O request

13.5.2 Device-Specific QIO Functions

Table 13-5 lists the device-specific functions of the QIO macro that are valid for the PCL11 receiver driver.

Table 13-5
Device-Specific QIO Functions for PCL11 Receivers

Format	Function
QIO$C IO.CRX,...,<tef,bufadd>	Connect for reception
OIO$C IO.RTF,...	Reject transfer
QIO$C IO.ATF,...,<stadd,size, retadd>	Accept transfer
QIO$C IO.DRX,...	Disconnect from reception

where:

tef	is the number of a "trigger" event flag which will be set whenever a flagword is received over the TDM bus.
bufadd	is the address of a 2-word buffer containing the transmitter id, trigger status and the flagword.
stadd	is the address of a data buffer to receive the message. This address must occur on a word boundary (even address).
size	is the data buffer size in bytes. The size specified must be an even, positive value.
retadd	is the address of a 6-word buffer into which the contents of the 6 PCL11 receiver hardware registers will be returned upon successful completion of the function. Information describing the contents of these registers can be obtained by referring to the hardware documentation supplied with the PCL11 option.

13.5.2.1 **IO.CRX** - This I/O function connects the issuing task to the receiver, if the receiver is not currently connected to another task. When connected, this task is the only task capable of receiving messages via the receiver on this CPU. The trigger event flag (a local, common, or group-global event flag) informs the task when a message is pending. It is set when a flagword is received over the TDM bus. When this happens, a significant event is declared and the connected task is considered "triggered". The flagword is the first word transmitted by a transmitter when attempting to send a message to the receiver unit.

The bufadd parameter must be included in this I/O function to specify the address of a 2-word block, as follows:

id	sts
flagwd	

where:

sts	is the current trigger status.
id	is the identification code of the transmitter attempting to send the message.
flagwd	is the flagword transmitted to the connected receiver.

Based on the information contained in the flagword and the identification code of the transmitter unit, the task can accept or reject the transfer. (Two I/O functions are provided for this purpose -- see Sections 13.5.2.2 and 13.5.2.3.) The receiver must respond to the transmitter's request within approximately 1.5 seconds; otherwise, an IE.DNR error status is returned to the task attempting the transmission.

13.5.2.2 **IO.RTF** - This function informs the transmitter device that the message is being rejected by the receiver. Any attempt to issue this I/O function when the trigger event flag is not set will be ignored, and an IE.NTR error status will be returned to the task.

13.5.2.3 **IO.ATF** - This function informs the transmitter device that the message is being accepted. Parameters specify the data buffer into which the received data will be transferred, and the 6-word buffer that will receive the contents of the receiver section hardware registers upon successfully completing the function.

Unlike the IO.RTF function, the IO.ATF function can be issued before the task is triggered. When this is done, the IO.ATF function is queued for reception of any flagword. When the flagword is received, the receiver driver immediately executes the IO.ATF function; the connected task is not triggered and the flagword is not made available to the task. This approach is useful when it is not necessary to examine flagwords or to accept messages based on the source.

13.5.2.4 **IO.DRX** - This function is issued by a task to disconnect the receiver for use by other tasks.

13.6 PCL11 RECEIVER DRIVER STATUS RETURNS

Table 13-6 lists PCL11 receiver driver return status codes and probable reasons.

Table 13-6
PCL11 Receiver Driver Status Returns

Code	Reason
IS.SUC	Successful completion The I/O function or triggering of the task was successfully completed. When this status is returned upon completion of the IO.ATF function, the high order byte of the first word in the I/O status block contains the identification code of the transmitter device that sent the flagword. The second word of the I/O status block contains the number of bytes transferred over the TDM bus. When this status is returned as a result of an IO.CRX function, and the task being triggered, the I/O status block contains information that enables the task to accept or reject the message (see Section 13.5.2.1).
IS.TNC	Successful transfer but message truncated This I/O status is returned when the message is terminated because the receiver task message buffer specified in the IO.ATF function is too small to contain the message being received. The second word of the I/O status word contains the number of bytes successfully transferred.
IE.BAD	Bad parameter specification A bad parameter specification was included in the requested function.
IE.DNR	Device not ready This error status return occurs in response to an IO.RTF or IO.ATF function when one of the following occurs: • Power failure in this CPU • Device timeout (no response from addressed receiver) • Receiver was too slow in accepting or rejecting the transfer request • The master section is inoperative

(continued on next page)

Table 13-6 (Cont.)
PCL11 Receiver Driver Status Returns

Code	Reason
IE.SPC	Illegal user buffer The buffer address specified in the IO.ATF function is outside of the issuing task's address space.
IE.DNA	Task not connected for reception The requested function can not be executed because the task is not connected to the receiver.
IE.DAO	Data overrun This I/O status code is returned when the task is triggered, but the previous transfer request has neither been accepted nor rejected. When the task issues an IO.RTF or IO.ATF function, it will apply to the new (most recent) flagword; the previous request is ignored.
IE.DAA	Device already connected for reception This I/O status code is returned in response to the IO.CRX function when the receiver is already connected to this task or any other task. No operation is performed.
IE.NTR	Task not triggered This I/O status code is returned when a task attempts to issue an IO.RTF function prior to the task being triggered.
IE.BBE	Transmission error This error status is returned when an IO.ATF function is in progress and a cycle redundancy check error or parity error has been detected.
IE.ABO	Request terminated This status is returned when a pending I/O function has been aborted in response to an IO.KIL function being issued by the task.
IE.FHE	Fatal hardware error The requested function cannot be executed because of a hardware failure.
IE.IFC	Illegal function A function code was specified in an I/O request that is illegal for PCL11 transmitters.

CHAPTER 14

ANALOG-TO-DIGITAL CONVERTER DRIVERS

14.1 INTRODUCTION

The AFC11 and AD01-D analog-to-digital (A/D) converters are used for the acquisition of industrial and laboratory analog data. (AFC11 and AD01-D driver support is not provided on RSX-11M-PLUS systems.) Although each has its own driver, programming for both is quite similar and both are multichannel, programmable gain devices. The AD01-D should not be confused with the ADU01, a UDC module, which is described in Chapter 15. Table 14-1 compares the AFC11 and the AD01-D briefly, and subsequent sections describe these devices in greater detail.

Table 14-1
Standard Analog-to-Digital Converters

	AFC11	AD01-D
Maximum sampling rate (points per second)	200 (20 per single) channel	Approximately 10,000
Number of bits	13 or 14	10 or 11
Maximum number of analog channels that can be multiplexed	1024	64

14.1.1 AFC11 Analog-to-Digital Converter

The AFC11 is a differential analog input subsystem for industrial data-acquisition and control systems. It multiplexes signals, selects gain, and performs a 13- or 14-bit analog-to-digital conversion under program control. With the use of appropriate signal-conditioning modules, the system can intermix and accept low-level, high-level, and current inputs,.with a high degree of noise immunity.

14.1.2 AD01-D Analog-to-Digital Converter

The AD01-D is an extremely fast analog data-acquisition system. It multiplexes signals, selects gain, and performs a 10- or 11-bit analog-to-digital conversion under program control. The AD01-D is normally unipolar, but an optional sign-bit facilitates bipolar operation.

14.2 GET LUN INFORMATION MACRO

If a GET LUN INFORMATION system directive is issued for a LUN associated with an analog-to-digital converter, word 2 (the first characteristics word) contains all zeros, words 3 and 4 are undefined, and word 5 is not significant, since there is no concept of a default buffer size for analog-to-digital converters.

14.3 QIO MACRO

This section summarizes standard and device-specific QIO functions for analog-to-digital converter drivers.

14.3.1 Standard QIO Function

The standard function that is valid for analog-to-digital converters is shown in Table 14-2.

Table 14-2
Standard QIO Function for the A/D Converters

Format	Function
QIO$C IO.KIL,...	Cancel I/O requests

Since all requests are processed within a small amount of time, no in-progress request is ever cancelled. This function simply cancels all queued requests.

14.3.2 Device-Specific QIO Function

The device-specific function of the QIO macro that is valid for analog-to-digital converters is shown in Table 14-3.

Table 14-3
Device-Specific QIO Function for the A/D Converters

Format	Function
QIO$C IO.RBC,...,<stadd,size,stcnta>	Initiate multiple A/D conversions

where:		
	stadd	is the starting address of the data buffer (must be on a word boundary).
	size	is the control buffer size in bytes (must be even and greater than zero); the data buffer is the same size.
	stcnta	is the starting address of the control buffer (must be on a word boundary); each control buffer word must be constructed as shown in Table 14-4.

Table 14-4
A/D Conversion Control Word

Bits	Meaning	AFC11	AD01-D
0-11	Channel number	Range: 0-1023	Range: 0-63
12-15	Gain value for this sample, expressed as a bit pattern as follows	Gain:	Gain:
	15 14 13 12		
	0 0 0 0	1	1
	0 0 0 1	2	2
	0 0 1 0	illegal	4
	0 0 1 1	illegal	8
	0 1 0 0	10	illegal
	0 1 0 1	20	illegal
	0 1 1 0	illegal	illegal
	0 1 1 1	illegal	illegal
	1 0 0 0	50	illegal
	1 0 0 1	100	illegal
	1 0 1 0	illegal	illegal
	1 0 1 1	illegal	illegal
	1 1 0 0	200	illegal
	1 1 0 1	1000	illegal
	1 1 1 0	illegal	illegal
	1 1 1 1	illegal	illegal

14.4 FORTRAN INTERFACE

A collection of FORTRAN-callable subroutines provide FORTRAN programs access to the AFC11 and the AD01-D. These are described in this section. All are reentrant and may be placed in a resident library.

14.4.1 Synchronous and Asynchronous Process Control I/O

The ISA standard provides for synchronous and asynchronous I/O. Synchronous I/O is indicated by appending a "W" to the name of the subroutine (e.g., AISQ/AISQW). The synchronous call suspends task execution until the I/O operation is complete. If the asynchronous form is used, execution continues and the calling program must periodically test the status word for completion.

14.4.2 The isb Status Array

The isb (I/O status block) parameter is a two-word integer array that contains the status of the FORTRAN call, in accordance with ISA convention. This array serves two purposes:

1. It is the 2-word I/O status block to which the driver returns a status code on completion of an I/O operation.

2. The first word of isb receives a status code from the FORTRAN interface in ISA-compatible format, with the exception of the I/O pending condition, which is indicated by a status of zero. The ISA standard code for this condition is +2.

The meaning of the contents of isb varies, depending on the FORTRAN call that has been executed, but Table 14-5 lists certain general principles that apply. The section describing each subroutine provides further details.

Table 14-5
Contents of First Word of isb

Contents	Meaning
isb(1) = 0	Operation pending; I/O in progress
isb(1) = 1	Successful completion
isb(1) = 3	Interface subroutine unable to generate QIO directive or number of samples is zero
3 < isb(1) < 300	QIO directive rejected and actual error code = -(isb(1) - 3)
isb(1) > 300	Driver rejected request and actual error code = -(isb(1) - 300)

Unless otherwise specified, the value of isb(2) is the value returned by the driver to the second word of the I/O status block.

FORTRAN interface subroutines depend on asynchronous system traps to set their status. Thus, if the trap mechanism is disabled, proper status cannot be set.

14.4.3 **FORTRAN Subroutine Summary**

Table 14-6 lists the FORTRAN interface subroutines supported for the AFC11 and AD01-D under RSX-11M.

Table 14-6
FORTRAN Interface Subroutines for the AFC11 and AD01-D

Subroutine	Function
AIRD/AIRDW	Perform input of analog data in random sequence
AISQ/AISQW	Read a series of sequential analog input channels
ASADLN	Assign a LUN to the AD01-D
ASAFLN	Assign a LUN to the AFC11

The following subsections briefly describe the function and format of each FORTRAN subroutine call. Note the use of ASADLN and ASAFLN to assign a default logical unit number.

14.4.4 AIRD/AIRDW: Performing Input of Analog Data in Random Sequence

The ISA standard AIRD/AIRDW FORTRAN subroutines input analog data in random sequence. These calls are issued as follows:

$$\text{CALL} \begin{Bmatrix} \text{AIRD} \\ \text{AIRDW} \end{Bmatrix} \text{(inm,icont,idata,[isb],[lun])}$$

where:		
	inm	specifies the number of analog input channels.
	icont	is an integer array containing terminal connection data - channel number (right-justified in bits 0-11) and gain (bits 12-15), as shown in Table 14-4.
	idata	is an integer array to receive the converted values.
	isb	is a two-word integer array to which the subroutine status is returned
	lun	is the logical unit number.

The isb array has the standard meaning defined in Section 14.4.2. If inm = 0, then isb(1) = 3. The contents of idata are undefined if an error occurs.

14.4.5 AISQ/AISQW: Reading Sequential Analog Input Channels

The ISA standard AISQ/AISQW FORTRAN subroutines read a series of sequential analog input channels. These calls are issued as follows:

$$\text{CALL} \begin{Bmatrix} \text{AISQ} \\ \text{AISQW} \end{Bmatrix} \text{(inm,icont,idata,[isb],[lun])}$$

where:		
	inm	specifies the number of analog input channels.
	icont	is an integer array containing terminal connection data - channel number (right-justified in bits 0-11) and gain (bits 12-15), as shown in Table 14-4.
	idata	is an integer array to receive the converted values.
	isb	is a 2-word integer array to which the subroutine status is returned.
	lun	is the logical unit number.

For sequential analog input, channel number is computed in steps of one, beginning with the value specified in the first element of icont. The channel number field is ignored in all other elements of the array.

The gain used for each conversion is taken from the respective element in icont. Thus, even though the channel number is ignored in all but the first element of icont, the gain must be specified for each conversion to be performed.

The isb array has the standard meaning defined in Section 14.4.2. If inm = 0, then isb(1) = 3. The contents of idata are undefined if an error occurs.

14.4.6 **ASADLN: Assigning a LUN to the AD01-D**

The ASADLN FORTRAN subroutine assigns the specified LUN to the AD01-D and defines it as the default logical unit number to be used whenever a LUN specification is omitted from an AIRD(W)/AISQ(W) subroutine call. It is issued as follows:

```
CALL ASADLN (lun,[isw],[iun])
```

where:

	lun	is the logical unit number to be assigned to the AD01-D and defined as the default unit.
	isw	is an integer variable to which the result of the ASSIGN LUN system directive is returned.
	iun	is the unit number to be assigned. If unspecified, a value of 0 is assumed.

Only the LUN specified in the last call to ASADLN or ASAFLN is defined as the default unit.

14.4.7 **ASAFLN: Assigning a LUN to the AFC11**

The ASAFLN FORTRAN subroutine assigns the specified LUN to the AFC11 and defines it as the default logical unit number to be used whenever a LUN specification is omitted from an AIRD(W)/AISQ(W) subroutine call. It is issued as follows:

```
CALL ASAFLN (lun,[isw],[iun])
```

where:

	lun	is the logical unit number to be assigned to AFC11 and defined as the default unit.
	isw	is an integer variable to which the status from the ASSIGN LUN system directive is returned.
	iun	is the unit number to be assigned. If unspecified, a value of 0 is assumed.

Only the LUN specified in the last call to ASAFLN or ASADLN is defined as the default unit.

14.5 **STATUS RETURNS**

The error and status conditions listed in Table 14-7 are returned by the analog-to-digital converter drivers described in this chapter.

Table 14-7
A/D Converter Status Returns

Code	Reason
IS.SUC	Successful completion The operation specified in the QIO directive was completed successfully. The second word of the I/O status block can be examined to determine the number of A/D conversions performed.
IS.PND	I/O request pending The operation specified in the QIO directive has not yet been executed. The I/O status block is filled with zeros.
IE.ABO	Operation aborted The specified I/O operation was cancelled via IO.KIL while still in the I/O queue.
IE.BAD	Bad parameter An illegal specification was supplied for one or more of the device-dependent QIO parameters (words 6-11). For the analog-to-digital converters, this code indicates that a bad channel number or gain code was specified in the control buffer.
IE.BYT	Byte-aligned buffer specified Byte alignment was specified for a data or control buffer, but only word alignment is legal for analog-to-digital converters. Alternately, the length of the data and control buffer is not an even number of bytes.
IE.DNR	Device not ready The physical device unit specified in the QIO directive was not ready to perform the desired I/O operation. For the AFC11, this code is returned if an interrupt timeout occurred or the power failed. In the case of the AD01-D, which is not operated in interrupt mode, this code indicates a software timeout occurred (i.e. a conversion did not complete within 30 microseconds).
IE.IFC	Illegal function A function code was specified in an I/O request that is illegal for analog-to-digital converters.

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Table 14-7 (Cont.)
A/D Converter Status Returns

Code	Reason
IE.OFL	Device off-line The physical device unit associated with the LUN specified in the QIO directive was not on-line. When the system was booted, a device check indicated that this physical device unit was not in the configuration.
IE.SPC	Illegal address space The data or control buffer specified for a conversion request was partially or totally outside the address space of the issuing task. Alternately, a byte count of zero was specified.

FORTRAN interface values for these subroutines are presented in Section 14.5.1.

14.5.1 **FORTRAN Interface Values**

The values listed in Table 14-8 are returned in FORTRAN subroutine calls.

Table 14-8
FORTRAN Interface Values

Status Return	FORTRAN Value
IS.SUC	+01
IS.PND	+00
IE.ABO	+315
IE.ADP	+101
IE.BAD	+301
IE.BYT	+319
IE.DAO	+313
IE.DNR	+303
IE.IEF	+100
IE.IFC	+302
IE.ILU	+99
IE.NOD	+323
IE.ONP	+305
IE.PRI	+316
IE.RSU	+317
IE.SDP	+102
IE.SPC	+306
IE.ULN	+08
IE.UPN	+04

14.6 FUNCTIONAL CAPABILITIES

The AFC11 and AD01-D operate only in multi-sample mode, because the user can simulate single-sample mode by simply specifying one sample. Multi-sample mode permits many channels to be sampled at approximately the same time without requiring the user to queue multiple I/O requests.

The maximum number of channels in the configuration is specified at system-generation time. This value is stored in the respective AFC11 and AD01-D unit control blocks.

14.6.1 Control and Data Buffers

The user must define two buffers of equal size, the control buffer and the data buffer. The former contains the control words needed to perform one A/D conversion per channel specified. Each control word indicates the channel to be sampled and the gain to be applied (see Table 14-4).

The data buffer receives the results of the conversions. Each result is placed in the data buffer location that corresponds to the control word that specified it.

14.7 PROGRAMMING HINTS

This section contains information on important programming considerations relevant to users of the analog-to-digital converter drivers described in this chapter.

14.7.1 Use of A/D Gain Ranges

Note that the A/D gain ranges overlap. The key to successful use of the A/D converters is to change to a higher gain whenever a full-scale reading is imminent and to change to a lower gain whenever the last A/D value recorded was less than half of full scale. This method maintains maximum resolution while avoiding saturation.

14.7.2 Identical Channel Numbers on the AFC11

When requesting sampling of more than one channel, the user should not specify multiple sampling of a single channel without 10 or more intervening samples on other channels. This ensures 50 milliseconds between samples on a single channel. If sampling occurs more often than this on a single channel, partial results are returned (see Section 14.7.3).

14.7.3 AFC11 Sampling Rate

Although the AFC11 can sample a maximum of 200 points per second, a single channel can only be sampled at 20 points per second. Because the channel capacitor needs 50 milliseconds to recharge after each conversion, more frequent sampling may result in partial readings. If this occurs, the user will receive no indication that information is being lost. To ensure that information is not lost on any one channel, the user should sample approximately ten other channels before returning to the first one.

14.7.4 Restricting the Number of AD01-D Conversions

The AD01-D is an extremely fast device, providing a 25-microsecond conversion rate, and is driven programmably to minimize system overhead. However, an excessive number of conversions in a single request essentially locks out the rest of the system because the driver does not return control to the system until it has finished all the specified conversions. No other task can run, although interrupts can still occur and are processed.

CHAPTER 15

UNIVERSAL DIGITAL CONTROLLER DRIVER

15.1 INTRODUCTION

The UDC11 is a digital input/output system for industrial and process control applications. It interrogates and/or drives up to 252 directly addressable digital sense and/or control modules. The UDC11 operates under program control as a high-level digital multiplexer, interrogating digital inputs and driving digital outputs. (UDC11 driver support is not provided on RSX-11M-PLUS systems.)

The UDC driver will support either the UDC11 or ICS11 subsystem. The ICS11 (Industrial Control Subsystem) operates as an input/output device that is functionally similar to the UDC11. A maximum of 16 I/O modules can be placed in one ICS11 subsystem. Up to 12 ICS11s can be interfaced to one computer system. The ICS11 subsystem is also supported by the ICS/ICR-11 driver described in chapter 18. The reader should consult that chapter for a comparison of driver features.

While performing analog-to-digital conversions, the UDC11 driver can handle other functions, such as contact or timer interrupts or latching output. These functions are performed immediately, without requiring any in progress analog-to-digital conversions to first be completed.

Unlike other RSX-11M I/O device drivers, the UDC11 driver is neither a multicontroller nor a multiunit driver.

15.1.1 Creating the UDC11 Driver

Each installation must assemble the driver source module with a prefix file that defines the particular hardware configuration. The prefix file is created during system generation according to the user's response to questions relating to the UDC11. This file is named RSXMC.MAC and includes symbolic definitions of the UDC11 configuration. These definitions encode the relative module number and the number of modules for each generic type specified in the system generation dialog. The encoding has the following format:

8	8
number of modules	starting module number

One or more of the following symbols is generated:

Symbol	Module Type
U$$ADM	Analog input
U$$AOM	Analog output
U$$CIM	Contact interrupt
U$$CSM	Contact sense input
U$$LTM	Latching digital output
U$$SSM	Single-shot digital output
U$$TIM	Timer (I/O counter)

Note that all modules of a given type must be installed together in sequential slots.

15.1.2 Accessing UDC11 Modules

RSX-11M provides two methods of accessing the UDC11:

1. A QIO macro call issued to the driver
2. Restricted direct access by any task to I/O page registers dedicated to the UDC11

The first method, access through the driver, is required to service interrupting modules and to set and record the state of latching digital output modules.

The second method, direct access, is a high-speed, low-overhead way to service noninterrupting modules. The following functions may be performed in this manner:

- Analog output
- Contact sense input
- Single-shot digital output
- Read a contact interrupt module
- Read a timer module

15.1.2.1 **Driver Services** - The driver services the following types of modules:

1. Contact interrupt
2. Timer (I/O counter)
3. Analog input
4. Latching digital output

Contact and timer interrupts need not be serviced by a single task. One task may be connected to contact interrupts, and another to timer interrupts. A nonprivileged task can connect to either or both of these classes by providing a circular buffer to receive interrupt information and an event flag to allow triggering of the task whenever a buffer entry is made.

15.1.2.2 **Direct Access** - A global common block within the I/O page provides restricted direct access to the UDC11 device registers. In a mapped system, the length of the block is set to prevent access to other device registers. In an unmapped system, the use of the common block is optional, unless ISA FORTRAN calls are used. The ISA routines refer symbolically to the UCD11 registers, and thus require the use of global common. Section 15.4 explains direct access more fully.

15.2 GET LUN INFORMATION MACRO

If a GET LUN INFORMATION system directive is issued for a LUN associated with the UDC11, word 2 (the first characteristics word) contains all zeros, words 3 and 4 are undefined, and word 5 is not significant, since there is no concept of a default buffer size for universal digital controllers.

15.3 QIO MACRO

This section summarizes standard and device-specific QIO functions for the UDC11 driver. In issuing them, note the numbering conventions described in 15.7.2.

15.3.1 Standard QIO Function

The standard function that is valid for the UDC11 is shown in Table 15-1.

Table 15-1
Standard QIO Function for the UDC11

Format	Function
QIO$C IO.KIL,...	Cancel I/O requests

IO.KIL cancels all queued requests and disconnects all interrupt connections, but does not stop any I/O that is currently in progress.

15.3.2 Device-Specific QIO Functions

Table 15-2 summarizes device-specific QIO functions that are supported for the UDC12.

Table 15-2
Device-Specific QIO Functions for the UDC11

Format	Function
QIO$C IO.CCI,...,<stadd,sizb,tevf>	Connect a buffer to contact interrupts
QIO$C IO.CTI,...,<stadd,sizb,tevf,arv>	Connect a buffer to timer interrupts
QIO$C IO.DCI,...	Disconnect a buffer from contact interrupts
QIO$C IO.DTI,...	Disconnect a buffer from timer interrupts
QIO$C IO.ITI,...,<mn,ic>	Initialize a timer
QIO$C IO.MLO,...,<opn,pp,dp>	Open or close latching digital output points
QIO$C IO.RBC,...,<stadd,size,stcnta>	Initiate multiple A/D conversions

where:	stadd	is the starting address of the data buffer (must be on a word boundary).
	sizb	is the data buffer size in bytes (must be even and large enough to include a 2-word buffer header plus one data entry; the buffer may cross a 4K boundary).
	tevf	is the trigger event flag number.
	arv	is the starting address of the table of initial/reset values (must be on a word boundary).
	mn	is the module number.
	ic	is the initial count.
	opn	is the first latching digital output point number, which must be on a module boundary (evenly divisible by 16).
	pp	is the 16-bit mask.
	dp	is the data pattern.
	size	is the control buffer size in bytes (must be even and greater than zero); the data buffer is the same size.
	stcnta	is the starting address of the control buffer (must be on a word boundary); each control buffer word must be constructed as shown in Table 15-3.

The following sections describe the functions listed in Table 15-2.

Table 15-3
A/D Conversion Control Word

Bits	Meaning	ADU01
0-11	Channel number	Range: 0-4095
12-15	Gain value for this sample, expressed as a bit pattern as follows	Gain:
	15 14 13 12	
	0 0 0 0	1
	0 0 0 1	2
	0 0 1 0	illegal
	0 0 1 1	illegal
	0 1 0 0	10
	0 1 0 1	20
	0 1 1 0	illegal
	0 1 1 1	illegal
	1 0 0 0	50
	1 0 0 1	100
	1 0 1 0	illegal
	1 0 1 1	illegal
	1 1 0 0	200
	1 1 0 1	1000
	1 1 1 0	illegal
	1 1 1 1	illegal

15.3.2.1 **Contact Interrupt Digital Input (W733 Modules)** - Digital input and change of state information from contact interrupt modules is reported in a requester-provided circular buffer. The buffer consists of a 2-word header, followed by a data area in the following format:

1	driver index
2	user index
3	entry
4	entry
.	.
.	.
.	.

Whenever a change of state occurs in one or more contact points an interrupt is generated. The UDC11 driver gains control, determines whether the change of state is of interest (i.e., a contact closure and point closing (PCL) is set on the module), and then optionally makes an entry in the data area of the buffer, updates the index words and sets the trigger event flag of the connected task.

Each entry consists of five words in the following format:

Word	Contents
0	Entry existence indicator
1	Change-of-state (COS) indicator
2	Module data (current point values)

Word	Contents
3	Module number (interrupting module)
4	Generic code (interrupting module)

The driver enters data in the location currently indicated by the driver index. This pointer can be considered as a FORTRAN index into the buffer, i.e., the first location of the buffer is associated with the index 1. The beginning of the data area is the location of the first entry (index 3). Entries are made in a circular fashion, starting at the beginning of the data area, filling in order of increasing memory address to the end of the data area, and then wrapping around from the end to the beginning of the data area.

It is expected that the connected task will maintain its own pointer (the user index) to the location in the buffer where it is next to retrieve contact interrupt data. When a task is triggered by the driver, it should process data in the buffer starting at the location indicated by its pointer and continuing in a circular fashion until the two pointers are equal or a zero entry existence indicator is encountered. Equality of pointers means that the connected task has retrieved all the contact interrupt information that the driver has entered into the buffer.

The entry existence indicator is set nonzero when a buffer entry is made. When a requester has removed or processed an entry, he must clear the existence indicator in order to free the buffer entry position.

If data input occurs in a burst sufficient to overrun the buffer, data is discarded and a count of data overruns is incremented. The nonzero entry existence indicator also serves as an overrun indicator. A positive value (+1) indicates no overruns between entries; a negative value is the two's complement of the number of times data have been discarded between entries.

The module number indicates a module on which a change of state in the direction of interest has been recognized for one or more discrete points. The direction of the change may be from 0 to 1 or 1 to 0, depending on the PCL (point closing) and POP (point opening) module jumpers. The change of state (COS) indicator specifies which point or points of the module have changed state.

The bit position of an on-bit in the COS indicator provides the low-order bits (3-0) of a point number and the module number provides the high order bits (15-4). The module data indicates the logical value (polarity) of each point in the module at the time of the interrupt.

Contact interrupt data can be reported to only one task. The functions IO.CCI and IO.DCI in Table 15-2 are provided to enable a task to connect and disconnect from contact interrupts. If the connection is successful, the second word of the I/O status block contains the number of words passed per interrupt in the low-order byte and the initial FORTRAN index to the beginning of the data area in the high-order byte.

NOTE

The size of the data area must be a multiple of the entry size.

15.3.2.2 **Timer (W734 I/O Counter Modules)** - A timer (I/O counter) module is a clock that is initialized (loaded), counts up or down, and then causes an interrupt. The UDC11 driver treats such modules in a way similar to that in which it handles contact interrupts. The requester provides a circular buffer similar to that for contact interrupts. Each entry consists of four words in the following format:

Word	Contents
0	Entry existence indicator
1	Module data (current value)
2	Module number (interrupting module)
3	Generic code (interrupting module)

The IO.CTI function in Table 15-2 enables a task to connect to timer interrupts. The table of initial/reset values is used to initially load the timers and to reload them on interrupt (overflow). The table contains one word for each timer module. The contents of the first word are used to load the first module, and so forth. If a timer has a nonzero value when it interrupts, it is not reloaded, so that self-clocking modules and modules that interrupt on half count can continue counting from the initial value.

The IO.DTI function in Table 15-2 disconnects a task from timer interrupts, and the IO.ITI function provides the capability of initializing a single timer. Requests to initialize a counter are valid only if the issuing task has connected a buffer for receiving counter interrupts.

NOTE

The size of the data area must be a multiple of the entry size.

15.3.2.3 **Latching Digital Output (M685, M803, and M805 Modules)** - Each module has 16 latching digital output points. The IO.MLO function in Table 15-2 opens or closes a set of up to 16 points. Bit n of the mask and data pattern corresponds to the point opn + n. If a bit in the mask is set, the corresponding point is opened or closed, depending on whether the corresponding bit in the data pattern is clear or set. If a bit in the mask is clear, the corresponding point remains unaltered.

15.3.2.4 **Analog-to-Digital Converter (ADU01 Module)** - Each ADU01 module has eight analog input channels. The IO.RBC function in Table 15-2 initiates A/D conversions on multiple ADU01 input channels. Restrictions on maximum sampling rates are the same as defined for the AFC11 in Chapter 14.

The converted analog value is returned as 12 bits, left-justified, in a 16-bit word with the low order 4 bits set to zero.

15.3.2.5 **ICS11 Analog-to-Digital Converter (IAD-IA Module)** - Each IAD-IA Module has eight analog input channels. The channel capacity may be expanded to 120 by the addition of IMX-IA multiplexers. Each multiplexer adds 16 input channels to the converter. Restrictions on maximum sampling rates are the same as defined for the AFC11 in Chapter 14. The IAD-IA module preempts eight module slots regardless of the number of IMX-IA multiplexers installed.

For addressing purposes, each converter occupies a block of 120 channels. Thus, A/D converter 0 is addressed by referencing channels 0 through 119; A/D converter 1 is addressed by referencing channels 120 through 239 etc. When fewer than seven multiplexers are installed, not all addresses within the block are valid.

The converted analog value is returned as 12 bits, left justified, in a 16-bit word with the low order 4 bits set to zero.

15.4 DIRECT ACCESS

Section 15.1.2 describes UDC11 functions that may be performed by referencing a module through its physical address in the I/O page. Under RSX-11M such access is accomplished by one of the following methods:

1. A privileged task or any task running in an unmapped system has unrestricted access to the I/O page and may therefore access each module by absolute address.

2. Using the Task Builder, a task may link to a global common area whose physical address limits span a set of locations in the I/O page. This method applies to either a mapped or unmapped system.

The latter method allows a task to be transported to any other system simply by relinking. Further, in a mapped system the memory management hardware will abort all references to device registers outside the physical address limits of the common block.

The operations required to implement each method may be summarized as follows:

1. Unrestricted access to the I/O page

   a. An object module is created which defines the UDC11 configuration through a list of absolute global addresses and addressing limits for each module type.

   b. The object module is included in the system library file.

   c. A task is created containing the appropriate global references. Such references are resolved when the task builder automatically searches the system library file.

Steps a and b are executed once, during system generation (see RSX-11M System Generation and Management Guide). Step c is performed each time a task is created that references the UDC12.

2. Access to the I/O page through a Global Common Block:

   a. An object module is created which defines the UDC11 configuration through a list of relocatable global addresses and addressing limits for each module type.

b. The object module is linked, using the Task Builder, to create an image of the Global Common block on disk.

c. The SET command is used to define a common block that resides on the I/O page.

d. The INSTALL MCR command is used to make the Global Common Block resident in memory.

e. A task is created containing the appropriate global references. Such references are resolved by directing the Task Builder to link the Task to the common block.

Steps a through d are executed once, during system generation. Step e is performed each time a task is created that references the UDC11 common block. The following paragraphs describe each step in detail.

15.4.1 **Defining the UDC11 Configuration**

The source module UDCOM.MAC[1], when assembled with the proper prefix file, provides global definitions for the following parameters:

- The starting address of each module type.
- The highest point number within a given module type.
- The highest module number within a given module type.

The last two parameters are absolute quantities that may be used to prevent a task from referencing a module that is nonexistent or out of limits.

By means of conditional assembly the list of addresses may be created as absolute symbols defining locations in the I/O page or as symbols within a relocatable program section to be used when building and linking to the UDC11 Global Common area.

15.4.1.1 **Assembly Procedure for UDCOM.MAC** - UDCOM.MAC is assembled with the RSX-11M configuration parameters contained in the file RSXMC.MAC.

To create relocatable module addresses either the parameter U$$DCM or M$$MGE must be defined. M$$MGE will be included in RSXMC.MAC if memory management was specified when the system was generated. If not, the user should edit the file to include the following definition:

```
U$$DCM=0
```

The file may then be assembled using the MCR command:

```
>MAC UDCOM,UDLST=[11,10]RSXMC,UDCOM
```

[1] This module resides on the RK05 cartridge of the RSX-11M RK distribution kit labeled EXECUTIVE SOURCE. For RP distribution kits, it resides on the RP image. The file is located under UIC [11,10].

This command invokes the MACRO-11 assembler which processes the input files RSXMC.MAC and UDCOM.MAC to create UDCOM.OBJ and UDLST.LST.

To create absolute module addresses, both U$$DCM and M$$MGE must be undefined. Edit RSXMC.MAC, if necessary, to remove definitions and then invoke the MACRO-11 assembler with the following MCR command:

```
>MAC UDCDF,UDLST=[11,10]RSXMC,UDCOM
```

In this sequence the files UDCDF.OBJ and UDLST.LST are created from the specified source modules. UDCDF.OBJ contains the module addresses in absolute form.

15.4.1.2 Symbols Defined by UDCOM.MAC - This section lists the symbolic definitions created by UDCOM.MAC.

The following symbols define the absolute or relocatable address of the first module of a given type:

Symbol	Module Type
$.ADM	Analog input
$.AOM	Analog output
$.CIM	Contact interrupt
$.CSM	Contact sense input
$.LTM	Latching digital output
$.SSM	Single-shot digital output
$.TIM	Timer (I/O counter)

The addresses in relocatable form are defined in a program section named UDCOM having the attributes:

```
REL - relocatable
OVR - overlaid
D   - data
GBL - global scope
```

Note that these attributes correspond to those attached to a named common block within a FORTRAN program.

In either the absolute or relocatable case, individual modules are referenced by the corresponding symbolic address plus a relative module index.

The following symbols define the highest digital point within a module type:

Symbol	Module Type
P$.CIM	Contact interrupt
P$.CSM	Contact sense input
P$.LTM	Latching digital output
P$.SSM	Single-shot digital output

The highest point number is defined relative to the first point on the first module of a specific type. For example if two contact interrupt modules are installed, the symbol P$.CIM will have an octal value of 37.

The following symbols define the highest module number within a given module type.

Symbol	Module Type
M$.ADM	Analog input
M$.AOM	Analog output
M$.CIM	Contact interrupt
M$.CSM	Contact sense input
M$.LTM	Latching digital output
M$.SSM	Single-shot digital output
M$.TIM	Timer (I/O counter)

The highest module number is defined relative to the first module of a given type. Thus, based on the previous example, M$.CIM will have a value of 1.

15.4.2 **Including UDC11 Symbolic Definitions in the System Object Module Library**

As described in 15.4, a task having unrestricted access to the I/O page may reference a UDC11 module by absolute address. The object module UDCDF contains symbolic definitions of absolute module addresses and may be included in the System Object Module Library:

```
          SY:[1,1]SYSLIB.OLB
```

The Task Builder automatically searches this file to resolve any undefined globals remaining after all input files have been processed.

The following example illustrates the procedure for including the file UDCDF.OBJ in the library.

```
          >SET /UIC=[1,1]
          >LBR SYSLIB/IN=[200,200]UDCDF
```

The SET MCR command is issued to establish the current UIC as [1,1]. Next, the RSX11M Librarian is invoked and instructed, through the use of the /IN switch to include the object module UDCDF.OBJ in the file SYSLIB.OLB.

15.4.3 **Referencing the UDC11 through a Global Common Block**

The following sections define the procedure for creating a Global Common block in the I/O PAGE, making the block resident in memory, and creating a task which references UDC11 modules within the block. Examples are given for both mapped and unmapped systems.

15.4.3.1 **Creating a Global Common Block** - The following sequence illustrates the use of the object file UDCOM.OBJ to create a disk image of the global common area in a mapped system.

```
          >SET /UIC=[1,1]
          >TKB
          TKB>UDCOM/MM,LP:,SY:UDCOM/PI/-HD=[200,200]UDCOM
          TKB>/
          ENTER OPTIONS:
          TKB>PAR=UDCOM:0:1000
          TKB>STACK=0
          TKB>/
```

In the above example, a current UIC of [1,1] is established and the Task Builder is initiated. The initial input line to the Task Builder specifies the following files:

- A core image output file to be named UDCOM.TSK
- A memory map output to the line printer
- A symbol table file to be named UDCOM.STB

All files reside on SY: under UIC [1,1]. The single input file, UDCOM.OBJ containing the UDC11 address definitions as relocatable values, constitutes the input.

The switches specified for the output files convey the following information to the Task Builder:

/MM	indicates that the core image of the common block will reside on a system with Memory Management.
/PI	indicates that the core image is position independent; that is the virtual address of the common block may appear on any 4K boundary within a task's address space.
/-HD	indicates that the core image will not contain a header. A header is only required for a core image file that is to be installed and executed as a task.

The names of the partition, task file, and symbol-table files must agree.

The STACK option must be used to eliminate the stack space.

The following sequence illustrates the corresponding procedure for an unmapped system:

```
>SET /UIC=[1,1]
>TKB
TKB>UDCOM/-MM,LP:,SY:UDCOM/PI/-HD=[200,200]UDCOM
TKB>/
ENTER OPTIONS:
TKB>STACK=0
TKB>PAR=UDCOM:171000:1000
TKB>/
```

Again the task builder is requested to produce a core image and symbol table file under the UIC [1,1] and a map file on the line printer from the input file UDCOM.OBJ. The output file switches convey the following information:

/-MM	indicates that the core image of the common block will reside on an unmapped system.
/PI	Indicates that the core image is position independent. In an unmapped system the core image is fixed in the same address space for all tasks; however, the global symbols defined in the symbol table file retain the relocatable attribute.
/-HD	indicates that a core image without a header is to be created.

The PAR option specifies the base and length of the common area to coincide with the standard UDC11 addresses in the I/O page. All references to the common block by tasks will be resolved within this region.

15.4.3.2 **Making the Common Block Resident** - The following SET command creates a UDC11 common block residing in the I/O page for a mapped system:

```
>SET /MAIN=UDCOM:7710:10:DEV
```

The corresponding command in an unmapped system is:

```
>SET /MAIN=UDCOM:1710:10:DEV
```

The preceding sequence specifies the allocation of a common block in the I/O page whose physical address limits correspond to the UDC11 standard locations. Note that the address bounds and length are defined in units of 32 words.

The command

```
>INS [1,1]UDCOM
```

declares the common block resident in the system.

15.4.3.3 **Linking a Task to the UDC11 Common Block** - A task may access UDC11 modules by linking to the common block as follows:

```
TKB>TASK,LP:=TASK.OBJ
TKB>/
ENTER OPTIONS:
TKB> COMMON=UDCOM:RW
TKB>/
```

The above sequence is valid for either a mapped or unmapped system. In both cases the Task Builder will link the task to the common block by resolving references to the Global symbol definitions contained in UDCOM.STB. If memory management is present, the Executive will map the appropriate physical locations into the task's virtual addressing space when the task is made active.

15.5 **FORTRAN INTERFACE**

A collection of FORTRAN-callable subroutines provide FORTRAN programs access to the UDC12. These are described in this section. All are reentrant and may be placed in a resident library.

Instead of using the FORTRAN-callable subroutines described in this section, a FORTRAN program may use the global common feature described in Section 15.4 to reference UDC11 modules directly in the I/O page, as shown in the following example:

```
C
C       UDC11 GLOBAL COMMON
C
        COMMON /UDCOM/ ICSM(10),IAO(10)
C
C       READ CONTACT SENSE MODULE 1 DIRECTLY
C
        ICS=ICSM(1)
```

Note that the position of each module type must correspond to the sequence in which storage is allocated in the common statements.

15.5.1 Synchronous and Asynchronous Process Control I/O

The ISA standard provides for synchronous and asynchronous process I/O. Synchronous I/O is indicated by appending a "W" to the name of the subroutine (e.g., AO/AOW). But due to the fact that nearly all UDC11 I/O operations are performed immediately, in most cases the "W" form of the call is retained only for compatibility and has no meaning under RSX-11M. In the case of A/D input, however, the "W" form is significant: the synchronous call suspends task execution until input is complete. If the asynchronous form is used, execution continues and the calling program must periodically test the status word for completion.

15.5.2 The isb Status Array

The isb (I/O status block) parameter is a 2-word integer array that contains the status of the FORTRAN call, in accordance with ISA (Instrument Society of America) convention. This array serves two purposes:

1. It is the 2-word I/O status block to which the driver returns an I/O status code on completion of an I/O operation.

2. The first word of isb receives a status code from the FORTRAN interface in ISA-compatible format, with the exception of the I/O pending condition, which is indicated by a status of zero. The ISA standard code for this condition is +2.

The meaning of the contents of isb varies, depending on the FORTRAN call that has been executed, but Table 15-4 lists certain general principles that apply. The section describing each subroutine gives more details.

In some cases, the values or states of points being read, pulsed, or latched are returned to isb word 2.

FORTRAN interface subroutines for analog input depend on asynchronous system traps to set their status. Thus, if the trap mechanism is disabled, proper status cannot be set.

Table 15-4
Contents of First Word of isb

Contents	Meaning
isb(1) = 0	Operation pending; I/O in progress
isb(1) = 1	Successful completion
isb(1) = 3	Interface subroutine unable to generate QIO directive or number of points requested is zero
3 < isb(1) < 300	QIO directive rejected and actual error code = -(isb(1) - 3)
isb(1) > 300	Driver rejected request and actual error code = -(isb(1) - 300)

For direct access calls (indicated in Table 15-5 below), errors are detected and returned by the FORTRAN interface subroutine itself, rather than by the driver. Although the use of a two-word status block is therefore unnecessary, these errors are returned in standard format to retain compatibility with functions called through QIO directives and handled by other drivers. Errors of this type that may be returned are:

isb(1) = 3	Number of points requested is zero
isb(1) = +321	Invalid UDC11 module

15.5.3 **FORTRAN Subroutine Summary**

Table 15-5 lists the FORTRAN interface subroutines supported for the UDC11 under RSX-11M. (D) indicates a direct access call and the optional logical unit number for such a call may be specified to retain compatibility with RSX-11D, but this specification is ignored by RSX-11M.

The following subsections briefly describe the function and format of each FORTRAN subroutine call. Note the use of ASUDLN to specify a default logical unit number. Also consider the numbering conventions described in 15.7.2.

The following FORTRAN functions do not perform I/O directly, but facilitate conversions between BCD and binary.

Convert four BCD digits to a binary number:

```
IBIN = KBCD2B(IBCD)
```

Convert a binary number to four BCD digits:

```
IBCD = KB2BCD(IBIN)
```

Table 15-5
FORTRAN Interface Subroutines for the UDC11

Subroutine	Function
AIRD/AIRDW	Perform input of analog data in random sequence
AISQ/AISQW	Read a series of sequential analog input channels
AO/AOW	Perform analog output on several channels (D)
ASUDLN	Assign a LUN to the UDC11
CTDI	Connect a circular buffer to receive contact interrupt data
CTTI	Connect a circular buffer to receive timer interrupt data
DFDI	Disconnect a buffer from contact interrupts
DFTI	Disconnect a buffer from timer interrupts
DI/DIW	Read several 16-point contact sense fields (D)
DOL/DOLW	Latch or unlatch several 16-point fields
DOM/DOMW	Pulse several 16-point fields (D)
RCIPT	Read the state of a single contact interrupt point (D)
RDCS	Read the contents of a contact interrupt circular buffer, returning data on only those points that have changed state.
RDDI	Read the contents of a contact interrupt circular buffer, one point for each call
RDTI	Read the contents of a timer interrupt circular buffer, one entry for each call
RDWD	Read the contents of a contact interrupt circular buffer, returning 16 bits of module data and change-of-state information.
RSTI	Read a single timer module (D)
SCTI	Set a timer module to an initial value

15.5.4 AIRD/AIRDW: Performing Input of Analog Data in Random Sequence

The ISA standard AIRD/AIRDW FORTRAN subroutines input analog data in random sequence. These calls are issued as follows:

$$\text{CALL} \left\{\begin{matrix}\text{AIRD} \\ \text{AIRDW}\end{matrix}\right\} \text{(inm,icont,idata,[isb],lun)}$$

where:	inm	specifies the number of analog input channels.
	icont	is an integer array containing terminal connection data - channel number (right-justified in bits 0-11) and gain (bits 12-15), as shown in Table 15-3.
	idata	is an integer array to receive the converted values.
	isb	is a two-word integer array to which the subroutine status is returned.
	lun	is the logical unit number.

NOTE

lun is a required parameter.

The isb array has the standard meaning defined in Section 15.5.2. If inm = 0, then isb(1) = 3. The contents of idata are undefined if an error occurs.

15.5.5 AISQ/AISQW: Reading Sequential Analog Input Channels

The ISA standard AISQ/AISQW FORTRAN subroutines read a series of sequential analog input channels. These calls are issued as follows:

$$\text{CALL} \left\{\begin{matrix}\text{AISQ} \\ \text{AISQW}\end{matrix}\right\} \text{(inm,icont,idata,[isb],lun)}$$

where:	inm	specifies the number of analog input channels.
	icont	is an integer array containing terminal connection data - channel number (right-justified in bits 0-11) and gain (bits 12-15), as shown in Table 15-3.
	idata	is an integer array to receive the converted values.
	isb	is a two-word integer array to which the subroutine status is returned.
	lun	is the logical unit number.

NOTE

lun is a required parameter.

For sequential analog input, channel number is computed in steps of one, beginning with the value specified in the first element of icont. The channel number field is ignored in all other elements of the array.

The gain used for each conversion is taken from the respective element in icont. Thus, even though the channel number is ignored in all but the first element of icont, the gain must be specified for each conversion to be performed.

The isb array has the standard meaning defined in Section 15.5.2. If inm = 0, then isb(1) = 3. The contents of idata are undefined if an error occurs.

15.5.6 **AO/AOW: Performing Analog Output**

The ISA standard AO/AOW FORTRAN subroutines initiate analog output on several channels. These calls are issued as follows:

$$\text{CALL} \begin{Bmatrix} \text{AO} \\ \text{AOW} \end{Bmatrix} \text{(inm,icont,idata,[isb],[lun])}$$

where:	inm	specifies the number of analog output channels.
	icont	is an integer array containing the channel numbers.
	idata	is an integer array containing the output voltage settings, in the range 0-1023.
	isb	is a two-word integer array to which the subroutine status is returned.
	lun	is the logical unit number (ignored if present).

The isb array has the standard meaning defined in Section 15.5.2.

15.5.7 **ASUDLN: Assigning a LUN to the UDC11**

The ASUDLN FORTRAN subroutine assigns the specified LUN to the specified unit and defines it as the default logical unit number to be used whenever a LUN specification is omitted from a UDC11 subroutine call. It is issued as follows:

```
CALL ASUDLN (lun,[isw],[iun])
```

where:	lun	is the logical unit number to be assigned to the specified unit, and defined as the default.
	isw	is an integer variable to which the result of the ASSIGN LUN system directive is returned.
	iun	is an integer defining the UDC11 unit number. If no number is specified, 0 is assumed.

15.5.8 **CTDI: Connecting to Contact Interrupts**

The CTDI FORTRAN subroutine connects a task to contact interrupts and specifies a circular buffer to receive contact interrupt data. The length of this buffer can be computed by considering the following:

- Rate at which contact module interrupts occur
- Number of modules that can interrupt simultaneously
- Rate at which the circular buffer is emptied

The UDC11 driver generates a five-word entry for each contact interrupt and the interface subroutine itself requires 10 words of additional storage. Thus the isz parameter, described below, can be computed as follows:

```
isz = (10 + 5 * n)
```

where n is the number of entries in the buffer and isz is expressed in words.

The call is issued as follows:

```
CALL CTDI (ibuf,isz,iev,[isb],[lun])
```

where:		
	ibuf	is an integer array that is to receive contact interrupt data.
	isz	is the length of the array in words, with a minimum size of 15.
	iev	is the trigger event flag number. The specified event flag is set whenever the driver inserts an entry in the data buffer.
	isb	is a 2-word integer array to which the subroutine status is returned.
	lun	is the logical unit number.

The isb array has the standard meaning defined in Section 15.5.2.

15.5.9 **CTTI: Connecting to Timer Interrupts**

The CTTI FORTRAN subroutine connects a task to timer interrupts and specifies a circular buffer to receive timer interrupt data. The length of this buffer can be computed by considering the following:

- Rate at which timer module interrupts occur
- Number of modules that can interrupt simultaneously
- Rate at which the circular buffer is emptied

The UDC11 driver generates a four-word entry for each timer interrupt and the interface subroutine itself requires 8 words of additional storage. Thus the isz parameter, described below, can be computed as follows:

```
isz = (8 + 4 * n)
```

where n is the number of entries in the buffer and isz is expressed in words.

When a timer module interrupt occurs, the driver resets the count to an initial value, normally that specified in iv. The initial value for a specific module can be modified by calling the SCTI subroutine (see Section 15.5.19).

The call is issued as follows:

```
CALL CTTI (ibuf,isz,iev,iv,[isb],[lun])
```

where:

ibuf	is an integer array that is to receive timer interrupt data.
isz	is the length of the array in words, with a minimum size of 12.
iev	is a trigger event flag number. The specified event flag is set whenever the driver inserts an entry in the data buffer.
iv	is an integer array which contains the initial timer module values, with one entry for each timer module, where entry n corresponds to timer module number n-1.
isb	is a 2-word integer array to which the subroutine status is returned.
lun	is the logical unit number.

The isb array has the standard meaning defined in Section 15.5.2.

15.5.10 **DFDI: Disconnecting from Contact Interrupts**

The DFDI FORTRAN subroutine disconnects a task from contact interrupts. It is issued as follows:

```
CALL DFDI ([isb],[lun])
```

where:

isb	is a 2-word integer array to which the subroutine status is returned.
lun	is the logical unit number.

The isb array has the standard meaning defined in Section 15.5.2.

15.5.11 **DFTI: Disconnecting from Timer Interrupts**

The DFTI FORTRAN subroutine disconnects a task from timer interrupts. It is issued as follows:

```
CALL DFTI ([isb],[lun])
```

where:

isb	is a 2-word integer array to which the subroutine status is returned.
lun	is the logical unit number.

The isb array has the standard meaning defined in Section 15.5.2.

15.5.12 DI/DIW: Reading Several Contact Sense Fields

The ISA standard DI/DIW FORTRAN subroutines read several 16-point contact sense fields. These calls are issued as follows:

$$\text{CALL} \begin{Bmatrix} \text{DI} \\ \text{DIW} \end{Bmatrix} \text{(inm,icont,idata,isb,[lun])}$$

where:

inm	specifies the number of fields to be read.
icont	is an integer array containing the initial point number of each field to be read.
idata	is an integer array that is to receive the input data, 16 bits of contact data for each field read.
isb	is a 2-word integer array to which the subroutine status is returned.
lun	is the logical unit number (ignored if present).

The isb array has the standard meaning defined in Section 15.5.2.

15.5.13 DOL/DOLW: Latching or Unlatching Several Fields

The ISA standard DOL/DOLW FORTRAN subroutines latch or unlatch one or more 16-point fields. These calls are issued as follows:

$$\text{CALL} \begin{Bmatrix} \text{DOL} \\ \text{DOLW} \end{Bmatrix} \text{(inm,icont,idata,imsk,[isb],[lun])}$$

where:

inm	specifies the number of fields to be latched or unlatched.
icont	is an integer array containing the initial point number of each 16-point field.
idata	is an integer array which specifies the points to be latched or unlatched; bit n of idata corresponds to point number icont + n; if the corresponding bit in imsk is set, the bit is changed; a bit value of 1 indicates latching, and 0 unlatching; each entry in the array specifies a string of 16 points.
imsk	is an integer array in which bits are set to indicate points whose states are to be changed in the corresponding idata bits; each entry in the array specifies a 16-bit mask word.
isb	is a 2-word integer array to which the subroutine status is returned.
lun	is the logical unit number.

The isb array has the standard meaning defined in Section 15.5.2.

15.5.14 **DOM/DOMW: Pulsing Several Fields**

The ISA standard DOM/DOMW FORTRAN subroutines pulse several 16-bit fields (one-shot digital output points). These calls are issued as follows:

$$\text{CALL} \left\{ \begin{array}{l} \text{DOM} \\ \text{DOMW} \end{array} \right\} \text{(inm,icont,idata,[idx],[isb],[lun])}$$

where:

inm	specifies the number of fields to be pulsed.
icont	is an integer array containing the initial point number of each 16-point field.
idata	is an integer array which specifies the points to be pulsed; bit n of idata corresponds to point number icont + n.
idx	is a dummy argument retained for compatibility with existing Instrument Society of America standard FORTRAN process control calls.
isb	is a 2-word integer array to which the subroutine status is returned.
lun	is the logical unit number (ignored if present).

The isb array has the standard meaning defined in Section 15.5.2.

15.5.15 **RCIPT: Reading a Contact Interrupt Point**

The RCIPT FORTRAN subroutine reads the state of a single contact interrupt point. It is issued as follows:

```
CALL RCIPT (ipt,isb,[lun])
```

where:

ipt	is the number of the point to be read; points are numbered sequentially from 0, the first point on the first contact interrupt module.
isb	is a 2-word integer array to which the subroutine status is returned.
lun	is the logical unit number (ignored if present).

The isb array has the same basic meaning defined in Section 15.5.2. However, isb word 2 is set to one of the following values, representing the state of the point:

Setting	Meaning
.FALSE. (0)	Point is open
.TRUE. (-1)	Point is closed

NOTE

To increase throughput, the subroutines RDCS, RDDI, RDTI, and RDWD described in the following four sections do not issue the clear Event Flag directive until a buffer-empty condition is detected. The calling task, therefore, must avoid issuing a Wait-For directive until a buffer-empty is reported.

15.5.16 **RDCS: Reading Contact Interrupt Change-of-State Data from a Circular Buffer**

The RDCS FORTRAN subroutine reads contact interrupt data from a circular buffer that was specified in a CTDI call (see Section 15.5.8). It does no actual input or output, but rather performs a point-by-point scan of an interrupt entry in the buffer, returning the state of each point that has changed state, as a logical value. The trigger event flag which was specified in the CTDI call is cleared when the "buffer empty" condition is detected.

On the initial call to RDCS, the module number, module data, and change-of-state word of the next interrupt entry are read from the circular buffer and stored for subsequent reference. The subroutine then searches the entry change-of-state word until a nonzero point is encountered. The point number is computed and returned to the caller along with the state of the point. Scanning for points that have changed state resumes on the next call; all other points are bypassed. The next entry is automatically read when the caller has received all change-of-state information from the current entry. If a valid entry is not found, ipt is set negative and ict (if specified) is either assigned a value of zero or an overrun count maintained by the UDC11 driver. If ict is zero, no further entries remain. A nonzero value indicates that the driver received more data than could be stored in the buffer, and ict represents the number of entries that were discarded.

The RDCS call is issued as follows:

```
CALL RDCS (ipt,ival,[ict])
```

where: ipt is a variable to which the digital input point number is returned; it may be set as follows:

- ipt < 0 if no valid entry is found (i.e., no interrupt data currently in buffer, or overrun detected). One of the following values is returned to indicate the condition detected:

  -1 = Buffer empty
  -2 = Overrun detected

- ipt => 0 if the value indicated is a point number that has changed state; the state is returned to ival.

ival is a variable to which the state of the point is returned; it may be set as follows:

- .FALSE. (0) if the point is open
- .TRUE. (-1) if the point is closed

ict is an integer variable for receiving the overrun count. A nonzero positive count indicates that the driver was unable to store the number of interrupts indicated.

15.5.17 **RDDI: Reading Contact Interrupt Data from a Circular Buffer**

The RDDI FORTRAN subroutine reads contact interrupt data from a circular buffer that was specified in a CTDI call (see Section 15.5.8). It does no actual input or output, but rather performs a point-by-point scan of an interrupt entry in the buffer, returning the state of each point as a logical value. The trigger event flag which was specified in the CTDI call is also cleared.

On the initial call to RDDI the module number and data of the next interrupt entry are read from the circular buffer and stored for subsequent reference. The subroutine then sets the current data bit number n to zero, examines the state of data bit n, and converts bit n to a point number via the following formula:

ipt = module number * 16 + n

On each subsequent call, n is incremented by one and then data bit n is examined in the stored module data. When n reaches 16, it is reset to zero and an attempt is made to read the next interrupt entry from the circular buffer. If a valid entry is not found, ipt is set negative and ict (if specified) is either assigned a value of zero or an overrun count maintained by the UDC11 driver. If ict is zero, no further entries remain. A nonzero value indicates that the driver received more data than could be stored in the buffer, and ict represents the number of entries that were discarded.

The RDDI call is issued as follows:

```
CALL RDDI (ipt,ival,[ict])
```

where: ipt is a variable to which the digital input point number is returned; it may be set as follows:

- ipt < 0 if no valid entry is found (i.e., no interrupt data currently in buffer, or buffer empty). One of the following values is returned to indicate the condition detected:

  -1=Buffer empty
  -2=Overrun detected

- ipt => 0 if the value indicated is a point number; the state is returned to ival

ival is a variable to which the state of the point is returned; it may be set as follows:

- .FALSE. (0) if the point is open
- .TRUE. (-1) if the point is closed

ict is a variable to which the overrun count may be returned; a nonzero positive count indicates that the driver was unable to store the number of entries indicated.

15.5.18 **RDTI: Reading Timer Interrupt Data from a Circular Buffer**

The RDTI FORTRAN subroutine reads timer interrupt data from a circular buffer that was specified in a CTTI call (see Section 15.5.9). It does no actual input or output, but rather performs a scan of each entry in the buffer, returning the timer value for each call. The trigger event flag which was specified in the CTTI call is also cleared.

When a timer module interrupt occurs, the UDC11 driver resets the count to an initial value, usually that specified in the iv array on the CTTI call. The initial value can be modified for a specific module by calling the subroutine SCTI (see Section 15.5.19).

The RDTI call is issued as follows:

```
CALL RDTI (imod,itm,[ivrn])
```

where: imod is a variable to which the module number is returned; it may be set as follows:

- imod < 0 if no valid entry is found (i.e., no interrupt data currently in buffer, or buffer empty). One of the following values is returned to indicate the condition detected:

  -1=Buffer empty
  -2=Overrun detected

- imod > 0 if the entry is valid, indicating a module number; the value of the timer module is returned in itm

itm is a variable to which the timer value is returned.

ivrn is a variable to which the overrun count may be returned; a nonzero positive count indicates that the driver was unable to store the number of values indicated.

15.5.19 **RDWD: Reading a Full Word of Contact Interrupt Data from the Circular Buffer**

The RDWD FORTRAN subroutine reads a full word of contact interrupt and change-of-state data from the circular buffer that was specified in a CTDI call (see Section 15.5.8). It does no actual input or output, but rather performs a scan of each entry, returning the state of a module and optionally, the change-of-state data for each call. The trigger event flag specified in the call to CTDI is cleared.

The call to RDWD is issued as follows:

```
CALL RDWD (imod,ist,[ivrn],[icos])
```

where: imod is a variable to which the module number is returned; it may be set as follows:

- imod < 0 if no valid entry is found (i.e., no interrupt data currently in buffer or overrun detected). One of the following values is returned to indicate the condition detected:

  -1=Buffer empty
  -2=Overrun detected

ist is a variable to which the module data is returned.

ivrn is a variable to which the overrun count may be returned; a nonzero, positive count indicates that the driver was unable to store the number of entries indicated.

icos is a variable to which the change-of-state data is returned. One bit is set for each point that has changed state in the direction indicated by the "point open" (POP) or "point closed" (PCL) jumpers on the module.

15.5.20 **RSTI: Reading a Timer Module**

The RSTI FORTRAN subroutine reads a single timer module. It is issued as follows:

```
CALL RSTI (imod,isb,[lun])
```

where: imod is the module number of the timer to be read.

isb is a 2-word integer array to which the subroutine status is returned.

lun is the logical unit number (ignored if present).

The isb array has the standard meaning defined in Section 15.5.2.

15.5.21 **SCTI: Initializing a Timer Module**

The SCTI FORTRAN subroutine sets a timer module to an initial value. It is issued as follows:

```
CALL SCTI (imod,ival,[isb],[lun])
```

where: imod is the module number of the timer to be set.

ival is the initial timer value.

isb is a 2-word integer array to which the subroutine status is returned.

lun is the logical unit number.

The isb array has the standard meaning defined in Section 15.5.2.

Calls to initialize a counter are valid only if the issuing task has connected a buffer for receiving counter interrupts via a call to CTTI.

15.6 STATUS RETURNS

Table 15-6 lists the error and status conditions that are returned by the UDC11 driver described in this chapter:

Table 15-6
UDC11 Status Returns

Code	Reason
IS.SUC	Sucessful completion The operation specified in the QIO directive was completed successfully. The second word of the I/O status block can be examined to determine the number of samples completed or converted.
IS.PND	I/O request pending The operation specified in the QIO directive has not yet been executed. The I/O status block is filled with zeros.
IE.ABO	Operation aborted The specified I/O operation was cancelled via IO.KIL while still in the I/O queue.
IE.BAD	Bad parameter An illegal specification was supplied for one or more of the device-dependent QIO parameters (words 6-11). For the UDC11, this code indicates an illegal channel number or gain code for the ADU01.
IE.BYT	Byte-aligned buffer specified Byte alignment was specified for a buffer but only word alignment is legal for the UDC12. Alternately, the length of a buffer was not an even number of bytes.
IE.CON	Connect error The task attempted to connect to contact or timer interrupts, but the interrupt was already connected to another task. Only one task can be connected to a timer or contact interrupt. Alternately a task which was not connected attempted to disconnect from contact or timer interrupts.

(continued on next page)

Table 15-6 (Cont.)
UDC11 Status Returns

Code	Reason
IE.DNR	Device not ready The physical device unit specified in the QIO directive was not ready to perform the desired I/O operation. For the ADU01, this code is returned if an interrupt timeout occurred or the power failed.
IE.IEF	Invalid event flag number An invalid trigger event flag number was specified in a connect function.
IE.IFC	Illegal function A function code was included in an I/O request that is illegal for the UDC11, or a request to initialize a counter (IO.ITI) was issued by a task that was not connected to receive counter interrupts. The function may also refer to a UDC11 feature which was not specified at system generation.
IE.MOD	Invalid UDC11 module On latching output, the user specified a starting point number which was not legal (defined at system generation) or was not evenly divisible by 16.
IE.OFL	Device off-line The physical device unit associated with the LUN specified in the QIO directive was not on-line. When the system was booted, a device check indicated that this physical device unit was not in the configuration.
IE.PRI	Privilege violation The task which issued the request was not privileged to execute that request. For the UDC11, this code indicates that a checkpointable task attempted to connect to timer or contact interrupts.
IE.SPC	Illegal address space The specified control, data, or interrupt buffer was partially or totally outside the address space of the issuing task. Alternately, the interrupt buffer was too small for a single data entry (6 words for timer interrupts and 7 words for contact interrupts) or a byte count of zero was specified.

FORTRAN interface values for these status returns are presented in Section 15.6.1.

15.6.1 FORTRAN Interface Values

The values listed in Table 15-7 are returned in FORTRAN subroutine calls.

Table 15-7
FORTRAN Interface Values

Status Return	FORTRAN Value
IS.SUC	+01
IS.PND	+00
IE.ABO	+315
IE.ADP	+101
IE.BAD	+301
IE.BYT	+319
IE.DAO	+313
IE.DNR	+303
IE.IEF	+100
IE.IFC	+302
IE.ILU	+99
IE.MOD	+321
IE.ONP	+305
IE.PRI	+316
IE.RSU	+317
IE.SDP	+102
IE.SPC	+306
IE.ULN	+08
IE.UPN	+04

15.7 PROGRAMMING HINTS

This section contains information on important programming considerations relevant to users of the UDC11 driver described in this chapter.

15.7.1 Numbering Conventions

Numbering is relative. Module numbers start at 0, beginning with the first module of a given type.

Channel numbers also start at 0, with channel 0 as the first channel on the first module of a given type. For the ADU01, channel 8 is the first channel on the second analog output module.

Each IAD-IA module installed in an ICS11 subsystem occupies 120 channels (regardless of the number of multiplexers installed). In this case, channel 120 is the first channel on the second IAD-IA A/D converter.

Point numbers start at 0, with point 0 as the first point on the first module of a given type. For instance, point 20 (octal) is the first point of the second contact sense module (i.e., relative module number 1).

15.7.2 Processing Circular Buffer Entries

Circular buffer entries should be processed in the following sequence.

1. Execute a WAITFOR system directive using the trigger event flag specified in the subroutine called to connect the circular buffer (CTTI or CTDI).

2. Repeatedly call the appropriate subroutine to read the circular buffer until all entries have been obtained, and ipt indicates that the buffer is empty (-1).

3. Perform any other processing and return to step 1.

CHAPTER 16

LABORATORY PERIPHERAL SYSTEMS DRIVERS

16.1 INTRODUCTION

The LPS11 and AR11 Laboratory Peripheral Systems are modular, real-time subsystems used for the acquisition and/or output of laboratory analog data. (Laboratory Peripheral Systems drivers are not supported on RSX-11M-PLUS systems.) Table 16-1 compares the LPS11 with the AR11.

Table 16-1
Laboratory Peripheral Systems

	LPS11	AR11
Analog-to-Digital Conversion (with sample and hold circuitry)	12 bits of precision 16-channel multiplexer with gain ranging Maximum of 64 channels without gain ranging	10 bits of precision 16-channel multiplexer without gain ranging
Programmable Real-Time Clock	Yes	Yes
Digital-to-Analog Output	12 bits of precision 10 channels (including display)	10 bits of precision 2 channels (including display)
Display Control	4096 by 4096 dot matrix	1024 by 1024 dot matrix
Digital I/O Option	16 digital points and programmable relays	16 digital points (available with DR11-K option)

At system generation, the user can specify the following:

- Number of A/D channels
- Presence or absence of the gain ranging option (LPSAM-SG) (LPS11 only) and the polarity of each channel (uni- or bi-polar).
- Presence or absence of the external D/A option (LPSVC and LPSDA), and if present, the number of D/A channels.
- Clock preset value

16.1.1 AR11 Laboratory Peripheral System

The AR11 is a 1-module, real-time analog subsystem that interfaces to the PDP-11 family of computers via a "hex" small peripheral controller slot. The system is a subset of the LPS11, and as such, enjoys the same degree of flexibility. The AR11 includes a 16-channel, 10-bit A/D converter with sample-and-hold, a programmable real-time clock with one external input, and a display control with two 10-bit D/A converters.

16.1.2 LPS11 Laboratory Peripheral System

The LPS11 is a high-performance, modular, real-time subsystem with the flexibility of serving a variety of applications, including biomedical research, analytical instrumentation, data collection and reduction, monitoring, data logging, industrial testing, engineering, and technical education. The basic subsystem, built in a compact size and designed for easy interface with external instrumentation, includes a 13-bit A/D converter, a programmable real-time clock, with two Schmitt triggers, a display controller with two 12-bit D/A converters, and a 16-bit digital I/O option. Up to nine different option types may be added to the basic package.

16.2 GET LUN INFORMATION MACRO

If a GET LUN INFORMATION system directive is issued for a LUN associated with a Laboratory Peripheral System, word 2 (the first characteristics word) contains all zeros, words 3 and 4 are undefined, and word 5 contains a 16-bit buffer preset value that controls the rate of the real-time clock interrupts, as explained in Section 16.6.1.

16.3 QIO MACRO

This section summarizes standard and device-specific QIO functions for the Laboratory Peripheral System drivers.

16.3.1 Standard QIO Function

Table 16-2 lists the standard function of the QIO macro that is valid for the Laboratory Peripheral Systems.

Table 16-2
Standard QIO Function for
Laboratory Peripheral Systems

Format	Function
QIO$C IO.KIL,...	Cancel I/O requests

IO.KIL cancels all queued and in-progress I/O requests.

16.3.2 Device-Specific QIO Functions (Immediate)

Except for IO.STP (see Section 16.3.4), all device-specific functions of the QIO macro that are valid for the Laboratory Peripheral Systems are either immediate or synchronous. Each immediate function performs a complete operation, whereas each synchronous function simply initiates an operation synchronized to the real-time clock. Table 16-3 lists the immediate functions.

Table 16-3
Device-Specific QIO Functions for the
Laboratory Peripheral Systems (Immediate)

Format	Function
QIO$C IO.LED,...,<int,num>	Display number in LED lights (LPS11 only)
QIO$C IO.REL,...,<rel,pol>	Latch output relay (LPS11 only)
QIO$C IO.SDI,...,<mask>	Read digital input register
QIO$C IO.SDO,...,<mask,data>	Write digital output register

where:		
	int	is the 16-bit signed binary integer to display.
	num	is the LED digit number where the decimal point is to be placed.
	rel	is the relay number (zero or one).
	pol	is the polarity (zero for open, nonzero for closed).
	mask	is the mask word.
	data	is the data word.

The following subsections describe the functions listed above.

16.3.2.1 **IO.LED** - This LPS11-only function displays a 16-bit signed binary integer in the light-emitting diode (LED) lights. The number is displayed with a leading blank (positive number) or minus sign (negative number) followed by five nonzero-suppressed decimal digits that represent the magnitude of the number. LED digits are numbered from right to left, starting at 1.

The number may be displayed with or without a decimal point. If the parameter num is a number from 1 to 5, then the corresponding LED digit is displayed with a decimal point to the right of the digit. If the LED digit number is not a number from 1 to 5, then no decimal point is displayed.

16.3.2.2 **IO.REL** - This LPS11-only function opens or closes the programmable relays in the digital I/O status register. Approximately 300 milliseconds are required to open or close a relay. The driver imposes no delays when executing this function. Thus it is the responsibility of the user to insure that adequate time has elapsed between the opening and closing of a relay.

16.3.2.3 **IO.SDI** - This function reads data qualified by a mask word from the digital input register. The mask word contains a 1 in each bit position from which data is to be read. All other bits are zero-filled and the resulting value is returned in the second I/O status word.

The operation performed is:

```
RETURN VALUE=MASK.AND.INPUT REGISTER
```

16.3.2.4 **IO.SDO** - This function writes data qualified by a mask word into the digital output register. The mask word contains a 1 in each bit position that is to be written. The data word specifies the data to be written in corresponding bit positions.

The operation performed is:

```
NEW REGISTER=<MASK.AND.DATA>.OR.<<.NOT.MASK>.AND.OLD REGISTER>
```

16.3.3 Device-Specific QIO Functions (Synchronous)

Table 16-4 lists the synchronous, device-specific functions of the QIO macro that are valid for the Laboratory Peripheral Systems.

Table 16-4
Device-Specific QIO Functions for the
Laboratory Peripheral Systems (Synchronous)

Format	Function
QIO$C IO.ADS,...,<stadd,size,pnt, ticks,bufs,chna>	Initiate A/D sampling
QIO$C IO.HIS,...,<stadd,size,pnt, ticks,bufs>	Initiate histogram sampling (LPS11 only)
QIO$C IO.MDA,...,<stadd,size,pnt, ticks,bufs,chnd>	Initiate D/A output
QIO$C IO.MDI,...,<stadd,size,pnt, ticks,bufs,mask>	Initiate digital input sampling
QIO$C IO.MDO,...,<stadd,size,pnt, ticks,bufs,mask>	Initiate digital output

where:	stadd	is the starting address of the data buffer (must be on a word boundary).
	size	is the data buffer size in bytes (must be greater than zero and a multiple of four bytes).
	pnt	is the digital point numbers (byte 0 - starting input/output point number; byte 1 - input point number to stop the function).
	ticks	is the number of real-time clock ticks between samples or data transfers, as appropriate.
	bufs	is the number of data buffers to transfer.
	chna	is the analog-to-digital conversion specification. Byte 0 contains the starting channel number. For LPS11 this must be in the range of 0-63; for AR11 the range is 0-15. If the LPS11 gain ranging option is present, the channel number must be in the range of 0-15, and bits 4 and 5 specify the gain code. Byte 1 contains the number of consecutive analog-to-digital channels to sample. For LPS11 this must be in the range of 1-64; for AR11 or the LPS11 with gain ranging, the range is 1-16.
	chnd	is the digital-to-analog output channel specification. Byte 0 contains the starting channel number. For LPS11 this must be in the range of 0-9; for the AR11 the range is 0-1. Byte 1 contains the number of consecutive channels to be output. For LPS11 this must be in the range of 1-10; for AR11 the range is 1-2.
	mask	is the mask word.

The following subsections describe the functions listed above.

16.3.3.1 **IO.ADS** - This function reads one or more A/D channels at precisely timed intervals, with or without auto gain-ranging. If two or more channels are specified, all are sampled at approximately the same time, once per interval.

Sampling may be started when the request is dequeued or when a specified digital input point is set. A digital output point may optionally be set when sampling is started. Sampling may be terminated by a program request (IO.STP or IO.KIL), by the clearing of a digital input point, or by the collection of a specified number of buffers of data.

All input is double-buffered with respect to the user task. Each time a half buffer of data has been collected, the user task is notified (via the setting of an event flag) that data is available to be processed while the driver fills the other half of the buffer. If the user task does not respond quickly enough, a data overrun may result. This occurs if the driver attempts to put another data item in the user buffer when no space is available.

The subfunction modifier bits are identical to those described in Section 16.3.3.2. In addition, setting bit 3 to a 1 means LPS11 auto gain-ranging is requested. Bit 3 is ignored for the AR11. If bits 7 and 6 are both set to 1, the digital input point and digital output point number are assumed to be the same.

If LPS11 auto gain-ranging is used, the LPSAM-SG hardware option must be present and specified at system generation. The auto gain-ranging algorithm causes a channel to be sampled at the highest gain at which saturation does not occur. If the gain-ranging option is present and auto gain-ranging is not specified in bit 3 of the subfunction code, then bits 4 and 5 of the starting channel number specify the gain at which samples are to be converted. Gain codes are as follows:

Code	Gain
00	1
01	4
10	16
11	64

Data words written into the user buffer contain the converted value in bits 0-11 and the gain code, as shown below, in bits 12-15:

Code	Gain
0000	1
0001	4
0010	16
0011	64

If the LPSAM-SG option is present, then each channel must have been defined as uni- or bi-polar at system generation. In addition, if bandwidth filtering is enabled (and so indicated at SYSGEN time), a software delay is imposed by the driver when the multiplexer channel is changed. This delay must have been specified at SYSGEN. See the LPS11 Laboratory Peripheral System User's Guide.

The AR11 always returns data which is equivalent to an LPS11 gain of 1. Channel polarity must always be specified for the AR11 at system generation since this operation is software selectable at the time sampling is initiated.

16.3.3.2 **IO.HIS** - This LPS11-only function measures the elapsed time between a series of events by means of Schmitt trigger one. Each time a sample is to be taken, a counter is incremented and Schmitt trigger one is tested. If it has fired, then the counter is written into the user buffer and reset to zero. Thus the data item returned to the user is the number of sample intervals between Schmitt trigger firings.

If the counter overflows before Schmitt trigger one fires, then a zero value is written into the user buffer. Sampling may be started and stopped as described in Section 16.3.3.1. All input is double-buffered with respect to the user task.

The subfunction modifier bits appear below. A setting of 1 indicates the action listed in the right-hand column.

Bit	Meaning
0-3	Unused
4	Stop on number of buffers
5	Stop on digital input point clear
6	Set digital output point at start of operation
7	Start on digital input point set (a zero specification means start immediately)

16.3.3.3 **IO.MDA** - This function writes data into one or more external D/A converters at precisely timed intervals. If two or more channels are specified, all are written at approximately the same time, once per interval. Output may be started or stopped as described in Section 16.3.3.1. All output is double-buffered with respect to the user task.

D/A converters 0 and 1 correspond to the X and Y registers of the display control. Note that there are no specific driver functions to set the display status register. This is reserved for the user. D/A converters 2 through 9 correspond to the LPS11, LPSDA external D/A option.

The subfunction modifier bits are identical to those described in Section 16.3.3.2.

16.3.3.4 **IO.MDI** - This function provides the capability to read data qualified by a mask word from the digital input register at precisely timed intervals. Sampling may be started and stopped as described in Section 16.3.3.1. All input is double-buffered with respect to the user task.

The mask word contains a 1 in each bit position from which data is to be read. All other bits are zero.

The subfunction modifier bits are identical to those described in Section 16.3.3.2.

16.3.3.5 **IO.MDO** - This function writes data qualified by a mask word into the digital output register at precisely timed intervals. Output may be started and stopped as described in Section 16.3.3.1. All output is double-buffered with respect to the user task.

The subfunction modifier bits are identical to those described in Section 16.3.3.2.

16.3.4 Device-Specific QIO Function (IO.STP)

Table 16-5 lists the device-specific function of the QIO macro, which is valid for the Laboratory Peripheral Systems.

Table 16-5
Device-Specific QIO Function for the Laboratory Peripheral Systems (IO.STP)

Format	Function
QIO$C IO.STP,...,<stadd>	Stop in-progress request

where: stadd is the buffer address of the function to stop (must be the same as the address specified in the initiating request).

16.3.4.1 IO.STP

IO.STP - IO.STP stops a single in-progress synchronous request. It is unlike IO.KIL in that it only cancels the specified request, whereas IO.KIL cancels all requests.

16.4 FORTRAN INTERFACE

A collection of FORTRAN-callable subroutines provide FORTRAN programs access to the Laboratory Peripheral Systems. These routines are described in this section.

Some of these routines may be called from FORTRAN as either subroutines or functions. All are reentrant and may be placed in a resident library.

16.4.1 The isb Status Array

The isb (I/O status block) parameter is a 2-word integer array that contains the status of the FORTRAN call, in accordance with ISA convention. This array serves two purposes:

1. It is the 2-word I/O status block to which the driver returns an I/O status code on completion of an I/O operation.

2. The first word of the isb receives a status code from the FORTRAN interface in ISA-compatible format, with the exception of the I/O pending condition, which is indicated by a status of zero. The ISA standard code for this condition is +2.

The meaning of its contents varies, depending on the FORTRAN call that has been executed, but Table 16-6 lists certain general principles that apply. The sections describing individual subroutines provide more details.

Table 16-6
Contents of First Word of isb

Contents	Meaning
isb(1) = 0	Operation pending; I/O in progress
isb(1) = 1	Successful completion
isb(1) = 3	Interface subroutine unable to generate QIO directive, or illegal time or buffer value
3 <= isb(1) < 300	QIO directive rejected and actual error code = -(isb(1) - 3)
isb(1) > 300	Driver rejected request and actual error code = -(isb(1) - 300)

FORTRAN interface routines depend on asynchronous system traps to set their status. Thus, if the trap mechanism is disabled, proper status cannot be set.

16.4.2 Synchronous Subroutines

RTS, DRS, HIST (LPS11 only), SDO, and SDAC are FORTRAN subroutines that initiate synchronous functions. When they are used, the appropriate laboratory peripheral system driver and the FORTRAN program communicate by means of a caller-specified data buffer of the following format:

Buffer Header	Current Buffer Pointer
	Address of Second I/O Status Word
	Address of End of Buffer + 1
	Address of Start of Data
Start of Data	
Half Buffer	
End of Buffer	

The buffer header is initialized when the synchronous function initiation routine is called. The length of the buffer must be even and greater than or equal to six. An even length is required so that the buffer is exactly divisible into half buffers.

The drivers perform double buffering within the half buffers. Each time a driver fills or empties a half buffer, it sets a user-specified event flag to notify the user task that more data is available or needed. The user task responds by putting more data into the buffer or by removing the data now available.

If the user task does not respond quickly enough, a data overrun may result. This occurs if the driver attempts to put another data item in the user buffer when no space is available (i.e., the buffer is full of data) or if the driver attempts to obtain the next data item from the user buffer when none is available (i.e., the buffer is empty).

All synchronous functions may be initiated immediately or when a specified digital input point is set (i.e., a start button is pushed).

They may be terminated by any combination of a program request, the processing of the required number of full buffers of data, or the clearing of a specified digital input point (i.e., a stop button is pushed). A digital output point may also optionally be set at the start of a synchronous function. This could be used, for example, as a signal to start a test instrument.

16.4.3 **FORTRAN Subroutine Summary**

Table 16-7 lists the FORTRAN interface subroutines supported for the Laboratory Peripheral Systems under RSX-11M. S and F indicate whether they can be called as subroutines or functions.

Table 16-7
FORTRAN Interface Subroutines for Laboratory Peripheral Systems

Subroutine	Function
ADC	Read a single A/D channel (F,S)
ADJLPS	Adjust buffer pointers (S)
ASARLN	Assign a LUN to AR0: (S)
ASLSLN	Assign a LUN to LS0: (S)
CVSWG	Convert a switch gain A/D value to floating-point (F)
DRS	Initiate synchronous digital input sampling (S)
HIST	Initiate histogram sampling (S) (LPS11 only)
IDIR	Read digital input (F,S)
IDOR	Write digital output (F,S)
IRDB	Read data from a synchronous function input buffer (F,S)
LED	Display number in LED lights (S) (LPS11 only)
LPSTP	Stop an in-progress synchronous function (S)
PUTD	Put data into a synchronous function output buffer (S)
RELAY	Latch an output relay (S) (LPS11 only)
RTS	Initiate synchronous A/D sampling (S)
SDAC	Initiate synchronous D/A output (S)
SDO	Initiate synchronous digital output (S)

The following subsections briefly describe the function and format of each FORTRAN subroutine call.

16.4.4 ADC: Reading a Single A/D Channel

The ADC FORTRAN subroutine or function reads a single converted value from an A/D channel. If the gain-ranging option is present in the LPS11 hardware, the channel may be converted at a specific gain or the driver can select the best gain (the gain providing the most significance). The converted value is returned as a normalized floating-point number. The call is issued as follows:

```
CALL ADC (ichan,[var],[igain],[isb])
```

where:

ichan specifies the A/D channel to be converted.

var is a floating-point variable that receives the converted value in floating-point format.

igain specifies the gain at which the specified A/D channel is to be converted. The default is 1. If specified, igain may have the following values:

igain	Gain
0	Auto gain-ranging (driver selects gain that provides most significance)
1	1
2	4
3	16
4	64

A gain of 1 is always used by the AR11 driver.

isb is a 2-word integer array to which the subroutine status is returned.

The isb array has the standard meaning described in Section 16.4.1.

When the function form of the call is used, the value of the function is the same as that returned in var. If this value is negative, an error has occurred during the A/D conversion (see Section 16.5.3). Otherwise, this value is a floating-point number calculated from the following formula:

```
var = (64 * converted value) / conversion gain
```

16.4.5 ADJLPS: Adjusting Buffer Pointers

The ADJLPS FORTRAN subroutine adjusts buffer pointers for a buffer that a laboratory peripheral system driver is either synchronously filling or emptying. It is usually called when indexing is being used for direct access to the data in a buffer.

When data in a buffer is to be processed only once, the IRDB and PUTD routines may be used. In some cases, however, it is useful to leave data in the buffer until processing is complete. The user program may process the data directly, then call ADJLPS to free half the buffer. Use of the routine for synchronous output functions is quite similar. When a half buffer of data is ready for output, ADJLPS is called to make the half buffer available.

When ADJLPS is used for either input or output, care must be taken to insure that the program stays in sync with the driver. If the program loses its position with respect to the driver, the function must be stopped and restarted. An attempt to over-adjust will cause a 3 to be returned in isb(1) and no adjustment to take place.

The call is issued as follows:

```
CALL ADJLPS (ibuf,iadj,[isb])
```

where:	ibuf	is an integer array which was previously specified in a synchronous input or output function.
	iadj	specifies the adjustment to be applied to the buffer pointers. For an input function this specifies the number of data values that have been removed from the data buffer. For an output function this specifies the number of data values that have been put into the data buffer.
	isb	is a 2-word integer array to which the subroutine status is returned.

The isb array has the standard meaning described in Section 16.4.1.

16.4.6 **ASLSLN: Assigning a LUN to LS0:**

The ASLSLN FORTRAN subroutine assigns a logical unit number (LUN) to the LPS11. It must be called prior to executing any other Laboratory Peripheral Systems FORTRAN function or subroutine. Subsequent calls to other interface routines then implicitly reference the LPS11 via the LUN assigned.

The call is issued as follows:

```
CALL ASLSLN (lun,[isb],[iun])
```

where:	lun	is the number of the LUN to be assigned to LS0:
	isb	is a 2-word integer array to which the subroutine status is returned.
	iun	is the unit number of the device to be assigned (defaults to 0 if not specified).

The isb array has the standard meaning described in Section 16.4.1.

16.4.7 ASARLN: Assigning a LUN to AR0:

The ASARLN FORTRAN subroutine assigns a logical unit number (LUN) to the AR11. It must be called prior to executing any other laboratory peripheral system FORTRAN function or subroutine. Subsequent calls to other interface routines then implicitly reference the AR11 via the LUN assigned.

The call is issued as follows:

```
CALL ASARLN (lun,[isb],[iun])
```

where:	lun	is the number of the LUN to be assigned to AR0:
	isb	is a 2-word integer array to which the subroutine status is returned.
	iun	is the unit number of the device to be assigned (defaults to 0 if not specified).

The isb array has the standard meaning described in Section 16.4.1.

16.4.8 CVSWG: Converting a Switch Gain A/D Value to Floating-Point

The CVSWG FORTRAN subroutine converts an A/D value from a synchronous A/D sampling function to a floating-point number. Each data item returned by a laboratory peripheral system driver consists of a gain code and converted value packed in a single word (see Section 16.3.3.1). This form is not readily usable by FORTRAN, but is much more efficient than converting each value to floating-point in the driver. This routine unpacks the gain code and value, then converts the result to a floating-point number. It may be conveniently used in conjunction with the IRDB routine (see Section 16.4.13).

The call is issued as follows:

```
CVSWG (ival)
```

where: ival is the value to be converted to floating point. Its format must be that returned by a synchronous A/D sampling function. The conversion is performed according to the following formula:

var = (64 * converted value)/conversion gain

For the various gain codes,

var = x * converted value

as shown below:

Gain	x
1	64
4	16
16	4
64	1

16.4.9 DRS: Initiating Synchronous Digital Input Sampling

The DRS FORTRAN subroutine reads data qualified by a mask word from the digital input register at precisely timed intervals. Sampling may be started or stopped as for RTS (see Section 16.4.18) and all input is double-buffered with respect to the user task. Data may be sequentially retrieved from the data buffer via the IRDB routine (see Section 16.4.12), or the ADJLPS routine (see Section 16.4.5) may be used in conjunction with direct access to the input data. The call is issued as follows:

```
CALL DRS (ibuf,ilen,imode,irate,iefn,imask,isb,[nbuf],
          [istart],[istop])
```

where:

ibuf — is an integer array that is to receive the input data values.

ilen — specifies the length of ibuf (must be even and greater than or equal to six).

imode — specifies the start, stop, and sampling mode. Its value is encoded by adding together the appropriate function selection values shown below.

Function Selection Value	Meaning
128	Start on digital input point set
64	Set digital output point at start
32	Stop on digital input point clear
16	Stop on number of buffers

Thus a value of 192 for imode specifies:

- The sampling is to be started when a specified digital input point is set.
- A digital output point is to be set when sampling is started.
- Sampling will be stopped via a program request.

irate — is a 2-word integer array that specifies the time interval between digital input samples. The first word specifies the interval units as follows:

irate(1)	Unit
1	Real-time clock ticks
2	Milliseconds
3	Seconds
4	Minutes

The second word specifies the interval magnitude as a 16-bit unsigned integer.

iefn	specifies the number of the event flag that is to be set each time a half buffer of data has been collected.
imask	specifies the digital input points to be read.
isb	is a 2-word integer array to which the subroutine status is returned.
nbuf	specifies the number of buffers of data to be collected. It is needed only if a function selection value of 16 has been added into imode.
istart	specifies the digital input pointer number to be used to trigger sampling and/or the digital output point number to be set when sampling is started. It is needed only if a function selection value of 128 or 64 has been added into imode.
istop	specifies the digital input point number to be used to stop sampling. It is needed only if a function selection value of 32 has been added into imode.

When sampling is in progress, the first word of the isb array is zero and the second word contains the number of data values currently in the buffer.

16.4.10 **HIST: Initiating Histogram Sampling (LPS11 only)**

The HIST FORTRAN subroutine measures the elapsed time between a series of events via Schmitt trigger one.

Each time a sample is to be taken, a counter is incremented and Schmitt trigger one is tested. If it has fired, then the counter is written into the user buffer and the counter is reset to zero. Thus the data returned to the user is the number of sample intervals between Schmitt trigger firings. If the counter overflows before Schmitt trigger one fires, a zero value is written into the user buffer. Sampling may be started and stopped as for RTS (see Section 16.4.18) and all input is double-buffered with respect to the user task. The call is issued as follows:

```
CALL HIST (ibuf,ilen,imode,irate,iefn,isb,[nbuf],
                [istart],[istop])
```

where:	ibuf	is an integer array that is to receive the input data values.
	ilen	specifies the length of ibuf (must be even and greater than or equal to six).

imode	specifies the start, stop and sampling mode. Its value is encoded by adding the appropriate function selection values shown below:

Function Selection Value	Meaning
128	Start of digital input point set
64	Set digital output point at start
32	Stop on digital input point clear
16	Stop on number of buffers

irate	is a 2-word integer array that specifies the time interval between samples. The first word specifies the interval units as follows:

irate(1)	Unit
1	Real-time clock ticks
2	Milliseconds
3	Seconds
4	Minutes

The second word specifies the interval magnitude as a 16-bit signed integer.

iefn	specifies the number of the event flag that is to be set each time a half buffer of data has been collected.
isb	is a 2-word integer array to which the subroutine status is returned.
nbuf	specifies the number of buffers of data to be collected. It is needed only if a function selection value of 16 has been added into imode.
istart	specifies the digital input point number to be used to trigger sampling and/or the digital output point number to be set when sampling is started. It is needed only if a function selection value of 128 or 64 has been added into imode.
istop	specifies the digital input point number to be used to stop sampling. It is needed only if a function selection value of 32 has been added into imode.

The isb array has the standard meaning described in Section 16.4.1.

When sampling is in progress, the first word of the isb array is zero and the second word contains the number of data values currently in the buffer.

16.4.11 **IDIR: Reading Digital Input**

The IDIR FORTRAN subroutine or function reads the digital input register as an unsigned binary integer or as four binary-coded decimal (BCD) digits. In the latter case, the BCD digits are converted to a binary integer before the value is returned to the caller. The call is issued as follows:

```
CALL IDIR (imode,[ival],[isb])
```

where:	imode	specifies the mode in which the digital input register is to be read. If imode equals zero, then the digital input register is read as four BCD digits and converted to a binary integer. Otherwise it is read as a 16-bit unsigned binary integer.
	ival	is a variable that receives the value read.
	isb	is a 2-word integer array to which the subroutine status is returned.

The isb array has the standard meaning described in Section 16.4.1.

When the function form of the call is used, the value of the function is the same as that returned in ival.

16.4.12 **IDOR: Writing Digital Output**

The IDOR FORTRAN subroutine or function clears or sets bits in the digital output register. The caller provides a mask word and output mode. Bits in the digital output registers corresponding to the bits specified in the mask word are either set or cleared according to the specified mode. The call is issued as follows:

```
CALL IDOR (imode,imask,[newval],[isb])
```

where:	imode	specifies whether the bits specified by imask are to be cleared or set in the digital output register. If imode equals zero, then the bits are to be cleared. Otherwise they are to be set.
	imask	specifies the bits to be cleared or set in the digital output register. It may be conveniently specified as an octal constant.
	newval	is a variable that receives the updated (actual) value written into the digital output register.
	isb	is a 2-word integer array to which the subroutine status is returned.

The isb array has the standard meaning described in Section 16.4.1.

When the function form of the call is used, the value of the function is the same as that returned in newval.

16.4.13 IRDB: Reading Data from an Input Buffer

The IRDB FORTRAN subroutine or function retrieves data sequentially from a buffer that a laboratory peripheral system driver is synchronously filling. If no data is available when the call is executed, the contents of the next location in the data buffer are returned without updating the buffer pointers. The call is issued as follows:

```
CALL IRDB (ibuf,[ival])
```

where:	ibuf	is an integer array which was previously specified in a synchronous input sampling request (i.e., DRS, HIST, or RTS).
	ival	is a variable that receives the next value in the data buffer.

When the function form of the call is used, the value of the function is the same as that returned in ival.

16.4.14 LED: Displaying in LED Lights (LPS11 only)

The LED FORTRAN subroutine displays a 16-bit signed binary integer in the LED lights. The number is displayed with a leading blank (positive number) or minus (negative number), followed by five non-zero suppressed decimal digits that represent the magnitude of the number. LED digits are numbered right to left starting at 1 and continuing to 5. The number may be displayed with or without a decimal point. The call is issued as follows:

```
CALL LED (ival,[idec],[isb])
```

where:	ival	is the variable whose value is to be displayed.
	idec	specifies the position of the decimal point. A value of 1 to 5 specifies that a decimal point is to be displayed. All other values specify that no decimal point is to be displayed.
	isb	is a 2-word integer array to which the subroutine status is returned.

The isb array has the standard meaning described in Section 16.4.1.

For example, the following call

```
CALL LED (-55,2)
```

would cause -0005.5 to be displayed in the LED lights.

16.4.15 **LPSTP: Stopping an In-Progress Synchronous Function**

The LPSTP FORTRAN subroutine selectively stops a single synchronous request. The call is issued as follows:

```
CALL LPSTP (ibuf)
```

where:	ibuf	is an integer array that specifies a buffer that was previously specified in a synchronous initiation request.

16.4.16 **PUTD: Putting a Data Item into an Output Buffer**

The PUTD FORTRAN subroutine puts data sequentially into a buffer that a laboratory peripheral system driver is synchronously emptying. If no free space is available, no operation is performed. The call is issued as follows:

```
CALL PUTD (ibuf,ival)
```

where:	ibuf	is an integer array which was previously specified in a synchronous output request (SDO or SDAC).
	ival	is a variable whose value is to be placed in the next free location in the data buffer.

16.4.17 **RELAY: Latching an Output Relay (LPS11 only)**

The RELAY FORTRAN subroutine opens or closes the LPS11 relays. The call is issued as follows:

```
CALL RELAY (irel,istate,[isb])
```

where:	irel	specifies which relay is to be opened or closed (zero for relay one, one for relay two).
	istate	specifies whether the relay is to be opened or closed. If istate equals zero, the relay is to be opened. Otherwise it is to be closed.
	isb	is a 2-word integer array to which the subroutine status is returned.

The isb array has the standard meaning described in Section 16.4.1.

16.4.18 **RTS: Initiating Synchronous A/D Sampling**

The RTS FORTRAN subroutine reads one or more A/D channels at precisely timed intervals, with or without auto gain-ranging. The auto gain-ranging algorithm (LPS11 only) causes the channels to be sampled at the highest gain at which saturation does not occur.

Sampling may be started when the interface subroutine is called or when a specified digital input point is set. A digital output point may optionally be set when sampling is started. Sampling may be terminated by a program request (stop-in-progress request or kill I/O), the clearing of a digital input point, or the collection of a specified number of buffers of data.

All input is double-buffered with respect to the user task. Each time a half buffer of data has been collected, the user task is notified (via the setting of an event flag) that data is available to be processed while the driver fills the other half of the buffer. Data may be sequentially retrieved from the data buffer via the IRDB routine (see Section 16.4.12, or the ADJLPS routine (see Section 16.4.5) may be used in conjunction with direct access to the input data. The call is issued as follows:

```
CALL RTS (ibuf,ilen,imode,irate,iefn,ichan,nchan,isb,
          [nbuf],[istart],[istop])
```

where:

ibuf	is an integer array that is to receive the converted data values.
ilen	specifies the length of ibuf (must be even and greater than or equal to six).
imode	specifies the start, stop, and sampling mode. Its value is encoded by adding together the appropriate function selection values as shown below:

Function Selection Value	Meaning
128	Start on digital input point set
64	Set digital output point at start
32	Stop on digital input point clear
16	Stop on number of buffers
8	Auto gain-ranging (LPS11 only)

irate	is a 2-word integer array that specifies the time interval between A/D samples. The first word specifies the interval unit as follows:

irate(1)	Unit
1	Real-time clock ticks
2	Milliseconds
3	Seconds
4	Minutes

The second word specifies the interval magnitude as a 16-bit unsigned integer.

iefn	specifies the number of the event flag that is to be set each time a half buffer of data has been collected.
ichan	specifies the starting A/D channel of the block of channels to be sampled synchronously (must be between 0 and 63 for LPS11 and between 0 and 15 for AR11).
nchan	specifies the number of A/D channels to be sampled (must be between 1 and 64 for LPS11 and between 1 and 16 for AR11).
isb	is a 2-word integer array to which the subroutine status is returned.
nbuf	specifies the number of buffers of data that are to be collected. It is needed only if a function selection value of 16 has been added into imode.
istart	specifies the digital input point number to be used to trigger sampling and/or the digital output point number to be set when sampling is started. It is needed only if a function selection value of 128 or 64 has been added into imode.
istop	specifies the digital input point number to be used to stop sampling. It is needed only if a function selection value of 32 has been added into imode.

The values listed for ichan and nchan above, are the maximum allowable for each of the devices. In practice, they are constrained by the number of channels available as specified during SYSGEN.

The isb parameter has the standard meaning described in Section 16.4.1.

When sampling is in progress, the first word of the isb array is zero and the second word contains the number of data values currently in the buffer.

16.4.19 SDAC: Initiating Synchronous D/A Output

The SDAC FORTRAN subroutine writes data into one or more external D/A converters at precisely timed intervals. Output may be started and stopped as for RTS (see Section 16.4.18) and all input is double-buffered with respect to the user task. One full buffer of data must be available when synchronous output is initiated.

After SDAC has initiated output and the specified event flag has been set to notify the task that free buffer space is available, the PUTD routine (see Section 16.4.16) may be used to put data values sequentially into the output data buffer. The ADJLPS routine (see Section 16.4.5) may be used in conjunction with direct access to the output data buffer. The SDAC call is issued as follows:

```
CALL SDAC (ibuf,ilen,imode,irate,iefn,ichan,nchan,isb,
           [nbuf],[istart],[istop])
```

where:

ibuf — is an integer array that contains the output data values.

ilen — specifies the length of ibuf (must be even and greater than or equal to six).

imode — specifies the start, stop and sampling mode. Its value is encoded by adding together the appropriate function selection values as shown below:

Function Selection Values	Meaning
128	Start on digital input point set
64	Set digital output point at start
32	Stop on digital input point clear
16	Stop on number of buffers

irate — is a 2-word integer array that specifies the time interval between D/A outputs. The first word specifies the interval units as follows:

irate(1)	Unit
1	Real-time clock ticks
2	Milliseconds
3	Seconds
4	Minutes

The second word specifies the interval magnitude as a 16-bit unsigned integer.

iefn — specifies the number of the event flag that is to be set each time a half buffer of data has been output.

ichan	specifies the starting D/A channel of the block of channels to be written into synchronously (must be between 0 and 9 for LPS11 and be 0 or 1 for AR11).
nchan	specifies the number of D/A channels to be written into (must be between 1 and 10 for LPS11 and be 1 or 2 for AR11).
isb	is a 2-word integer array to which the subroutine status is returned.
nbuf	specifies the number of buffers of data to be output. It is needed only if a function selection value of 16 has been added into imode.
istart	specifies the digital input point number to be used to trigger sampling and/or the digital output point number to be set when sampling is started. It is needed only if a function selection value of 128 or 64 has been added into imode.
istop	specifies the digital input point number to be used to stop sampling. It is needed only if a function selection value of 32 has been added into imode.

The isb array has the standard meaning described in Section 16.4.1.

When sampling is in progress, the first word of the isb array is zero and the second word contains the number of free positions in the buffer.

16.4.20 **SDO: Initiating Synchronous Digital Output**

The SDO FORTRAN subroutine writes data qualified by a mask word into the digital output register at precisely timed intervals. Sampling may be started and stopped as for RTS (see Section 16.4.18) and all input is double-buffered with respect to the user task. One full buffer of data must be available when output is initiated.

After SDO has initiated output and the specified event flag has been set to notify the task that free buffer space is available, the PUTD routine (see Section 16.4.16) may be used to put data values sequentially into the output data buffer. The ADJLPS routine (see Section 16.4.5) may be used in conjunction with direct access to the output data buffer. The SDO call is issued as follows:

```
          CALL SDO (ibuf,ilen,imode,irate,iefn,imask,isb,[nbuf],
                    [istart],[istop])
```

where:	ibuf	is an integer array that contains the digital output values.
	ilen	specifies the length of ibuf (must be even and greater than or equal to six).

imode	specifies the start, stop, and sampling mode. Its value is encoded by adding together the appropriate function selection values as shown below:

Function Selection Value	Meaning
128	Start on digital input point set
64	Set digital output point at start
32	Stop on digital input point clear
16	Stop on number of buffers

irate	is a 2-word integer array that specifies the time interval between digital outputs. The first word specifies the interval units as follows:

irate(1)	Unit
1	Real-time clock ticks
2	Milliseconds
3	Seconds
4	Minutes

The second word specifies the interval magnitude as a 16-bit unsigned integer.

iefn	specifies the number of the event flag that is to be set each time a half buffer of data has been output.
imask	specifies the digital output points that are to be written. It may be conveniently specified as an octal constant.
isb	is a 2-word integer array to which the subroutine status is returned.
nbuf	specifies the number of buffers of data to be output. It is needed only if a function selection value of 16 has been added into imode.
istart	specifies the digital input point number to be used to trigger sampling and/or the digital output point number to be set when sampling is started. It is needed only if a function selection value of 128 or 64 has been added into imode.
istop	specifies the digital input point number to be used to stop sampling. It is needed if a function selection value of 32 has been added into imode.

The isb parameter has the standard meaning described in Section 16.4.1.

When sampling is in progress, the first word of the isb array is zero and the second word contains the number of free positions in the buffer.

16.5 STATUS RETURNS

The error and status conditions listed in Table 16-8 are returned by the Laboratory Peripheral System drivers described in this chapter.

Table 16-8
Laboratory Peripheral Systems Status Returns

Code	Reason
IS.SUC	Successful completion The operation specified in the QIO directive was completed successfully. The second word of the I/O status block can be examined to determine the number of data values processed.
IS.PND	I/O request pending The operation specified in the QIO directive has not yet been completed.
IE.ABO	Operation aborted The specified I/O operation was cancelled (via IO.KIL or IO.STP) while in progress.
IE.BAD	Bad parameter An illegal specification was supplied for one or more of the device-dependent QIO parameters (words 6-11). The second I/O status word is filled with zeros.
IE.BYT	Byte-aligned buffer specified Byte alignment was specified for a data buffer but only word alignment is legal for Laboratory Peripheral Systems. Alternately, the length of a buffer is not an even number of bytes.
IE.DAO	Data overrun For Laboratory Peripheral Systems, the driver attempted to get a value from the user buffer when none was available or attempted to put a value in the user buffer when no space was available.

(continued on next page)

Table 16-8 (Cont.)
Laboratory Peripheral Systems Status Returns

Code	Reason
IE.DNR	Device not ready The physical device unit specified in the QIO directive was not ready to perform the desired I/O operation. For Laboratory Peripheral Systems, this code is returned if a device time-out occurs while a function is in progress. The second I/O status word contains the number of free positions in the buffer, as appropriate.
IE.IEF	Invalid event flag number An invalid event flag number was specified in a synchronous function.
IE.IFC	Illegal function A function code was included in an I/O request that is illegal for the LPS11 or AR11.
IE.NOD	Insufficient buffer space Dynamic storage space has been depleted, and there is insufficient buffer space available to allocate a secondary control block for a synchronous function.
IE.OFL	Device off-line The physical device unit associated with the LUN specified in the QIO directive was not on-line. When the system was booted, a device check indicated that this physical device unit was not in the configuration.
IE.ONP	Option not present An option dependent function or subfunction was requested, and the required feature was not specified at system generation. For example the gain-ranging option or D/A option is not present. The second I/O status word contains zero.
IE.PRI	Privilege violation The task which issued the request was not privileged to execute that request. For Laboratory Peripheral Systems, a checkpointable task attempted to execute a synchronous sampling function.

(continued on next page)

Table 16-8 (Cont.)
Laboratory Peripheral Systems Status Returns

Code	Reason
IE.RSU	Resource in use A resource needed by the function requested in the QIO directive was being used (see Section 16.5.1).
IE.SPC	Illegal address space The buffer specified for a read or write request was partially or totally outside the address space of the issuing task. Alternately a byte count of zero was specified. The second I/O status word contains zero.

FORTRAN interface values for these status returns are presented in Section 16.5.4.

16.5.1 IE.RSU

IE.RSU is returned if a function requests a resource that is currently being used. The requesting task may repeat the request at a later time or take any alternative action required.

Because certain functions do not need such resources, they never cause this code to be returned. Other functions return this code under the following conditions:

Function	When IE.RSU Is Returned
IO.SDO	One or more specified digital output bits are in use
IO.ADS	Digital output point (if specified) is in use
IO.HIS	Digital output point (if specified) is in use
IO.MDA	Digital output point (if specified) is in use
IO.MDI	Digital output point (if specified) or digital input points to be sampled are in use
IO.MDO	Digital output point (if specified) or output bits to be written are in use

The following components of the Laboratory Peripheral Systems are each considered a single resource:

Resource	When Sharable
The A/D Converter and clock	Always sharable.
Each bit in the digital output register	Never sharable.

Resource	When Sharable
Each bit in the digital input register	Always sharable when used by IO.SDI or for start/stop conditions (specified in subfunction modifier bits), even when in use by another function; when specified by a synchronous digital input function, not sharable with another such function.

Each resource is allocated on a first-come-first-served basis (i.e., when a conflict arises, the most recent request is rejected with a status of IE.RSU).

16.5.2 Second I/O Status Word

On successful completion of a function specified in a QIO macro call, the IS.SUC code is returned to the first word of the I/O status block.

Table 16-9 lists the contents of the second word of the status block, on successful completion for each function.

Table 16-9
Returns to Second Word of I/O Status Block

Successful Function	Contents of Second Word
IO.KIL	Number of data values before I/O was canceled
IO.LED	Zero
IO.REL	Zero
IO.SDI	Masked value read from digital input register
IO.SDO	Updated value written into digital output register
IO.ADS	Number of data values remaining in buffer
IO.HIS	Number of data values remaining in buffer
IO.MDA	Number of free positions in buffer
IO.MDI	Number of data values remaining in buffer
IO.MDO	Number of free positions in buffer
IO.STP	Zero

When IE.BAD is returned, the second I/O status word contains zero. Laboratory Peripheral Systems drivers return the IE.BAD code under the following conditions:

Function	When IE.BAD is Returned
IO.REL	Relay number not 0 or 1
IO.ADS IO.MDA	No I/O status block, illegal digital I/O point number, or illegal channel number
IO.HIS IO.MDI IO.MDO	No I/O status block or illegal digital I/O point number

16.5.3 IO.ADS and ADC Errors

While IO.ADS or the ADC FORTRAN subroutine is converting a sample, two error conditions may arise. Both of these conditions are reported to the user by placing illegal values in the data buffer. A -1 (177777 octal) is placed in the buffer if an A/D conversion does not complete within 30 microseconds. A -2 (177776 octal) is placed in the buffer if an error occurs during an A/D conversion (LPS11 only).

16.5.4 FORTRAN Interface Values

The values listed in Table 16-10 are returned in FORTRAN subroutine calls.

Table 16-10
FORTRAN Interface Values

Status Return	FORTRAN Value
IS.SUC	+01
IS.PND	+00
IE.ABO	+315
IE.ADP	+101
IE.ALN	+334
IE.BAD	+301
IE.BYT	+319
IE.DAO	+313
IE.DNR	+303
IE.IEF	+100
IE.IFC	+302
IE.ILU	+99
IE.NOD	+323
IE.OFL	+365
IE.ONP	+305
IE.PRI	+316
IE.RSU	+317
IE.SDP	+102
IE.SPC	+306
IE.ULN	+08
IE.UPN	+04

16.6 PROGRAMMING HINTS

This section contains information on important programming considerations relevant to users of the Laboratory Peripheral Systems drivers described in this chapter.

16.6.1 The LPS11/AR11 Clock and Sampling Rates

The basic real-time clock frequency (count rate) for all synchronous functions is always 10KHz. Device characteristics word 4 contains a 16-bit buffer preset value, set dynamically or at system generation, that controls the rate of "ticks" (i.e., the rate at which the clock interrupts). The quotient that results when this value is divided into 10KHz is the rate of "ticks". For example, if this value is 2, the "tick" rate is 5KHz. The user may use a Get LUN Information system directive to examine the value and a SET /BUF MCR function to modify it while the system is running.

The ticks parameter in a synchronous function specifies the number of "ticks" between samples or data transfers. The value of ticks is a 16-bit number. Thus 65,536 discrete sampling frequencies are possible for each of 65,536 different "tick" rates. This provides a maximum single-channel sample rate of 1 sample every 100 microseconds (possible in hardware but impractical in software) and a minimum of 1 sample every 429,495 seconds. A single-channel rate greater than 2KHz is possible, but not recommended.

The figures below represent initial timing tests run under RSX-11M. It should be noted that no computation was performed on the data other than continuously removing it from or inserting it into the data buffer.

The following data is for the LPS11 on a PDP-11/40 with memory management, with no gain-ranging option, and with digital I/O option.

Analog rates:

1 request for 1 channel at 2.5KHz

1 request for 2 channels at 2.0KHz (aggregate 4KHz)

2 requests for 1 channel at 2.0KHz (aggregate 4KHz)

Digital rates:

1 request for 2 channels at 2.5KHz (aggregate 5KHz)

The following data is for the AR11 on a PDP-11/40 with no memory management, no digital I/O option, and no uni-polar sampling.

Analog rates:

1 request for 1 channel at 3.3KHz

1 request for 2 channels at 2.5KHz (aggregate 5.0KHz)

2 requests for 1 channel at 2.5KHz (aggregate 5.0KHz)

Digital rate:

2 requests for 2 channels at 3.3KHz (aggregate 6.6KHz)

16.6.2 Importance of the I/O Status Block

An I/O status block must be specified with every synchronous function. If the first I/O status word is nonzero, the request has been terminated and the value indicates the reason for termination. Otherwise, the request is in progress, and the second I/O status word contains the number of data values remaining in the buffer (or the number of free positions in the buffer for IO.MDA and IO.MDO).

16.6.3 Buffer Management

The buffer unload protocol for synchronous input functions is described below. The user constructs a five-word block that contains the following:

```
IOSB:     .BLKW    2           ; I/O STATUS DOUBLE-WORD
CURPT:    .WORD    BUFFER      ; ADDRESS OF BUFFER
LSTPT:    .WORD    BUFFER+n    ; ADDRESS OF END OF BUFFER
FSTPT:    .WORD    BUFFER      ; ADDRESS OF BUFFER
```

Two of these words are required by the driver (I/O status block) and the remaining three by the user to unload data values from the buffer.

The user then issues the I/O request with the appropriate parameters and the address of the above block as the I/O status block. The QIO directive zeros both I/O status words to initialize them.

If the driver accepts the request, it sets up a write pointer to the first word in the user buffer. Thus the user has a buffer read pointer and the driver has a buffer write pointer. The user and the driver share the second I/O status word, which is the number of data words in the buffer that contain data.

Each time the driver attempts to put a sample value into the buffer, it increments the second I/O status word and compares the result with the size of the buffer. If the result is greater, buffer overrun has occurred and the request is terminated. Otherwise the value is stored in the buffer at the address specified by the driver's write pointer and the write pointer is updated.

If the value stored in the user buffer fills half of the buffer, the event flag specified in the I/O request is set in order to notify the user that a half buffer of data is available to be processed. Each time the user task is awakened, it should execute the following code:

```
5$:       CLEF$S    #EFN           ;CLEAR EFN
10$:      TST       IOSB+2         ;ANY DATA IN BUFFER?
          BEQ       30$            ;IF EQ NO
          MOV       @CURPT,R0      ;GET NEXT VALUE FROM BUFFER
          DEC       IOSB+2         ;REDUCE NUMBER OF ENTRIES
          ADD       #2,CURPT       ;UPDATE BUFFER READ POINTER
          CMP       CURPT,LSTPT    ;END OF BUFFER?
          BLOS      20$            ;IF LOS NO
          MOV       FSTPT,CURPT    ;RESET BUFFER READ POINTER
20$:      Process data value       ;
          BR        10$            ;TRY AGAIN
30$:      TSTB      IOSB           ;REQUEST TERMINATED?
          BNE       40$            ;IF NE YES
          WTSE$S    #EFN           ;WAIT FOR EFN
          BR        5$             ;
40$:      Determine reason for termination
```

For IO.MDA and IO.MDO, this protocol differs slightly. The user task maintains a write pointer and the driver a read pointer. The entire buffer must be full when the request is executed.

16.6.4 Use of ADJLPS for Input and Output

The following FORTRAN example illustrates the proper protocol for using ADJLPS for synchronous input and output.

Synchronous input:

```
      DIMENSION IBF(1004),IERR(2),INTVL(2)
C
C INITIATE SYNCHRONOUS A/D SAMPLING,
C
        INTVL(1)=2
        INTVL(2)=5
        CALL RTS(IBF,1004,160,INTVL,IEFN,6,6,IERR,50,16,15)
C
C INITIALIZE HALF BUFFER INDEX
C
        INDX=4
C
C WAIT FOR HALF BUFFER OF DATA
C
 10     CALL WAITFR(IEFN)
C
C CLEAR EVENT FLAG
C
 15     CALL CLREF(IEFN)
C
C PROCESS HALF BUFFER OF DATA
C
        SUM=0
        DO 20 I=1,500
        SUM=SUM+CVSWG(IBF(I+INDX))
 20     CONTINUE
        AVERG=SUM/500
C
C FREE HALF BUFFER FOR MORE DATA
C
        CALL ADJLPS(IBF,500)
C
C ADJUST BUFFER INDEX
C
        INDX=INDX+500
        IF(INDX.GE.1004) INDX=4
C
C CHECK IF ANOTHER HALF BUFFER OF DATA IS AVAILABLE
C
        IF(IERR(2).GE.500 GO TO 15
        IF(IERR(1).NE.0) GO TO end of sampling
        GO TO 10
```

Synchronous output:

```
       DIMENSION IBF(1004),IERR(2),INTVL(2)
C
C FIRST BUFFER OF DATA MUST BE AVAILABLE AT START
C
C THIS EXAMPLE ASSUMES FIRST BUFFER IS FULL AT START
C
C START SYNCHRONOUS DIGITAL OUTPUT FUNCTION
C
       INTVL(1)=2
       INTVL(2)=5
       CALL SDO(IBF,1004,160,INTVL,IEFN,MASK,IERR,50,16,15)
C
C INITIALIZE HALF BUFFER INDEX
C
       INDX=4
C
C WAITFOR ROOM IN BUFFER
C
 10    CALL WAITFR(IEFN)
C
C CLEAR EVENT FLAG
C
 15    CALL CLREF(IEFN)
C
C CALCULATE VALUES TO PUT IN BUFFER
C
       X=(Y+2)*Z
       DO 20 I=1,500
       IBF(I+INDX)=X**5/A
 20    CONTINUE
C
C SIGNIFY ANOTHER HALF BUFFER IS FULL
C
       CALL ADJLPS(IBF,500)
C
C ADJUST BUFFER INDEX
C
       INDX=INDX+500
       IF(INDX.GE.1004) INDX=4
C
C CHECK IF ANOTHER HALF BUFFER IS EMPTY
C
       IF(IERR(2).GE.500) GO TO 15
       IF(IERR(1).NE.0) GO TO end of sampling
       GO TO 10
```

NOTE

In both the examples above, care is taken to ensure that the program stay "in sync" with the driver. If the program "loses" its position with respect to the driver the function must be stopped and restarted since this is the only way to recover. Caution should be exercised to ensure that the program sequence above be used to avoid a possible loss of data.

CHAPTER 17

PAPER TAPE READER/PUNCH DRIVERS

17.1 INTRODUCTION

The RSX-11M/M-PLUS paper tape reader/punch drivers support the PC11 paper tape reader/punch and the PR11 paper tape reader. The PC11 is a high-speed reader/punch capable of reading eight-hole, unoiled, perforated paper tape at 300 characters per second, and punching tape at 50 characters per second. The PR11 has the same characteristics as the paper tape reader portion of the PC11. All transfers are image mode only, with no interpretation of data.

17.2 GET LUN INFORMATION MACRO

Word 2 of the buffer filled by the GET LUN INFORMATION system directive (the first characteristics word) contains the following information for paper tape devices. A bit setting of 1 indicates that the described characteristic is true for these devices.

Bit	Setting	Meaning
0	1	Record-oriented device
1	0	Carriage-control device
2	0	Terminal device
3	0	File structured device
4	0	Single-directory device
5	0	Sequential device
6	0	Reserved
7	0	User-mode diagnostics supported
8	0	MASSBUS device
9	0	Unit software write-locked
10	0	Input spooled device
11	0	Output spooled device

Bit	Setting	Meaning
12	0	Pseudo device
13	0	Device mountable as a communications channel
14	0	Device mountable as a FILES-11 volume
15	0	Device mountable

Words 3 and 4 of the buffer are undefined; word 5 indicates the default buffer size, which is 64 bytes for paper tape devices.

17.3 QIO MACRO

Table 17-1 lists the standard functions of the QIO macro that are valid for the paper tape reader/punch.

Table 17-1
Standard QIO Functions for the Paper Tape Reader/Punch

Format	Function
QIO$C IO.ATT,...	Attach device
QIO$C IO.DET,...	Detach device
QIO$C IO.KIL,...	Cancel I/O requests
QIO$C IO.RLB,...,<stadd,size>	Read logical block (reader only)
QIO$C IO.RVB,...,<stadd,size>	Read virtual block (reader only)
QIO$C IO.WLB,...,<stadd,size>	Write logical block (punch only)
QIO$C IO.WVB,...,<stadd,size>	Write virtual block (punch only)

where:		
	stadd	is the starting address of the data buffer (may be on a byte boundary)
	size	is the data buffer size in bytes (must be greater than zero)

IO.KIL never cancels an in-progress read request. In-progress write requests are cancelled only when the punch driver is waiting for the punch to become ready at the start of a transfer.

The paper tape drivers support no device-specific functions.

17.4 STATUS RETURNS

Table 17-2 lists error and status conditions that are returned by the paper tape reader/punch drivers.

Table 17-2
Paper Tape Reader/Punch Status Returns

Code	Reason
IS.SUC	Successful completion. The operation specified in the QIO directive was completed successfully. The second word of the I/O status block can be examined to determine the number of bytes processed, if the operation involved reading or writing.
IS.PND	I/O request pending. The operation specified in the QIO directive has not yet been executed. The I/O status block is filled with zeros.
IE.ABO	Operation aborted. The I/O request was cancelled while in progress or while still in the I/O queue.
IE.DAA	Device already attached. The physical device unit specified in an IO.ATT function was already attached by the issuing task. This code indicates that the issuing task has already attached the desired physical device unit, not that the unit was attached by another task.
IE.DNA	Device not attached. The physical device unit specified in an IO.DET function was not attached by the issuing task. This code has no bearing on the attachment status of other tasks.
IE.DNR	Device not ready. The reader and punch drivers return this code when a time-out occurs. The reader driver also returns this code when an error condition (see Section 17.4.1) is encountered before the initiation of the first transfer after an ATTACH command has been issued.
IE.EOF	End-of-file encountered. The reader driver encountered an error condition (see Section 17.4.1) at a time other than the initiation of the first read after a valid ATTACH command. The second word of the I/O status buffer contains a count of bytes successfully read before the error condition was encountered.

(continued on next page)

Table 17-2 (Cont.)
Paper Tape Reader/Punch Status Returns

Code	Reason
IE.IFC	Illegal function. An illegal function code was specified in an I/O request that is not legal for the respective paper tape drivers.
IE.OFL	Device off-line. The physical device unit associated with the LUN specified in the QIO directive was not on-line. When the system was booted, a device check indicated that this physical device unit was not in the configuration.
IE.SPC	Illegal address space. The buffer specified for a read or write request was partially or totally outside the address space of the issuing task. Alternatively, a byte count of zero was specified.
IE.VER	Unrecoverable hardware error (punch only). The punch driver encountered an error condition (see Section 17.4.1) at a time other than the initiation of a transfer. Section 17.4.2 describes the action of the punch driver when an error condition is encountered upon the initiation of a transfer.

17.4.1 **Error Conditions**

There are four error conditions that are indistinguishable to the paper tape drivers. These conditions are:

1. No tape
2. Reader off-line
3. Power low
4. Hardware malfunction

17.4.2 **Ready Recovery**

When the punch driver encounters an error condition upon the initiation of a transfer, the following message is displayed:

```
*** PPn:  -- NOT READY
```

where n is the unit number of the paper tape punch that is not ready. This message is repeated every 15 seconds until the error condition is corrected, or until the I/O request is cancelled. When the error condition has been corrected, the transfer will begin within one second.

17.5 PROGRAMMING HINTS

This section contains information on important programming considerations relevant to users of the paper tape drivers described in this chapter.

17.5.1 Special Action Resulting from Attach and Detach

When an Attach or Detach is issued to the punch, the punch driver initiates a transfer of 170 (decimal) nulls. Upon the first read after an attach to the reader, all nulls preceding the first non-null character on the tape are read and discarded by the reader driver.

17.5.2 Reading Past End-of-Tape

When the reader driver reads past the physical end-of-tape, it normally generates at least two incorrect data bytes. These bytes are included in the byte count returned by the driver. User software that does not prevent reads past the physical end-of-tape should discard at least the last six characters in the buffer when IE.EOF is returned by the driver.

CHAPTER 18

INDUSTRIAL CONTROL SUBSYSTEMS

18.1 INTRODUCTION

This chapter describes RSX-11M drivers for two process I/O subsystems: the ICS/ICR11 and the DSS/DRS11. (I/O subsystems driver support is not provided in RSX-11M-PLUS systems.)

ICS11 and ICR11 are local, and remote process I/O subsystems respectively. They operate under program control as devices capable of interrogating digital and analog input, and driving digital and analog output.

DSS11 and DRS11 are digital input and output subsystems, respectively. Under program control they drive digital output and interrogate digital input.

18.1.1 Hardware Configuration

A single ICS or ICR controller can handle up to 16 I/O modules in any configuration; a module contains 16 bits of input or output data, providing a total of 256 digital points. Up to 12 ICR or ICS units are supported. The ICS/ICR driver is tailored to the user's needs, interactively, through the SYSGEN (System Generation program) dialogue. The driver is capable of handling any combination of ICR or ICS controllers installed on a single system.

The DSS11 provides 49 optically isolated inputs, including 48 nonbuffered sense-data inputs and one interrupt input. The DRS11 provides 48 open-collector buffered outputs plus one interrupt input. The DSS/DRS driver is shaped to the user's system configuration in the SYSGEN dialog. The driver supports up to 16 DSS11 and/or DRS11 modules.

18.1.1.1 **ICS/ICR Address Assignments** - Each ICR11A Unibus interface or ICS11 file box must be configured at SYSGEN time for individually addressable interrupt vectors, Control and Status Registers (ICSR), and module Address Registers (ICAR) as shown in Table 18-1.

Table 18-1
ICS/ICR Address Assignments

ICS/ICR UNIT NO.	MODULE ADDRESSES	ICSR/ICAR ADDR.	INTERRUPT VECT.
0	171000-171036	171770-171776	234-236
1	171040-171076	171760-171766	XXX-XXX+2
2	171100-171136	171750-171756	XXX+4-XXX+6
3	171140-171176	171740-171746	XXX+10-XXX+12
4	171200-171236	171730-171736	XXX+14-XXX+16
5	171240-171276	171720-171726	xxx+20-xxx+22
6	171300-171336	171710-171716	xxx+24-xxx+26
7	171340-171376	171700-171706	xxx+30-xxx+32
10	171400-171436	171670-171676	xxx+34-xxx+36
11	171440-171476	171660-171666	xxx+40-xxx+42
12	171500-171536	171650-171656	xxx+44-xxx+46
13	171540-171576	171640-171646	xxx+50-xxx+52

NOTES

nnnnn6 = Control and Status Register
nnnnn4 = Address Register

Additional controllers are assigned vector addresses above 300.

18.1.1.2 **DSS/DRS Address Assignments** - Unlike the ICS/ICR subsystem, DSS/DRS devices are not restricted to specified bus addresses. The following constraints apply, however:

1. All DSS11 modules must occupy a contiguous set of bus addresses.
2. All DRS11 modules must occupy a contiguous set of bus addresses.
3. The total number of DSS11 and DRS11 modules may not exceed 16.
4. If both module types are installed in a system, the DRS11 must occupy the lower set of bus and interrupt-vector addresses.
5. Bus request priority is BR4.

18.1.1.3 **Supported ICS/ICR I/O Modules** - The following modules, all optional, are supported by the ICS/ICR driver.

D/A Converters

IDA-OA -	4-channel digital-to-analog converter.

A/D Converters

IAD-IA -	8-channel wide-range differential analog-to-digital converter.
IMX-IA -	16-channel flying capacitor relay multiplexer.

Counters

IDC-IC -	16-bit binary counter.

Bistable Digital Outputs

IDC-OA -	D/C flip-flop driver.
IAC-OA -	A/C flip-flop driver.
IRL-OA -	Bistable relay output.
IRL-OB -	Flip-flop relay output.

Momentary Digital Output

IDC-OB -	D/C momentary driver.
IAC-OB -	A/C momentary driver.

Digital Inputs (Noninterrupting)[1]

IDC-IA -	D/C voltage sense input.
IDC-ID -	D/C voltage input module.
IAC-IA -	A/C voltage input module.

Digital Inputs (Interrupting)

IDC-IB -	D/C voltage interrupt input.
IAC-IB -	A/C voltage interrupt input.

Terminal Input/Output

110 CPS Remote Terminal Interface to ICR11.

18.1.2 Alternate ICS11 Support

The ICS11 Industrial Control Subsystem is supported either by the UDC11 or ICS/ICR11 device driver. If the system does not have an ICR11 controller, and if a driver of minimum size is required, then UDC11 support should be considered. The hardware requirements for such support are as follows:

1. Each file box must be assigned to the same interrupt vector address (normally 234).

[1] Note that noninterrupting input modules are accessed directly by a task. Hence, while FORTRAN interface routines are available, no support for such modules is included in the driver.

2. The control and status register within each file box must appear at the same address within the I/O page (normally 171776).

If support of the IAD-IA A/D converter is required, the following module addressing and installation conventions are imposed:

1. Each IAD-IA converter and associated IMX-IA relay multiplexers are assigned a fixed block of 120 logical channel numbers. No more than 32 IAD-IA converters may be installed in a single system. Based on this convention, A/D converter 0 occupies channels 0-119, A/D converter 1 occupies 120-239, etc.

2. Regardless of the actual number of IMX-IA multiplexers installed, each converter preempts a block of eight contiguous module slots.

3. The slots reserved for all A/D converters and multiplexers must occupy a block of contiguous module slots.

If necessary, the vector and address changes can be made by Field Service personnel. Assuming the hardware configuration is correct, the user can implement the desired UDC11 software support by answering in the affirmative all SYSGEN questions relating to the UDC11.

If the additional ICS/ICR-11 driver features are required (at a commensurate increase in the memory requirements), then each ICS11 file box must be configured for individually addressable interrupt vectors and control status registers. This change can be performed by Field Service personnel. The necessary software support is incorporated by answering in the affirmative all SYSGEN questions relating to the ICS/ICR11.

The additional ICS11 capabilities provided by the ICS/ICR11 driver may be summarized as follows:

1. Multi-controller, parallel operation.

2. Increased A/D conversion throughput.

3. Activation of tasks directly from digital interrupts or counters.

4. No requirement to install modules of the same type in contiguous slots.

Section 18.7 summarizes the software differences between the UDC and ICS/ICR drivers in detail.

18.1.3 **Software Support**

Both ICS/ICR and DSS/DRS operations are divided into two categories:

1. Functions performed directly by any task.

2. Functions requiring driver services.

Direct functions are accomplished through memory references to the ICS/ICR or DSS/DRS registers on the I/O page. In a protected system any task may gain restricted access to the device registers by linking to a global common block that resides within the appropriate physical memory limits. Direct functions consist of:

1. Reading counter modules

2. Reading any digital input module (DSS)

NOTE

All functions listed in this subsection apply to ICS/ICR modules. Those which also apply to the DSS and/or DRS subsystems are so marked.

Driver requests are divided into the following categories:

1. Noninterrupting output functions

   a. Bistable (flip-flop) digital output (DRS)

   b. Analog output

   c. Momentary (single-shot) digital output

2. Requests for interrupting functions

   a. Analog input

   b. Remote terminal output

3. Requests for unsolicited interrupts

   a. Digital interrupts (DSS/DRS)

   b. Counter interrupts

   c. Remote terminal input

   d. Remote unit or serial line errors

With the exception of A/D input and remote terminal output, all functions are complete upon return to the user's task.

Under RSX-11M, noninterrupting output functions are immediately submitted to the controller through a circular buffer that is filled at driver level and emptied at interrupt level. A QIO is considered successfully completed when the request is inserted in the circular buffer.

The following operations are in this category:

1. Bistable digital outputs

2. Analog outputs

3. Momentary digital outputs

Interrupting functions are those operations that generate an interrupt within some fixed time after initiation. The driver allows a list of multiple transactions to be specified in a single QIO. Each transaction is initiated in sequence without waiting for the preceding interrupt, until either the list is exhausted or all modules of the specified type are active. The following operations are in this category:

1. A/D inputs
2. Remote terminal output

Unsolicited interrupts may require no initiation by the processor and occur at indeterminate intervals. The following functions are in this category:

1. Interrupting digital inputs (DSS/DRS)
2. Counter modules
3. Remote terminal input
4. Error interrupts

All unsolicited interrupt data, except for errors, may be placed in a task-provided circular buffer. On interrupt, an event flag specified by the task is set. Such data for each module type is supplied to only one task per controller. In addition, the driver will activate selected tasks on the occurrence of digital or terminal input interrupts.

Error interrupts are described later in this chapter.

Terminal support is restricted to passing terminal data between the device and a task. The only special character is Control-C (003), which may cause a user-specified task to be made active. There is no other special processing for terminal I/O except that the parity bit is removed. This is similar to the terminal driver function of IO.RAL.

1. MCR is not invoked.
2. Characters are not echoed.
3. Carriage control is not performed.
4. TABs, RUBOUTs, etc. are not recognized.
5. Line terminators are not recognized.
6. Fill characters are not generated.

18.1.4 UDC11 Software Compatibility

Many of the MACRO and FORTRAN interfaces described in the following paragraphs are fully compatible with existing UDC11 applications software; however, the user should consult Section 18.7 for a summary of differences that do exist between UDC and ICS/ICR software.

18.1.5 **Module Addressing Conventions**

Table 18-2 illustrates the relationship between physical slot numbers, bus addresses and relative addresses for a given ICS/ICR configuration. It is referred to in the following discussion.

Each A/D converter is assigned a block of 120 channels. The number of channels in use within the block depends on the number of multiplexers installed. Specifically, each A/D converter has eight channels, and each associated multiplexer has 16.

As noted, a block of 120 relative addresses is reserved for each A/D converter. The converter and multiplexer in slots 10 and 11 contain channels 0 through 23. The converter in slot 17 contains channels 120 through 127. An attempt to access a nonexistent channel (e.g., channel 30 or channel 129) will be rejected by the driver.

The user should observe that the bistable drivers in slots 13 and 15 contain relative point numbers 0 through 15, and 16 through 29 although the modules are not physically adjacent. In general, the relationship between slot number, module type, bus address, and relative address is as follows:

1. A set of contiguous relative addresses is defined for each module of a given type that is installed. Each relative address, when qualified by type, uniquely identifies a digital point or channel.

2. A set of slot numbers and bus addresses, possibly not contiguous, is occupied by all modules of a given type. Such addresses may be assigned solely on the basis of hardware and installation considerations. Increasing relative addresses correspond to increasing bus addresses.

Table 18-2
Sample ICS/ICR Configuration

Unit: 0

Slot Number	Type	Bus Address	Relative Addresses
9.	D/A Converter	171000	0-3.
10.	A/D Converter	171002	0-119.
11.	A/D Multiplexer	------	-----
12.	Counter	171006	0
13.	Flip-Flop driver	171010	0-15.
14.	D/A Converter	171012	4-7.
15.	Flip-Flop driver	171014	16.-31.
16.	Counter	171016	1.
17.	A/D Converter	171020	120.-239.

Table 18-3 is an example of the relationship among bus addresses, interrupt points, and point numbers for a sample DSS11/DRS11 configuration.

All addressing is by point number. Except for the interrupts, all points are numbered sequentially by type (DSS or DRS), starting with the first point on the lowest address assigned to a given module type. Interrupt points are defined by means of a 16-bit mask word. Each bit in the mask defines an interrupting module; high-order bits correspond to increasing bus addresses.

Table 18-3
Sample DSS/DRS Configuration

Bus Addresses	Module Type	Points	Interrupt Point
160030-160036	DRS11	0-47.	0
160040-160046	DRS11	48.-95.	1
170010-170016	DSS11	0-47.	2
170020-170026	DSS11	48.-95.	3

18.2 LUN INFORMATION

A request for logical unit information returns the following device-dependent data in words 2 through 5 of the buffer:

WD 02 - 0

WD 03 - undefined

WD 04 - undefined

WD 05 - 0

18.3 ASSEMBLY LANGUAGE INTERFACE

Table 18-4 summarizes standard and device-specific QIO functions supported by the ICS/ICR driver. Only the five functions indicated by a footnote are supported by the DSS/DRS driver.

Table 18-4
Summary of Industrial Control QIO Functions

Format	Function
QIO$C IO.CCI,...,<stadd,sizb,tevf>	Connect a buffer to digital interrupts
QIO$C IO.CTI,...,<stadd,sizb,tevf, arv>	Connect a buffer to counter interrupts
QIO$C IO.CTY,...,<stadd,sizb,tevf>	Connect a buffer to terminal interrupts
QIO$C IO.DCI,...	Disconnect a buffer from digital interrupts
QIO$C IO.DTI,...	Disconnect a buffer from counter interrupts
QIO$C IO.DTY,...	Disconnect a buffer from terminal interrupts

(continued on next page)

Table 18-4 (Cont.)
Summary of Industrial Control QIO Functions

Format	Function
QIO$C IO.FLN,...	Set controller offline
QIO$C IO.ITI,...,<mn,ic>	Initialize a counter
[1]QIO$C IO.LDI,...,<tname,[,tevf], pn,csm>	Link task to digital interrupts
QIO$C IO.LKE,...,<tname,[,tevf]>	Link task to error interrupts
QIO$C IO.LTI,...,<tname,[,tevf] cn[,arv]>	Link task to counter interrupts
QIO$C IO.LTY,...,<tname,[,tevf]>	Link task to remote terminal interrupts
[1]QIO$C IO.MLO,...,<opn,pp,dp>	Open or close bistable digital output points
QIO$C IO.MSO,...,<opn,dp>	Pulse momentary digital output points
[1]QIO$C IO.NLK,...,<tname>	Unlink a task from all interrupts
QIO$C IO.ONL,...	Place ICS/ICR controller online
[1]QIO$C IO.RAD,...,<stadd>	Read activating data
QIO$C IO.RBC,...,<stadd,size, stcnta>	Initiate multiple A/D conversions
QIO$C IO.SAO,...,<chn,vout>	Perform analog output
[1]QIO$C IO.UDI,...,<tname>	Unlink a task from digital interrupts
QIO$C IO.UER,...,<tname>	Unlink a task from error interrupts
QIO$C IO.UTI,...,<tname>	Unlink a task from counter interrupts
QIO$C IO.UTY,...,<tname>	Unlink a task from terminal interrupts.
QIO$C IO.WLB,...,<stadd,sizb>	Transmit data to the ICR remote terminal

[1] These functions are supported by the DSS/DRS driver.

Where:

arv	is the starting address of a buffer containing initial or reset counter values. The buffer must be aligned on a word boundary.
chn	is the D/A channel number
cn	is the counter number
csm	is the change-of-state mask
dp	is the binary data pattern
ic	is the initial count
mn	is the module number
opn	is the first bistable (latching) digital output point number. This value must be on a module boundary (evenly divisible by 16)
pn	is the point number (must be assigned on a module boundary)
pp	is a 16-bit mask
sizb	is the data buffer size in bytes. For a circular buffer connected to unsolicited interrupts, this value must be even and large enough to include one entry plus the 2-word header
size	is the data and control buffer size in bytes. This value must be an even number that is greater than zero.
stadd	is the starting address of the data buffer (must be on a word boundary)
staddb	is the starting address of the terminal output buffer. May be aligned on a byte boundary
stcnta	is the starting address of the control buffer (must be on a word boundary); each control buffer word must be constructed as described in Table 18-5 (Section 18.3.2)
tevf	is an event flag number in the range 0 to 96, (if the group-global event flag SYSGEN option was selected), or 0 to 64 if group-global event flags are not supported
tname	is a task name composed of 1 to 6 alphanumeric characters in a 2-word RADIX-50 format. Two arguments, each containing three characters, are required for this parameter. For example, the task name ICNAME is specified as: `<^RICN,^RAME,...>` If the task name is less than 4 characters, a null argument must be specified as follows for task ABC: `<^RABC,,...>`
vout	is a binary number between 0 and 1023. that is to be converted to an analog output

The following sections contain a detailed description of each function. In the discussion of QIO request parameters, the following conventions apply.

All numbering is relative.

Module numbers start at 0 beginning with the first module of a given type. Increasing module numbers correspond to increasing physical bus addresses.

Channel numbers start at 0, with channel 0 as the first channel on the first module of a given type.

Point numbers start at 0 with point 0 as the first point on the first module of a given type. Points within a module are numbered "from right to left" in increasing order.

It should be remembered that there is no requirement for ICS/ICR modules of a given type to occupy contiguous slots; thus, for example, digital points 15(10) and 16(10) need not reside on physically adjacent modules. This restriction does apply to DSS/DRS modules, however.

It is assumed that the number of points or channels per module is a constant for each generic type. Specifically the following weights apply:

1. Each ICS/ICR Digital I/O Module contains 16 points.

2. Each DSS/DRS Digital I/O Module contains 48 points.

3. Each Counter Module contains 1 channel.

4. Each D/A Module contains 4 channels.

5. Each A/D Converter contains 120 channels.

As stated above, an A/D converter is assigned a block of 120 channels. The number of channels in use within the block depends on the number of multiplexers installed. The driver will reject an attempt to address a nonexistent channel.

18.3.1 General Error Status Returns

The system recognizes and handles two kinds of status conditions when they occur in I/O requests:

- Directive conditions, which indicate the acceptance or rejection of the QIO directive itself

- I/O status conditions, which indicate the success or failure of the I/O operation

Table 18-7 lists numerical values of returns for both assembly language and FORTRAN interfaces.

The following directive and I/O status returns apply uniformly to all requests.

18.3.1.1 Directive Conditions

IS.SUC - Directive accepted. The first six parameters of the QIO directive were valid, and sufficient dynamic memory was available to allocate an I/O packet. The directive is accepted.

IE.ADP - Invalid address. The I/O status block or the QIO DPB was outside of the issuing task's address space or was not aligned on a word boundary.

IE.IEF - Invalid event flag number.

IE.ILU - Invalid logical unit number. The lun specification in a QIO directive was invalid for the issuing task. For example, there were only five logical unit numbers associated with the task, and the value specified for lun was greater than five.

IE.NOD - Insufficient dynamic memory. There was not enough dynamic memory to allocate an I/O packet for the I/O request. The user can try again later by blocking the task with a WAITFOR SIGNIFICANT EVENT directive. Note that WAITFOR SIGNIFICANT EVENT is the only effective way for the issuing task to block its execution, since other directives that could be used for this purpose themselves require dynamic memory for their execution (e.g., MARK TIME).

IE.SDP - Invalid DIC number or DPB size. The directive identification code (DIC) or the size of the directive parameter block (DPB) was incorrect; the legal range for a DIC is from 1 through 127, and all DIC values must be odd. Each individual directive requires a DPB of a certain size. If the size is not correct for the particular directive, this code is returned.

IE.ULN - Unassigned LUN. The logical unit number in the QIO directive was not associated with a physical device unit. The user may recover from this error by issuing a valid Assign LUN directive and then reissuing the rejected directive.

18.3.1.2 I/O Conditions

IE.ABO - Operation aborted. The specified operation was cancelled via IO.KIL or the request timed out while the unit was offline.

IE.OFL - Controller offline. The physical device unit associated with the LUN specified in the QIO directive was not online. An ICS/ICR controller may be offline because a device check during bootstrap load has indicated that the controller is not in the configuration.

IE.DNR - Controller not ready. A nonrecoverable controller error has been detected.

IE.IFC - Illegal function. A function code was included in an I/O request that is illegal for the ICS/ICR. The function may also refer to an ICS/ICR module type or function that was not specified during system generation.

18.3.2 A/D Input - Read Multiple A/D Channels

This function provides the capability of reading several A/D channels at any permissible gain. The driver is capable of initiating parallel transfers when more than one A/D converter is installed in a file box; however, only one interrupt module request (remote terminal or A/D) may be in progress at a given time.

QIO DPB format:

```
QIO$C IO.RBC,...,<stadd,size,stcnta>
```

where:

stadd	= the starting address of the data buffer (must be on a word boundary).
size	= the data buffer size in bytes (must be even and greater than zero); the control buffer is the same size.
stcnta	= the starting address of the control buffer (must be on a word boundary); each control buffer word must be constructed as shown in Table 18-5.

Return Status:

IS.SUC	- Function successfully completed.
IE.BAD	- Illegal channel or gain code specified.
IE.BYT	- Data buffer is byte aligned. Alternatively, the length of the buffer is not an even number of bytes.
IE.DNR	- Device not ready. A/D converter interrupt timeout occurred.

Note that the second I/O Status word contains a count of the number of conversions successfully completed.

One control word is paired with each data word. That is, the data appearing in a data array element is obtained using the gain and channel number specified in the corresponding element of the control array. Control words specify the gain and channel in the format shown in Table 18-5.

Upon receipt and validation of the parameters within the I/O packet, the driver will initiate the following sampling procedure:

1. The control word is fetched and tested for validity (i.e., for legal gain and channel). If an error is encountered or no further control words remain, processing is terminated as described in Step 4.

2. Assuming the A/D converter board is idle, the driver starts the conversion, sets this resource busy and returns to Step 1. If the converter is busy the driver returns control to the system after saving the data required to initiate the conversion when the channel becomes idle.

3. On the occurrence of an A/D interrupt, the interrupt service routine initiates the appropriate processing at the non-interrupt level that will either set the channel idle or initiate a previous request stored during Step 2. The occurrence of the latter results in processing of additional control words as described in Step 1.

Table 18-5
A/D Conversion Control Word

Bits	Meaning				
0-11	Channel Number range: 0-1919				
12-15	Gain value for this sample. The binary value is as follows:				Gain
	15	14	13	12	
	0	0	0	0	1
	0	0	0	1	2
	0	0	1	0	illegal
	0	0	1	1	illegal
	0	1	0	0	10
	0	1	0	1	20
	0	1	1	0	illegal
	0	1	1	1	illegal
	1	0	0	0	50
	1	0	0	1	100
	1	0	1	0	illegal
	1	0	1	1	illegal
	1	1	0	0	200
	1	1	0	1	1000
	1	1	1	0	illegal
	1	1	1	1	illegal

4. The converted value is returned as 12 bits, left-justified, in a 16-bit word, with the low order 4 bits set to zero.

5. A/D requests are terminated under any of the following conditions:

   a. All control words have been processed.

   b. A hardware error has occurred.

   c. An error in a control word has been detected.

Regardless of the cause, the driver cannot complete request processing until all pending A/D transfers have gone to completion.

Because of overlapped processing, multiple errors can occur (e.g., a hardware error and an erroneous control word). The driver will return the status associated with the earliest transaction that caused an error condition. Thus, at the user interface, the driver will appear to execute all conversions sequentially.

18.3.3 Analog Output

This function provides the capability of setting a single analog output channel to a specified voltage.

QIO DPB format:

```
     QIO$C IO.SAO,...,<chn,vout>
```

where:

chn	= the output channel number
vout	= the output voltage representation

Output voltage varies linearly with the binary input to the channel, where 0 to plus ten volts (+10v.) is represented by integers from 0 to 1023.

Return Status:

IS.SUC - Function submitted for output to controller.

IE.MOD - Nonexistent D/A channel was specified.

The second I/O status word is zero.

18.3.4 **Momentary Digital Output - Multi-Point**

This function provides the capability of pulsing a field of up to 16 momentary (single-shot) digital output points. Fields must be aligned on module boundaries.

QIO DPB format:

```
QIO$C IO.MSO,...,<opn,dp>
```

where:

opn	= the starting digital output point number. Point number must be aligned on a module boundary (i.e., must be a multiple of 16).
dp	= the 16-bit mask. One point is pulsed corresponding to each bit set in the mask word.

Return Status:

IS.SUC - Function submitted for output to the controller.

IE.MOD - Invalid starting point number specified. Point is nonexistent or not aligned on a module boundary.

18.3.5 **Bistable Digital Output - Multi-Point**

This function provides the capability of setting or resetting a field of up to 16 bistable digital output points. Fields must be aligned on a module boundary.

QIO DPB format:

```
QIO$C IO.MLO,...,<opn,pp,dp>
```

where:

opn	= the starting digital output point number. Point number must be aligned on a module boundary (i.e., must be a multiple of 16).

pp	= the 16-bit mask.
dp	= the data pattern.

A bit is set in the mask word for each point that may change state. The state of points corresponding to reset mask bits is unaltered. When the mask bit is set, the output will be "closed" if the data bit is set and "open" if the data bit is clear.

Return Status:

IS.SUC - Function submitted for output to the controller.

IE.MOD - Invalid starting point number specified. Point does not exist or is not aligned on a module boundary.

18.3.6 **Unsolicited Interrupt Processing**

Unsolicited interrupts consist of the following:

1. Digital interrupts
2. Counter interrupts
3. Remote terminal input
4. Hardware Errors

Based on the type of interrupt, the driver may dispose of the interrupt data in one or more of the following ways:

1. The data may be furnished to a task that has issued a request to monitor such information continually. This alternative is not available in the DSS/DRS driver.
2. A task may be activated by a specific input. That is, a dormant task can be requested to run, or an event flag may be set if the task is currently active.

The driver will allow continual monitoring for digital, counter, and terminal inputs with the provision that, for each controller, only one task per module type may receive such inputs.

Task activation is permitted for digital, terminal, and error interrupts. The processing related to hardware errors is discussed in Section 18.5. Activation of tasks by digital, counter, and terminal inputs is covered in Section 18.3.7.

The driver functions described in the following paragraphs allow a task to continually receive interrupt data. To monitor such data a task must provide:

1. A buffer that is filled by the driver and emptied by the task in circular fashion.
2. An event flag that will be set upon the occurrence of each interrupt.

The driver will connect a single task per controller to receive interrupts from a specific module type.

The buffer to be connected has the format shown below:

FORTRAN Index	Contents
1	driver index
2	user index
3	word 0 of entry
4	word 1 of entry
.	.
.	.
.	.

The buffer consists of a two-word header containing the driver and user index, as shown, followed by a data area that is subdivided into fixed length entries. Each entry consists of a word containing the entry existence indicator followed by one or more words of device-dependent data. Such information usually consists of module data, relative module number, and a code identifying a module type. On the occurrence of an interrupt, the driver enters data in the location currently indicated by the driver index. This index can be considered as a FORTRAN index into the buffer. That is, the first location in the buffer is associated with the index 1. The beginning of the data area is associated with the first entry, index 3. Entries are made in a circular fashion starting at the beginning of the data area, filling in order of increasing memory address, and wrapping around to the beginning of the data area when there is insufficient space for an entry at the end. Note that the size of the data area must be an integer multiple of the entry size.

It is expected that the connected task will maintain the user index, ensuring that it indicate where, in the buffer, the task is to process interrupt data next.

When the task is activated by the driver, it should process data in the buffer starting at the location indicated by its pointer, and continuing in circular fashion until an existence indicator is encountered that is zero.

The existence indicator is set to +1 when a buffer entry is made. Except to record a hardware error, the contents of an entry are not altered by the driver if the indicator is nonzero. Hence, when a requester has removed or processed the entry, he must clear the existence indicator in order to free the buffer entry position. If the driver detects a nonzero indicator, i.e., data input has occurred in a burst sufficient to overrun the buffer, the data is discarded and a count of data overruns is incremented. The count is maintained in the entry existence indicator which, as noted above, is set to +1 to indicate no overruns between entries, +2 to indicate a hardware error entry, or a negative value recording the two's complement of the number of times data has been discarded between entries. The overrun count will never be allowed to wrap around to a positive value.

In the event of a nonrecoverable controller error (remote unit power-fail or hard data error) all connected tasks are activated with the following entry in the circular buffer:

```
     WD 00            Hardware error indicator (+2)
         .
         .
         .
     WD nn            Contents of ICSR register
     WD nn+1          Physical unit number
     WD nn+2          Generic code indicator
                      set to 177770(8)
```

nn = offset to module data word.

This entry is always placed in the buffer regardless of overflow status.

The error flags are obtained from the controller ICSR word at the time the error was detected (see Table 18-7).

18.3.6.1 **Connect to Digital Interrupts** - This function allows a single task to receive digital interrupt data.

QIO DPB format:

```
     QIO IO.CCI,...,<stadd,sizb,tevf>
```

where:

stadd	= starting address of buffer to be connected (must be word aligned)
sizb	= length of buffer in bytes (must be even). Minimum buffer length is 14 bytes
tevf	= trigger event flag number

Return Status:

IS.SUC -	Function successfully completed. Second I/O status word contains the number of words passed per interrupt in the low byte, and the initial FORTRAN index in the high byte.
IE.BYT -	Buffer address is byte aligned or length is an odd number of bytes.
IE.CON -	Interrupt already connected to another task.
IE.IEF -	Invalid event flag number.
IE.PRI -	Task checkpointable and not fixed in memory.
IE.SPC -	Interrupt circular buffer was not wholly within the address space of the task. Alternatively, the buffer was too small for a single data entry (7 words minimum).

Entry Format:

```
     WD 00 - Existence Indicator
     WD 01 - Change of state indicator
     WD 02 - Module data
     WD 03 - Relative module number
     WD 04 - Generic Code 1, 2 or 3, indicating a digital interrupt
```

The contents of the existence indicator have been described previously.

The change-of-state indicator records those bits for which a change of state in the direction of interest has been detected. The direction of the change may be from 0 to 1 (point closed (PCL)) or 1 to 0 (point open (POP)) depending upon the PCL or POP jumper connections on the digital interrupt module. The driver will assume that at least one of these signals is always asserted.

The relative module number indicates the module on which the change of state was recognized.

The module data word records data received at the time the interrupt was serviced.

The generic code identifies the type of module that caused the interrupt. A digital interrupting module may have the value 1, 2 or 3 as selected by user-installed jumpers on the module.

18.3.6.2 **Disconnect from Digital Interrupts** - This function allows a task to terminate the processing of digital interrupt data.

QIO DPB format:

```
     QIO$C IO.DCI,...
```

Return Status:

IS.SUC -	Function successfully completed. Second I/O status word is zero.
IE.CON -	Task was not connected. Second I/O status word is zero.

18.3.6.3 **Connect to Counter Module Interrupts** - This function allows a single task to receive counter interrupt data.

QIO DPB format:

```
     QIO$C IO.CTI,...,<stadd,sizb,tevf,arv>
```

where:

stadd	= starting address of circular buffer (must be word aligned)
sizb	= length of buffer in bytes (must be even). Minimum buffer length is 12 bytes.
tevf	= trigger event flag number
arv	= starting address of table of initial counter values (must be word aligned)

Word 03 defines an array of initial counter values. One entry is required for each counter installed in a physical unit. Entries are paired with modules in logically ascending sequence. The counter is set to the initial value upon receipt of the connect function and whenever an overflow interrupt occurs (i.e., when the count reaches zero).

Return Status:

IS.SUC -	Function successfully completed. The second I/O status word contains the number of words passed per interrupt in the low byte, and the initial FORTRAN index in the high byte.
IE.BYT -	Buffer address is byte aligned or length is an odd number of bytes.
IE.CON -	Interrupt already connected to another task.
IE.IEF -	Invalid event flag number.
IE.PRI -	Task checkpointable and not fixed in memory.
IE.SPC -	Interrupt circular buffer or table of initial values was not wholely within the address space of the task. Alternately, the buffer was too small for a single data entry (6 words minimum).

Entry Format:

WD 00 - Existence indicator

WD 01 - Module data

WD 02 - Relative module number

WD 03 - Generic code (4, 5 or 6)

18.3.6.4 **Set Counter Initial Value** - This function allows a counter initial value to be established. A task need not be connected to counter interrupts to perform this function.

QIO DPB format:

```
QIO$C IO.ITI,...,<mn,ic>
```

where:

mn	= relative module number
ic	= new initial count

Return Status:

IS.SUC -	New value submitted for output to the controller. The second word of I/O status is set to zero.
IE.MOD -	Nonexistent module number specified.

Upon receipt of the request, the new initial value is immediately queued for output to the controller. The counter will be reinitialized with this value on overflow if a task is connected to counter interrupts.

18.3.6.5 **Disconnect from Counter Interrupts** - This function allows a task to terminate counter interrupt processing.

QIO DPB format:

```
     QIO$C IO.DTI,...
```

Return Status:

IS.SUC - Function successfully completed. The second word of I/O status is set to zero.

IE.CON - Task was not connected to timer interrupts.

After disconnect is complete, counters will not be reset to the initial value at the time of the interrupt.

18.3.6.6 **Connect to Terminal Interrupts** - This function allows a task to receive terminal inputs from the selected ICR11 controller.

QIO DPB format:

```
     QIO$C IO.CTY,...,<stadd,sizb,tevf>
```

where:

stadd	= address of circular buffer (must be word aligned)
sizb	= length of buffer (must be even). Minimum buffer length is 12 bytes.
tevf	= trigger event flag number

Return Status:

IS.SUC - Function successfully completed. The second I/O status word contains the number of words passed per interrupt in the low byte, and the initial FORTRAN index in the high byte.

IE.BYT - Buffer is byte aligned or length is an odd number of bytes

IE.CON - Interrupt already connected to another task.

IE.IEF - Invalid event flag number.

IE.MOD - Nonexistent device. Controller is ICS11.

IE.SPC - Interrupt circular buffer was not wholly within the address space of the task. Alternatively, the buffer was too small for a single entry (6 words minimum).

Entry Format:

WD 00 - Existence indicator

WD 01 - High byte = 0, low byte = terminal input character

WD 02 - Relative module number (normally 0)

WD 03 - Generic code indicator (normally 0)

Note that words 2 and 3 are nonzero only when the entry was made as the result of a nonrecoverable controller error.

All remote terminal data is conveyed to the requesting task as input, but with the parity bit removed.

NOTE

Remote terminal input is not echoed by the driver.

18.3.6.7 **Disconnect from Terminal Input** - This function allows a task to discontinue the processing of terminal input.

QIO DPB format:

```
     QIO$C IO.DTY,...
```

Return Status:

IS.SUC - Function successfully completed. The second word of I/O status is set to zero.

IE.CON - Task was not connected to remote terminal interrupts.

18.3.7 Activating a Task by Unsolicited Interrupts

The functions described in the following paragraphs provide the capability of:

1. Activating a task in response to unsolicited interrupts.
2. Interrogating the driver to determine the reason for activation.
3. Removing a task from the activation list.

The QIO DPB parameters specify the task name, an optional trigger event flag to be set if the task is active, and device-dependent parameters that identify the interrupt source. A task is linked to interrupts (i.e., made eligible for activation) provided that:

1. the resource exists,
2. the task is installed, and
3. no other task is linked to the resource.

If another task is linked to the resource, the driver will reject the request with a status of resource-in-use (IE.RSU). A resource is defined as a single interrupt point, remote terminal (Control-C input only), or counter module.

On the occurrence of the appropriate interrupt, the task is made active if dormant; otherwise, a trigger event flag, if specified, is set. The task may interrogate the driver to determine the conditions that caused activation, and to signify interrupt recognition. The function of the event flag is to allow such a task to recognize an event that has occurred while the task was active. Recognition is ensured prior to the completion of task execution by issuing the Exit If system directive followed by the Clear Event Flag directive.

The linkage between a task and a specific interrupt is removed by issuing the appropriate unlink request via the QIO directive.

Only one task may be associated with each interrupt source (i.e., one task per digital interrupt point, terminal input, or counter module.

NOTE

The MCR command REMOVE automatically unlinks a task from all interrupts.

18.3.7.1 **Link a Task to Digital Interrupts** - The following function allows a task to be activated on the occurrence of digital interrupts.

QIO DPB format:

```
    QIO$C IO.LDI,...,<tname,[,tevf],pn,csm>
```

where:

tname	= a 1- to 6-character alphanumeric task name in 2-word, Radix-50 format
tevf	= trigger event flag (0=none)
pn	= point number (must be aligned on a module boundary)
csm	= change-of-state mask

The change-of-state mask indicates those bits for which a change of state in the direction specified by the PCL and POP jumpers causes the task to be activated. Only one task may be linked to a given interrupt point. A zero change of state mask is not permitted.

Return Status:

IS.SUC	- Function successfully completed. The second word of I/O status is set to zero.
IE.BAD	- Change-of-state mask set to zero.
IE.IEF	- Invalid event flag number.
IE.MOD	- Nonexistent module or point not aligned on a module boundary.
IE.NOD	- Insufficient dynamic memory to allocate secondary control block.
IE.NST	- Task "tname" is not installed.
IE.RSU	- One or more of the specified points is in use by other tasks.

18.3.7.2 **Link a Task to Counter Interrupts** - This function allows a task to be activated by means of an interrupt from a single counter module.

QIO DPB format:

```
     QIO$C IO.LTI,...,<tname,[,tevf],cn[,ic]>
```

where:

tname	= a 1- to 6-character alphanumeric task name in 2-word Radix-50 format.
tevf	= trigger event flag (0=none)
cn	= relative module number
ic	= counter value (optional)

The counter value if nonzero, is used to reinitialize the module in a manner similar to that described for the Set Counter function in Section 18.3.6.4. Initialization may be bypassed by setting this parameter to zero.

Return Status:

IS.SUC	- Function successfully completed. The second word of I/O status is set to zero.
IE.IEF	- Invalid event flag number.
IE.MOD	- Nonexistent module specified.
IE.NOD	- Insufficient dynamic memory to allocate a secondary control block.
IE.RSU	- Counter is linked to another task.

18.3.7.3 **Link a Task to Terminal Interrupts** - This function allows a task to be activated by means of an interrupt from a remote terminal. The task will be activated only in response to the Control-C character (octal 003).

QIO DPB format:

```
     QIO$C IO.LTY,...,<tname,[,tevf]>
```

where:

tname	= a 1- to 6-character alphanumeric task name in 2-word, Radix-50 format.
tevf	= trigger event flag (0=none).

Return Status:

IS.SUC	- Function successfully completed. The second word of I/O status is zero.
IE.IEF	- Invalid event flag number.
IE.MOD	- Nonexistent module (unit is ICS11 controller).

IE.NOD	- insufficient dynamic storage to allocate secondary control block.
IE.NST	- Task "tname" is not installed.
IE.RSU	- Remote terminal is linked to another task.

18.3.7.4 **Link a Task to Error Interrupts** - This function allows a single task to be activated whenever a remote unit power-fail or nonrecoverable serial line error is detected on any or all remote units in a system. Only one task within a system may be linked to error interrupts. Once linked, the selected task may receive error reports from any ICR controller.

QIO DPB format:

```
QIO$C IO.LKE,...,<tname,[,tevf]>
```

where:

tname	= a 1- to 6-character alphanumeric task name in 2-word Radix-50 format.
tevf	= trigger event flag (0 = none)

Return Status:

IS.SUC	- Function successfully completed. The second word of I/O status is zero.
IE.IEF	- Invalid event flag number.
IE.IFC	- No ICR11 subsystems are installed.
IE.NOD	- Insufficient dynamic storage to allocate secondary control block.
IE.NST	- Task "tname" is not installed.
IE.RSU	- Another task is linked to error interrupts.

18.3.7.5 **Read Activating Data** - This function allows a task to determine the conditions that caused it to be activated.

QIO DPB format:

```
QIO$C IO.RAD,...,<stadd>
```

where:

stadd	= address of 6-word buffer to receive activation data (must be word aligned).

The buffer receives data in the following format:

WD 00	- Activation indicator
WD 01	- Physical unit number
WD 02	- Generic Code

WD 03	- Relative module number
WD 04	- Hardware dependent data
WD 05	- Hardware dependent data

The activation indicator is similar in function to the existence indicator used when reading circular buffer entries. The indicator is set to +1 on the occurrence of an interrupt to which the requesting task is linked, and the appropriate data is stored. The indicator is cleared when the data is solicited by the task. If an interrupt linked to the task occurs and the parameter is nonzero then the previously stored data is not modified and the driver sets this element with the two's complement of the number of linked interrupts not recorded.

The physical unit number specifies the controller that received the interrupt.

The generic code is identical to that specified for circular buffer entries, namely:

0 - Terminal (Control-C)

1,2,3 - Digital interrupt

4,5,6 - Counter interrupt

177770 - Fatal controller error

Hardware-dependent data is associated with generic code and will consist of the following:

Terminal:

WD 04	- Terminal buffer contents (low byte)
WD 05	- undefined

Digital Interrupts:

WD 04	- Module data
WD 05	- Change-of-state indicator

Counter:

WD 04	- Module data
WD 05	- undefined

Fatal Controller Error:

WD04	- Contents of ICSR register (see Table 18-7)
WD05	- Contents of ICAR register (see Table 18-8)

Return Status:

IS.SUC	- Function successfully completed. The second word of I/O status is zero.
IE.BYT	- Buffer address is aligned on an odd byte boundary.

IE.NLK - Task "tname" was not linked to interrupts.

IE.SPC - Buffer not totally within the task's address space.

18.3.7.6 **Unlink a Task from Interrupts** - The functions described in the following paragraphs provide the capability of:

1. Unlinking a task from all interrupts on a controller,

2. Selectively unlinking a task from interrupts by module type.

a. Unlink a Task from All Interrupts

This function unlinks a task from all interrupts on a given controller and from error interrupts.

QIO DPB format:

```
QIO$C IO.NLK,....,<tname>
```

where:

tname	= 1- to 6-character alphanumeric task name in 2-word Radix-50 format.

Return Status:

IS.SUC -	Function successfully completed. The second word of I/O status is zero.
IE.NLK -	Task "tname" was not linked to interrupts.

b. Unlink a Task from all Digital Interrupts

This function provides the capability of unlinking a task from all digital interrupt points on a controller.

QIO DPB format:

```
QIO$C IO.UDI,...,<tname>
```

where:

tname	= a 1- to 6-character alphanumeric task name in 2-word Radix-50 format.

Return Status:

IS.SUC -	Function successfully completed. The second word of I/O status is zero.
IE.NLK -	Task "tname" was not linked to the specified class of interrupt.
IE.NST -	Task not installed.
IE.MOD -	Nonexistent module type specified.

c. Unlink a Task from Counter Interrupts

This function provides the capability of unlinking a task from all counter module interrupts.

QIO DPB format:

```
     QIO$C IO.UTI,...,<tname>
```

where:

tname = a 1- to 6-character alphanumeric task name in 2-word Radix-50 format.

Return Status:

IS.SUC -	Function successfully completed. The second word of I/O status is zero.
IE.NLK -	Task "tname" was not linked to the specified interrupts.
IE.NST -	Task not installed.
IE.MOD -	Nonexistent module type specified.

d. Unlink a Task from Terminal Interrupts

This function provides the capability of unlinking a task from terminal interrupts.

QIO DPB format:

```
     QIO$C IO.UTY,...,<tname>
```

where:

tname = a 1- to 6-character alphanumeric task name in 2-word Radix-50 format.

Return Status:

IS.SUC -	Function successfully completed. The second word of I/O status is zero.
IE.NLK -	Task "tname" was not linked to the specified interrupts.
IE.NST -	Task not installed.
IE.MOD -	Nonexistent module specified (i.e., device is an ICS11 controller).

e. Unlink a Task from Error Interrupts

This function provides the capability of unlinking a task from all error interrupts.

QIO DPB format:

```
     QIO$C IO.UER,...,<tname>
```

where:

tname = 1- to 6-character alphanumeric task name in 2-word Radix-50 format.

Return Status:

IS.SUC -	Function successfully completed. The second word of I/O status is zero.
IE.IFC -	No ICR11 controllers exist in the system.
IE.NLK -	Task "tname" was not linked to error interrupts.
IE.NST -	Task not installed.

18.3.8 **Terminal Output**

This function allows a task to perform output to the terminal device. Characters are output exactly as they appear in the buffer. The carriage control parameter is not recognized. It should be noted that only one interrupt module request per controller (terminal or A/D) may be in progress at a given time. Thus, the driver will not initiate an A/D operation on a given controller, until any terminal output in progress for that controller has been completed.

QIO DPB format:

```
     QIO$C IO.WLB,...,<staddb,sizb>
```

where:

staddb	= Buffer address (may be odd)
sizb	= Byte count (may be odd)

Return Status:

IS.SUC -	Function successfully completed. Second word of I/O status contains the number of bytes output.
IE.MOD -	Nonexistent hardware function. Request was issued for an ICS11 controller.

18.3.9 **Maintenance Functions**

The functions described below allow a privileged task to enable and disable error reporting while troubleshooting or maintenance on a remote unit is in progress.

18.3.9.1 **Disable Hardware Error Reporting** - This function allows a privileged task to disable error reporting and error interrupts, and restrict access to the controller while remote unit troubleshooting or module calibration is in progress (see Section 18.5.1). Upon receipt and validation of the request, error interrupts are disabled and subsequent controller timeouts are ignored. The occurrence of device timeout while A/D conversion or remote terminal input is in progress results in termination of the request with the error code IE.ABO.

When error reporting is disabled in this manner, access to the controller for input or output to I/O modules is restricted to privileged tasks. All other requests not requiring the transmission of data to or from the device, are permitted for all tasks. Such requests are as follows:

a. Disconnect from digital, counter, or remote terminal interrupts

b. Unlink from interrupts

c. Read activating data

d. Link to digital, remote terminal, or error interrupts

e. Connect a buffer to digital or remote terminal interrupts

All other requests not issued by a privileged task are rejected with the error code IE.DNR.

QIO DPB format:

```
QIO$C IO.FLN,...
```

Return Status:

IS.SUC	-	Function successfully completed.
IE.FLN	-	Unit already offline.
IE.PRI	-	Task not privileged.

18.3.9.2 **Enable Hardware Error Reporting** - This function allows a privileged task to enable error reporting and device error interrupts. Upon receipt and validation of the function, all device error interrupts are enabled and the unit is marked online. These actions are performed regardless of the current state of the unit.

QIO DPB format:

```
QIO$C IO.ONL,...
```

Return Status:

IS.SUC	-	Function successfully completed.
IE.PRI	-	Task not privileged.

18.3.10 Special Functions

18.3.10.1 **I/O Rundown** - An I/O rundown request from the Executive will automatically cause the task to be disconnected from all interrupts. The rundown operation is not finished until any A/D input in progress for the task has been completed.

18.3.10.2 **Kill I/O** - The kill I/O function allows a task to initiate I/O rundown processing for itself on any device. Request processing is identical to that described for I/O rundown.

QIO DPB format:

```
    QIO$C IO.KIL,...
```

Return Status:

IS.SUC - Function successfully completed.

18.4 FORTRAN INTERFACE

Table 18-6 lists the FORTRAN interface subroutines supported for the ICS/ICR subsystem. (D) indicates a direct access call. The six subroutines supported by the DSS/DRS driver are indicated by a footnote.

Unless specifically noted, all subroutines are reentrant (but not necessarily position-independent) and may be placed in an absolute resident library.

Table 18-6
FORTRAN Interface

Subroutine	Function
AIRD/AIRDW	Input analog data from multiple channels in random sequence.
AISQ/AISQW	Read a series of sequential analog input channels at random gain.
AO/AOW	Perform analog output on several channels.
ASICLN/ ASUDLN	Assign a LUN to an ICS/ICR controller.
[1]ASISLN	Assign a LUN to a DSS/DRS controller.
CTDI	Connect a circular buffer to receive digital interrupt data.
CTTI	Connect a circular buffer to receive counter interrupt data.
CTTY	Connect a circular buffer to receive ICR11 remote terminal data.
DFDI	Disconnect a buffer from digital interrupts.

[1] These subroutines are supported by the DSS/DRS driver.

(continued on next page)

Table 18-6 (Cont.)
FORTRAN Interface

Subroutine	Function
DFTI	Disconnect a buffer from counter interrupts.
DFTY	Disconnect a buffer from remote terminal interrupts.
[1]DI/DIW	Read several 16-point digital sense fields (D).
[1]DOL/DOLW	Latch or unlatch several 16-point bistable output fields.
DOM/DOMW	Pulse multiple 16-point momentary digital output fields.
[1]LNK	Link a task to unsolicited interrupts.
OFLIN	Suppress error reporting. Place unit in not ready status.
ONLIN	Enable error reporting. Return unit to ready status.
RCIPT	Read a single digital interrupt point (D).
[1]RDACT	Read interrupt activation data.
RDDI	Read the digital interrupt circular buffer.
RDTI	Read the counter interrupt circular buffer.
RDCS	Read digital interrupt circular buffer. Return data on only those points for which a change of state has been recognized.
RDWD	Read digital interrupt circular buffer. Return a full data word.
RSTI	Read a single counter module (D).
RTO/RTOW	Perform output to a remote ICR11 terminal.
[1]UNLNK	Unlink a task from unsolicited interrupts.

[1] These subroutines are supported by the DSS/DRS driver.

18.4.1 Synchronous and Asynchronous Process Control I/O

The Instrument Society of America (ISA) standard provides for synchronous and asynchronous I/O. Synchronous I/O is indicated by appending a W to the name of the subroutine (e.g., AO/AOW). Except for analog input and terminal output, all QIOs issued by the process control subroutines are serviced immediately by the driver and are complete upon return to the issuing task. In such cases there is no functional difference between the synchronous and asynchronous forms; however, both forms of the name are recognized. In the case of A/D input and terminal output, the subroutines are functionally distinct. If the asynchronous form is used, execution continues and the calling program must periodically test the status word for completion.

18.4.2 Return Status Reporting

The I/O status parameter is a 2-word integer array. The first element of the array receives the status of the FORTRAN call in accordance with ISA convention.

This array serves two purposes:

1. It is the 2-word I/O status block to which the driver returns an I/O status code on completion of an I/O request.

2. The first word of the status block receives a status code from the FORTRAN interface subroutine in ISA-compatible format, with the exception of the I/O pending condition, which is indicated by a status of zero. The ISA standard code for this condition is +2.

For asynchronous analog input and terminal output, status is set by means of an asynchronous trap, therefore the trap mechanism must be enabled while these functions are in progress.

For compatibility, the two-word status block is also required for status returned by the direct access calls. Errors of this type that may be returned are:

Word 1 = 3	Number of points requested is zero.
Word 1 = +321	Invalid ICS/ICR module.

The status code must be interpreted in the context of the function requested; however, the following general conditions will apply:

Contents of Status Word 1	Meaning
0	Operation pending, I/O in progress
+1	Successful completion
+3	Error in a calling argument has been detected by the interface subroutine
3<Word 1< 300.	QIO directive rejected. Actual error code = -(WORD 1 - 3)
Word 1 > 300	Request rejected by driver. Actual error code = -(WORD 1 - 300)

Table 18-7 lists all possible status values: the FORTRAN value, assembly language mnemonic, actual value, and related definition.

Table 18-7
Return Status Summary

FORTRAN Interface Value	Assembly Language Value	Assembly Language Mnemonic	Definition
+0	+0	IS.PND	Operation pending.
+1	+1	IS.SUC	Successful completion.
+3	none	none	Error detected in FORTRAN calling sequence.
+4	-1	IE.UPN	Insufficient dynamic storage to allocate I/O packet.
+8	-5	IE.ULN	Unassigned LUN.
-6	-6	IE.LNL	LUN usage interlocked.
+99	-96	IE.ILU	Invalid LUN.
+100	-97	IE.IEF	Invalid event flag number.
+101	-98	IE.ADP	Part of DPB out of user's addressing space.
+102	-99	IE.SDP	Invalid DIC or DPB size.
+301	-1	IE.BAD	Bad parameters.
+302	-2	IE.IFC	Invalid I/O function code.
+303	-3	IE.DNR	Device not ready.
+306	-6	IE.SPC	Illegal buffer.
+315	-15	IE.ABO	Request aborted.
+316	-16	IE.PRI	Privilege violation.
+317	-17	IE.RSU	Resource in use.
+319	-19	IE.BYT	Buffer address or length is odd.
+321	-21	IE.MOD	Illegal module number.
+322	-22	IE.CON	Another task already connected to interrupts.
+323	-23	IE.NOD	Insufficient dynamic memory to allocate secondary control block.
+379	-79	IE.NLK	Task not linked to interrupts.
+380	-80	IE.FLN	ICR11 already offline.
+381	-81	IE.NST	Task is not installed.
+397	-97	IE.IEF	Invalid event flag number.

18.4.3 Optional Arguments

The calling sequences discussed in subsequent sections frequently contain optional arguments. These arguments are enclosed in square brackets within the calling sequence description. A statement containing such arguments may be written with these parameters deleted by truncating the argument list if the optional parameters are at the end of the calling sequence, or replacing them with commas if they are embedded elsewhere in the list. Consider the routine XYZ below having two optional arguments.

```
        CALL XYZ(ibuf [,ilen] [,ival])
```

If the argument ival is to be omitted, the calling sequence would be:

```
        CALL XYZ(IBUF,ILEN)
```

When an optional argument in the middle of the list is to be omitted it is replaced with a comma. Consider the routine XYZ, above. The following statement is used to omit the parameter ilen:

```
        CALL XYZ(IBUF,,IVAL)
```

NOTE

In some subroutines, lun - the logical unit number - is indicated to be an optional argument. It is optional only if one of the Assign LUN subroutines has been called (ASICLN, ASUDLN, ASISLN). Otherwise the lun argument is mandatory.

18.4.4 Assigning Default Logical and Physical Units for Input and Output - ASICLN/ASUDLN (ICS/ICR) and ASISLN (DSS/DRS)

The following subroutines must be called to assign and record a default LUN and physical unit if either parameter is to be unspecified in subsequent FORTRAN calls for which these parameters are optional.

Calling Sequence:

```
        CALL ASICLN([lun] [,idsw] [,iunt])
        CALL ASUDLN([lun] [,idsw] [,iunt])
        CALL ASISLN(lun[,idsw][,iunt])
```

Before a task can issue the call to ASUDLN, the ASN command must be issued through MCR to assign logical device UDnn to the appropriate physical ICS/ICR unit.

Argument Description:

lun -	An integer variable whose value is the number of the LUN to be assigned to the physical unit specified by iunt or unit 0. If unspecified, no LUN is assigned. The lun argument is mandatory for ASISLN (used for DRS11 only).
idsw -	An optional integer variable to receive the result of the assign lun directive.
iunt -	An optional integer variable that specifies the unit number to be assigned. Assumed to be zero if omitted.

Return Status:

The following values are returned to idsw:

+1	-	Assignment or function successfully completed.
-5	-	LUN usage is interlocked because LUN is assigned to a device that is attached to another device or a file is currently open on the LUN
-96	-	Invalid LUN

The call to ASUDLN assigns a LUN to logical device UD: and is provided for compatibility with existing UDC11 software. The call to ASICLN assigns a LUN to device IC:. The call to ASISLN assigns a LUN to device IS:.

Upon successful issuance of the Assign LUN directive, the subroutine executes a Get LUN Information directive to obtain the actual unit numbers to be saved. It is therefore possible to alter the default physical unit referenced in a direct access call, by means of the ASN MCR function, provided that such logical assignments are done before the task is made active.

Examples:

1. Assign LUN 5 to ICR unit 3.

```
     CALL ASICLN (5,IERR,3)
     IF(IERR) 20,10,10
10 --------------
```

2. Assign LUN 1 to logical device UD:, unit 0

   a. The following MCR command is issued to create logical device UD0:, and assign all references to physical device IC1:.

      ```
      >ASN IC1:  = UD:
      ```

   b. The FORTRAN call

      ```
      CALL ASUDLN (1)
      ```

      assigns logical device UD0: to LUN 1. Because of the previous ASN command the Executive will assign this LUN to physical device IC1: and return a value of one (1) for the unit number in response to the GET LUN Information directive. This value will be stored and later referenced whenever the physical unit number is unspecified in any of the FORTRAN calls that reference the I/O page directly.

3. Assign LUN 6 to logical device IS:, unit 2.

```
     CALL ASISLN(6,,2)
```

18.4.5 **Analog Input**

The following routines provide the capability of performing A/D input:

AIRD/AIRDW -	ISA Standard call to read multiple channels in random order. This call requires one or more control variables containing A/D channel and gain in the format shown in Table 18-5 (Section 18.3.2).
AISQ/AISQW -	ISA Standard call to read multiple channels in sequential order.

18.4.5.1 **AIRD/AIRDW: Analog Input - Specified Channel Sequence** - The ISA standard call provides the capability of reading multiple A/D channels in a specified sequence.

```
        CALL AIRD(inm,icont,idata[,isb],lun)
or
        CALL AIRDW(inm,icont,...etc.)
```

Argument Descriptions:

inm	-	Integer variable specifying the number of channels to be read.
icont	-	An integer array of size inm containing control data in the format shown in Table 18-5 (Section 18.3.2).
idat	-	An integer array of dimension inm to receive the converted values. Each element in the array is paired with a control element in icont that defines the channel and gain.
isb	-	An optional 2-word integer array to receive the results of the call as follows:

+1	-	Conversion successfully completed. The second word contains the number of channels converted.
+3	-	Number of channels requested was zero.
+4	-	Insufficient dynamic storage to allocate I/O packet.
+8	-	LUN was not assigned.
+99	-	Invalid LUN.
+301	-	At least one invalid control word was specified. The second I/O status word contains the number of channels successfully converted.
+303	-	Device not ready. Interrupt response was not received from an A/D channel within one second after initiation. The second word of I/O status contains the number of channels successfully converted.
+306	-	Control or data buffer not wholly within the user's addressing space.
+319	-	Control or data buffer is byte aligned.

lun	-	An integer variable specifying the ICS/ICR logical unit number. This parameter is required.

Example:

The following example illustrates how A/D throughput can be increased when several IAD-IA A/D Converters are in a system. This is accomplished by means of interleaved samples that initiate parallel conversions on each module. Samples are to be obtained from 12 channels on three IAD-IA A/D converter modules at a gain of 1.

```
C
C PROGRAM TO SAMPLE 12 A/D CHANNELS
C IN RANDOM SEQUENCE FOR MAXIMUM
C THRUPUT.
C
C CHANNELS TO BE SAMPLED:
C
C          0
C          1      -A/D MODULE 0
C          2
C          3
C        120
C        121      -A/D MODULE 1
C        122
C        123
C        240
C        241      -A/D MODULE 2
C        242
C        243
C
C INTERLEAVED SEQUENCE FOR MAXIMUM
C THRUPUT.
C
C          0
C        120
C        240
C          1
C        121
C        241
C          2
C        122
C        242
C          3
C        123
C        243
C
C THE FORTRAN CONVENTION FOR ARRAY
C STORAGE CAN BE USED TO REPRESENT
C THE ABOVE SEQUENCE IN AN N X I INTEGER
C CONTROL ARRAY.  WHERE:
C
C       N = NUMBER OF MODULES TO BE SAMPLED
C       I = NUMBER OF SAMPLES PER/MODULE
C
C ALLOCATE STORAGE FOR CONTROL ARRAY
C
        DIMENSION ICONT (3,4)
C
C INITIALIZE CONTROL ARRAY FOR IAD-IA MODULE 0
C
        DATA ICONT(1,1),ICONT(1,2),ICONT(1,3),ICONT(1,4)/0,1,2,3/
C
C INITIALIZE CONTROL ARRAY FOR IAD-IA MODULE 1
```

```
C
      DATA ICONT(2,1),ICONT(2,2),ICONT(2,3),ICONT(2,4)/120,121,122,123/
C
C INITIALIZE CONTROL ARRAY FOR IAD-IA MODULE 2
C
      DATA ICONT(3,1),ICONT(3,2),ICONT(3,3),ICONT(3,4)/240,241,242,243/
C
C ALLOCATE STORAGE FOR DATA ARRAY
C IN SIMILAR FASHION TO FACILITATE
C CHANNEL REFERENCES
C
      DIMENSION IDATA (3,4)
C
C     BEGIN EXECUTABLE STATEMENTS
C
                .
                .
                .
C
C INITIATE A/D SYNCHRONOUS CONVERSION ON LUN 3
C
      CALL AIRDW(12,ICONT,IDATA,,3)
                .
                .
                .
```

18.4.5.2 **AISQ/AISQW: Analog Input - Sequential Channel Sequence** - The ISA standard call described below provides the capability of sampling multiple A/D channels in sequential order. Channels are sampled in increments of one, beginning with the channel specified in icont(1).

```
      CALL AISQ(inm,icont,idata [,isb],lun)
or
      CALL AISQW(inm,icont...etc.)
```

Argument Descriptions:

inm	-	Integer variable specifying the number of elements to be read.
icont	-	An integer array of size inm containing initial channel in the first element only, and gain in the format shown in Table 18-5 in the remaining elements.
idat	-	An integer array of size inm to receive the converted values. Each element is paired with the corresponding control element in icont that defines the gain parameter. Channels are sampled sequentially starting with the first channel specified in element 1 of icont.
isb	-	An optional 2-word integer array to receive the results of the call as follows:

+1	-	Conversion successfully completed. The second word contains the number of channels converted.
+3	-	Number of channels requested was zero
+4	-	Insufficient dynamic storage to allocate I/O packet

+8	-	LUN was not assigned
+99	-	Invalid LUN
+301	-	At least one invalid control word was specified. The second I/O status word contains the number of channels successfully converted.
+303	-	Device not ready. Interrupt response was not received from an A/D channel within one second after initiation. The second word of I/O status contains the number of channels successfully converted.
+306	-	Control or data buffer not wholly within the user's addressing space
+319	-	Control or data buffer is byte aligned

lun - An integer variable containing the logical unit number. This parameter is required.

Example:

The following example illustrates the procedure for sequential sampling. Five channels are converted at gains of 1, 2, 20, 50, and 1000, starting at channel 3.

```
C
C ALLOCATE SPACE FOR STATUS ARRAY
C
        DIMENSION ISB (2)
C
C ALLOCATE SPACE FOR CONTROL ARRAY
C AND ESTABLISH INITIAL VALUES
C
        DIMENSION ICONT(5)
        DATA ICONT(1),ICONT(2),ICONT(3)/0000003,0010000,0050000/
        DATA ICONT(4),ICONT(5)/0100000,0150000/
C
C ALLOCATE SPACE FOR DATA ARRAY
C
        DIMENSION IDAT (5)
                .
                .
                .
C
C INITIATE SEQUENTIAL, ASYNCHRONOUS CONVERSION
C VIA LUN 1
C
        CALL AISQ(5,ICONT,IDAT,ISB,1)
10      IF(ISB(1).NE.0) GO TO 20

        (continue processing)
                .
                .
                .
C
C TEST CONVERSION STATUS
C
        GO TO 10
```

```
20      (test for errors or process converted data)
                  .
                  .
                  .
        END
```

18.4.6 AO/AOW: Analog Output - Multichannel

This ISA standard routine is called to output voltage from multiple D/A channels.

Calling Sequence:

```
        CALL AO(inm,icnt,idat[,isb][,lun])
```

or

```
        CALL AOW(inm,icnt...etc.)
```

Argument Descriptions:

inm - Integer variable containing the number of channels to be output.

icnt - Integer array containing the channel numbers to receive output.

idat - Integer array containing the output voltage setting as a value between 0 and 1023 where:

0 = 0 volts dc and

1023 = +9.99 volts (full scale).

isb - Optional 2-word integer array to receive status. One of the following values is returned in isb(1). The second element is always zero.

+1	-	Function successfully completed.
+3	-	Zero channels requested.
+4	-	Insufficient dynamic storage to allocate an I/O packet.
+8	-	LUN was not assigned.
+99	-	Invalid LUN.
+303	-	Controller not ready.
+321	-	Nonexistent channel specified.

lun - Integer variable containing the logical unit number.

Example:

Output the variable voltages contained in IV(1) and IV(2) to D/A channels 2 and 3 respectively.

```
C
C ALLOCATE DATA ARRAY
C
        DIMENSION IV(2)
C
C ALLOCATE CONTROL ARRAY
C
        DIMENSION ICNT(2)
C
C ALLOCATE STATUS ARRAY
C
        DIMENSION ISB(2)
C
C INITIALIZE CONTROL ARRAY
C
        DATA ICNT(1),ICNT(2)/2,3/
                  .
                  .
                  .
C
C PERFORM A/D OUTPUT VIA LUN 3
C
        CALL AOW(2,ICNT,IV,ISB,3)
        IF (ISB(1).GE.3) go to error processor
```

18.4.7 **DOL/DOLW: Digital Output - Bistable Multiple Fields**

The following ISA standard call provides the capability of latching or unlatching multiple 16-point bistable digital output fields.

Calling Sequence

```
        CALL DOL(inm,icnt,idat,imsk[,isb][,lun])
or
        CALL DOLW(inm,icnt...etc.)
```

Argument Descriptions:

inm	-	Integer variable specifying the number of fields to be latched or unlatched.
icnt	-	Integer array containing the initial point within each field.
idat	-	Integer array containing binary data that defines points within the field to be latched or unlatched. The state of each bit is interpreted as follows: 1 = latch point. 0 = unlatch point.

imsk	-	Integer array containing binary data that defines points within the field for which a change of state is permitted. A bit set to 1 defines a point that may assume the state defined by the corresponding bit in idat. A 0 bit specifies a point for which no change of state is permitted.
isb	-	Optional 2-word integer array to receive the results of the call. Status is returned in isb(1) as shown below. isb(2) is always zero.

+1	-	Function successfully completed.
+3	-	Zero points specified.
+4	-	Insufficient dynamic storage to allocate an I/O packet.
+8	-	LUN not assigned.
+99	-	Invalid LUN.
+303	-	Controller not ready.
+321	-	Nonexistent point number specified. One or more points within the field do not exist.

lun	-	Integer specifying the Logical Unit Number.

Example:

Reset points 0,1,20 and 21

```
      DIMENSION ICNT(2),IDAT(2),IMSK(2)
C
C INITIALIZE THE CONTROL ARRAY
C
      DATA ICNT(1),ICNT(2)/0,20/
C
C INITIALIZE MASK ARRAY TO EFFECT A
C CHANGE-OF-STATE ONLY ON THE SPECIFIED
C POINTS.
C
      DATA IMSK(1),IMSK(2)/0000003,0000003/
              .
              .
              .
C
C RESET THE SPECIFIED POINTS.  ICR IS ASSIGNED
C TO LUN 3.
C
      CALL DOLW(2,ICNT,IDAT,IMSK,,3)
              .
              .
              .
```

18.4.8 Digital Input

Both of the following subroutines perform their functions through direct access to the ICS/ICR hardware registers. Therefore, the physical unit number replaces LUN in the calling sequences described below. Note that any need for conversion of BCD encoded digital input into binary, can be accomplished through the FORTRAN function

IBIN=KBCD2B (IBCD).

Binary data can be converted to BCD through the FORTRAN function

IBCD=KB2BCD (IBIN).

The maximum input value for conversion is 9999.

NOTE

When the physical unit number is explicitly included in the calling sequence, it cannot be reassigned by the MCR command ASN.

18.4.8.1 **DI/DIW: Digital Input - Digital Sense Multiple Fields** - This ISA standard subroutine provides the capability of reading multiple 16-point digital sense fields.

Calling Sequence:

```
        CALL DI(inm,icnt,idat[,isb][,iun])
or
        CALL DIW(inm,icnt...etc.)
```

Argument Descriptions:

inm	-	Integer variable specifying the number of fields to be read.
icnt	-	Integer array containing the initial point number of each field.
idat	-	Integer array to receive the input data
isb	-	Optional, 2-word integer array to receive the results of the call. The status is returned in isb (1) as follows:

+1	-	Function succesfully completed.
+3	-	Zero points requested.
+321	-	Nonexistent point requested. One or more points within the 16-bit field does not exist.

iun	-	Optional integer variable specifying the physical unit number.

Example:

Read two contact sense fields starting at points 3 and 27 on physical unit IC2:.

```
     DIMENSION  ICNT(2), IDAT(2),ISB(2)
     DATA   ICNT(1),ICNT(2)/3,27/
            .
            .
     CALL DI (2,ICNT,IDAT,ISB,2)
     IF (ISB(1).GE.3) go to error procedure
            .
            .
            .
```

18.4.8.2 **RCIPT: Digital Input - Digital Interrupt Single-Point** - The following subroutine returns the state of a single digital interrupt point as a logical value.

Calling Sequence:

```
     CALL RCIPT (ipt,isb[,iun])
```

Argument Descriptions:

ipt - Integer variable defining the point to be read.

isb - 2-word integer array to receive status and data as follows. Status is returned to isb(1).

- +1 - Function successfully completed. Data is returned to isb(2) as a logical value, where:

  .TRUE. (-1) = Point closed.

  .FALSE. (0) = Point open.

- +321 - Nonexistent point specified.

iun - Optional integer variable defining the physical unit number.

Example:

Read the state of contact interrupt point 3 on unit 0.

```
     DIMENSION ISB (2)
          .
          .
          .
     CALL RCIPT (3,ISB,0)
     IF (ISB(2).EQ..FALSE.) go to point open routine.
```

18.4.9 **DOM/DOMW: Digital Output Momentary - Multiple Fields**

This ISA standard call allows multiple 16-bit fields to be pulsed.

Calling Sequence:

```
     CALL DOM (inm,icnt,idat[,idx][,isb][,lun])
or
     CALL DOMW (inm,icnt...etc.)
```

Argument Descriptions:

inm	-	Integer variable specifying the number of fields to be pulsed.
icnt	-	Integer array containing the initial point in each field.
idat	-	Integer array defining the points to be pulsed. A bit is set corresponding to each point that is to be triggered.
idx	-	Optional dummy integer variable retained for compatibility with the standard form of the call.
isb	-	Optional 2-word integer array to receive the results of the call as follows in isb(1), isb(2) is set to zero.

+1	-	Function successfully completed.
+3	-	Number of fields to be output is zero.
+4	-	Insufficient dynamic storage to allocate on I/O packet.
+8	-	LUN not assigned.
+99	-	Invalid LUN.
+303	-	Controller not ready
+321	-	Nonexistent point specified. One or more points within a field do not exist.

lun	-	Integer variable defining the logical unit number.

Example:

Pulse momentary digital output fields defined by points 20, 37 and 0 on LUN 1.

```
     DIMENSION ICONT(3),IDAT(3)

     DATA ICONT(1),ICONT(2),ICONT(3)/20,37,0/

     CALL DOM(3,ICONT,IDAT,,1)
```

18.4.10 **RTO/RTOW: Remote Terminal Output**

The following function provides the capability of transmitting a character string to a remote ICR11 terminal. Both synchronous and asynchronous forms are supported.

```
     CALL RTO (ibc,idat[,isb][,lun])
or
     CALL RTOW (ibc,idat....etc.)
```

Argument Descriptions:

ibc	-	Integer variable specifying the number of bytes to output.
idat	-	Byte array (LOGICAL * 1) containing the character string to be output.
isb	-	Optional, 2-word integer array to receive the results of the call in isb(1) as follows. isb(2) is set to the number of bytes actually transferred to the device.

0	-	Operation pending.
+1	-	Function successfully completed.
+3	-	Zero bytes to be transmitted.
+4	-	Insufficient dynamic storage to allocate I/O packet.
+8	-	Unassigned LUN.
+99	-	Invalid LUN.
+303	-	Device not ready. Terminal failed to respond within 1 second after character was transmitted.
+306	-	Part or all of buffer is out of the issuing task's addressing space.
+321	-	Nonexistent module. Device is ICS11.

lun	-	Integer variable defining the logical unit number.

Example:

Output a character string to a remote terminal via the ICR unit assigned to LUN 3.

```
     CALL RTOW(32,'APPLY +5 VOLTS TO A/D CHANNEL 10',,3)
```

18.4.11 **Unsolicited Interrupt Data - Continual Monitoring**

Subroutines are provided, that permit a FORTRAN program to continually monitor unsolicited interrupt data supplied to a user circular buffer as described in Section 18.3.6. Such routines allow the program to connect a buffer for input, disconnect the buffer upon completion and read and return the buffer contents in a format suitable for FORTRAN processing. The calls summarized below perform these functions for interrupting digital input modules, counters, and remote terminal inputs:

Interrupting Digital Inputs

CTDI	- Connect a buffer to receive digital interrupts.
RDDI	- Read the state of a single interrupting point.
RDCS	- Read the state of a single interrupting point for which a change of state has been detected.
RDWD	- Read 16 bits of interrupt data from the circular buffer.
DFDI	- Disconnect a buffer from digital interrupts.

Counter Modules

CTTI	- Connect a buffer to receive counter interrupts.
RDTI	- Read the counter circular buffer.
DFTI	- Disconnect a buffer from counter interrupts

Remote Terminal Input

CTTY	- Connect a buffer to receive remote terminal inputs.
RDTY	- Read remote terminal data from the circular buffer.
DFTY	- Disconnect a buffer from remote terminal interrupts.

18.4.11.1 **CTDI: Connect a Buffer for Receiving Digital Interrupt Data** - The following routine allows a task to provide a circular buffer that will receive digital interrupt data, and define an event flag that will be set upon the occurrence of each interrupt.

Calling Sequence:

```
     CALL CTDI (ibuf,isz,iev[,isb][,lun])
```

Argument Descriptions:

ibuf - An integer array making up the circular buffer that is to receive interrupt data.

isz - Integer variable specifying the length of the circular buffer in words.

iev - Integer variable specifying the event flag that is to be set whenever the driver receives an interrupt from a digital input module.

isb - Optional, 2-word integer array to receive the results of the call. The status values specified below are returned to isb(1).

+1 - Function successfully completed. isb(2) receives the number of words passed per interrupt in the low byte.

+4 - Insufficient dynamic storage to allocate an I/O packet.

+8	- Unassigned LUN.
+99	- Invalid LUN.
+306	- Part of buffer is out of the user's address space or buffer is too small to accommodate a single entry.
+316	- Privilege violation - task is checkpointable and not fixed in memory.
+319	- Buffer address or length is an odd number of bytes.
+322	- Another task is already connected to interrupts.
+397	- Invalid event flag specified

lun - Integer variable specifying the logical unit number.

The space allocated for the circular buffer must be large enough to accommodate at least one 5-word entry plus an additional 10 words of storage that are required by the subroutines that read circular buffer contents. Thus the buffer allocation specified by the integer variable isz may be computed as

```
     isz = (10 + 5 * n)
```

where n is the number of entries to be contained in the buffer and isz is expressed in words.

18.4.11.2 **Reading Digital Interrupt Data** - Each of the following routines reads data that has been stored in the circular buffer and performs the following common processing:

1. Detects, and optionally reports, the occurrence of an error entry that has been placed in the buffer by the driver because of a nonrecoverable device fault (e.g., fatal serial line error or remote power-fail).
2. Clears the trigger event flag when no further entries remain to be processed.
3. Clears and optionally reports any overrun conditions.

Only one of the following three routines can be invoked by a single task.

a. RDDI: Read Digital Interrupt Data from a Circular Buffer

The RDDI FORTRAN subroutine reads contact interrupt data from a circular buffer that was specified in a CTDI call (see 18.4.11.1). It does no actual input or output, but rather performs a point-by-point scan of an interrupt entry in the buffer, returning the state of each point as a logical value.

On the initial call to RDDI, the module number and data of the next interrupt entry are read from the circular buffer and stored for subsequent reference. The subroutine then sets the current data bit number n to zero, examines the state of data bit n, and converts bit n to a point number via the following formula:

```
     ipt = module number * 16 + n
```

On each subsequent call, n is incremented by one and then data-bit n is examined in the stored module data. When n reaches 16, it is reset to zero and an attempt is made to read the next interrupt entry from the circular buffer. If a valid entry is not found, ipt is set negative and ict (if specified) is either assigned a value of zero or an overrun count that is maintained by the ICS/ICR driver. If ict is zero, no further entries remain. A nonzero value indicates that the driver received more data than could be stored in the buffer, and ict represents the number of entries that were discarded.

The variable ict, receives the control register contents that are set by the driver as described in Section 18.3.6 whenever a nonrecoverable controller error occurs.

Calling Sequence:

```
CALL RDDI (ipt,ival[,ict])
```

Argument Descriptions:

ipt - is a variable to which the digital input point number is returned. It may be set as follows:

1. ipt < 0 if no valid entry is found

   The specific value of ipt reflects the error that was detected as follows:

   -1 - no data (i.e., no interrupt data currently in buffer)
   -2 - overrun
   -3 - hardware error

2. ipt => 0 if the value indicated is a point number; the state is returned to ival.

ival - is a variable to which the state of the point is returned; it may be set as follows:

1. .FALSE. (0) if the point is open

2. .TRUE. (-1) if the point is closed

ict - Optional integer variable to receive the overrun count. or the contents of the CSR register on the occurrence of a fatal controller error. Otherwise set to zero.

NOTE

A task reading the circular buffer should not issue a Wait-For directive until a buffer-empty condition is reported. See Section 18.4.11.11 for an example of how to read circular-buffer entries.

b. RDCS: Read Digital Interrupt Points That Have Changed State

The RDCS FORTRAN subroutine returns data in the format of subroutine RDDI as described above except that only points that have changed state are processed, resulting in significantly improved throughput and reduced processing overhead for the calling task.

Processing specific to the routine is as follows:

On the initial call, the module number, module data and change of state information are read from the circular buffer and stored for later reference. The subroutine then sets the current data bit number n to zero and begins scanning the change-of-state word until a nonzero bit is found. The point number and current state are then reported as previously described. If no change of state is found or when no further bits remain to be processed, the next entry is fetched as described above.

The processing of error conditions is identical to subroutine RDDI.

Calling Sequence:

```
     CALL RDCS (ipt,ival[,ict])
```

Argument Descriptions:

ipt - Integer variable to receive the digital input point number. It may be set as follows:

1. ipt < 0 if no valid entry is found (i.e., overrun, error or no data in buffer). The specific value of ipt reflects the error that was detected as follows:

   -1 - no data
   -2 - overrun
   -3 - hardware error

2. ipt => 0 if the value indicated is a point number, the state is returned to ival.

ival - Integer variable to receive the state of the point as a logical value where:

1. .FALSE. (0) = point open

2. .TRUE. (-1) = point closed

ict - Optional integer variable. A nonzero value indicates that the variable has been set with an overrun count returned by the driver, or with the contents of the CSR register on the occurrence of a fatal controller error. Otherwise set to zero.

NOTE

A task reading the circular buffer should not issue a Wait-For directive until a buffer-empty condition is reported. See Section 18.4.11.11 for an example of how to read circular-buffer entries.

c. RDWD: Read a Full Word of Digital Interrupt Data

The following subroutine is called to return a full word of digital interrupt data from the circular buffer, and optionally change of state information. A new entry is read for each call; hence, throughput is high when processing is contingent upon several possible conditions within a module.

Calling Sequence:

```
CALL RDWD (imod,ival[,ict][,icos])
```

Argument Descriptions:

imod - an integer variable to receive the module number or status as follows:

1. imod < 0 if no data is present or an overrun condition or error was detected

   The specific value of ipt reflects the error that was detected as follows:

   -1 - no data
   -2 - overrun
   -3 - hardware error

2. imod => 0 Module number. Interrupt data is in ival

ival - Integer variable to receive the digital interrupt data.

ict - Optional integer variable. A nonzero value indicates that the variable has been set with an overrun count returned by the driver, or with the contents of the CSR register on the occurrence of a fatal error. Otherwise set to zero.

icos - Optional integer variable to receive change-of-state information. Bits set to a 1 correspond to points for which a change of state has been recorded.

NOTE

A task reading the circular buffer should not issue a Wait-For directive until a buffer-empty condition is reported. See Section 18.4.11.11 for an example of how to read circular-buffer entries.

18.4.11.3 **DFDI: Disconnect a Buffer from Digital Interrupts** - The following routine is called to disconnect a task's circular buffer from digital interrupts.

Calling Sequence:

```
CALL DFDI ([isb][,lun])
```

Argument Descriptions:

isb - Optional 2-word integer array to receive the results of the call as follows. isb(2) is always zero.

+1 - Function successfully completed.

+4 - Insufficient dynamic storage to allocate I/O packet.

+8 - Unassigned LUN.

	+99 -	Invalid LUN.
	+322 -	Task not connected to interrupts.
lun	-	Integer variable containing logical unit number.

18.4.11.4 **CTTI: Connect a Buffer for Receiving Counter Data** - The following subroutine may be called to connect a circular buffer that is to receive counter data and to define an event flag that is to be set upon occurrence of each interrupt.

Calling Sequence:

```
     CALL CTTI (ibuf,isz,iev,iv[,isb][,lun])
```

Argument Descriptions:

ibuf	-	An integer array making up the circular buffer that is to receive interrupt data.
isz	-	Integer variable specifying the length of the circular buffer in words.
iev	-	Integer variable defining an event flag that is to be set whenever the driver receives an interrupt from a counter module.
iv	-	Integer array of initial counter values. One element is required for each counter in the physical unit. The value is used to initialize and reset the counter when a value of zero is reached. This parameter may be reset for a specific module through a call to SCTI.
isb	-	Optional 2-word integer array to receive the results of the call. The status values specified below are returned to isb(1).
	+1 -	Function successfully completed. isb(2) receives the number of words passed per interrupt in the low byte.
	+4 -	Insufficient dynamic storage to allocate an I/O packet.
	+8 -	Unassigned LUN.
	+99 -	Invalid LUN.
	+303 -	Controller not ready.
	+306 -	Part of buffer is out of the user's address space or buffer is too small to accommodate a single entry.
	+316 -	Privilege violation - task is checkpointable and not fixed in memory.
	+319 -	Buffer address or length is an odd number of bytes.
	+322 -	Another task is already connected to interrupts.
	+397 -	Invalid event flag specified.
lun	-	Integer variable specifying the logical unit number.

The space allocated for the circular buffer must be large enough to accommodate at least one 4-word entry plus an additional 8 words of storage required by the subroutine that reads buffer contents (RDTI). The buffer allocation specified by the variable isz may be computed as

```
     isz = (8 + 4 * n)
```

where n is the number of entries to be contained in the buffer.

NOTE

A task reading the circular buffer should not issue a Wait-For directive until a buffer-empty condition is reported. See Section 18.4.11.11 for an example of how to read circular-buffer entries.

18.4.11.5 **RDTI: Read Counter Data from the Circular Buffer** - The following call returns counter interrupt data from the circular buffer. A new entry is read on each call.

Calling Sequence:

```
     CALL RDTI (imod,ival[,ict])
```

Argument Descriptions:

imod - Integer variable to receive module number and status as follows:

1. imod < 0 No data in buffer, data overrun or error condition detected The specific value of ipt reflects the error that was detected as follows:

   -1 - no data
   -2 - overrun
   -3 - hardware error

2. imod => 0 Module number of counter. Interrupt data is in ival.

ival - Integer variable to receive the counter data at interrupt.

ict - Optional integer variable to receive the overrun count, or the ICSR contents returned by the driver on the occurrence of a fatal hardware error. Otherwise, set to zero.

NOTE

A task reading the circular buffer should not issue a Wait-For directive until a buffer-empty condition is reported. See Section 18.4.11.11 for an example of how to read circular-buffer entries.

18.4.11.6 **Miscellaneous Counter Routines**

a. RSTI: Read a Counter Module

The following routine directly accesses a counter register to return its current value.

Calling Sequence:

```
     CALL RSTI (imod,isb[,iun])
```

Argument Descriptions:

imod	-		An integer variable containing the number of the counter to be read.
isb	-		A two-word integer array to receive status and data as follows. Status is returned to isb(1).
	+1	-	Function successfully completed. Data is returned to isb(2).
	+321	-	Nonexistent module specified.
iun	-		Optional integer variable specifying the ICS/ICR physical unit number.

b. SCTI: Reset a Counter Initial Value

The following routine may be called by any task to revise the initial value that is used to activate a counter.

Calling Sequence:

```
     CALL SCTI (imod,ival[,isb][,lun])
```

Argument Descriptions:

imod	-		Integer variable specifying the relative module number of the counter to be reset.
ival	-		Integer value specifying the new initial value.
isb	-		Optional 2-word integer array to receive status as follows. isb(2) is always zero.
	+1	-	Function successfully completed.
	+4	-	Insufficient dynamic storage to allocate an I/O packet.
	+8	-	Unassigned LUN.
	+99	-	Invalid LUN.
	+303	-	Controller not ready.
	+321	-	Nonexistent module specified.
lun	-		Integer specifying the logical unit number.

18.4.11.7 **DFTI: Disconnect a Buffer from Counter Interrupts** - The following subroutine is called to disconnect the task's circular buffer from interrupts.

Calling Sequence:

```
     CALL DFTI ([isb][,lun])
```

Argument Descriptions:

isb - Optional 2-word integer array to receive status as follows. isb(2) is always zero.

- +1 - Function successfully completed.
- +4 - Insufficient dynamic storage to allocate an I/O packet.
- +8 - Unassigned LUN.
- +99 - Invalid LUN.
- +322 - Task was not connected to interrupts.

lun - Integer variable specifying the Logical Unit Number.

18.4.11.8 **CTTY: Connect a Circular Buffer to Terminal Interrupts** - The following routine allows a task to provide a circular buffer to receive remote terminal input data, and to define an event flag that is set on the occurrence of each interrupt.

Calling Sequence:

```
     CALL CTTY (ibuf,isz,iev[,isb][,lun])
```

Argument Descriptions:

The following arguments are identical in form and function to those described for subroutine CTDI (Section 18.4.11.1).

ibuf - An integer array making up the circular buffer, that receives interrupt data.

isz - Length of the circular buffer in words.

iev - Event flag to be set on each terminal interrupt.

Buffer size is computed as

```
     isz = (8 + 4 * n)
```

where n is the number of entries that can be stored in the buffer.

isb - Optional 2-word integer array to receive the results of the call. The status values specified below are returned to isb(1).

- +1 - Function successfully completed. isb(2) receives the number of words passed per interrupt in the low byte.
- +4 - Insufficient dynamic storage to allocate an I/O packet.
- +8 - Unassigned LUN.

	+99 -	Invalid LUN.
	+306 -	Part of buffer is out of the user's address space or buffer is too small to accommodate a single entry.
	+316 -	Privilege violation - task is checkpointable and not fixed in memory.
	+319 -	Buffer address not on a word boundary or length is an odd number of bytes.
	+321 -	Nonexistent module specified. Unit is ICS11.
	+322 -	Another task is already connected to interrupt.
	+397 -	Invalid event flag specified.
lun	-	Logical unit number.

18.4.11.9 **RDTY: Read a Character from the Terminal Buffer** - This subroutine retrieves a single character from the terminal circular buffer on each call.

Calling Sequence:

```
     CALL RDTY (ind,ichr[,ivr])
```

Argument Descriptions:

ind - An integer variable to receive status as follows:

1. =0 character retrieved from buffer is in ichr
2. <0 no data in buffer, overrun, or hardware error

The specific value of ind reflects the error that was detected as follows:

-1 - no data
-2 - overrun
-3 - hardware error

ichr - Logical * 1 or integer variable to receive the terminal data. If an integer is specified only the low byte will be set.

ivr - Optional integer variable to receive the overrun count, or the ICSR contents on the occurrence of a fatal hardware error. Otherwise set to zero.

NOTE

A task reading the circular buffer should not issue a Wait-For directive until a buffer-empty condition is reported. See Section 18.4.11.11 for an example of how to read circular-buffer entries.

18.4.11.10 **DFTY: Disconnect a Circular Buffer from Terminal Input** - The following routine disconnects a task's circular buffer from terminal inputs.

Calling Sequence:

```
     CALL DFTY ([isb][,lun])
```

Argument Descriptions:

isb	-		Optional, 2-word integer array to receive status in isb(1) as follows. isb(2) is always set to zero.
	+1	-	Function successfully completed.
	+4	-	Insufficient dynamic storage to allocate an I/O packet.
	+8	-	Unassigned LUN.
	+99	-	Invalid LUN.
	+322	-	Task was not connected to interrupts.
lun	-		An integer specifying the logical unit number.

18.4.11.11 **Programming Example** - The following are excerpts from a FORTRAN program that is to monitor a remote terminal for input and echo the received characters when a carriage return is detected.

```
C
C    SPECIFY BYTE FORMAT FOR TERMINAL DATA
C
     LOGICAL*1 TCHR
C
C    ALLOCATE STORAGE FOR THE TERMINAL
C    BUFFER
C
     DIMENSION IBUF(32)
C
C    ALLOCATE STORAGE FOR THE PACKED
C    INPUT DATA SO THAT IT IS ALIGNED
C    ON A WORD BOUNDARY
C
     DIMENSION ICHR(40)
     DIMENSION TCHR(80)
     EQUIVALENCE (TCHR,ICHR)
C
C    ALLOCATE STORAGE FOR A
C    2-WORD STATUS BLOCK
C
     DIMENSION ISB(2)
C
C    INITIALIZE ICR11 LOGICAL UNIT(7) AND
C    TRIGGER EVENT FLAG NUMBER(2)
C
     DATA IEV, LUN/2, 7/
          .
          .
          .
C
```

```
C     CONNECT THE TASK TO TERMINAL
C     INPUTS. IF CONNECT FAILS--STOP 1
C
      CALL CTTY (IBUF,32,IEV,ISB,LUN)
      IF (ISB(1).GE.3) STOP 1
C
C     10--POLL THE CIRCULAR BUFFER
C         FOR DATA. ECHO THE LINE WHEN
C         80 CHARACTERS ARE RECEIVED
C         OR A CARRIAGE RETURN IS
C         DETECTED.
C
10    DO 70 I = 1,80
C
C     20--WAIT FOR TRIGGER EVENT FLAG
C
20    CALL WAITFR (IEV)
C
C     30--PACK THE CIRCULAR BUFFER DATA
C         INTO THE BYTE ARRAY
C
30    CALL RDTY (ISB,TCHR(I), IVR)
C
C     DISPATCH ON ERROR CONDITION
C
      GO TO (20,50,40)-ISB
      GO TO 60
C
C     40--REPORT HARDWARE FAULT
C
40    CALL ALARM (IVR)
          .
          .
          .
      GO TO 30
C
C     50--REPORT OVERRUN CONDITION
C
50    CALL LOST (IVR)
          .
          .
          .
      GO TO 30
C
C     60--CHECK FOR CARRIAGE RETURN,
C         EXIT TO ECHO ROUTINE IF
C         PRESENT
C
60    IF (TCHR(I).EQ."15) GO TO 80

70    CONTINUE
C
C     80--FALL THROUGH TO ECHO A LINE
C
      CALL RTOW (I,TCHR,,LUN)
C
C     DISCONNECT TERMINAL BUFFER, EXIT
C
      CALL DFTY (,LUN)
      CALL EXIT
      END
```

The procedure for reading the buffer in the example above may be summarized as follows:

1. Wait for the trigger event flag specified in the call to connect the buffer.

2. Upon regaining control, call the appropriate routine to read the buffer until one of the following terminal conditions is detected:

   a. All data has been read,

   b. An overrun count is detected,

   c. A fatal error is encountered.

3. On the occurrence of 2a or 2b, perform any appropriate processing; then return to scan for additional data.

4. If a hardware error is detected, use the ICSR register contents for further fault analysis and warning as appropriate. In the event of such an error, the event flag will not be set by the driver again unless normal service is resumed.

5. A calling task should not execute the Wait-For directive until a buffer-empty condition is detected. This is because the user's buffer pointer is advanced after detecting and clearing an overrun condition, and the trigger-event flag is cleared only when a buffer-empty condition is detected.

18.4.12 Unsolicited Interrupt Processing - Task Activation

The following routines provide the capability of linking a task to an interrupt, soliciting information from the driver concerning how the task was activated, and unlinking a task from all interrupts.

18.4.12.1 **LNK: Link a Task to Interrupts** - This subroutine allows any installed task to be activated on the occurrence of any unsolicited interrupt.

Calling Sequence:

```
CALL LNK (tnam,iprm[,isb][,lun])
```

Argument Descriptions:

tnam	-	Real variable containing task name in RADIX-50 format.
iprm	-	5-word integer array containing the following data:
iprm(1)	-	Interrupt class. May be one of the following:

0 - Digital interrupts

1 - Counters

2 - Remote terminal (Control-C only)

3 - Error interrupts.

iprm(2) - Reserved

iprm(3) - Optional event flag set if task to be activated is not dormant when the interrupt occurs.

iprm(4) - Hardware-dependent parameters as follows:
iprm(5)

Interrupt Class	Parameter Contents
Digital	iprm(4) = Point number iprm(5) = Change-of-state mask
Counter	iprm(4) = Module number iprm(5) = Counter initial value
Remote Terminal	iprm(4) = not used iprm(5) = not used
Error	iprm(4) = not used iprm(5) = not used

isb - Optional 2-word integer array to receive status in isb(1) as follows. isb(2) is always set to zero.

+1 - Function successfully completed.

+3 - Unrecognized interrupt class specified.

+4 - Insufficient dynamic storage to allocate I/O packet.

+8 - Unassigned LUN.

+99 - Invalid LUN.

+301 - Task tnam not installed.

+303 - Controller not ready.

+317 - Resource in use. Other task already linked to interrupt.

+323 - Insufficient dynamic memory to allocate secondary control block.

+380 - Task tnam not installed.

+397 - Invalid event flag number specified.

lun - Optional integer specifying the logical unit number.

Example:

Link task ALARM to report fatal hardware errors arising from a malfunction on any ICR11 physical unit.

```
      DIMENSION IPRM(5)
      C
      C  INITIALIZE PARAMETER ARRAY WITH:
      C     1.  INTERRUPT CLASS
      C     2.  RESERVED ELEMENT CLEARED
      C     3.  GLOBAL EVENT FLAG
      C

      DATA IPRM(1), IPRM(2), IPRM(3)/3,0,64/

      DATA ALARM/6RALARM /
           .
           .
           .
      CALL LNK (ALARM,IPRM,,7)
           .
           .
           .
```

18.4.12.2 **RDACT: Read Activation Data** - The following call allows a task to determine the interrupt conditions that caused it to become active.

Calling Sequence:

```
      CALL RDACT (iprm[,isb][,lun])
```

Argument Descriptions:

iprm	-	6-word integer array to receive activation data in the following format.
iprm(1)	-	Activation indicator (see Section 18.3.7.5).
iprm(2)	-	Physical unit number of ICR.
iprm(3)	-	Generic code. Set to one of the following values. 0 - Remote terminal 1,2,3 - Digital interrupt 4,5,6 - Counter interrupt 177770 - Fatal hardware error
iprm(4)	-	Relative module number.

iprm(5)
iprm(6)
	-	Hardware-dependent data.

The following data is returned based upon the type of interrupt module.

Module Type	Generic Code	Parameter Contents
Remote Terminal	0	iprm(5) = terminal input character iprm(6) = undefined
Digital Interrupt	1,2,3	iprm(5) = module data iprm(6) = change-of-state data
Counter	4,5,6	iprm(5) = value of the counter at interrupt iprm(6) = undefined
Error	177770	iprm(5) = contents of ICSR iprm(6) = contents of ICAR.

isb - Optional 2-word integer array to receive status in isb(1) as follows. isb(2) is set to zero.

+1 -	Function successfully completed.
+4 -	Insufficient dynamic storage to allocate I/O packet.
+8 -	Unassigned LUN.
+99 -	Invalid LUN.
+306 -	iprm array not fully within the task's addressing space.
+319 -	Address of iprm is odd.
+379 -	Task not linked to ICS/ICR interrupts.

lun - Integer variable specifying the logical unit number.

Example:

The following is an excerpt from a program that reads activating data into array IACT and conditionally exits if the event flag (IEFN) specified in a previous link request, issued by another task, is not set.

```
C
C     ALLOCATE SPACE FOR DATA ARRAY
C
      DIMENSION IACT(6)
           .
           .
           .
10    CALL RDACT (IACT,,7)
           .
           .
           .
C
C     CLOSE ALL FILES
C
      CALL CLOSE(1)
      CALL CLOSE(2)
C
C     EXIT IF TRIGGER EVENT FLAG IS NOT SET
C     ELSE CLEAR EVENT FLAG AND RESTART.
C
      CALL EXITIF (IEFN)
C
```

```
C     FLAG WAS SET.  CLEAR IT AND
C     CONTINUE.
C
      CALL CLREF (IEFN)
      GO TO 10
      STOP
      END
```

The foregoing example illustrates the following considerations when a task is made active by ICS/ICR interrupts:

1. To avoid race conditions, the Exit-If directive should be used to test the state of the event flag and conditionally exit. Issuing a Test Event Flag directive followed by an Exit would cause a flag set condition occurring after the test to go unrecognized.

2. Use of the Exit-If directive bypasses the closure of all files that is normally done automatically by the FORTRAN object time system when the program executes a STOP or CALL EXIT statement. Thus, to exit cleanly, the program must explicitly close all files before invoking the directive.

18.4.12.3 **UNLNK: Remove Interrupt Linkage to a Task** - The following call removes all linkage between a task and ICS/ICR interrupts.

Calling Sequence:

```
     CALL UNLNK (tnam,iprm[,isb][,lun])
```

Argument Descriptions:

tnam - Real variable containing task name in Radix-50 format.

iprm - Integer variable containing the interrupt class. May be one of the following:

0 - Digital interrupts

1 - Counters

2 - Remote terminal

3 - Error interrupts

4 - All interrupts.

isb - Optional, 2-word integer array to receive the results of the call in isb(1) as follows. isb(2) is set to zero.

+1 -	Function successfully completed.
+4 -	Insufficient dynamic storage to allocate an I/O packet.
+8 -	Unassigned LUN.
+99 -	Invalid LUN.
+379 -	Task not linked to ICS/ICR interrupts.
+380 -	Task not installed.

lun - Integer variable specifying the logical unit number.

Example:

Remove the linkage between task ALARM and all ICS/ICR interrupts.

```
     DATA ALARM/6RALARM /

     CALL UNLNK (ALARM,,,7)
```

18.4.13 Maintenance Functions

The following functions cause the ICS/ICR driver to suppress or enable hardware error reporting while online maintenance and troubleshooting is in progress as described in Section 18.3.9.

OFLIN	- Place selected unit offline.
ONLIN	- Return selected unit to online status.

These calls may be issued only by a privileged task.

18.4.13.1 **OFLIN: Place Selected Unit in Offline Status** - The following call is executed to set a controller offline:

```
     CALL OFLIN ([isb] [,lun])
```

Argument Descriptions:

isb - Optional 2-word integer array to receive the results of the call in isb(1) as follows. isb(2) is always zero.

+1	- Function successfully completed.
+4	- Insufficient dynamic storage to allocate an I/O packet.
+8	- LUN not assigned.
+99	- Invalid LUN.
+316	- Issuing task not privileged.
+380	- Device already offline.

lun - Integer variable specifying the ICS/ICR logical unit number.

18.4.13.2 **ONLIN: Return a Device to Online Status** - The following call will return the selected unit to online status.

```
     CALL ONLIN ([isb] [,lun])
```

Argument Descriptions:

isb - Optional 2-word integer array to receive the results of the call in isb(1) as follows. isb(2) is always zero.

+1	- Function successfully completed.
+4	- Insufficient dynamic storage to allocate an I/O packet.

	+8 -	LUN not assigned.
	+99 -	Invalid LUN.
	+316 -	Issuing task not privileged.
lun	-	Integer variable specifying the logical unit number.

18.5 ERROR DETECTION AND RECOVERY

Error Detection and recovery procedures encompass the following contingencies.

1. Nonrecoverable serial line errors
2. Power-fail at the remote station
3. Power recovery at the processor
4. No response from an interrupting module

The first two conditions are dealt with in a manner similar to other types of unsolicited interrupts. Specifically, such occurrences may cause a task to be activated, and are reported to all tasks that are connected to digital, counter or terminal input. The following paragraphs discuss specific driver activity relating to each error condition.

18.5.1 Serial Line Errors

The driver detects nonrecoverable serial line errors. A nonrecoverable error condition is defined as the occurrence of a predetermined number of error interrupts in an interval of 1 second or no response from the controller upon initiation of an output data transfer via the serial line. The occurrence of such a condition causes the driver to perform as follows:

1. Place the controller in a "not ready" status
2. Disable further error interrupts
3. Report the condition to the task that is linked to errors, and to any tasks connected to receive unsolicited interrupt data from the faulty unit. Subsequent QIO requests that transfer data to or from the unit are rejected with a status of IE.DNR.

Requests for interrupting modules that are pending (A/D converters and terminal output) are allowed to time out with the error code IE.DNR. The serial line error rate required to consider the link inoperative may be specified by the user at the time of system generation.

After reporting the error as described above, the driver will automatically remove the "not ready" status when the error condition is not detected at the end of any 1-second interval. If requested during system generation, the state of the following remote modules will be restored as described.

1. Bistable outputs - set to last recorded state
2. Counters - reinitialized to last initial value
3. Analog outputs - restored to last output value.

18.5.2 Power-Fail at a Remote Site

The detection of AC-low from the remote site will immediately trigger the processing described in Section 18.5.1. The absence of AC-low will automatically return the unit to the "ready" status.

If specified, the state of the following remote modules will then be restored as described:

1. Bistable outputs - set to last recorded state
2. Counters - reinitialized to last initial value
3. Analog outputs - restored to last output value.

18.5.3 Power Recovery at the Processor

Power recovery by the processor will initiate the activity described in Section 18.5.2 for both local and remote file boxes. However, power recovery processing at the processor will not be reported to a task that is linked to error interrupts or connected to receive unsolicited interrupt data.

18.5.4 Unit in Offline Status

A unit that is offline (see Section 18.3.9.1) is considered to be under manual control for purposes of diagnosis and maintenance. Under these conditions, error reporting as described in Section 18.5.1 is unnecessary and frequently undesirable since fault indications are generally a by-product of these activities (i.e., a remote unit is shut down to install an I/O module) not the result of a genuine controller fault.

Furthermore, to permit the operation of diagnostic software, it is advisable to attempt to service all QIO requests regardless of the controller status. Consequently, under these circumstances, error reporting and detection are modified as follows when the controller is offline:

1. Access to the controller with the intention of transmitting data to or from the device is restricted to privileged tasks.
2. The task linked to error interrupts and any tasks receiving interrupt data are not notified of remote power-fail or fatal serial line errors.
3. All device error interrupts become disabled.
4. An attempt is made to service all QIO requests if issued by a privileged task. If such requests time out (i.e., A/D converter or remote terminal output), they are terminated with the error code IE.ABO rather than with IE.DNR. No hardware errors are reported for I/O requests that are normally completed immediately (e.g., bistable digital output).

18.5.5 Error Data - ICSR and ICAR Registers

Whenever a reportable error occurs, the driver returns the contents of the appropriate control and status register (ICSR) and, in some cases, the contents of the address register (ICAR) to assist in fault diagnosis. Tables 18-8 and 18-9 describe the contents of these registers.

Table 18-8
ICSR Contents

Bit	Name	Read/ Write	Description
15	OUTPUT BUSY	R	Indicates output buffer cannot accept new data.
14	MAINT	R/W	Maintenance.
13	NOT USED	R	Always set to 1.
12	ERROR	R	Indicates occurrence of communication serial line error. Reset when ICAR is read.
11	MAINT	R/W	Maintenance.
10	PWR FAIL	R	Remote Power Supply AC LO indicator.
9	TBMT INT EN	R/W	Enables bit 15 of ICAR to interrupt.
8	MAINT	R/W	Maintenance.
7	MOD INT	R	Indicates I/O Module requires interrupt servicing.
6	RESET	W	Resets all I/O modules. Always read as 0.
5	TTY ENABLE	R/W	Activates TTY mode, disables I/O mode.
4	PWR FAIL INT ENABLE	R/W	Enables bit 10 to interrupt.
3	BMT INT ENABLE	R/W	Enables complement of bit 15 to interrupt.
2	MOD INT ENABLE	R/W	Enables Bit 7 to interrupt.
1	ERROR INT ENABLE	R/W	Enables Bit 12 to interrupt.
0	RIF	R/W	Resets the interrupting module's flag when set and the module is addressed. This clearing action also resets the RIF bit.

Table 18-9
ICAR Contents

Bit	Name	Description
15	TBMT	Indicates TTY output buffer can accept new data.
14	PCL	Pulse closed. This bit is set by a jumper on a digital interrupt module. This jumper is removed if contact closures are not of interest to the user.
13	POP	Pulse Opened. This bit is set by a jumper on a digital interrupt module. This jumper is removed if contacts opening are not of interest to the user.
12	DA	Indicates terminal character has been received. Cleared by reading terminal character.
11-08	Generic Code	A 4-Bit binary code that identifies the the type of module requesting the interrupt.
07-00	Module Address	8-Bit address of the module requesting the interrupt.

18.6 **DIRECT ACCESS**

Section 18.1.3 notes those ICS/ICR11 functions that may be performed by referencing a module through its physical address in the I/O page. Under RSX-11M such access is accomplished by one of the following methods:

1. A privileged task or any task running in an unmapped system has unrestricted access to the I/O page and may therefore access each module by absolute address.

2. Using the Task Builder, a task may link to a global common area whose physical address limits span a set of locations in the I/O page. This method applies to either a mapped or unmapped system.

The latter method allows a task to be transported to any other system simply by relinking. Moreover, in a mapped system the memory management hardware aborts all references to device registers outside the physical address limits of the common block.

Because the software allows arbitrary module placement, direct reference, in either case, must be accomplished by translating a relative module number to a physical or virtual register address within the I/O page. This translation or mapping is performed by means of a table (ICTAB.MAC) that is created during system generation, and inserted in the system object module library.

The operations required to implement each method may be summarized as follows:

1. Unrestricted access to the I/O page

   a. Based upon the user's response to the ICS/ICR SYSGEN queries, the MACRO source file ICTAB.MAC is automatically created under UIC [11,10] on the source disk. This file contains tables that describe the physical location of each counter, digital interrupt, and digital sense module in the target system.

   b. ICTAB.MAC is assembled for eventual inclusion in the system object module library.

   c. The MACRO source file ICOM.MAC, under UIC [11,10] on the source disk, is assembled to generate global definitions for the first ICS/ICR address on the I/O page and the number of ICS/ICR controllers in the target system. The resulting object file is incorporated in the system library file.

   d. A task is built containing the appropriate global references. Such references are resolved when the Task Builder automatically searches the system library.

Steps a, b, and c are executed once. Step d is performed each time a task that references the ICS/ICR11 is created.

NOTE

ICS/ICR inputs are not valid until 3ms after power recovery at the processor. Tasks that are referencing inputs directly may establish a power recovery AST entry point that suspends task execution for the necessary time interval.

2. Access to the I/O page through a Global Common Block:

   a. Steps 1a and 1b are performed.

   b. File ICOM.MAC under UIC [11,10] is assembled to define the first ICS/ICR module address as a relocatable value, the number of I/O page locations required, and the number of controllers present on the target system.

   c. File ICOM.OBJ, created in step b, is linked using the Task Builder to create an image of the Device Common Block on Disk.

   d. The SET and INSTALL MCR or VMR commands are used to allocate space for the common block and declare the block resident in the target system.

   e. A task is created containing the appropriate global references to the common block and mapping table. Common block references are resolved by directing the Task Builder to link the Task to the device common block (ICOM). The mapping table reference is resolved from the system library module ICTAB.

The detailed procedure for creating the necessary object files and device common block is performed automatically as part of the system generation process, and is described fully in the RSX-11M System Generation and Management Guide. Therefore, the discussion in the following paragraphs is limited to procedures for linking to the device common block, and using the file ICTAB.MAC to determine module addresses within the I/O page.

18.6.1 **Linking a Task to the ICS/ICR Common Block**

Once the device common block has been created, a task may access ICS/ICR modules by linking to the common block. This can be done by using the Task Builder commands shown in the following example.

```
TKB>TASK,LP:=TASK.OBJ
TKB>/
ENTER OPTIONS:
TKB> COMMON=ICOM:RO
TKB>/
```

The illustration is valid for either a mapped or unmapped system. In both cases the Task Builder links the task to the common block by relocating the global symbol definitions contained in the common block symbol table file ICOM.STB located under UIC [1,1]. If memory management is present, the Executive will map the appropriate physical locations into the task's virtual addressing space when the task is made active.

18.6.2 **Accessing the I/O Page**

After the task has been linked to the I/O page, either directly or through reference to the device common block, access to specific ICS/ICR counter, or digital input modules during task execution is a three-step process:

1. The task generates a request for module data by specifying module type, relative module number and physical unit number.

2. The data contained in module ICTAB is accessed to translate the arguments of step 1 to a physical offset from the ICS/ICR base address on the I/O page.

3. The ICS/ICR base address, defined in the common block or system library module that was created from file ICOM.MAC, is added to the offset to compute a physical or virtual address and the module data is read.

The next few paragraphs describe the format of the system library module ICTAB, and common block module ICOM in detail. A sample MACRO subroutine that references these modules is then presented.

18.6.2.1 **Mapping Table Format** - The mapping table created by SYSGEN (file ICTAB.MAC) is used to translate module type, relative module number, and physical unit number for counter, digital interrupt, and digital sense modules, to the physical or virtual address of the module on the I/O page. This module must be assembled and inserted in the system object module library before the standard FORTRAN callable routines can be used to read digital input and counter modules. The table contains one set of entries for each physical unit. The entry sets are arranged in order of ascending unit number (Figure 18-1). Entries within each unit are arranged in sequence by module type as shown in this figure.

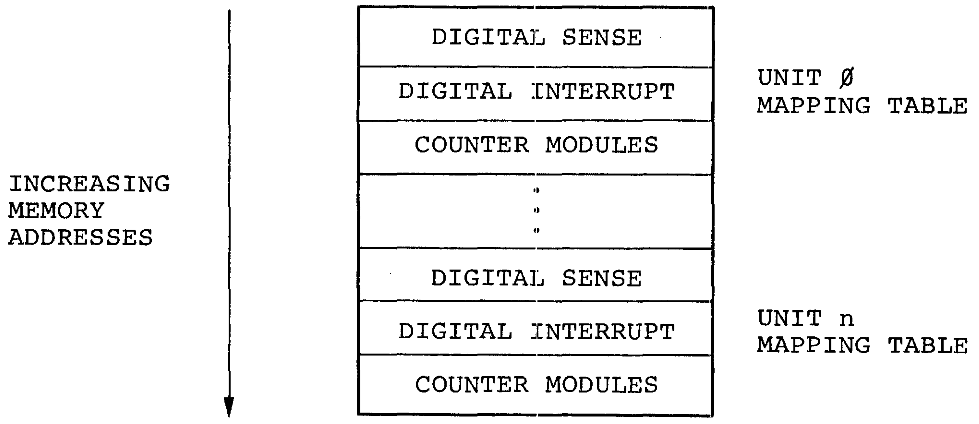


Figure 18-1 Mapping Table Format

The structure of each entry is depicted in Figure 18-2. Entries are 18 bytes long. Byte 0 contains the highest number of modules of a given type that can be referenced for the controller. Bytes 2 through 17, when indexed by relative module numbers, yield a value between 0 and 255 representing the physical location of the module within the set of external page addresses allocated to the ICS/ICR11.

The following global symbols are defined by this module:

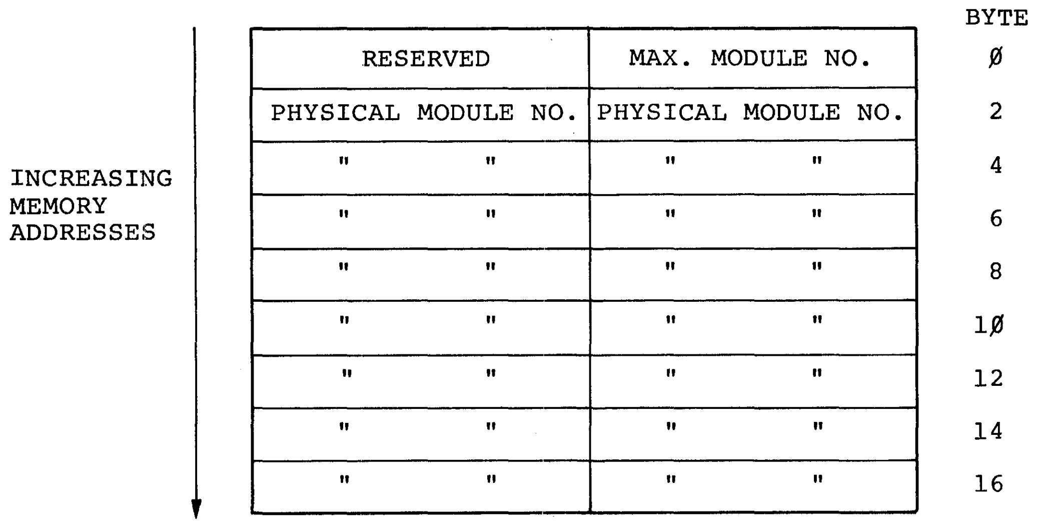
.ICTAB = Location of mapping tables

I.CTBL = Length in bytes of one set of entries

18.6.2.2 **I/O Page Global Definitions** - As previously mentioned, module ICOM contains symbolic definitions for I/O page references that are resolved either through unrestricted access or by means of a device common block that is resident on the I/O page. The procedures for implementing either method are carried out during system generation. Upon completion, the following global symbols are defined and later referenced by the FORTRAN callable subroutines:

.ICMD =	First ICS/ICR virtual or physical address within the I/O page.
I$$C11 =	Number of ICS/ICR controllers

If the global common block was built, the definitions above are contained in the symbol table file that was created by the Task Builder; otherwise, they are included in the system object module library.[1]



		BYTE
RESERVED	MAX. MODULE NO.	Ø
PHYSICAL MODULE NO.	PHYSICAL MODULE NO.	2
" "	" "	4
" "	" "	6
" "	" "	8
" "	" "	1Ø
" "	" "	12
" "	" "	14
" "	" "	16

Figure 18-2 Mapping Table Entry Format

18.6.2.3 **Sample Subroutine** - The following subroutine, residing in the system library, utilizes the modules previously described, to read ICS/ICR module data.

[1] The definitions are included in module ICOM in the system library or in the STB file ICOM.STB under UIC[1,1] on the system disk. The STB file is automatically referenced by the Task Builder in response to the use of the LIBR keyword.

```
;
; READ ICS/ICR-11 DIRECT ACCESS INPUTS
;
; LOCAL DATA
;
; ADDRESS OF ICS/ICR-11 MAPPING TABLES
;
        .ENABL  LSB
N=0                             ;
ICMAP:                          ;

        .REPT   12.

        .WORD   .ICTAB+<I.CTBL*N>
N=N+1
        .ENDR

;+
;
; **-.RDIC-READ ICS/ICR-11 DIRECT ACCESS INPUTS
;
; THIS SUBROUTINE IS CALLED TO TRANSLATE RELATIVE MODULE NUMBER
; TO PHYSICAL EXTERNAL PAGE ADDRESS AND READ THE MODULE DATA.
;
; INPUTS:
;
;       R0 = RELATIVE MODULE NUMBER
;       R1 = MODULE CODE
;
;               WHERE:
;                       0 = CONTACT SENSE
;                       1 = CONTACT INTERRUPTS
;                       2 = COUNTERS
;
;       STACK SETUP IS AS FOLLOWS:
;               (SP)+00 = RETURN TO CALLER
;               (SP)+02 = I/O STATUS BLOCK ADDRESS (NOT REFERENCED).
;               (SP)+04 = PHYSICAL UNIT NUMBER
; OUTPUTS:
;
;       C/CLEAR
;
;               R0 = MODULE DATA
;
;       C/SET:
;
;               NONEXISTENT PHYSICAL UNIT NUMBER OR MODULE SPECIFIED
;
;-

.RDIC::                         ;
        MOV     4(SP),R2        ; GET PHYSICAL UNIT NUMBER
        CMP     #I$$C11-1,R2    ; LEGAL UNIT NUMBER?
        BLO     10$             ; IF LO NO
        ASL     R2              ; CONVERT PHYSICAL UNIT NUMBER TO WORD
                                ; OFFSET
        MOV     ICMAP(R2),R2    ; GET ADDRESS OF MAPPING TABLE
                                ; ENTRIES FOR THIS UNIT
        ASL     R1              ; CONVERT CODE TO WORD OFFSET
        ADD     R1,R2           ; MULTIPLY OFFSET BY 9 AND ADD
                                ; TO TABLE ADDRESS
        ASL     R1              ; ...
        ASL     R1              ; ...
        ASL     R1              ; ...
        ADD     R1,R2           ; COMPUTE OFFSET TO TABLE
        TSTB    (R2)            ; MODULE EXIST?
        SEC                     ; ASSUME NO
        BEQ     10$             ; IF EQ NO
        INCB    R0              ; CONVERT TO NUMBER OF MODULES
        CMPB    (R2)+,R0        ; LEGAL MODULE NUMBER?
        BLO     10$             ; IF LO NO
        INC     R2              ; POINT TO TABLE ENTRIES
        ADD     R0,R2           ; OFFSET TO MODULE NUMBER
        CLR     R0              ; SET FOR MOVB WITHOUT SIGN EXTEND
        BISB    (R2),R0         ; GET INDEX TO MODULE
        ASL     R0              ; CONVERT TO WORD OFFSET
        MOV     .ICMD(R0),R0    ; GET MODULE DATA
10$:                            ;
        RETURN                  ;

        .END
```

18.7 CONVERSION OF EXISTING SOFTWARE

The following paragraphs are intended as guidance in converting existing UDC or ICS software to run under the ICS/ICR-11 driver and associated FORTRAN support routines. The differences described here are restricted to module support and features that would affect existing software. New features, unsupported in previous systems, are not discussed.

18.7.1 Features

Principal features affecting existing software are:

1. Support for the ICS/ICR11 as a multi-unit, multi-controller device.

2. Removal of software restrictions on the placement of functionally similar modules.

Multi-unit support affects any software that addresses modules outside the range of a single file box. In general, such software must be modified at the source level.

Unrestricted module placement affects MACRO-11 programs that directly access digital input and counter modules. Such programs may utilize the library routine described in Section 18.3 to read data from these modules.

18.7.2 Module Support

18.7.2.1 IAD-IA A/D Converter and IMX-IA Multiplexer

MACRO Interface: Identical to UDC11 driver
FORTRAN Interface: Same as UDC11

Functional Differences:

The ICS/ICR driver can initiate parallel conversions on each IAD-IA in a file box that is referenced by a single QIO request. The UDC11 driver performs all conversions serially.

The ICS/ICR driver supports any permissible configuration of IAD-IA A/D converters and IMX-IA multiplexers. The UDC11 driver requires that eight module slots be reserved for each IAD-IA in the system regardless of the actual number of multiplexers installed.

18.7.2.2 **16-Bit Binary Counter**

MACRO Interface: Identical to UDC11 driver

FORTRAN Interface: Same as UDC11; however, if the counter is read through a call to RDTI then the task must be relinked to incorporate the revised FORTRAN Interface routine.

Functional differences:

The ICS/ICR driver permits any task to reset an initial counter value (via FORTRAN call SCTI or through the IO.ITI QIO function). The UDC11 driver restricts this operation to a task that has connected to counter interrupts.

18.7.2.3 **Bistable Digital Output**

MACRO Interface: Identical to UDC11
FORTRAN Interface: Identical to UDC11

Functional Differences: None

18.7.2.4 **Momentary Digital Output**

MACRO Interface:

User interface is via the QIO IO.MSO issued to the ICS/ICR-11 driver. The UDC11 driver does not support this function since the module may be accessed directly through the UDC device common block.

FORTRAN Interface:

Identical to UDC11; however, existing FORTRAN tasks must be relinked to include ICS/ICR11 FORTRAN interface routines.

Functional Differences:

Momentary output operations are now processed by the ICS/ICR driver, rather than through direct access to the I/O page.

18.7.2.5 **Noninterrupting Digital Input**

MACRO Interface:

MACRO Interface is by means of the ICS/ICR11 device common block and mapping table described in Section 18.6.

FORTRAN Interface: Identical to UDC11; however, existing tasks must be relinked to include revised ICS/ICR11 FORTRAN interface routines.

Functional Differences: None

18.7.2.6 **Analog Output**

MACRO Interface:

User interface is via the QIO IO.SAO issued to the ICS/ICR driver. The UDC11 driver does not support this function since the module may be accessed directly through the UDC device common block.

FORTRAN Interface:

Identical to UDC11; however, existing FORTRAN tasks must be relinked to include ICS/ICR11 FORTRAN interface subroutines.

Functional Differences:

Analog output operations are now processed by the ICS/ICR driver rather than through direct access to the I/O page.

18.7.2.7 **Interrupting Digital Input**

MACRO Interface: Identical to UDC11 driver

FORTRAN Interface:

Identical to UDC11 driver; however, if digital inputs are read through the call to RCIPT then the task must be relinked to incorporate the revised ICS/ICR11 FORTRAN interface routines.

Functional Differences: None.

CHAPTER 19

NULL DEVICE DRIVER

RSX-11M provides a driver for a software construct called the "null device." The mnemonic for the null device is NL:. Its characteristics are as follows:

- A read from NL: returns an end-of-file error (IE.EOF).
- A write to NL: immediately returns success (IS.SUC).

The null device functions as a "black hole" to which you can direct output, and from which it will never return. It is particularly useful when used in conjunction with an indirect command file and MCR ASN commands, as in the example below.

Figure 19-1 shows the contents of a Task Builder command file called TESTBLD.CMD. Symbolic device names are used for the output file, map file, and input file. These names may be reassigned at task-build time. In particular, in the example below, the map file is assigned to the null device and thus is thrown away.

```
>ASN SY:=OU:

>ASN NL:=MP:

>ASN DK1:=IN:

>TKB @TESTBLD
```

```
OU:TEST,MP:TEST=IN:[200,220]TEST
/
ASG=TI:2
//
```

Figure 19-1 Indirect TKB Command File TESTBLD.CMD.

CHAPTER 20

GRAPHICS DISPLAY DRIVER

20.1 INTRODUCTION

RSX-11M provides support for two graphics display peripherals, the VT11 and the VS60. Graphics display drivers are not supported in RSX-11M-PLUS systems. Each consists of a CRT display, light pen, and display-processing unit (DPU). Either may be purchased separately or as part of a complete system. For example, the GT46 is a "starter system" consisting of a VT11 and a PDP-11T/34 with 32K words of memory and disk storage.

20.1.1 VT11 Graphics Display Subsystem

The VT11 is a low-cost, line-drawing graphics display subsystem. It steals cycles asynchronously from the CPU whose UNIBUS it shares. Its DPU instruction set supports the following features:

- Relative and absolute vectors -- solid, long dash, short dash, or dotted
- Point plotting
- Character generation
- Blinking display
- Eight levels of intensity
- Light-pen interaction.

20.1.2 VS60 Graphics Display Subsystem

The VS60 supports all these features at a higher rate of performance than the VT11. In addition, the VS60 supports hardware subroutining, scaling, and windowing. A second CRT may be added to the VS60.

20.2 GET LUN INFORMATION MACRO

Word 2 of the buffer filled by the GET LUN INFORMATION system directive (the first characteristics word) contains zeros in all bits for graphics display devices. Words 3, 4, and 5 are undefined.

20.3 QIO MACRO

Table 20-1 lists the standard and device-specific functions of the QIO macro that are valid for graphics display devices.

The standard QIO functions IO.ATT and IO.DET have little use in the graphics display driver, because the specific functions IO.CON and IO.DIS are available.

Table 20-1
Standard and Device-Specific QIO Functions for Graphics Displays

Format	Function
STANDARD FUNCTIONS:	
QIO$C IO.ATT,...	Attach device
QIO$C IO.DET,...	Detach device
QIO$C IO.KIL,...	Cancel I/O requests
DEVICE-SPECIFIC FUNCTIONS:	
QIO$C IO.CON,...,<stadd,size [,lpef] [,lpast]>	Connect to graphics device, start DPU
QIO$C IO.CNT,...	Continue (restart DPU)
QIO$C IO.DIS,...	Disconnect from graphics device, halt DPU
QIO$C IO.STP,...	Stop (halt DPU)

Where: stadd is the starting address of a display file (must be word-aligned). The display file must be within the lowest 28K of physical memory for the VT11.

size is the size of the display buffer in bytes.

lpef is the optional number of an event flag to be set upon light-pen hit; in the range 1-64 (decimal).

lpast is the optional address of an asynchronous system trap (AST) entry point to be used upon light-pen hit.

20.4 STATUS RETURNS

Table 20-2 lists error and status conditions that are returned by the graphics display driver in the first word of the I/O status block. The second I/O status word always contains zero.

Table 20-2
Graphics Display Status Returns

Code	Reason
IS.SUC	Successful completion The operation specified in the QIO directive was completed successfully.
IE.ABO	Operation aborted The I/O operation was cancelled by IO.KIL while in progress or in the I/O queue.
IE.CNR	Connection rejected The graphics device specified in an IO.CON function was already connected to another task.
IE.DNA	Device not attached The graphics device specified in an IO.DET function was not attached to the issuing task.
IE.IEF	Illegal event flag An event flag number specified in an IO.CON function (lpef argument) was not in the range 1-64 decimal.
IE.IFC	Illegal function code A function code was specified in an I/O request that is illegal for graphics display devices.
IE.SPC	Illegal address space The display buffer specified in an IO.CON function (stadd argument) was not word-aligned, or (for VT11 only) was not completely within the lowest 28K of memory.

20.5 PROGRAMMING HINTS

The graphics display driver does not determine what appears on the screen of the VT11 or VS60. The key to what is drawn is the collection of DPU instructions in the display buffer.

Under normal circumstances, the display buffer is generated by calls to a set of FORTRAN graphics subroutines. These subroutines provide a more convenient access to the graphics features of the hardware than do the raw DPU instructions. The subroutines are described in the DECgraphic-11 FORTRAN Reference Manual, order number DEC-11-GFRMA-A-D.

Aborting a VT11 task may cause an RSX-11M system to hang up indefinitely, requiring a bootstrap. The VT11 DPU has no Halt instruction, but the I/O driver must halt the DPU before it can return a success status in response to an IO.KIL request. (IO.KIL is automatically generated when a task is aborted.) This hang situation can not arise with a VS60.

CHAPTER 21

LABORATORY PERIPHERAL ACCELERATOR DRIVER

21.1 INTRODUCTION

The Laboratory Peripheral Accelerator (LPA11-K) is an intelligent, direct memory access (DMA) controller for DIGITAL's laboratory data acquisition I/O devices. It is a fast, flexible, and easy to use microprocessor subsystem that allows analog data acquisition rates up to 150,000 samples per second. The LPA11-K is designed for applications requiring concurrent data acquisition and data reduction at high rates.

The LPA11-K is supported through a device driver and a set of program-callable routines. The device driver supports multiple controllers and can be configured as resident or loadable. The program-callable support routines are linked with the user's task at task build time. These routines are highly modular. Therefore, a particular task contains only that code necessary for the facilities actually used.

The LPA11-K operates in two distinct modes -- dedicated and multirequest. The subsections that follow summarize each mode.

21.1.1 LPA11-K Dedicated Mode of Operation

In dedicated mode, only one user (i.e., one request) can be active at a time and only analog I/O data transfers are supported. Up to two analog converters can be controlled simultaneously. Sampling is initiated by an overflow of the real-time clock or by an externally supplied signal.

21.1.2 LPA11-K Multirequest Mode of Operation

In multirequest mode, sampling from all device types is supported. Up to eight users can be simultaneously active. The sampling rate for each user is a multiple of the common real-time clock rate. Independent rates can be maintained for each user. Both the sampling rate and the device type are specified as part of each data transfer request.

21.2 GET LUN INFORMATION MACRO

If a Get LUN Information system directive is issued for a LUN associated with an LPA11-K, word 2 (the first characteristics word) contains all zeros, words 3 and 4 are undefined, and word 5 contains a

16-bit buffer preset value that controls the rate of the real-time clock interrupts.

21.3 THE PROGRAM INTERFACE

A collection of program-callable subroutines provides access to the LPA11-K. The formats of these calls are fully documented here for FORTRAN programs. MACRO-11 programmers access these same subroutines either through the standard subroutine linkage or through the use of two special-purpose macros. Optionally, MACRO-11 users can control an LPA11-K directly through the use of device-specific QIO functions. Both FORTRAN and MACRO programs must contain at least one I/O Status Block (IOSB) for retrieval of status information. The following subsections, therefore, describe:

- The FORTRAN interface
- The MACRO-11 interface
- The I/O status block

NOTE

The subroutines documented in this chapter represent the high-level interface to the LPA11-K. Use of these subroutines requires an understanding of hardware capabilities, configuration details, and hardware status codes as described in the LPA11-K Laboratory Peripheral Accelerator User's Guide.

21.3.1 FORTRAN Interface

Table 21-1 lists the FORTRAN interface subroutines for accessing the LPA11-K.

Table 21-1
FORTRAN Subroutines for the LPA11-K

Subroutine	Function
ADSWP	Initiate synchronous A/D sweep
CLOCKA	Set Clock A rate
CLOCKB	Control Clock B
CVADF	Convert A/D input to floating point
DASWP	Initiate synchronous D/A sweep
DISWP	Initiate synchronous digital input sweep
DOSWP	Initiate synchronous digital output sweep

(continued on next page)

Table 21-1 (Cont.)
FORTRAN Subroutines for the LPA11-K

Subroutine	Function
FLT16	Convert unsigned integer to a real constant
IBFSTS	Get buffer status
IGTBUF	Return buffer number
INXTBF	Set next buffer
IWTBUF	Wait for buffer
LAMSKS	Set masks buffer
RLSBUF	Release data buffer
RMVBUF	Remove buffer from device queue
SETADC	Set channel information
SETIBF	Set array for buffered sweep
STPSWP	Stop sweep
XRATE	Compute clock rate and preset

The calling sequences of the routines listed in Table 21-1 are compatible with the K-series support routines, described in Chapter 22, except as noted. The following subsections briefly describe the function and format of each FORTRAN subroutine call.

21.3.1.1 **ADSWP: Initiate Synchronous A/D Sweep** - The ADSWP routine initiates a synchronous A/D input sweep through an LPS-11 or an AD11-K (and, if present, the AM11-K).

If differential input is desired for the AD11-K/AM11-K, the channel increment must be set to 2 by calling the SETADC routine. The default channel increment is 1 (single-ended input).

The ADSWP call is as follows:

```
     CALL ADSWP (ibuf,lbuf,[nbuf],[mode],[idwell],[ietn],[ldelay],
                 [ichn],[nchn],[ind])
```

where

ibuf	is a 40-word array initialized by the SETIBF routine. The first two words of the array are the I/O status block (IOSB).
lbuf	is the size in words of each data buffer. All data buffers must be equal in size and lbuf must be greater than 0. In dedicated mode, lbuf must be at least 257 words.

nbuf	is the number of buffers to be filled. If nbuf is omitted or set equal to 0, indefinite sampling occurs. The STPSWP routine terminates indefinite sampling.
mode	specifies sampling options. The default is 0. The mode bit values listed below that are preceded by a plus sign (+) are independent and can be ADDed or ORed together (assuming that the sampling options are applicable to the mode of operation). Those values not preceded by a plus sign are mutually exclusive and only one such value can be used at a time. All bit values not listed below are reserved.

The following values can be specified:

0	Absolute channel addressing (default). This mode allows the user to directly access all 64 channels of an A/D converter.
+32	Dual A/D conversion serial/parallel. This option applies to dedicated mode only. It is ignored in multirequest mode.
+64	Multirequest mode. If this value is not specified, the request is for dedicated mode. If the request mode does not match the mode of the hardware (that is, different microcode in the master microprocessor), the LPA11-K rejects the request with an appropriate error code.
+512	External trigger (ST1). This mode is used when a user-supplied external sweep trigger is desired. The external trigger is supplied via a jumper connecting the AD11-K External Start input to the KW11-K Schmitt Trigger 1 output. This external trigger connection can only be used in Dedicated Mode. If mode 512 is selected, the user task must specify a Clock A rate of -1 for proper A/D sampling. This is non-clock driven sampling.
+1024	Time stamp with Clock B (Multirequest mode only).
+2048	Event marking (Multirequest mode only). LAMSKS must be called to specify an event mark channel and event mark mask.
+4096	Start method. If set, digital input start. If clear, immediate start. LAMSKS must be called to specify a digital start channel and digital start mask. (Multirequest mode only).
+8192	Dual A/D converter (Dedicated mode only).
+16384	Data overrun NON-FATAL/FATAL. If selected, data overrun is considered non-fatal. The LPA11-K automatically defaults to fill buffer 0. (See Section 21.4 for a discussion of buffer management.)

idwell — is the number of clock overflows (pulses) between data sample sequences. As an example, if idwell is 20 and nchn is 3, the following occurs: after 20 pulses, one channel is sampled on each of the next three pulses. Then, no sampling takes place for the next 20 pulses. In multirequest mode, this facility permits different sample rates for the same hardware clock rate and preset. In dedicated mode, the clock hardware rate controls sampling and this idwell argument is ignored.

If compatibility with K-series support routines is desired, the user task must first establish the clock preset by calling the CLOCKA routine. The default idwell value of 1 is used in the sweep start command. For the K-series, this procedure sets the rate as desired.

NOTE

This parameter is called iprset in the K-series support routines described in Chapter 22. Its function is different from the idwell parameter described here.

iefn — is the event flag (1 to 28, 30 to 96), the name of a completion routine, or 0. If 0 or defaulted, event flag 30 will be used for internal synchronization. If iefn is an event flag, the selected event flag is set as each buffer is filled. Note that event flag 29 is reserved for use by the LPA11-K support routines for internal synchronization. If iefn is greater than 96, it is considered to be a completion routine that will be called with a JSR PC. Such routines must return with an RTS PC (or a FORTRAN RETURN statement). Further, FORTRAN completion routines must not do any I/O through the FORTRAN runtime system, since this may cause unpredictable results or fatal task errors.

If multiple sweeps are initiated, the user should specify different event flags. Adherence to this limitation cannot be enforced by the software.

ldelay — is the delay from the start event (DR11-K) until the first sample in IRATE units. This feature is supported in multirequest mode only. Default or 0 indicates no delay.

ichn — is the number of the first channel to be sampled. The default of 0 applies only if ichn was not established in a prior call to the SETADC routine.

nchn — is the number of channels to sample. The default is 1. nchn may be set up with the SETADC routine. The number of channels specified are sampled at a rate of 1 per clock interrupt. If nchn equals 1, the single channel bit is set in the mode word of the start RDA.

ind receives a success or failure code as follows:

1 indicates that the sweep was successfully initialized.

0 indicates an illegal argument list, or SETIBF was not called prior to this call.

-1 indicates a QIO directive failure. The directive error code is placed in IOSB(1) in IBUF.

NOTE

The ind parameter is not supported by the K-series support routines. If compatibility with K-series support routines is desired, this parameter must be ignored.

21.3.1.2 **CLOCKA: Set Clock A Rate** - The CLOCKA routine sets the rate for Clock A. This routine is called as follows:

```
CALL CLOCKA (irate,iprset,[ind],[lun])
```

where

irate is the clock rate. One of the following must be specified:

-1	Direct-coupled Schmitt Trigger 1 (used only for A/D sweeps in Dedicated Mode +512. -- Not supported by K-series support routines)
0	Clock B overflow or no rate
1	1 MHz
2	100 KHz
3	10 KHz
4	1 KHz
5	100 Hz
6	Schmitt Trigger 1
7	Line frequency

iprset is the 2's complement value for clock preset. The clock rate divided by the negative clock preset value yields the clock overflow rate. For example, to obtain a clock overflow rate of 10 Khz with a clock rate of 1Mhz, iprset = -100. (minus 100 decimal). The XRATE routine can be used to calculate a clock preset value.

ind receives a success or failure code as follows:

0 indicates an illegal argument list or I/O error. Possible causes are: microcode not loaded; driver not loaded; device offline or not in system.

1 indicates Clock A set to start when sweep requested.

lun is the logical unit number. The default is 7.

21.3.1.3 **CLOCKB: Control Clock B** - The CLOCKB routine gives the user control over the KW11-K Clock B.

The CLOCKB call is as follows:

```
     CALL CLOCKB ([irate],iprset,mode,[ind],[lun])
```

where

irate — is the clock rate. When irate is nonzero, the clock is set running at the selected rate after the preset value specified by iprset is loaded. A zero irate stops the clock. When irate is 0 or default, the iprset and mode parameters are ignored.

The following values are acceptable for irate:

0	Stop Clock B
1	1MHz
2	100 KHz
3	10 KHz
4	1 KHz
5	100 Hz
6	Schmitt Trigger 3
7	Line frequency

iprset — is the count by which to divide clock rate to yield overflow rate. Overflow events can be used to drive clock A. The preset parameter must be specified as 0 or as a negative number in the range -1 to -255. The value in iprset can be established by use of the XRATE routine.

mode — specifies options. The mode bit values listed below that are preceded by a plus sign (+) are independent and can be ADDed or ORed together. Those values not preceded by a plus sign are mutually exclusive and only one such value can be used at a time. All bit values not listed below are reserved.

1 indicates Clock B operates in non-interrupt mode. The 16-bit clock is not incremented or altered. This allows a greater than 10KHz pulse to be sent to Clock A.

+2 indicates the feed B to A bit will be set in the Clock B status register.

ind — receives a success or failure code as follows:

0 indicates an illegal argument list or I/O error. Possible causes are: microcode not loaded; driver not loaded; device offline or not in system.

1 indicates Clock B started.

lun — is the logical unit number (LUN). The default LUN is 7.

21.3.1.4 **CVADF: Convert A/D Input to Floating Point** - The CVADF routine converts an A/D input value to a floating point number. The routine can be invoked as a subroutine or a function as follows:

```
     CALL CVADF (ival,val)
```

or

```
     val = CVADF(ival)
```

where

ival	is a value obtained from A/D input. Bits 12-15 are zero. Bits 0-11 represent the value.
val	(REAL*4) receives the converted value. The converted value is calculated with a gain equal to one.

21.3.1.5 **DASWP: Initiate Synchronous D/A Sweep** - The DASWP routine initiates synchronous D/A output to an AA11-K.

The DASWP call is as follows:

```
     CALL DASWP (ibuf,lbuf,[nbuf],[mode],[idwell],[iefn],ldelay,
                 [ichn],[nchn],[ind])
```

where

ibuf — is a 40-word array initialized by the SETIBF routine. The first two words of the array are the I/O status block (IOSB).

lbuf — is the size in words of each data buffer. All data buffers must be equal in size and lbuf must be greater than 0. In dedicated mode, lbuf must be at least 257 words.

nbuf — is the number of buffers to be filled. If nbuf is omitted or set equal to 0, indefinite sampling occurs. The STPSWP routine terminates indefinite sampling.

mode — specifies the start criteria. Except where noted, the plus sign (+) preceding mode bit values listed below indicates that they are independent and can be ADDed or ORed together. All bit values not listed below are reserved.

The following values can be specified:

0	indicates immediate start. This is the default.
+64	Multirequest mode. If this value is not specified, the request is for dedicated mode. If the request mode does not match the mode of the hardware (i.e., different microcode in master microprocessor), the LPA11-K rejects the request with an appropriate error code.
+4096	Start method. If set, digital input start. If clear, immediate start. LAMSKS must be called to specify a digital start channel and a digital start mask. (Multirequest mode only).

+16384 Data overrun NON-FATAL/FATAL. If selected, data overrun is considered non-fatal. The LPA11-K automatically fills buffer 0. (See Section 21.4 for a discussion of buffer management.)

idwell is the number of clock overflows (pulses) between data sample sequences. For example, if idwell is 20 and nchn is 3, the following occurs: after 20 pulses, one channel is sampled on each of the next three pulses. Then, no sampling takes place for the next 20 pulses. In multirequest mode, this facility permits different sample rates for the same hardware clock rate and preset. In dedicated mode, the clock hardware rate controls sampling and idwell in the sweep start command is ignored.

If compatibility with K-series support routines is desired, the user task must first establish the clock preset by calling the CLOCKA routine. The default value (1) for the idwell parameter in the sweep start command must be used. For the K-series, this procedure sets the rate as desired. For the LPA11-K this procedure results in idwell in the sweep call defaulting to 1, thus yielding the same clock rate.

NOTE

This parameter is called iprset in the K-series support routines described in Chapter 22. Its function is different from the idwell parameter described here.

iefn is an event flag number (1 to 28, 30 to 96), or the name of a completion routine, or 0. If 0 or default, event flag 30 is used for internal synchronization. If iefn is an event flag, the selected event flag is set as each buffer is filled. Note that event flag 29 is reserved for use by the LPA11-K support routines for internal synchronization. If iefn is greater than 96, it is considered to be a completion routine that will be called with a JSR PC. Such routines must return with an RTS PC instruction (or a FORTRAN RETURN statement). Further, FORTRAN completion routines must not perform I/O through the FORTRAN runtime system since this may cause unpredictable results or fatal task errors.

If multiple sweeps are initiated, the user task should specify different event flags. This limitation cannot be enforced by the LPA11 driver.

ldelay is the delay from start event (DR11-K) until the first sample in irate units. A minimum delay of 150 microseconds is required (not verified by the LPA11 driver). This feature is supported in multirequest mode only.

ichn is the first channel number. Default is channel number 0.

nchn is the number of channels. Default is 1 channel.

ind receives a success or failure code as follows:

1 indicates that the sweep was successfully initialized.

0 indicates an illegal argument list, or SETIBF was not called prior to this call.

-1 indicates a QIO directive failure. The directive error code is placed in IOSB(1) in IBUF.

NOTE

The ind parameter is not supported by the K-series support routines. If compatibility with K-series routines is desired, this parameter must be ignored.

21.3.1.6 **DISWP: Initiate Synchronous Digital Input Sweep** - The DISWP routine initiates a synchronous digital input sweep through a DR11-K. It can be called in multirequest mode only.

The DISWP call is as follows:

```
CALL DISWP (ibuf,lbuf,[nbuf],[mode],[idwell],[iefn],[ldelay],
            [iunit],[nchn],[ind])
```

where

ibuf is a 40-word array initialized by the SETIBF routine. The first two words of the array are the I/O status block (IOSB).

lbuf is the size in words of each data buffer. All data buffers must be equal in size and lbuf must be greater than 5.

nbuf is the number of buffers to be filled. If nbuf is 0 or defaulted, indefinite sampling occurs. The STPSWP routine is used to terminate indefinite sampling.

mode specifies the sampling options. The default is 0. The plus signs (+) preceding the mode bit values listed below indicate that they are independent and can be ADDed or ORed together. All bit values not listed below are reserved.

The following values can be specified:

0 Immediate start. This is the default mode.

+512 External trigger. The input sampling will be triggered by interrupts generated by the DR11-K's external control lines or its input bits if they are interrupt enabled.

+1024 Time stamped sampling with Clock B. The double word consists of one data word followed by the value of the 16-bit clock at the time of the sample. IOSB(2) contains the number of 2-word samples in the buffer.

+2048	Event marking. LAMSKS must be called to specify an event mark word and an event mark mask.
+4096	Start method. If specified, digital input start. If clear, immediate start. LAMSKS must be called to specify a digital start channel and a digital start mask. The digital start channel need not differ from the input channel (iunit).
+16384	Data overrun NON-FATAL/FATAL. If selected, data overrun is considered non-fatal. The LPA11-K automatically fills buffer 0. (See Section 21.4 for a discussion of buffer management.)

idwell is the number of clock overflows (pulses) between data sample sequences. As an example, if idwell is 20 and nchn is 3, the following occurs: after 20 pulses, one channel is sampled on each of the next three pulses. Then, no sampling takes place for the next 20 pulses. In multirequest mode, this facility permits different sample rates for the same hardware clock rate and preset.

If compatibility with K-series support routines is desired, the user task must first establish the clock preset by calling the CLOCKA routine. The default value (1) for the idwell parameter in the sweep start command must be used. For the K-series, this procedure sets the rate as desired. For the LPA11-K, this procedure results in idwell in the sweep call defaulting to 1, thus yielding the same clock rate.

NOTE

This parameter is called iprset in the K-series support routines described in Chapter 22. Its function is different from the idwell parameter described here.

iefn is an event flag number (1 to 28, 30 to 96), or the name of a completion routine, or 0. If default or a value of 0 is specified for iefn, event flag 30 is used for internal synchronization. If iefn is a valid event flag, the selected event flag is set as each buffer is filled. Note that event flag 29 is reserved for use by the LPA11-K support routines for internal synchronization. If iefn is greater than 96, it is considered to be a completion routine that will be called with a JSR PC. Such routines must return with an RTS PC instruction (or a FORTRAN RETURN statement). Further, FORTRAN completion routines must not perform I/O through the FORTRAN runtime system since this may cause unpredictable results or fatal task errors.

If multiple sweeps are initiated, the user task should specify different event flags. This limitation cannot be enforced by the LPA11 driver.

ldelay is the delay from start event (DR11-K) until the first sample in irate units. Default or 0 indicates no delay.

iunit — is the DR11-K unit number. Default is unit number 0. Values 0-4 are valid.

nchn — is the number of channels. The LPA11-K treats each DR11-K in its configuration as one channel. Default is 1 channel.

ind — receives a success or failure code as follows:

1 indicates that the sweep was successfully initialized.

0 indicates an illegal argument list, or SETIBF was not called prior to this call.

-1 indicates a QIO directive failure. The directive error code is placed in IOSB(1) in IBUF.

NOTE

The nchn and ind parameters are not supported by the K-series support routines. If compatibility with K-series support routines is desired, these last two parameters must be ignored.

21.3.1.7 **DOSWP: Initiate Synchronous Digital Output Sweep** - The DOSWP routine initiates a synchronous digital output sweep through a DR11-K. It can be called in multirequest mode only.

The DOSWP call is as follows:

```
CALL DOSWP (ibuf,lbuf,[nbuf],[mode],[idwell],[iefn],ldelay,
                [iunit],[nchn],[ind])
```

where

ibuf — is a 40-word array initialized by the SETIBF routine. The first two words of the array are the I/O status block (IOSB).

lbuf — is the size in words of each data buffer. All data buffers must be equal in size and lbuf must be greater than 5.

nbuf — is the number of buffers to be filled. If nbuf is 0 or default, indefinite sampling occurs. The STPSWP routine is used to terminate indefinite sampling.

mode — specifies the start criteria.

The following values can be specified in the high-order byte of mode:

0	Immediate start. This is the default mode.
+512	External trigger. The output sampling will be triggered by interrupts generated by the DR11-K's external control lines or its input bits if they are interrupt enabled.

+4096	Start method. If set, digital input start. If clear, immediate start. LAMSKS must be called to specify a digital start channel and a digital start mask. The digital start channel need not differ from the output channel (iunit).
+16384	Data overrun NON-FATAL/FATAL. If selected, data overrun is considered non-fatal The LPA11-K automatically fills buffer 0. (See Section 21.4 for a discussion of buffer management.)

idwell is the number of clock overflows (pulses) between data sample sequences. For example, if idwell is 20 and nchn is 3, the following occurs: after 20 pulses, one channel is sampled on each of the next three pulses. Then, no sampling takes place for the next 20 pulses. In multirequest mode, this facility permits different sample rates for the same hardware clock rate and preset.

If compatibility with K-series support routines is desired, the user task must first establish the clock preset by calling the CLOCKA routine. The default value (1) for the idwell parameter in the sweep start command must be used. For the K-series, this procedure sets the rate as desired. For the LPA11-K, this procedure results in idwell in the sweep call defaulting to 1, thus yielding the same clock rate.

NOTE

This parameter is called iprset in the K-series support routines described in Chapter 22. Its function is different from the idwell parameter described here.

iefn is an event flag number (1 to 28, 30 to 96), or the name of a completion routine, or 0. If default or a value of 0 is specified for iefn, event flag 30 is used for internal synchronization. If iefn is a valid event flag, the selected event flag is set as each buffer is filled. Note that event flag 29 is reserved for use by the LPA11-K support routines for internal synchronization. If iefn is greater than 96, it is considered to be a completion routine that will be called with a JSR PC. Such routines must return with an RTS PC instruction (or a FORTRAN RETURN statement). Further, FORTRAN completion routines must not perform I/O through the FORTRAN runtime system since this may cause unpredictable results or fatal task errors.

If multiple sweeps are initiated, the user task should specify different event flags. This limitation cannot be enforced by the LPA11 driver.

ldelay is the delay from start event (DR11-K) until the first sample in irate units. A minimum delay of 150 microseconds is required (not verified by the LPA11 driver).

iunit	is the DR11-K unit number. Default is unit number 0. Values 0-4 are valid.
nchn	is the number of channels. The LPA11-K treats each DR11-K in its configuration as one channel. Default is 1 channel.
ind	receives a success or failure code as follows:

- 1 indicates that the sweep was successfully initialted.
- 0 indicates an illegal argument list, or SETIBF was not called prior to this call.
- -1 indicates a QIO directive failure. The directive error code is placed in IOSB(1) in IBUF.

NOTE

The nchn and ind parameters are not supported by the K-series support routines. If compatibility with K-series support routines is desired, these last two parameters must be ignored.

21.3.1.8 **FLT16: Convert Unsigned Integer to a Real Constant** - The FLT16 routine converts an unsigned 16-bit integer to a real constant (REAL*4). It can be invoked as a subroutine or a function as follows:

```
     CALL FLT16 (ival,val)
```

or

```
     val=FLT16(ival[,val])
```

where

ival	is an unsigned 16-bit integer.
val	is the converted (REAL*4) value.

21.3.1.9 **IBFSTS: Get Buffer Status** - The IBFSTS routine returns information on buffers being used in a sweep.

The IBFSTS call is as follows:

```
     CALL IBFSTS (ibuf,istat)
```

where

ibuf	is the 40-word array specified in the call that initiated a sweep.
istat	is an array with as many elements as there are buffers involved in the sweep. The maximum is 8. IBFSTS fills each element in the array with the status of the corresponding buffer. The possible status codes are as follows:

+2	indicates that the buffer is in the device queue. That is, RLSBUF has been called for this buffer.
+1	indicates that the buffer is in the user task queue. That is, it is full of data (for input sweeps) or is available to be filled (for output sweeps).
0	indicates that the status of the buffer is unknown. That is, it is not the current buffer nor is it in either the device or the user queue.
-1	indicates that the buffer is currently in use.

21.3.1.10 **IGTBUF: Return Buffer Number** - The IGTBUF routine returns the number of the next buffer to use. This routine should be called by user task completion routines to determine which is the next buffer to access. It should not be used if an event flag was specified in the sweep-initiating call; if an event flag was specified, use the IWTBUF routine.

IGTBUF can be invoked as a subroutine or a function as follows:

```
     CALL IGTBUF (ibuf,ibufno)
```

or

```
     ibufno=IGTBUF(ibuf[,ibufno])
```

where

ibuf	is the 40-word array specified in the call that initiated a sweep.
ibufno	receives the number of the next buffer to access. If there is no buffer in the queue, ibufno contains -1.

On the return from a call to IGTBUF, the following are the possible combinations of ibufno and IOSB contents:

ibufno	IOSB(1)	IOSB(2)	Explanation
n	400 (octal)	(word count)	Normal buffer complete. Sweep still active.
n	1	(word count)	Buffer complete. Sweep terminated. There may be additional buffers in the queue filled and ready for processing.
-1	0	0	No buffers in queue. Request still active.
-1	1	0	No buffers in queue. Sweep terminated.

ibufno	IOSB(1)	IOSB(2)	Explanation
-1	RSX-11M error code (decimal)	LPA11-K error code (octal)	No buffers in queue. Sweep terminated due to error condition. (Refer to Section 21.3.3 for error code summary.) Note that the error is not returned until there are no more buffers in the user queue.

21.3.1.11 **INXTBF: Set Next Buffer** - The INXTBF routine alters the normal buffer selection algorithm. It allows the user task to specify the number of the next buffer to be filled or emptied.

INXTBF can be invoked as a subroutine or a function as follows:

```
     CALL INXTBF (ibuf,ibufno[,ind])
```

or

```
     ind=INXTBF(ibuf,ibufno[,ind])
```

where

ibuf	is the 40-word array specified in the call that initiated a sweep.
ibufno	is the number of the next buffer the user wants filled or emptied. The buffer must already be in the device queue.
ind	receives an indication of the result of the operation: 0 indicates that the specified buffer was not in the device queue. 1 indicates that the next buffer was successfully set.

21.3.1.12 **IWTBUF: Wait for Buffer** - The IWTBUF routine allows a user task to wait for the next buffer to fill or empty. It should be used in conjunction with the specification of an event flag in the sweep-initiating call. This routine should not be used if a completion routine was specified in the call to initiate a sweep; when event flags are specified, use the IGTBUF routine.

IWTBUF can be invoked as a subroutine or a function as follows:

```
     CALL IWTBUF (ibuf,[iefn],ibufno)
```

or

```
     ibufno=IWTBUF(ibuf,[iefn],[ibufno])
```

where

ibuf	is the 40-word array specified in the call that initiated a sweep.

iefn	is the event flag on which the task will wait. This should be the same event flag as that specified in the sweep-initiating call. If iefn equals 0 or default, event flag 30 is used.
ibufno	receives the number of the next buffer to be filled or emptied by the user task.

On the return from a call to IWTBUF, the following are the possible combinations of ibufno and IOSB contents:

ibufno	IOSB(1)	IOSB(2)	Explanation
n	400 (octal)	(word count)	Normal buffer complete. Sweep still active.
n	1	(word count)	Buffer complete. Sweep terminated. There may be additional buffers in the queue filled and ready for processing.
-1	1	0	No buffers in queue. Sweep terminated.
-1	RSX-11M error code (decimal)	LPA11-K error code (octal)	No buffers in queue. Sweep terminated due to to error condition. (Refer to Section 21.3.3 for error code summary.) Note that the error is not returned until there are no more buffers in the user queue.

21.3.1.13 **LAMSKS: Set Masks Buffer** - The LAMSKS routine initializes a user buffer containing a LUN, a digital start mask and event mark mask, and channel numbers for the two masks. The routine then assigns the LUN. Each DR11-K is considered to be one channel. Each channel has both input and output capabilities.

LAMSKS must be called if digital input starting or event marking is to be utilized, or if a LUN other than the default LUN 7 will be assigned to LA0. LAMSKS must also be called if multiple LPA11-Ks are being used. If LAMSKS is to be called it must be called prior to calling SETIBF. Unlike SETIBF, LAMSKS does not have to be called before each sweep initiation unless one or more parameters are to be changed.

The LAMSKS call is as follows:

```
     CALL LAMSKS (lamskb,[lun],[iunit],[idsc],[iemc],[idsw],
                  [iemw],[ind])
```

where

lamskb	is a 4-word array.
lun	is a logical unit number. Default LUN is 7.
iunit	is the physical unit number of the LPA11-K. Default physical unit number is LA0.

idsc	is the digital start word channel. Default is channel 0.
iemc	is the event mark word channel. Default is channel 0.
idsw	is the digital start word mask. Default is 0 (disable digital input starting).
iemw	is the event mark word mask. Default is 0 (disable event marking).
ind	receives a success or failure code as follows:

1 indicates successful initialization.

0 indicates an illegal argument list.

-n indicates a LUN assignment failure. n is the directive error code.

NOTE

If compatibility with K-series support routines is desired, ignore this parameter.

For a discussion of event marking and digital starting, see the LPA11-K Laboratory Peripheral Accelerator User's Guide.

21.3.1.14 **RLSBUF: Release Data Buffer** - The RLSBUF routine declares one or more buffers free for use by the interrupt service routine.

The RLSBUF routine must be called to release buffer(s) to the device queue before the sweep is initiated. The device queue must always contain at least one buffer to maintain continuous sampling. Otherwise, buffer overrun occurs (see Section 21.4 for a discussion of buffer management). Note that RLSBUF does not verify whether or not the specified buffers are already in a queue.

The RLSBUF call is as follows:

```
     CALL RLSBUF (ibuf,[ind],n0[,n1...,n7])
```

where

ibuf — is the 40-word array specified in the call that initiated a sweep.

ind — receives a success or failure code as follows:

0 indicates illegal buffer number specified, illegal number of buffers specified, or a double buffer overrun has been detected.

1 indicates buffer(s) successfully released.

n0,n1,etc. — are the numbers (0-7) of the buffers to be released. A maximum of eight can be specified.

21.3.1.15 **RMVBUF: Remove Buffer from Device Queue** - The RMVBUF routine removes a buffer from the device queue.

The RMVBUF call is as follows:

```
     CALL RMVBUF (ibuf,n[,ind])
```

where

ibuf	is the 40-word array specified in the call that initiated a sweep.
n	is the number of the buffer to remove.
ind	receives a success or failure code as follows: 0 indicates that the specified buffer was not in the device queue. 1 indicates that the specified buffer was removed from the queue.

21.3.1.16 **SETADC: Set Channel Information** - The SETADC routine establishes channel start and increment information for all sweeps. The SETIBF routine must be called to initialize the 40-word array (ibuf) before SETADC is called.

If, in the call to SETADC, nchn is 1 or inc is 0, the single channel bit will be set in the mode word of the start RDA when the sweep start routine is called.

SETADC can be invoked as a subroutine or a function as follows:

```
     CALL SETADC (ibuf,[iflag],[ichn],[nchn],[inc],[ind])

          or

     ind = ISTADC(ibuf,[iflag],[ichn],[nchn],[inc],[ind])
```

where

ibuf	is a 40-word array initialized by the SETIBF routine.
iflag	is ignored. It is included for compatibility with K-series support routines.
ichn	is the first channel number. Default is 0. If inc equals 0 (or default), ichn is the address of a random channel list. A random channel list is an array of n elements, where each element is a channel number. The final element must have bit 15 set to indicate the end of the list.
nchn	is the number of samples to be taken per sequence. Default is 1 sample.
inc	is the channel increment. Default is 1. The user should specify an increment of 2 for differential A/D input. If inc equals 0, ichn is an array of random channels to receive input.

ind	receives a success or failure code as follows: 0 indicates an illegal channel number or SETIBF was not called prior to the SETADC call. 1 indicates successful recording of channel information for the sweep call.

21.3.1.17 **SETIBF: Set Array for Buffered Sweep** - The SETIBF routine initializes an array required by buffered sweep routines.

The SETIBF call is as follows:

```
     CALL SETIBF (ibuf,[ind],[lamskb],buf0[,buf1...buf7])
```

where

ibuf	is a 40-word array.
ind	receives a success or failure code as follows: 0 indicates a parameter or buffer error. 1 indicates the array was successfully initialized.
lamskb	is the name of a 4-word array. This array allows the use of multiple LPA11-Ks within the same program, since the LUN is specified in the first word of the array. Refer to the description of the LAMSKS routine. If compatibility with K-series software is desired, the default (LUN 7) lamskb parameter should be used, and LUN 7 will be assigned to LA0: in the task build command file for the user task.
buf0, etc.	is the name of a buffer. A maximum of eight buffers can be specified. Any buffer names in excess of eight are ignored. At least two buffers must be specified to maintain continuous sampling.

Each buffer specified in the call to SETIBF is assigned a number ranging from 0 to 7.

The assignment of these numbers is based on the order in which buffer names appear in the argument list. The first buffer whose name appears in the list is assigned number 0, the second is assigned number 1, and so forth. In all subsequent calls to other routines involving the set of buffers specified in a call to SETIBF, these numbers, rather than names, are used to refer to particular buffers.

21.3.1.18 **STPSWP: Stop Sweep** - The STPSWP routine stops a sweep that is in progress.

The STPSWP call is as follows:

```
     CALL STPSWP (ibuf[,iwhen],[ind])
```

where

ibuf	is the 40-word array specified in the call that initiated a sweep.
iwhen	specifies when to stop the sweep:

- 0 stops the sweep immediately aborting the sweep. This is the default stop method. The sweep will be stopped asynchronously by the LPA11-K hardware. When IOSB(1) equals 1, the sweep has been stopped. Call IWTBUF continously after calling STPSWP until the sweep has actually been stopped. When stopping (aborting) a sweep in this manner the data contents of the current data buffer cannot be guaranteed.
- +n (any positive value) stops the sweep at the end of the current buffer. This is considered to be the normal means for stopping a sweep.
- -n (any negative value) is reserved. (Do not use.)

ind receives a success or failure code as follows:

- 1 indicates that the sweep will be stopped (at the time indicated by iwhen).
- 0 indicates an illegal argument list.
- -n is a directive error code indicating that the stop sweep QIO failed.

21.3.1.19 **XRATE: Compute Clock Rate and Preset** - The XRATE routine allows the user task to compute a clock rate and preset. The clock rate divided by the clock preset yields the desired dwell (inter-sample interval).

NOTE

The XRATE routine can be used only on systems that have a FORTRAN or BASIC-PLUS-2 compiler. This module is not included with the other LPA11-K support routines in object module format. Rather, it is included in source code format with the K-series source modules in [45,10] on the system disk.

XRATE can be invoked as a subroutine or a function as follows:

```
     CALL XRATE (dwell,irate,iprset,iflag)

          or

     adwell = XRATE(dwell,irate,iprset,iflag)
```

where

dwell	is the inter-sample time desired by the user. The time is expressed in decimal seconds (REAL*4).
irate	receives the computed clock rate as a value from 1 to 5.
iprset	receives the clock preset.
iflag	specifies whether the computation is intended for Clock A or Clock B: 0 indicates the computation is for Clock A. nonzero indicates the computation is for Clock B.
adwell	is the actual dwell rate for the clock based on the irate and iprset parameters.

21.3.2 MACRO-11 Interface

The MACRO-11 interface to the LPA11-K consists of either the callable routines described in Section 21.3.1 or a set of device-specific QIO functions.

21.3.2.1 **Accessing Callable LPA11-K Support Routines** - MACRO-11 programmers access the LPA11-K support routines through either of two techniques:

1. The standard subroutine linkage mechanism and the CALL op code.
2. Special-purpose macros that generate an argument list and invoke a subroutine.

These techniques are described in the following subsections.

21.3.2.1.1 **Standard Subroutine Linkage and CALL Op Code** - LPA11-K routines can be accessed through use of the standard subroutine linkage mechanism and the CALL op code. The format of this procedure is:

```
                .PSECT  code
                MOV     #arglist,R5   ;ARGUMENT ADDRESS TO R5
                CALL    lsubr         ;CALL LPA11-K ROUTINE

                .PSECT  data
     arglist:   .BYTE   narg,0        ;NUMBER OF ARGUMENTS
                .WORD   addr1         ;FIRST ARGUMENT ADDRESS
                      .
                      .
                      .
                .WORD   addrn         ;LAST ARGUMENT ADDRESS
```

In this sample, the two PSECT directives are shown only to indicate the noncontiguity of the code and data portions of the linkage mechanism. Within the argument list, any argument that is to be defaulted must be represented by a -1 address (i.e., 177777(8)).

21.3.2.1.2 **Special-Purpose Macros** - To facilitate the calling of LPA11-K support routines from a MACRO-11 program, two macros are provided in file [45,10]LABMAC.MAC. These macros are:

1. INITS

2. CALLS

INITS is an initialization macro. It must be invoked at the beginning of the MACRO-11 source module.

CALLS invokes an LPA11-K support routine. The format of this macro call is as follows:

```
     CALLS lsubr,<arg1,...,argn>
```

where

lsubr	is the name of an LPA11-K support routine.
arg1,etc.	are arguments to be formatted into an argument list and passed to the routine. Each argument can be either a symbolic name or a constant (interpreted as a positive decimal number) or can be defaulted.

An example showing the use of these macros is as follows:

```
        .TITLE  EXAMPLE
        .IDENT  /01.00/
IBUF:   .BLKW   40.
ISTAT:  .BLKW   5
        INITS           ; INITIALIZATION
          .
          .
          .
          .
          .
START:
          .
          .
          .
          .
          .
;
; FIND STATUS OF 5 SWEEP BUFFERS
; BEING USED IN CURRENT SWEEP
;
        CALLS   IBFSTS(IBUF,ISTAT)
          .
          .
          .
          .

        .END    START
```

21.3.2.2 **Device-Specific QIO Functions** - Table 21-2 lists the device-specific functions of the QIO system directive macro that are available for the LPA11-K. Programmers using these functions are entirely responsible for buffer management (refer to Section 21.4) as well as all other interfaces (for example, the request descriptor array). Little (if any) performance improvement over the use of FORTRAN support routines can be expected by using QIOs. Therefore, it is recommended that routines described in Section 21.3.1 be used.

Table 21-2
Device-Specific QIO Functions for the LPA11-K

QIO Function	Purpose
IO.CLK	Start clock
IO.INI	Initialize LPA11-K
IO.LOD	Load microcode
IO.STA	Start data transfer
IO.STP	Stop request

The MACRO-11 programmer must set up the appropriate Request Descriptor Array (RDA) before the corresponding QIO request is issued. In the case of the IO.STA function (start data transfer), the RDA is set up with buffer virtual addresses. The LPA11-K driver address checks and relocates these buffers, changing them from single word to double word addresses. The RDA is fully described in the source code of the driver.

21.3.2.2.1 **IO.CLK** - The IO.CLK function writes an image into the LPA11-K real-time clock control register and issues a clock start command. The format of the QIO request is:

```
QIO$C IO.CLK,...,<mode,ckcsr,preset>
```

where

mode	is the mode.
ckcsr	is the image to be written into the clock control register. To achieve the function of clock rate -1 (see Section 21.3.1.2), for Clock A only set a clock rate of 0 and set the Schmitt Trigger 1 Interrupt Enable bit in the Clock A Status Register.
preset	is the clock preset.

21.3.2.2.2 **IO.INI** - The IO.INI function initializes the LPA11-K. The task issuing the QIO request must be privileged. The format of the request is as follows:

```
QIO$C IO.INI,...,<irbuf,278.>
```

where

irbuf	is a buffer containing an LPA11-K initialize RDA. The buffer size must be at least 278. bytes.

21.3.2.2.3 **IO.LOD** - The IO.LOD function loads a buffer of LPA11-K microcode. The issuing task must be privileged. The function verifies that there are no active users for the LPA11-K and resets the hardware. It then loads and verifies the microcode, starts the LPA11-K and enables interrupts. The function returns to the issuing task when the Ready Interrupt is posted.

The format of the QIO request for the IO.LOD function is as follows:

```
QIO$C IO.LOD,...,<mbuf,2048.>
```

where

mbuf	is a buffer containing microcode to be loaded. The buffer size must be 2048. bytes.

21.3.2.2.4 **IO.STA** - The IO.STA function issues an LPA11-K data transfer start command. The format of the QIO request is:

```
QIO$C IO.STA,...,<bufptr,40.>
```

where

bufptr	is a pointer to a buffer containing an LPA11-K sample start RDA. The buffer size must be at least 40. bytes.

The subfunction codes defined for the IO.STA function are:

Bit 0 = 0	indicates that an AST is to be generated for every buffer (if an AST is specified).
Bit 0 = 1	indicates that an AST is to be generated only for exception conditions.

21.3.2.2.5 **IO.STP** - The IO.STP function stops a data transfer request. The issuing task must be the same task that initiated the data transfer. The format of the QIO request is as follows:

```
QIO$C IO.STP,...,<userid>
```

where

userid	is the index number associated with the user whose request is to be stopped.

21.3.3 The I/O Status Block (IOSB)

Each active sweep must have its own I/O status block. The I/O status block (IOSB) is a 2-word array allocated in the user program. It is used to receive the status of a call to an LPA11-K support routine. When a data sweep routine is called, the IOSB is always the first two words of the 40-word array specified as the first argument of the call. The first word of the IOSB contains the status code. The second word contains the buffer size in words.

NOTE

The 2-word IOSB is not directly used by the LPA11-K driver. Instead, the driver uses a 4-word IOSB for internal communications with support routines; this 4-word IOSB is completely transparent to FORTRAN support routine users. However, when issuing QIOs, it is the 4-word IOSB that must be referenced.

The first two words of the 4-word IOSB function as a 2-word overall IOSB for returning QIO completion status. The driver returns status such as sweep done, system errors, and LPA11-K hardware errors via this 2-word portion of the IOSB.

The remaining two words function as an intermediate IOSB for passing status information during the data sweeps. MACRO-11 programs using QIO calls always receive the correct 2-word portion of the IOSB in the AST generated by the LPA11-K driver.

The codes that can appear in the first word of an I/O status block are in ISA-compatible format (with the exception of the I/O pending condition). Table 21-3 lists all return codes.

Table 21-3
Contents of First Word of IOSB

IOSB(1)		Meaning
FORTRAN	MACRO	
0	IO.PND	Operation pending; I/O in progress
1	IS.SUC	Successful completion
301	IE.BAD	Invalid arguments
302	IE.IFC	Invalid function code
303	IE.DNR	Device not ready (See Section 21.7)
304	IE.VER	Unrecoverable hardware error caused by powerfail
305	IE.ULN	LUN not assigned to LPA11-K
306	IE.SPC	Illegal buffer specification
309	IE.DUN	Insufficient UMRs available for request

(continued on next page)

Table 21-3 (Cont.)
Contents of First Word of IOSB

IOSB(1)		Meaning
FORTRAN	MACRO	
313[1]	IE.DAO	Data overrun
315[1]	IE.ABO	Request terminated; LPA11-K status code in IOSB(2)
316	IE.PRI	Privilege violation
317[1]	IE.RSU	Resource in use (load microcode only)
320	IE.BLK	Executive blocked driver waiting for UMRs
323	IE.NOD	System dynamic memory exhausted
359[1]	IE.FHE	Fatal hardware error on device
366	IE.BCC	LPA11-K load microcode error
397	IE.IEF	Invalid Event Flag specified

[1] IOSB(2) contains an LPA11-K status code. Refer to the LPA11-K User's Manual for explanation of status code.

21.4 BUFFER MANAGEMENT

The management of buffers for data transfers by LPA11-K support routines involves the use of two FIFO (First-In, First-Out) queues:

1. The device queue (DVQ)
2. The user queue (USQ).

The device queue (DVQ) contains the numbers of all buffers that the user task has released to the support routines in a call to RLSBUF. The buffers represented by these numbers are ready to be filled with data (input sweeps) or to be emptied of data (output sweeps). Any buffer specified in a call to INXTBF must already be in DVQ.

The user queue (USQ) contains the numbers of buffers available to the user task. For output sweeps, this queue contains the numbers of buffers that have already been emptied by the driver. For input sweeps, the buffers represented by USQ are those which are filled with data. In both instances, the user task determines the next buffer to use (that is, it extracts the first element of USQ) by calling IGTBUF or IWTBUF.

Both the DVQ and USQ are initialized to -1, indicating no buffers, when the user task calls the SETIBF routine. The user task must call RLSBUF before initiating any sweep, since at least one buffer must be present in DVQ for the first input or output to occur.

For input sweeps, it is recommended that the user task call RLSBUF, specifying the numbers associated with all the buffers to be used in the sweep.

For output sweeps, the user task can specify two buffers (for continuous sweeps) in the call to RLSBUF. The first action then taken either in a completion routine or after a call to IWTBUF is to release the next buffer. However, note that this approach does not represent true multiple buffering since data overrun occurs if the second buffer is not released in time.

If a buffer overrun occurs, the LPA11-K normally aborts the affected sweep and returns an appropriate error code. However, the option of having buffer overruns treated as non-fatal error conditions can be selected by specifying the appropriate mode argument in any of the sweep calls. Then, when a buffer overrun occurs, the LPA11-K automatically defaults to buffer 0 for its next data buffer. In this case, the following special considerations regarding buffer management must be observed.

Call RLSBUF before calling any of the sweep control calls. However, if buffer overruns are to be treated as non-fatal conditions, the task should not specify buffer zero in the initial call to RLSBUF. (It is assumed at the outset that buffer zero is available for use in this manner and, therefore, should not be released.)

Once a buffer overrun has occurred, buffer 0 is used by the LPA11-K and placed on the user queue just like any other data buffer. At this point, buffer 0 is no longer available for buffer overruns. The task then removes buffer 0 from the user queue via IWTBUF or IGTBUF for possible processing. It is the task responsibility to release buffer 0 for future buffer overruns by specifying buffer 0 in a call to RLSBUF. Note that the task cannot determine that buffer overrun occurred until it receives buffer 0 from IWTBUF or IGTBUF.

The LPA11-K always uses buffer 0 following a buffer overrun if that condition was specified as non-fatal. Thus, when a second buffer overrun occurs before buffer 0 has been processed and made available for that purpose, a condition called "double buffer overrun" occurs. In this case, buffer 0 is not put on the user queue since the actual contents of buffer 0 cannot be determined at this time, and buffer 0 may actually still be on that queue. The double buffer overrun condition is detected when the task attempts to make buffer 0 available for future buffer overruns via the call to RLSBUF. Note that this is the first time that the task is notified of the condition. If a double buffer overrun condition is detected during the call to RLSBUF, the task must be notified of the condition indicating that the previous processing of buffer 0 contents may have been of no value (the LPA11-K probably changed the buffer's contents while it was being processed).

21.5 **LOADING THE LPA-11 MICROCODE**

LAINIT is a privileged task that is used to load all versions of LPA11-K microcode. When called, LAINIT issues an IO.LOD function in a QIO request, followed by IO.INI and IO.CLK function requests. The IO.CLK function starts the clock with a default clock rate of 1 MHz.

During SYSGEN Phase 1, a command file is generated with LPA11-K support selected through operator response to SYSGEN questions. During SYSGEN Phase 2, the command file builds LAINIT using additional information obtained through operator response to SYSGEN questions. This information further defines the LPA11-Ks system environment and characteristics for the specific user application.

Separate tasks are built during SYSGEN that invoke LAINIT to load appropriate LPA11-K microcode. These tasks are named LAINn, where n corresponds to unit number (starting with unit number 0) for each LPA11-K unit in the system. Thus, LAINIT is never directly invoked by the user.

SYSGEN automatically generates command lines in INSTALL.CMD that will install LAINIT and LAIN0; LAIN1 and subsequent LPA11-K unit-numbered tasks are not automatically included in the command file. Thus, the user must install these tasks (if they are required) via VMR or MCR.

Once LAINIT and LAINn tasks have been installed, a particular version of LPA11-K microcode for a specific unit can be loaded by running the corresponding LAINn task. For example,

```
>RUN LAIN2
```

executes LAIN2, loading microcode for LPA11-K unit 2.

When a powerfail recovery occurs, the LPA11-K driver terminates all outstanding activity and requests execution of initiating task(s) (LAINn) for each unit. This automatically provides powerfail recovery for the LPA11-K microprocessor, provided the LAINIT and LAINn tasks are installed. Note that when the RSX-11M system is either bootstrapped or the LPA11-K driver is loaded, a simulated powerfail (resulting in driver powerfail recovery) occurs, loading microcode for each LPA11-K unit. In addition, when the LPA11-K is brought on-line on an RSX-11M-PLUS system, a simulated powerfail occurs.

If the request for the initiating task (LAINn) fails or the loader fails to load the driver, the LPA11-K unit does not become initialized. Any further attempt to use the LPA11-K will fail with the device not ready (IE.DNR) code returned to the requesting task.

All versions of LAINn set the real-time clock frequency to 1MHz by default. The UCB device characteristics word 4 (U.CW4) contains a 16-bit buffer preset value that controls the rate of ticks (that is, the rate at which the clock interrupts). This value can be set dynamically or during SYSGEN. The quotient resulting when this value is divided into 1 MHz is the rate of ticks. For example, if U.CW4 contains 2, the tick rate is 500kHZ. The user can issue a Get LUN Information system directive to examine the preset value and the MCR SET /BUF command can be used to modify it while the system is running. This modification will take effect the next time the LPA11-K is reloaded with micro-code via LAINx.

21.6 UNLOADING THE DRIVER

In order to attain maximum LPA11-K performance, the LPA11-K driver is designed to appear not busy to the RSX-11M/M-PLUS Executive. As a result, the potential problem exists that any privileged user can unload the driver while the LPA11-K is servicing other users. Therefore, the user must first determine that the LPA11-K is not being used prior to unloading the driver.

21.7 TIMEOUT OF THE LPA11-K

The error code IO.DNR means that the LPA11-K timed out while processing a user request. In dedicated mode, this condition can have special meaning.

The LPA11-K driver (LADRV) disables the timeout countdown following LPA11-K acknowledgement of the user task request. In all cases in multi-request mode, and in most cases in dedicated mode, this acknowledgement is received almost immediately after the user task request is passed to the LPA11-K. The only case when this is not true is when the user task requests that a data sweep be started while in dedicated mode. In this case, the LPA11-K waits to transfer the first 256 words of data before acknowledging the sweep request.

If a task is sampling at extremely slow data rates in dedicated mode, the time to transfer that first 256 words may exceed the timeout count for the device. This can be avoided by using the multi-request mode.

If a task must use dedicated mode for high sampling rates, and the start of the sweep will be delayed for an extended period of time, the timeout count for the LPA11-K must be disabled. (Refer to the note in LADRV describing this timeout problem and showing where the timeout can be safely disabled for sweep calls.)

NOTE

This procedure will disable the detection of real timeouts for sweep calls in dedicated mode.

21.8 22-BIT ADDRESSING SUPPORT

The LPA11-K driver supports 22-bit addressing on systems having that capability. When the system employs 22-bit addressing, certain restrictions are imposed. As a result, tasks written for use with earlier LPA11-K driver versions may not run without user task modifications. These restrictions are discussed in the remainder of this section.

When the LPA11-K driver is executed on 22-bit systems, a certain contiguity of user task data structures must be established. The task data transfer buffers and the IBUF array must be contiguous. In addition the task random channel list (if present) and the last data transfer buffer must be contiguous. Thus, the correct sequence for user task data is the IBUF array, followed by the task data transfer buffers, followed by the task random channel list. Failure to structure the user task data in this manner can result in illegal buffer specification errors (IE.SPC) being returned or possible corruption of task address space by data sweeps.

Since the LPA11-K user task can potentially request more buffer space than there is UMR mapping space, a limit on the total number of UMRs that can be used by the LPA11-K driver at any time must be specified. This limit is specified during SYSGEN part 1, along with the interrupt vector and CSR address for the LPA11-K.

If a task UMR requirements will cause the total number of UMRs currently in use by the LPA11-K to exceed the SYSGEN-specified limit, the task will receive an Insufficient UMRs Available For Request (IE.DUN) error code in IOSB(1) of the IBUF array.

This condition can be avoided by setting the UMR limit to the expected minimum number required for smooth LPA11-K operation for all expected users. Since each UMR maps 8K bytes, each user's requirements can be calculated as follows:

- Each IBUF array requires 76. bytes of UMR mapping
- Add this result to the byte length of all the contiguous transfer buffers to be used in the sweep
- Add this result to the byte length of the random channel list (if it exists)
- The number of UMRs the user task needs is the total byte count divided by 8192 (8K) and rounded up to the next 8K (if not an exact multiple of 8192).

Because there are only 31 UMRs available for the entire system, it is not desirable to allow the LPA11-K driver (through the SYSGEN-specified limit) to have access to all or nearly all UMRs at any given time. Since other device drivers may also require UMR mapping, the total allocation of UMRs by LADRV can slowly choke a system, and for that reason allocation of UMRs must be carefully considered.

The UMR allocation limit for the LPA11-K can be changed by directly modifying the value in the LPA11-K's UCB word U.LAUB; it is not necessary to do another SYSGEN. Use the OPEN command to access and change the limit to the new value. Possible values can range from 0-31. Then, make the required change, UNLOAD, and then LOAD the LPA11-K driver. If the LPA11-K driver is resident, the value in U.LAUB+2 must also be changed to the new value.

NOTE

Be sure the LPA11-K is idle before attempting to access the UCB.

It is possible for a condition to exist where there may not be enough UMRs available for the Executive to allocate to the driver at the time the request is made, even if the number of UMRs necessary to map the user task's request are within the SYSGEN-defined limit. When this happens, the Executive blocks the driver until its UMR request can be granted. Since this condition can introduce sweep timing errors, the current sweep is unconditionally aborted and an appropriate error code (IE.BLK) is returned to the task in IOSB(1).

21.9 SAMPLE PROGRAMS

```
C       LPA11-K SAMPLE PROGRAM
C
C SAMPLE SHOWS THE BASIC FLOW FOR PROGRAMMING THE LPA11-K IN A HIGHER
C LEVEL LANGUAGE.  IT IS EXPECTED THE USER WILL TEST IOSB RETURNS AND
C ERROR INDICATORS (IND) AS NECESSARY.  SYNCHRONOUS PROGRAM TERMINATION
C IS SUGGESTED. NOTE: THIS SAMPLE PROGRAM WILL NOT EXECUTE CORRECTLY IN
C 22-BIT MODE
C
C       D/A DEDICATED MODE WITH CONTINUOUS SAMPLING
C
C       PROGRAM RUNS 3 LOOPS (BASED ON NCNT).  ON FIRST LOOP,
C       STOPS SYNCHRONOUSLY AT END OF PRESENT BUFFER WHICH HAPPENS
C       TO BE BUFFER #3 BEING FILLED FOR THE 2ND TIME.
C       THE 2ND LOOP TERMINATES ASYNCHRONOUSLY (IWHEN=0).
C       THE 3RD LOOP TERMINATES ASYNCHRONOUSLY ALSO.
C
C
        DIMENSION IBUF(40),IOSB(2),NB(1024,8)
        EQUIVALENCE (IBUF(1),IOSB(1))
        EQUIVALENCE (N0,NB(1,1)),(N1,NB(1,2)),(N2,NB(1,3)),(N3,NB(1,4))
        EQUIVALENCE (N4,NB(1,5)),(N5,NB(1,6)),(N6,NB(1,7)),(N7,NB(1,8))
        CALL CLOCKA (4,-1)
        IWHEN=1
        NCNT=0
2       ICNT=1
    5   CALL SETIBF(IBUF,IND,,N0,N1,N2,N3)
C
C INITIALIZE BUFFERS TO ALL -2'S
C
        DO 10 J=1,8
        DO 10 K=1,1024
   10   NB(K,J)=-2
        CALL RLSBUF(IBUF,IND,1,2,3)
        CALL DASWP(IBUF,1024,,,,20)
20      CALL IWTBUF(IBUF,20,IBUFNO)
        CALL RLSBUF (IBUF,IND,IBUFNO)
        WRITE (1,300) IBUFNO,IOSB(1),IOSB(2),ICNT
        IF (NCNT.EQ.3) GOTO 40
        IF (ICNT.EQ.6) GOTO 2
        ICNT=ICNT+1
        IF (ICNT.NE.4) GOTO 20
        CALL STPSWP (IBUF,IBUFNO)
        IWHEN=0
        NCNT=NCNT+1
        GOTO 20
40      CALL IGTBUF(IBUF,IBUFNO)
        WRITE (1,300) IBUFNO,IOSB(1),IOSB(2),ICNT
300     FORMAT (3X,I10,2O8,I10)
        STOP
        END
```

The following sample program will test the digital I/O interface of the LPA11-K. It will execute correctly in 22-bit mode.

```
C
C PROGRAM TO TEST DIGITAL INPUT AND OUTPUT FOR LPA11-K
C DIGITAL EQUIPMENT CORPORATION
C
C THIS PROGRAM IS DESIGNED TO OUTPUT A DATA BUFFER TO THE LPA11-K
C DIGITAL I/O INTERFACE AND AT THE SAME INSTANT FOR EACH SAMPLE
C WORD READ THE RESULTS BACK. THE DATA BUFFERS ARE COMPARED TO
C MAKE SURE THE TRANSFER IS COMPLETED SUCCESSFULLY.
```

```
C
C  ****** NOTE! ******
C       THIS PROGRAM WILL WORK IF AND ONLY IF THE DIGITAL I/O MODULE
C       UNIT SPECIFIED HAS THE MAINTENANCE JUMPER "WRAP-AROUND" CABLE
C       INSTALLED !!!!
C
C
C RESERVE STORAGE FOR LPA11-K ROUTINES
C
C       THIS PROGRAM WILL WORK IN 22-BIT MODE
C
C DATA BUFFERS
C
        INTEGER*2 IBUFI(40),INBUF(300,4)
        INTEGER*2 COMMI(1240)
        EQUIVALENCE(IBUFI(1),COMMI(1))
        EQUIVALENCE(INBUF(1,1),COMMI(41))

        INTEGER*2 IBUFO(40),OUTBUF(300,4)
        INTEGER*2 COMMO(1240)
        EQUIVALENCE(IBUFO(1),COMMO(1))
        EQUIVALENCE(OUTBUF(1,1),COMMO(41))

C RESERVE STORAGE AND EQUIVALENCE FOR RSX I/O STATUS BLOCKS
        LOGICAL*1 INIOS(4),OUTIOS(4)
        EQUIVALENCE (IBUFO(1),OUTIOS(1)),(IBUFI(1),INIOS(1))
C
C SET BUFFER SIZE TO USE FOR THIS REQUEST - MAXIMUM OF 300 WITHOUT
C CHANGING THE DIMENSION STATEMENTS. MUST BE EVEN!
        ISIZE=300
C
C INITIALIZE THE PASS COUNTER FOR THE LOOP
        IPASS=1
C
C SET LPA11-K LOGICAL UNIT NUMBER AND ASSIGN IT TO LA0:
        ILUN=7
        CALL ASSIGN(ILUN,'LA:',0,ISTAT)
        IF(ISTAT .LT. 0)GO TO 100
C
C INITIALIZE THE OUTPUT DATA BUFFER
        DO 2 J=1,4
        DO 2 I=1,ISIZE,2
        OUTBUF(I,J)="125252
        OUTBUF(I+1,J)="052525
2       CONTINUE
C
C STOP LPA11-K REAL TIME CLOCK "A" THIS WILL MAKE SURE THAT
C NOTHING HAPPENS WHEN WE INITIALIZE THE TWO SWEEPS.
5       CALL CLOCKA(0,0,ISTAT,ILUN)
        IF(ISTAT .NE. 1)GO TO 110
C
C INITIALIZE THE INPUT DATA BUFFER. ASSUME THE LPA11-K DIGITAL
C I/O INTERFACE IS CONFIGURED IN THE DATA LATCH MODE (AS OPPOSED
C TO SENSE). THUS THE OUTPUT DATA BUFFER MUST CONTAIN A BIT CHANGE
C FOR EVERY BIT POSITION IN SUCCEEDING DATA WORDS.
        DO 10 J=1,4
        DO 10 I=1,ISIZE
        INBUF(I,J)=0
10      CONTINUE
C
C INITIALIZE DIGITAL OUTPUT SWEEP.  THIS MUST BE DONE BEFORE INIT
C OF DIGITAL INPUT SWEEP! THE LPA11-K PROCESSES THE TRANSFER OF
C DATA IN THE ORDER OF THE SPECIFICATION OF THE SWEEPS.  THUS WE
C WANT TO OUTPUT BEFORE WE INPUT.
```

```
        CALL SETIBF(IBUFO,ISTAT,,OUTBUF(1,1),OUTBUF(1,2),OUTBUF(1,3),
        1   OUTBUF(1,4))
        IF(ISTAT .NE. 1)GO TO 120
C
C RELEASE BUFFER FOR OUTPUT SWEEP
C ALL FOUR BUFFERS -- INDEXES 0,1,2,3 -- ARE RELEASED
        CALL RLSBUF(IBUFO,ISTAT,0,1,2,3)
        IF(ISTAT .NE. 1)GO TO 130
C
C "START" DIGITAL OUTPUT SWEEP. REMEMBER NOTHING WILL HAPPEN UNTIL
C WE START THE REAL TIME CLOCK. THE LPA11-K WILL PROCESS THE REQUEST
C AND BE ALREADY TO TRANSFER DATA WHEN WE RESUME THE CLOCK.
C EVENT FLAG 14 IS SPECIFIED. A DIFFERENT EVENT FLAG MUST BE
C SPECIFIED FOR THE DIGITAL INPUT SWEEP SO THE FORTRAN PROGRAM
C CAN SYNCHRONIZE WITH TWO INDEPENDENT, ASYNCHRONOUS PROCESSES.
        CALL DOSWP(IBUFO,ISIZE,4,0,1,14,30,0)
C
C
C NOW INITIALIZE FOR DIGITAL INPUT SWEEP.  THE SAMPLING PARAMETERS
C MUST BE THE SAME FOR BOTH THE INPUT AND OUTPUT SWEEP.  WE WANT
C TO WRITE AND READ THE SAME DATA WORD AT THE SAME TIME.
        CALL SETIBF(IBUFI,ISTAT,,INBUF(1,1),INBUF(1,2),INBUF(1,3),
        1   INBUF(1,4))
        IF(ISTAT .NE. 1)GO TO 140
C
C RELEASE THE INPUT BUFFERS
        CALL RLSBUF(IBUFI,ISTAT,0,1,2,3)
        IF(ISTAT .NE. 1)GO TO 150
C
C "START DIGITAL OUTPUT SWEEP. AGAIN, NOTHING WILL HAPPEN UNTIL
C WE RESUME THE LPA11-K REAL TIME CLOCK.
C EVENT FLAG 15 IS SPECIFIED TO SEPARATE THE INPUT AND OUTPUT SWEEPS.
        CALL DISWP(IBUFI,ISIZE,4,0,1,15,30,0)
C
C NOW FOR THE BIG EVENT! WE START THE CLOCK AND SEE WHAT HAPPENS.
        CALL CLOCKA(1,-150,ISTAT,ILUN)
        IF(ISTAT .NE. 1)GO TO 150
C
C
C THE LPA11-K SHOULD NOW BEGIN TO TRANSFER DATA
C FIRST WE WAIT FOR THE DIGITAL OUTPUT SWEEP TO FINISH.  IT WAS
C STARTED FIRST AND SHOULD FINISH FIRST.  WE VERIFY THAT IT
C FINISHES CORRECTLY OR CHECK FOR ERRORS.
15      CALL IWTBUF(IBUFO,14,IBUFNO)
C
C IF BUFFER NUMBER IS -1, THEN ERROR
C IF BUFFER NUMBER IS 0,1, OR 2, THEN CONTINUE
C IF BUFFER NUMBER IS 3, THEN FINISHED
        IF(IBUFNO .LT. 0) GO TO 160
C
C NOW WAIT FOR THE DIGITAL INPUT SWEEP TO FINISH.  THE SAME ERROR
C CONDITIONS APPLY.
        CALL IWTBUF(IBUFI,15,IBUFNO)
        IF(IBUFNO .LT. 0)GO TO 170
        IF(IBUFNO .LE. 2)GO TO 15
C
C THE FACT THAT WE HAVE GOTTEN HERE SAYS THE LPA11-K HAS DONE ITS
C THING.
C CHECK THE INPUT DATA BUFFERS AGAINST THE OUTPUT DATA BUFFERS
        DO 20 J=1,4
        DO 20 I=1,ISIZE
        IF(INBUF(I,J) .NE. OUTBUF(I,J))GO TO 180
20      CONTINUE
C
```

```
C SUCCESSFUL COMPLETION, LET EVERYONE KNOW. THEN GO BACK AND DO IT
C AGAIN.
        WRITE(5,1000)IPASS
1000    FORMAT('  REQUEST COMPLETE!',2X,I6)
        IPASS=IPASS+1
        GO TO 5
C
C REPORT ANY ERRORS THAT HAVE BEEN UNCOVERED IN THE EXAMPLE.
C
100     WRITE(5,1010)ISTAT
1010    FORMAT(//,' ERROR ASSIGNING LUN TO LPA11-K   ',I6)
        CALL EXIT
110     WRITE(5,1020)ISTAT
1020    FORMAT(//,' ERROR STOPPING LPA11-K CLOCKA    ',I6)
        CALL EXIT
120     WRITE(5,1030)ISTAT
1030    FORMAT(//,' ERROR FROM SETIBF - OUTPUT BUFFER   ',I6)
        CALL EXIT
130     WRITE(5,1040)ISTAT
1040    FORMAT(//,' ERROR FROM RLSBUF - OUTPUT BUFFER   ',I6)
        CALL EXIT
140     WRITE(5,1050)ISTAT
1050    FORMAT(//,' ERROR FROM SETIBF - INPUT BUFFER   ',I6)
        CALL EXIT
150     WRITE(5,1060)ISTAT
1060    FORMAT(//,' ERROR FROM RLSBUF - INPUT BUFFER   ',I6)
        CALL EXIT
160     WRITE(5,1070)IBUFNO,(OUTIOS(I),I=1,4)
1070    FORMAT(//,' ERROR FROM DOSWP   ',I2,4(3X,O4))
C
C *** WARNING *** DISWP MIGHT STILL BE ACTIVE WHEN YOU EXIT
C
        CALL EXIT
170     WRITE(5,1080)IBUFNO,(INIOS(I),I=1,4)
1080    FORMAT(//,' ERROR FROM DISWP   ',I2,4(3X,O4))
C
C *** WARNING *** DOSWP MIGHT STILL BE ACTIVE WHEN YOU EXIT
C
        CALL EXIT
180     WRITE(5,1090)I,J,OUTBUF(I,J),INBUF(I,J)
1090    FORMAT(//,' *DATA ERROR* - WORD # ',I4,2X,I4,4X,O6,2X,O6)
        CALL EXIT
        END
```

CHAPTER 22

K-SERIES PERIPHERAL SUPPORT ROUTINES

22.1 INTRODUCTION

K-series laboratory peripheral modules are supported through a set of program-callable routines that are linked with the user's task at task build time. These routines are highly modular. Therefore, a particular task contains only that code necessary for the facilities actually used. Additionally, the support routines perform input and output operations through the Connect to Interrupt Vector (CINT$) Executive directive. This directive allows the user's task to bypass normal QIO processing and perform I/O almost completely independent of the Executive.

The following subsections briefly describe the K-series laboratory peripherals, the features provided by the K-series support routines, and the generation and use of these routines.

22.1.1 K-Series Laboratory Peripherals

The K-series peripheral support routines provide single-user, task-level support for the following laboratory peripheral modules:

● AA11-K	D/A converter
● AD11-K	A/D converter
● AM11-K	multiple gain multiplexer
● DR11-K	digital I/O interface
● KW11-K	dual programmable real-time clock

The maximum supported hardware configuration consists of one KW11-K and sixteen of each of the AA11-K, AD11-K (with optional AM11-K), and DR11-K modules. The minimum configuration, if synchronous sweeps are desired, would be one KW11-K and any one of the three other modules. A single DR11-K supports non-clocked, interrupt-driven I/O sweeps or single digital input or output. A single AD11-K supports single word A/D input and non-clocked overflow-driven sampling (provided that the A/D conversion is started with the EXT start input on the AD11-K). An AA11-K supports burst mode output and scope control.

22.1.1.1 **AA11-K D/A Converter** - The AA11-K includes four 12-bit digital-to-analog converters (DACs) and an associated display control. The display control permits the user to display data in the form of a 4096 x 4096 dot array. Under program control, a dot may be produced at any point in this array, and a series of these dots may be programmed sequentially to produce graphical output. The display control may output to chart or X/Y recorder or CRT display unit.

22.1.1.2 **AD11-K A/D Converter** - The AD11-K is a 12-bit successive approximation converter that enables the user to sample analog data at specified rates and to store the equivalent digital value for subsequent processing. The basic subsystem consists of an input multiplexer (switch-selectable between 16-channel single-ended or 8-channel differential), sample-and-hold circuitry, and a 12-bit A/D converter. By changing jumpers, the analog inputs can be made bipolar or unipolar.

22.1.1.3 **AM11-K Multiple Gain Multiplexer** - The AM11-K is a multiplexer expander that supplements the 16-channel single-ended (eight differential) analog input multiplexer in the AD11-K. The expansion is done in three independent groups on the AM11-K. Each group can be set to sixteen single-ended or pseudo-differential or eight differential input channels; each group can have a gain of 1, 4, 16, or 64 assigned to it by a switch in the amplifier.

22.1.1.4 **DR11-K Digital I/O Interface** - The DR11-K is a general purpose digital input/output interface capable of the parallel transfer of up to sixteen bits of data, under program control, between a PDP-11 UNIBUS computer and an external device (or another DR11-K).

22.1.1.5 **KW11-K Dual Programmable Real-Time Clock** - The KW11-K is a dual programmable real-time clock option used in PDP-11 UNIBUS computers. Features include:

<u>Clock A</u>

- 16-bit counter
- 16-bit programmable Preset/Buffer register
- Four modes of operation
- Two external inputs (Schmitt triggers)
- Eight clock rates, program selectable
- Five clock frequencies, crystal controlled for accuracy
- Processor actions synchronized to external events

<u>Clock B</u>

- 8-bit counter
- 8-bit programmable preset register
- Repeated interval mode of operation
- One external input (Schmitt trigger)
- Seven clock rates, program selectable
- Five clock frequencies, crystal controlled for accuracy

22.1.2 Support Routine Features

The RSX-11M program-callable K-series support routines provide the following features:

- Clock overflow or trigger-driven A/D sweep
- Clock overflow or interrupt-driven digital input sweep
- Clock overflow or interrupt-driven digital output sweep
- Clock overflow or burst mode D/A sweep
- Single digital input
- Single digital output

- Single A/D input
- Scope control
- Histogram sampling
- Schmitt Trigger simulation
- Clock control
- 16-bit software clock
- A/D input to real number conversion
- Buffer control

Immediate digital input or output can be performed at any time. Multiple clock-driven sweeps can be initiated if this optional feature was selected during the K-series generation dialog (see Section 22.1.3.1). Such sweeps, however, are subject to the following restrictions:

1. Regardless of the number of controllers present, there can be only one active A/D sweep at any point in time. The same restriction holds true for D/A sweeps. It is possible, however, to perform digital input and digital output sweeps simultaneously, using the same DR11-K, so long as this feature is selected during the generation dialog.

2. There can be no conflict in clock rates among the sweeps.

3. Only the first sweep can use the delay from start event.

4. The inter-event time data gathering routine cannot run in parallel with any other clock-driven sweeps.

22.1.3 Generation and Use of K-series Routines

To use K-series support routines, the user must do the following three things during SYSGEN:

- Reserve necessary vector space.
- Specify that the CINT$ Executive directive is to be included in the system.
- Specify that AST support is required.

At a point in time subsequent to SYSGEN, the user follows particular procedures for the:

1. Generation of K-series support routines.

2. Program use of K-series routines.

These two procedures are detailed in the following subsections.

22.1.3.1 **Generation of K-series Support Routines** - An indirect command file, similar to those used for SYSGEN itself, is used to generate the K-series support routine library and other necessary facilities. This command file is invoked by typing the following:

```
>@[200,200]SGNKLAB
```

The dialog initiated by this command determines the device configuration of the subsystem, the maximum number of buffers that will be used on a per sweep basis, and the inclusion or omission of optional features such as multiple clock-driven sweeps and duplex digital I/O sweeps.

After this information has been obtained, the command file creates the following:

1. A prefix file, [45,10]KPRE.MAC for use during assembly of K-series support routines.

2. A data base file, [45,10]KIODT.MAC, containing control blocks needed to support the devices.

3. A common block file, [45,10]KCOM.MAC, that allows user tasks to access the I/O page. This file is used only on mapped systems.

4. On mapped systems only, two indirect command files:

   - [45,24]KCOMBLD.CMD which is a TKB build file for the common block, and

   - [1,54]INSKCOM.CMD that is used to install the common block.

At the user's option, the K-series routines themselves can then be assembled and an object library created. The user can specify the name of this library or accept the following default file specification:

```
LB:[1,1]KLABLIB.OLB
```

22.1.3.2 **Program Use of K-series Routines** - The steps required for routine program use of K-series support routines are as follows:

1. Compile or assemble the program. If the task will be overlaid, it is required that both the buffers used by the K-series support routines and the support routines themselves reside in the root section of the overlay structure.

2. Invoke TKB:

   a. On mapped systems only, use the /PR:0 switch to indicate that the task is privileged.

   b. Include the following indirect command among the responses to the TKB prompt:

      ```
      TKB>@[1,5x]LNK2KLAB
      ```

      where x is 0 for unmapped systems and 4 for mapped systems.

   c. On mapped systems only, enter the following indirect command in response to the prompt for options:

      ```
      ENTER OPTIONS
      @[1,54]LNK2KCOM
            .
            .
            .
      //
      ```

3. On mapped systems only, enter the following indirect command from a privileged terminal before executing the program:

   ```
   >@[1,54]INSKCOM
   ```

The following is a complete example of the steps previously described:

```
>F4P KTEST,KTEST/-SP=KTEST
>TKB
TKB>KTEST/PR:0,KTEST/-SP=KTEST,[1,1]F4POTS/LB
TKB>@[1,54]LNK2KLAB
TKB>/
ENTER OPTIONS
TKB>@[1,54]LNK2KCOM
    .
    .
    .
TBK>//
```

22.2 THE PROGRAM INTERFACE

A collection of program-callable subroutines provides access to the K-series laboratory peripherals. The formats of these calls are fully documented here for FORTRAN programs. MACRO-11 programmers access these same subroutines either through the standard subroutine linkage or through the use of two special-purpose macros. Both techniques are described in Section 22.2.2. Both FORTRAN and MACRO programs must contain at least one I/O Status Block (IOSB), described in Section 22.2.3, for retrieval of status information.

22.2.1 FORTRAN Interface

Table 22-1 lists the FORTRAN interface subroutines for accessing K-series laboratory peripherals.

Table 22-1
FORTRAN Subroutines for K-series Laboratory Peripherals

Subroutine	Function
ADINP	Initiate single analog input
ADSWP	Initiate synchronous A/D sweep
CLOCKA	Set Clock A rate
CLOCKB	Control Clock B
CVADF	Convert A/D input to floating point
DASWP	Initiate synchronous D/A sweep
DIGO	Digital start event
DINP	Digital input
DISWP	Initiate synchronous digital input sweep
DOSWP	Initiate synchronous digital output sweep

(continued on next page)

Table 22-1 (Cont.)
FORTRAN Subroutines for K-series Laboratory Peripherals

Subroutine	Function
DOUT	Digital output
FLT16	Convert unsigned integer to a real constant
GTHIST	Gather inter-event time data
IBFSTS	Get buffer status
ICLOKB	Read 16-bit clock
IGTBUF	Return buffer number
INXTBF	Set next buffer
IWTBUF	Wait for buffer
RCLOKB	Read 16-bit clock
RLSBUF	Release data buffer
RMVBUF	Remove buffer from device queue
SCOPE	Control scope
SETADC	Set channel information
SETIBF	Set array for buffered sweep
STPSWP	Stop sweep
XRATE	Compute clock rate and preset

The calling sequences of the routines listed in Table 22-1 are compatible with the routines for the LPA-11, described in Chapter 21. The following subsections briefly describe the function and format of each FORTRAN subroutine call.

22.2.1.1 **ADINP: Initiate Single Analog Input** - The ADINP routine obtains a single word as input from the A/D converter.

ADINP can be invoked as a subroutine or a function as follows:

```
     CALL ADINP ([iflag],[ichan],ival)
```

or

```
     ival=IADINP ([iflag],[ichan],[ival])
```

where

iflag specifies the gain options:

0 Absolute channel addressing (default). This is the only mode supported on the ADV11 (Q-bus).

1 Sample at a gain of 1. In modes 1, 2, 3, 4, and 5 each AD11-K/AM11-K is treated as 16 channels with channels 17-63 strapped to gains 4, 16, and 64. The 48 multiplexer channels are selected by the software according to the gain specification. Mode values 1, 2, 3, 4, and 5 are not supported on the ADV11 (Q-bus version).

2 Sample at a gain of 4.

3 Sample at a gain of 16.

4 Sample at a gain of 64.

5 Perform auto gain ranging.

ichan	selects the channel to be sampled. The default is 0.
ival	receives the sample. The gain bits will be inserted if iflag is nonzero.

22.2.1.2 **ADSWP: Initiate Synchronous A/D Sweep** - The ADSWP routine initiates a synchronous A/D input sweep through an AD11-K (and, if present, the AM11-K). The analog input word placed in the user buffer consists of the 12 bits read from the A/D converter and (except when the mode parameter equals 0) the 2 gain bits read from the A/D status register. A value of 177776(8) is returned for A/D timeout. A value of 177777(8) is returned on an A/D conversion error. Such errors are typically caused by conversions occurring too fast.

If differential input is desired, the channel increment must be set to 2 by calling the SETADC routine. The default channel increment is 1 (single-ended input).

NOTE

This routine will expect to have the ST1 OUT from the KW11-K or similar trigger jumpered to EXT START on the AD11-K if mode 512 is desired. This also requires the A EVENT OUT from the KW11-K clock trigger jumpered to the KW overflow on the AD11-K if clock driven sweeps are desired.

The format of the ADSWP call is as follows:

```
     CALL ADSWP (ibuf,lbuf,[nbuf],[mode],[iprset],[iefn],[ldelay],
                 [ichn],[nchn])
```

where

ibuf	is a 40-word array initialized by the SETIBF routine. The first two words of the array are the I/O status block (IOSB).
lbuf	is the size in words of each data buffer. All data buffers must be equal in size and lbuf must be greater than 0.

nbuf	is the number of buffers to be filled. If nbuf is omitted or set equal to 0, indefinite sampling occurs. The STPSWP routine terminates indefinite sampling.
mode	specifies sampling options. The default is 0. The mode bit values listed below that are preceded by a plus sign (+) are independent and can be ADDed or ORed together. Those values not preceded by a plus sign are mutually exclusive and only one such value can be used at a time. All bit values not listed below are reserved.

The following values can be specified:

0	Absolute channel addressing (default). This mode allows the user to directly access all 63 channels of an AD11-K/AM11-K combination. This is the only mode that is LPA-11 compatible.
1	Sample with a gain of 1. In modes 1, 2, 3, 4, and 5 each AD11-K/AM11-K is treated as 16 channels with channels 17-63 strapped to gains 4, 16, and 64. The 48 multiplexer channels are selected by the software according to the gain specification. Mode values 1, 2, 3, 4, and 5 are not supported on the ADV11 (Q-bus version).
2	Gain of 4. See also mode value 1.
3	Gain of 16. See also mode value 1.
4	Gain of 64. See also mode value 1.
5	Driver will perform auto-gain ranging to return the result with the most significance. Note that use of auto-gain ranging may require dual sampling and will impact performance. See also mode value 1.
7	Use user-supplied interrupt routine. The routine must be named .ADINU and must follow the interrupt service routine coding conventions used in this subsystem. Refer to the source module KADIN5.MAC for an example of an A/D interrupt routine.
+256	External start (ST1).
+512	Non-clock overflow sampling triggered by ST1.

iprset	is the clock preset. The clock rate divided by the clock preset value yields the clock overflow rate. The XRATE subroutine can be used to calculate a clock preset value. If the iprset argument is omitted from the ADSWP call, the user must specify a mode value of +512. Otherwise, an error status code of 301 (invalid arguments) is returned into the IOSB.
iefn	is the event flag (1-96), a completion routine, or 0. If 0 or defaulted, event flag 30 will be utilized for internal synchronization. If iefn is an event flag (1-96), the selected event flag is set as each buffer is filled. If iefn is greater than 96, it is considered to be a completion routine that will be called with a JSR PC. Such routines must return with an RTS PC (or a FORTRAN RETURN statement). Further, FORTRAN completion

routines must not do any I/O through the FORTRAN runtime system, since this may cause unpredictable results or fatal task errors.

If multiple sweeps are initiated, the user should specify different event flags. Adherence to this limitation cannot be enforced by the software.

ldelay	is the delay from the start event (ST1) until the first sample in IRATE units. Default or 0 indicates no delay.
ichn	is the number of the first channel to be sampled. The default of 0 applies only if ichn was not established in a prior call to the SETADC routine.
nchn	is the number of channels to sample. The default is 1. nchn may be set up with the SETADC routine. All nchn channels will be sampled on one clock interrupt.

22.2.1.3 **CLOCKA: Set Clock A Rate** - The CLOCKA routine sets the rate for Clock A. The format of the call to this routine is as follows:

```
CALL CLOCKA (irate,iprset,[ind],[lun])
```

where

irate is the clock rate. One of the following must be specified:

0	Clock B overflow (not on Q-bus version) or no rate
1	1 MHz
2	100 KHz
3	10 KHz
4	1 KHz
5	100 Hz
6	Schmitt Trigger 1
7	Line frequency

iprset is the clock preset. The clock rate divided by the clock preset value yields the clock overflow rate. The XRATE routine can be used to calculate a clock preset value.

ind receives a success or failure code as follows:

0 indicates illegal arguments.

1 indicates Clock A set to start when sweep requested.

lun is the logical unit number. Present for LPA-11 compatibility. Ignored by K-series software.

22.2.1.4 **CLOCKB: Control Clock B** - The CLOCKB routine gives the user control over the KW11-K Clock B, which is used to maintain a 16-bit software clock. This feature is not available on Q-bus versions. The 16-bit clock is incremented once per Clock B interrupt. The maximum value of the clock is 65535.

The format of the call to CLOCKB is as follows:

```
     CALL CLOCKB ([irate],[iprset],[mode],[ind],[lun])
```

where

irate — is the clock rate. When irate is nonzero, the clock is set running at the selected rate after the preset value specified by iprset is loaded. The 16-bit software clock is not altered by starting the clock. The initial value of the 16-bit clock is zero when the program is loaded.

When irate is zero, clock B is stopped but the 16-bit software clock is unaltered.

When irate is defaulted, the 16-bit software clock is zeroed but clock B continues to run.

The following are the acceptable values for irate:

0	Stop Clock B
1	1MHz
2	100 KHz
3	10 KHz
4	1 KHz
5	100 Hz
6	Schmitt Trigger 3
7	Line frequency

iprset — is the count by which to divide clock rate to yield overflow rate. Overflow events can be used to maintain the 16-bit software clock and/or drive clock A. The default value is 1. The maximum practical overflow rate in interrupt mode is 10 KHz. The range of iprset is 1-255. The value in iprset can be established by use of the XRATE routine.

mode — specifies options. Either of the following can be specified:

0 indicates normal operations. This is the default. The 16-bit software clock is updated on Clock B overflow. The overflow rate should not exceed 10KHz. The software does not check the overflow rate.

1 indicates Clock B operates in non-interrupt mode. The 16-bit clock is not incremented or altered. This allows a greater than 10KHz pulse to be sent to clock A.

ind — receives a success or failure code as follows:

0 indicates a failure to start Clock B

1 indicates Clock B started

lun — is the logical unit number. This argument is ignored by the K-series routines. It is present for LPA-11 compatibility.

22.2.1.5 **CVADF: Convert A/D Input to Floating Point** - The CVADF routine converts an A/D input value to a floating point number. The routine can be invoked as a subroutine or a function as follows:

```
     CALL CVADF (ival,val)
```

or

```
     val = CVADF(ival)
```

where

ival	is a value obtained from A/D input. Bits 12-15 are the gain. Bits 0-11 represent the value.
val	(REAL*4) receives the converted value.

22.2.1.6 **DASWP: Initiate Synchronous D/A Sweep** - The DASWP routine initiates synchronous D/A output to an AA11-K.

The format of the DASWP call is as follows:

```
     CALL DASWP (ibuf,lbuf,[nbuf],[mode],[iprset],[iefn],[ldelay],
                    [ichn],[nchn])
```

where

ibuf is a 40-word array initialized by the SETIBF routine. The first two words of the array are the I/O status block (IOSB).

lbuf is the size in words of each data buffer. All data buffers must be equal in size and lbuf must be greater than 0.

nbuf is the number of buffers to be filled. If nbuf is omitted or set equal to 0, indefinite sampling occurs. The STPSWP routine terminates indefinite sampling.

mode specifies the start criteria. Except where noted, the plus sign (+) preceding mode bit values listed below indicates that they are independent and can be ADDed or ORed together. All bit values not listed below are reserved.

The following values can be specified:

0 indicates immediate start. This is the default.

1 indicates that a group of data words, whose number is specified by nchn, is preceded by a scope control word (refer to Section 22.2.1.22 for a description of scope control words). This bit setting is ignored if +512 is also specified. This feature is not included in the Q-bus (AAV11) version.

The buffer size specified by lbuf must be a multiple of nchn+1 words. The DASWP routine, however, does not enforce this restriction.

2	sets the intensify bit after each pair of channels (nchn must be 2) have been output. This feature is supported on the Q-bus version only. It assumes that bit 0 of DAC3 on the AAV11 is connected to the intensify input on the oscilloscope.
+256	indicates external start (ST1).
+512	indicates nonclock-overflow non-interrupt driven output (burst mode). This value cannot be specified with either external start (+256) or a nonzero ldelay value. A completion routine must be specified if nbuf is greater than the number of buffers supplied or if continuous burst output is desired. If nbuf equals -1, burst mode must be stopped by calling STPSWP from the completion routine.

iprset is the clock preset. The clock rate divided by the clock preset value yields the clock overflow rate. The XRATE subroutine can be used to calculate a clock preset value.

If the iprset argument is omitted, the user must specify a mode value of +512. Otherwise, an error status code of 301 (invalid arguments) is returned into the IOSB.

iefn is an event flag number (from 1 to 96), or a completion routine, or 0. If 0 or defaulted, event flag 30 is used for internal synchronization. If iefn is an event flag from 1 to 96, the selected event flag is set as each buffer is filled. If iefn is greater than 96, it is considered a completion routine that will be called with a JSR PC. Such routines must return with an RTS PC instruction (or a FORTRAN RETURN statement). Further, FORTRAN completion routines must not perform I/O through the FORTRAN runtime system since this may cause unpredictable results or fatal task errors.

If multiple sweeps are initiated, the user should specify different event flags. This limitation cannot be enforced by the software.

ldelay is the delay from start event (ST1) until the first sample in irate units. Default or 0 indicates no delay.

ichn is the first channel number. The default is 0.

nchn is the number of channels. The default is 1. When nchn equals 2 and mode does not contain +1, the size of data buffers specified in lbuf must be an even number. The software does not check this requirement.

22.2.1.7 **DIGO: Digital Start Event** - The DIGO routine allows the user to specify the digital input bits that, when set, will cause the simulation of an external start event and the start of a pending sweep.

The format of the call to DIGO is:

```
CALL DIGO ([iunit],[mask],[kount])
```

where

iunit	is the DR11-K unit number. The default is 0.
mask	is a logical mask that specifies one or more start bits. If zero, a pending digital start event request is immediately cancelled. If defaulted, an ST1 event is immediately simulated and the current value of the 16-bit software clock is returned in kount, if specified.
kount	receives the current value of the 16-bit software clock when the defaulting of mask causes the simulation of an ST1 event.

22.2.1.8 **DINP: Digital Input** - The DINP routine inputs a single 16-bit word from a DR11-K. Bits read as a 1 can be masked with a 1 causing the clearing of the bit in the DR11-K input buffer.

During the K-series routines generation dialog, it is possible to select one of two versions of the DINP routine:

1. A slow version containing all functions described below.

2. A fast version that omits the functions provided by the mask, iosb, and input arguments.

The fast version of DINP can be invoked as a function (IDINP) only. The slow version of DINP can be invoked as a subroutine or a function. The formats of the invocations are as follows:

```
     CALL DINP ([iunit],[mask],iosb,input)
```

or

```
     ind=IDINP(iunit,[mask],iosb,[input])
```

where

iunit	is the DR11-K unit number. This argument is required for the fast version of DINP. For the slow version, the default is 0.
mask	is the bit mask used to specify which input bits will be cleared in the digital input register. The default is 177777(8) indicating all bits will be cleared.
iosb	is a 2-word I/O status block array (see Section 22.2.3).
input	receives the data input from the DR11-K.
ind	receives the data input from the DR11-K if DINP is invoked as a function.

22.2.1.9 **DISWP: Initiate Synchronous Digital Input Sweep** - The DISWP routine initiates a synchronous digital input sweep through a DR11-K.

The format of the call to DISWP is:

```
CALL DISWP (ibuf,lbuf,[nbuf],[mode],[iprset],[iefn],[ldelay],
                [iunit])
```

where

ibuf — is a 40-word array initialized by the SETIBF routine. The first two words of the array are the I/O status block (IOSB).

lbuf — is the size in words of each data buffer. All data buffers must be equal in size and lbuf must be greater than 0.

nbuf — is the number of buffers to be filled. If nbuf is 0 or defaulted, indefinite sampling occurs. The STPSWP routine is used to terminate indefinite sampling.

mode — specifies the sampling options. The default is 0. The plus signs (+) preceding the mode bit values listed below indicate that they are independent and can be ADDed or ORed together.

The following values can be specified:

0	Single-word sample, immediate start. This is the default mode.
+256	External start (ST1).
+512	Non-clock overflow interrupt driven input. External start and delay are illegal.
+1024	Time stamped sampling. The double word consists of one data word followed by the value of the 16-bit software clock at the time of the sample. This option is not available if the KW11-K clock is not being used (e.g., on the Q-bus).

iprset — is the clock preset. The clock rate divided by the clock preset value yields the clock overflow rate. The XRATE subroutine can be used to calculate a clock preset value.

If the iprset argument is omitted, the user must specify a mode value of +512. Otherwise, an error status code of 301 (invalid arguments) is returned into the IOSB.

iefn — is an event flag number (from 1 to 96), or a completion routine, or 0. If 0 or defaulted, event flag 30 is used for internal synchronization. If iefn is an event flag from 1 to 96, the selected event flag is set as each buffer is filled. If iefn is greater than 96, it is considered a completion routine that will be called with a JSR PC. Such routines must return with an RTS PC instruction (or a FORTRAN RETURN statement). Further, FORTRAN completion routines must not perform I/O through the FORTRAN runtime system since this may cause unpredictable results or fatal task errors.

If multiple sweeps are initiated, the user shold specify different event flags. This limitation cannot be enforced by the software.

ldelay	is the delay from start event (ST1) until the first sample in irate units. Default or 0 indicates no delay.
iunit	is the DR11-K unit number. The default is 0.

22.2.1.10 **DOSWP: Initiate Synchronous Digital Output Sweep** - The DOSWP routine initiates a synchronous digital output sweep through a DR11-K.

The format of the call to DOSWP is as follows:

```
     CALL DOSWP (ibuf,lbuf,[nbuf],[mode],[iprset],[iefn],[ldelay],
                [iunit])
```

where

ibuf — is a 40-word array initialized by the SETIBF routine. The first two words of the array are the I/O status block (IOSB).

lbuf — is the size in words of each data buffer. All data buffers must be equal in size and lbuf must be greater than 0.

nbuf — is the number of buffers to be filled. If nbuf is 0 or defaulted, indefinite sampling occurs. The STPSWP routine is used to terminate indefinite sampling.

mode — specifies the start criteria. The default is 0.

The following values can be specified in the high-order byte of mode:

0	Immediate start. This is the default.
+256	External event start (ST1).
+512	Non-clock overflow, interrupt driven output. External start and delay are illegal.

iprset — is the clock preset. The clock rate divided by the clock preset value yields the clock overflow rate. The XRATE subroutine can be used to calculate a clock preset value.

If the iprset argument is omitted, the user must specify a mode value of +512. Otherwise, an error status code of 301 (invalid arguments) is returned into the IOSB.

iefn — is an event flag number (from 1 to 96), or a completion routine, or 0. If 0 or defaulted, event flag 30 is used for internal synchronization. If iefn is an event flag from 1 to 96, the selected event flag is set as each buffer is filled. If iefn is greater than 96, it is considered a completion routine that will be called with a JSR PC. Such routines must return with an RTS PC instruction (or a FORTRAN RETURN statement). Further, FORTRAN completion routines must not perform I/O through the FORTRAN runtime system since this may cause unpredictable results or fatal task errors.

If multiple sweeps are initiated, the user should specify different event flags. This limitation cannot be enforced by the software.

ldelay	is the delay from start event (ST1) until the first sample in irate units. Default or 0 indicates no delay.
iunit	is the DR11-K unit number. The default is 0.

22.2.1.11 **DOUT: Digital Output** - The DOUT routine outputs a single 16-bit word to a DR11-K. Only those bits in the output word specified by corresponding ones in a mask field are altered.

During the K-series routines generation dialog, it is possible to select one of two versions of the DOUT routine:

1. A slow version containing all functions described below.

2. A fast version that omits the functions provided by the mask and iosb arguments.

The slow version of DOUT can be invoked as a subroutine or a function. The fast version of DOUT can be invoked as a subroutine only. The formats of the invocations are as follows:

```
CALL DOUT ([iunit],[mask],iosb,idata)
```

or

```
iout=IDOUT([iunit],[mask],iosb,idata)
```

where

iunit	is the DR11-K unit number. The default is 0.
mask	is used to select which bits can be altered. The default is 177777(8), indicating all bits.
iosb	is a 2-word I/O status block (see Section 22.2.3).
idata	is the 16-bit output value for the DR11-K. A one sets a corresponding bit. A zero clears the corresponding bit.
iout	receives a copy of the DR11-K output register after it has been altered.

22.2.1.12 **FLT16: Convert Unsigned Integer to a Real Constant** - The FLT16 routine converts an unsigned 16-bit integer to a real constant (REAL*4). It can be invoked as a subroutine or a function as follows:

```
CALL FLT16 (ival,val)
```

or

```
val=FLT16(ival[,val])
```

where

ival	is an unsigned 16-bit integer.
val	is the converted (REAL*4) value.

22.2.1.13 **GTHIST: Gather Inter-event Time Data** - The GTHIST routine initiates sampling to measure the elapsed time between events. The value of the Clock A buffer/preset register at the time of ST2 firing is stored in a user-provided buffer.

GTHIST is an optional facility that must be explicitly selected during the K-series generation dialog prior to its use in any program. The format of the call to GTHIST is as follows:

```
CALL GTHIST (ibuf,lbuf,[nbuf],[mode],[iprset],[iefn],[kount])
```

where

ibuf — is a 40-word array initialized by the SETIBF routine. The first two words of the array are the I/O status block (IOSB).

lbuf — is the size in words of each data buffer. All data buffers must be equal in size and lbuf must be greater than 0.

nbuf — is the number of buffers to be filled. If nbuf is 0 or defaulted, indefinite sampling occurs. The STPSWP routine is used to terminate indefinite sampling.

mode — specifies sampling options as follows:

- 0 indicates external event timing without Zero Base. This is the default.
- 1 indicates external event timing with Zero Base. This is the only mode supported for the KWV11.

iprset — is a null argument. It is present only to maintain compatibility with other sweep routine calling sequences.

iefn — is an event flag number (from 1 to 96), or a completion routine, or 0. If 0 or defaulted, event flag 30 is used for internal synchronization. If iefn is an event flag from 1 to 96, the selected event flag is set as each buffer is filled. If iefn is greater than 96, it is considered a completion routine that will be called with a JSR PC. Such routines must return with an RTS PC instruction (or a FORTRAN RETURN statement). Further, FORTRAN completion routines must not perform I/O through the FORTRAN runtime system since this may cause unpredictable results or fatal task errors.

If multiple sweeps are initiated, the user should specify different event flags. This limitation cannot be enforced by the software.

kount — is a counter used by GTHIST, as described below.

To take Post-Stimulus Time data, set mode to 0. ST1 signals the occurrence of a stimulus and starts the clock (i.e., no data is taken until the first ST1 occurs). Each response is signalled by ST2, and the buffer/preset register contents are placed in the user buffer. Each ST1 resets the counter register to zero, and increments kount by 1. Thus, kount keeps track of the number of stimuli (ST1 events). Clock overflow stops the clock. The clock waits for the next ST1 event before restarting. The maximum stimulus-response interval is a function of the clock rate.

To obtain Inter-Stimulus-Interval data, set mode to 1. The time between successive events, as signalled by ST2, is recorded. The maximum inter-event time is a function of the clock rate. When clock overflow occurs, the value returned on the next ST2 firing is 177777(8) and KOUNT is incremented. Thus, kount represents the number of times the maximum inter-event time was exceeded. In general, the user should ignore values of 177777(8).

22.2.1.14 **IBFSTS: Get Buffer Status** - The IBFSTS routine returns information on buffers being used in a sweep.

The format of the call to IBFSTS is as follows:

```
CALL IBFSTS (ibuf,istat)
```

where

ibuf	is the 40-word array specified in the call that initiated a sweep.
istat	is an array with as many elements as there are buffers involved in the sweep. The maximum is 8. IBFSTS fills each element in the array with the status of the corresponding buffer. The possible status codes are as follows:

+2	indicates that the buffer is in the device queue. That is, it is waiting to be filled or emptied.
+1	indicates that the buffer is in the user queue. That is, it is full of data (for input sweeps) or is waiting to be filled (for output sweeps).
0	indicates that the status of the buffer is unknown. That is, it is not the current buffer nor is it in either the device or the user queue.
-1	indicates that a service routine is currently using the buffer.

22.2.1.15 **ICLOKB: Read 16-bit Clock** - The ICLOKB function returns the contents of the 16-bit software clock as an integer value to the user.

The format of the ICLOKB function call is as follows:

```
itim=ICLOKB(0)
```

where

itim	receives the curent value of the 16-bit software clock as an unsigned integer.

NOTE

MACRO-11 programmers need not establish an argument block for the ICLOKB function. The current value of the software clock is returned in R0.

22.2.1.16 **IGTBUF: Return Buffer Number** - The IGTBUF routine returns the number of the next buffer to use. This routine should be called by user completion routines to determine the next buffer to access. It should not be used if an event flag was specified in the sweep-initiating call. Rather, the IWTBUF routine should be used with event flags.

IGTBUF can be invoked as a subroutine or a function. The formats of the invocations are:

```
     CALL IGTBUF (ibuf,ibufno)
```

or

```
     ibufno=IGTBUF(ibuf[,ibufno])
```

where

ibuf	is the 40-word array specified in the call that initiated a sweep.
ibufno	receives the number of the next buffer to access. If there is no buffer in the queue, ibufno contains -1.

22.2.1.17 **INXTBF: Set Next Buffer** - The INXTBF routine alters the normal buffer selection algorithm. It allows the user to specify the number of the next buffer to be filled or emptied.

INXTBF can be invoked as a subroutine or a function. The formats of the invocations are:

```
     CALL INXTBF (ibuf,ibufno[,ind])
```

or

```
     ind=INXTBF(ibuf,ibufno[,ind])
```

where

ibuf	is the 40-word array specified in the call that initiated a sweep.
ibufno	is the number of the next buffer the user wants filled or emptied. The buffer must already be in the device queue.

ind	receives an indication of the result of the operation: 0 indicates that the specified buffer was already active or was not in the device queue. 1 indicates that the next buffer was successfully set.

22.2.1.18 **IWTBUF: Wait for Buffer** - The IWTBUF routine allows a user task to wait for the next buffer to fill or empty. It should be used in conjunction with the specification of an event flag in the sweep-initiating call. This routine should not be used if a completion routine was specified in the call to initiate a sweep. Rather, the IGTBUF routine should be used with completion routines.

IWTBUF can be invoked as a subroutine or a function. The formats of the invocations are as follows:

```
     CALL IWTBUF (ibuf,[iefn],ibufno)
```

or

```
     ibufno=IWTBUF(ibuf,[iefn],[ibufno])
```

where

ibuf	is the 40-word array specified in the call that initiated a sweep.
iefn	is the event flag on which the task will wait. This should be the same event flag as that specified in the sweep-initiating call. If iefn equals 0 or is defaulted, event flag 30 is used.
ibufno	receives the number of the next buffer to be filled or emptied by the user's task.

22.2.1.19 **RCLOKB: Read 16-bit Clock** - The RCLOKB routine returns to the user's task the contents of the 16-bit software clock as a real constant.

RCLOKB can be invoked as a subroutine or a function as follows:

```
     CALL RCLOKB (rlast,time)
```

or

```
     time=RCLOKB(rlast,time)
```

where

time	receives the current value of the 16-bit software clock as a real constant (REAL*4).
rlast	is a value (REAL*4) to be subtracted from the current 16-bit software clock before it is returned into the time field.

22.2.1.20 **RLSBUF: Release Data Buffer** - The RLSBUF routine declares one or more buffers free for use by the interrupt service routine.

The RLSBUF routine must be called to release buffer(s) to the device queue before the sweep is initiated. The device queue must always contain at least one buffer to maintain continuous sampling. Otherwise, buffer overrun occurs (see Section 22.3 for a discussion of buffer management). Note that RLSBUF does not verify whether or not the specified buffers are already in a queue.

The format of the call to RLSBUF is as follows:

```
     CALL RLSBUF (ibuf,ind,n0[,n1...,n7])
```

where

ibuf	is the 40-word array specified in the call that initiated a sweep.
ind	receives a success or failure code as follows: 0 indicates illegal buffer number specified. 1 indicates buffer(s) successfully released.
n0,n1,etc.	are the numbers of buffers to be released. A maximum of eight can be specified.

22.2.1.21 **RMVBUF: Remove Buffer from Device Queue** - The RMVBUF routine removes a buffer from the device queue.

The format of the call to RMVBUF is as follows:

```
     CALL RMVBUF (ibuf,n[,ind])
```

where

ibuf	is the 40-word array specified in the call that initiated a sweep.
n	is the number of the buffer to remove.
ind	receives a success or failure code as follows: 0 indicates that the specified buffer was not in the device queue. 1 indicates that the specified buffer was removed from the queue.

22.2.1.22 **SCOPE: Control Scope** - The SCOPE routine allows the user to control the status register of an AA11-K.

The format of the call to SCOPE is as follows:

```
     CALL SCOPE (iunit,icntrl,iosb)
```

where

iunit	is the AA11-K unit number.

icntrl	is a combination of bit values as shown in Table 22-2. Any bits not listed in this table are cleared before output to the AA11-K status register
iosb	is a 2-word I/O status block (see Section 22.2.3).

Table 22-2
Scope Control Word Values

Decimal Value	Octal Value	Function
4096	10000	Erase storage CRT
2048	4000	Set write-through mode
1024	2000	Set store mode
512	1000	A digital signal available in the AA11-K.
12	14	Intensify on X or Y
8	10	Intensify on Y
4	4	Intensify on X
2	2	Fast intensify enable
1	1	Intensify pulse

The values in Table 22-2 are also used to create scope control words for calls to the DASWP routine with a mode value of 1.

22.2.1.23 **SETADC: Set Channel Information** - The SETADC routine establishes channel start and increment information for an A/D sweep.

SETADC can be invoked as a subroutine or a function as follows:

```
     CALL SETADC (ibuf,[iflag],[ichn],[nchn],[inc],[ind])

          or

     ind = ISTADC(ibuf,[iflag],[ichn],[nchn],[inc],[ind])
```

where

ibuf	is a 40-word array initialized by the SETIBF routine.
iflag	equals zero if the user wants absolute addressing and nonzero for programmable gain addressing. The default is zero.
ichn	is the first channel number. The default is zero.
nchn	is the number of samples to be taken per interrupt. The default is 1.

inc	is the channel increment. The default is 1. The user should specify an increment of 2 for differential A/D input.
ind	receives a success or failure code as follows:
	0 indicates an illegal channel number.
	1 indicates successful recording of channel information for an A/D sweep.

22.2.1.24 **SETIBF: Set Array for Buffered Sweep** - The SETIBF routine initializes an array required by buffered sweep routines.

The format of the call to SETIBF is as follows:

```
     CALL SETIBF (ibuf,[ind],[lamskb],buf0[,buf1...buf7])
```

where

ibuf	is a 40-word array.
ind	receives a success or failure code as follows:
	0 indicates an illegal number of buffers was specified. SETIBF initializes the array according to the maximum number of buffers allowed. This maximum number of buffers is specified by the user during the K-series generation dialog.
	1 indicates the array was successfully initialized.
lamskb	is present for compatibility with LPA-11 routines. It is ignored by K-series software.
buf0, etc.	is the name of a buffer. A maximum of eight buffers can be specified. Any buffer names in excess of eight are ignored. At least two buffers must be specified to maintain continuous sampling.

Each buffer specified in the call to SETIBF is assigned a number from 0 to 7.

The assignment of these numbers is based on the order in which buffer names appear in the argument list. The first buffer whose name appears in the list is assigned number 0, the second is assigned number 1, and so forth. In all subsequent calls to other K-series routines involving the set of buffers specified in a call to SETIBF, these numbers, rather than names, are used to refer to particular buffers.

22.2.1.25 **STPSWP: Stop Sweep** - The STPSWP routine allows the user to stop a sweep that is in progress.

The format of the call to STPSWP is as follows:

```
     CALL STPSWP (ibuf[,iwhen],[ind])
```

where

ibuf	is the 40-word array specified in the call that initiated a sweep.
iwhen	specifies when to stop the sweep:
	0 indicates at the next sample. This is the default.
	+n (any positive value) indicates at the end of the current buffer.
	-n (any negative value) is reserved.
ind	receives a success or failure code as follows:
	0 indicates that the sweep was not active or no sweep could be found that was associated with the specified ibuf.
	1 indicates that the sweep will be stopped (at the time indicated by iwhen).

22.2.1.26 **XRATE: Compute Clock Rate and Preset** - The XRATE routine computes an appropriate clock rate and preset that will achieve a desired dwell (inter-sample interval).

NOTE

The XRATE routine can be used only on systems that have a FORTRAN or BASIC-PLUS-2 compiler.

XRATE can be invoked as a subroutine or a function as follows:

```
CALL XRATE (dwell,irate,iprset,iflag)

     or

adwell = XRATE(dwell,irate,iprset,iflag)
```

where

dwell	is the inter-sample time desired by the user. The time is expressed in decimal seconds (REAL*4).
irate	receives the computed clock rate as a value from 1 to 5.
iprset	receives the clock preset.
iflag	specifies whether the computation is intended for Clock A or Clock B:
	0 indicates the computation is for Clock A.
	nonzero indicates the computation is for Clock B.
adwell	is the actual dwell rate for the clock based on the irate and iprset parameters.

22.2.2 MACRO-11 Interface

MACRO-11 programmers access the K-series support routines described in Section 22.2.1 through either of two techniques:

1. The standard subroutine linkage mechanism and the CALL op code.

2. Special-purpose macros that generate an argument list and invoke a subroutine.

These techniques are described in the following subsections.

22.2.2.1 **Standard Subroutine Linkage and CALL Op Code** - K-series routines can be accessed through use of the standard subroutine linkage mechanism and the CALL op code. The format of this procedure is:

```
          .PSECT  code
          MOV     #arglist,R5    ;ARGUMENT ADDRESS TO R5
          CALL    ksubr          ;CALL K-SERIES ROUTINE
          .PSECT  data
arglist:  .BYTE   narg,0         ;NUMBER OF ARGUMENTS
          .WORD   addr1          ;FIRST ARGUMENT ADDRESS
              .
              .
              .
          .WORD   addrn          ;LAST ARGUMENT ADDRESS
```

In this sample, the two PSECT directives are shown only to indicate the noncontiguity of the code and data portions of the linkage mechanism. Within the argument list, any argument that is to be defaulted must be represented by a -1 (i.e., 177777(8)).

22.2.2.2 **Special-Purpose Macros** - To facilitate the calling of K-series support routines from a MACRO-11 program, two macros are provided in file [45,10]LABMAC.MAC. These macros are:

1. INITS

2. CALLS

INITS is an initialization macro. It should be invoked at the beginning of the MACRO-11 source module.

CALLS invokes a K-series support routine. The format of this macro call is as follows:

```
CALLS ksubr,<arg1,...,argn>
```

where

ksubr	is the name of a K-series support routine.
arg1,etc.	are arguments to be formatted into an argument list and passed to the routine. Each argument can be either a symbolic name or a constant (interpreted as a positive decimal number) or can be defaulted.

22.2.3 The I/O Status Block (IOSB)

Each active sweep must have its own I/O status block. The I/O status block (IOSB) is a 2-word array allocated in the user's program. It is used to receive the status of a call to a K-series support routine. When a data sweep routine is called, the IOSB is always the first two words of the 40-word array specified as the first argument of the call. The first word of the IOSB contains the status code. The second word contains the buffer size in words.

The codes that can appear in the first word of an I/O status block are in ISA-compatible format (with the exception of the I/O pending condition). Table 22-3 lists all return codes.

Table 22-3
Contents of First Word of IOSB

IOSB word 1	Meaning
0	Operation pending; I/O in progress
1	Successful completion
301	Invalid arguments
305	Hardware or software option not present
306	Illegal buffer specification
313	Data overrun
315	Request terminated
317	Resource in use
397	Invalid event flag

22.3 BUFFER MANAGEMENT

The management of buffers for data sweeps by K-series support routines involves the use of two FIFO (First-In, First-Out) queues:

1. The device queue (DVQ)

2. The user queue (USQ).

The device queue (DVQ) contains the numbers of all buffers that the user has released to the support routines in a call to RLSBUF. The buffers represented by these numbers are ready to be filled with data (input sweeps) or to be emptied of data (output sweeps). Any buffer specified in a call to INXTBF must already be in DVQ.

The user queue (USQ) contains the numbers of buffers available to the user. For output sweeps, this queue contains the numbers of buffers that have already been emptied by the driver. For input sweeps, the buffers represented by USQ are those which are filled with data. In both instances, the user's task determines the next buffer to use (that is, extracts the first element of USQ) by calling IGTBUF or IWTBUF.

Both the DVQ and USQ are initialized to -1, indicating no buffers, when the user's task calls the SETIBF routine. The task must call RLSBUF before initiating any sweep, since at least one buffer must be present in DVQ for the first input or output to occur.

For input sweeps, the best strategy is to call RLSBUF, specifying the numbers associated with all the buffers to be used in the sweep.

For output sweeps, one approach is to specify two buffers (for continuous sweeps) in the call to RLSBUF. The first action then taken either in a completion routine or after a call to IWTBUF would be to release the next buffer. Note, however, that this approach does not represent true multiple buffering, since data overrun occurs if the second buffer is not released in time.

22.4 SAMPLE FORTRAN PROGRAMS

Two sample FORTRAN programs showing the use of K-series support routines are presented in this section. The first program uses event flags for internal synchronization. The second program demonstrates the use of user-supplied completion routine for synchronization.

22.4.1 Sample Program Using Event Flag

```
        IMPLICIT INTEGER (A-Z)

        DIMENSION BUF(1024,8), IBUF (40), IOSB(2)
        EQUIVALENCE (IBUF(1),IOSB(1))

C
C        INITIALIZE THE IBUF ARRAY FOR THE A/D SWEEP
C
        CALL SETIBF (IBUF,IND, , BUF(1,1), BUF(1,2), BUF(1,3),
        * BUF(1,4), BUF(1,5), BUF(1,6), BUF(1,7), BUF(1,8))

        WRITE (1, 900)
        READ (1, 910) IRATE, IPRSET
C
C        SET THE CLOCK RATE AND PRESET FOR THE SWEEP
C
        CALL CLOCKA (IRATE, IPRSET,IND)
C
C        THIS IS INPUT, SO RELEASE ALL BUFFERS TO SERVICE
C        ROUTINE
C
        CALL RLSBUF (IBUF,IND, 0,1,2,3,4,5,6,7)
C
C        START THE SWEEP. USE 1024 WORD BUFFERS, SAMPLE
C        FOREVER, EXTERNAL START, EVENT FLAG 30, 1 CHANNEL (0).
C
        CALL ADSWP (IBUF, 1024, -1, 256, IPRSET,
        * 30, 0, 0, 1)


C
C        HERE WE COULD CHECK THE I/O STATUS BLOCK TO ENSURE
C        THAT THE SWEEP IS ACTUALLY RUNNING.
C
        IBFCNT=0
C
C        THIS IS THE TOP OF THE DATA PROCESSING LOOP. WE
```

```
C          WAIT FOR A BUFFER TO BE COMPLETED, AND THEN DUMP
C          THE FIRST 100 WORDS OF THE BUFFER TO LUN 1.
C
 10       IBUFNO = IWTBUF(IBUF, 30)+1
C
C          IWTBUF WILL RETURN A POSITIVE BUFFER NUMBER
C          AS LONG AS THERE IS A BUFFER OF DATA AVAILABLE.
C          IF IND IS -1, WE PROBABLY HAD DATA OVERRUN, SO STOP.
C
          IF (IBUFNO .EQ. 0) STOP
          IBFCNT=IBFCNT+1
          WRITE (1,920) IBFCNT
          WRITE (1,930) (BUF(I,IBUFNO), I=1,100)
C
C          RELEASE BUFFER FOR SERVICE ROUTINE TO REFILL
C
          CALL RLSBUF(IBUF,IND,IBUFNO-1)
          GOTO 10
 900      FORMAT (' ENTER IRATE, IPRSET:', $)
 910      FORMAT (I, O)
 920      FORMAT (' DUMP OF BUFFER NUMBER ',I5,/)
 930      FORMAT (1X,10O7)
          END
```

22.4.2 Sample Program Using Completion Routine

```
          IMPLICIT INTEGER (A-Z)
          EXTERNAL AST

          DIMENSION BUF(1024,8), IBUF (40), IOSB(2)
          COMMON /KDATA/ BUF, IBUF, IBFCNT
          EQUIVALENCE (IBUF(1),IOSB(1))

C
C              INITIALIZE THE IBUF ARRAY FOR THE A/D SWEEP
C
          CALL SETIBF (IBUF,IND, , BUF(1,1), BUF(1,2), BUF(1,3),
          * BUF(1,4), BUF(1,5), BUF(1,6), BUF(1,7), BUF(1,8))

          WRITE (1, 900)
          READ (1, 910) IRATE, IPRSET
C
C              SET THE CLOCK RATE AND PRESET FOR THE SWEEP
C
          CALL CLOCKA (IRATE, IPRSET,IND)
C
C              THIS IS INPUT, SO RELEASE ALL BUFFERS TO SERVICE
C              ROUTINE
C
          CALL RLSBUF (IBUF,IND, 0, 1, 2, 3, 4, 5, 6, 7)
C
C              START THE SWEEP. USE 1024 WORD BUFFERS, SAMPLE
C              FOREVER, EXTERNAL START, EVENT FLAG 30, 1 CHANNEL (0).
C
          IBFCNT = 0
          CALL ADSWP (IBUF, 1024, -1, 256, IPRSET
          * AST, 0, 0, 1)

C
C              HERE WE COULD CHECK THE I/O STATUS BLOCK TO ENSURE
C              THAT THE SWEEP IS ACTUALLY RUNNING.
C
```

```
 10       CALL WAITFR (23)
C
C              WHEN EVENT FLAG 23 IS SET THE SWEEP IS COMPLETED.
C              WE MAY EXIT NOW.
C
          STOP

 900      FORMAT (' ENTER IRATE, IPRSET:', $)
 910      FORMAT (I, O)
          END
          SUBROUTINE AST
C
C              THIS SUBROUTINE IS CALLED AT AST LEVEL WHENEVER
C              A BUFFER IS COMPLETED. THIS ROUTINE PROCESSES
C              THE CONTENTS OF THE BUFFER AND THEN RELEASES
C              IT FOR THE SERVICE ROUTINE. IF THE SWEEP IS TO
C              TERMINATE (IOSB NON-ZERO) THEN EVENT FLAG 23. IS
C              SET TO INDICATE TO THE MAINLINE CODE THAT WE ARE
C              DONE.
          IMPLICIT INTEGER (A-Z)
          DIMENSION BUF(1024,8), IBUF(40), IOSB(2)
          COMMON /KDATA/ BUF, IBUF, IBFCNT
          EQUIVALENCE (IBUF(1),IOSB(1))

          IBUFNO = IGTBUF (IBUF) +1

          IF (IBUFNO-1) .GE. 0 GOTO 20
          IF (IOSB(1) .EQ. 0) PAUSE 'INCONSISTENT STATE'
          CALL SETEF (23)
          RETURN

20        IBFCNT = IBFCNT + 1
C
C         HERE WE WOULD PROCESS THE DATA
C
C
C            • RELEASE BUFFER FOR SERVICE ROUTINE
C
          CALL RLSBUF (IBUF, IND, IBUFNO-1)
          RETURN

          END
```

CHAPTER 23

UNIBUS SWITCH DRIVER

23.1 INTRODUCTION

The UNIBUS switch driver supports DT07 UNIBUS switch hardware on RSX-11M-PLUS systems. UNIBUS switches are electronic devices that allow peripherals to be switched from one CPU to another, enabling CPUs to share peripheral devices. UNIBUS switches also facilitate on-line system back-up and allow dynamic reconfiguration of systems in which high availability of certain peripherals is required.

23.1.1 DT07 UNIBUS Switches

DT07 UNIBUS switches can provide two, three, or four ports for connecting an external UNIBUS run to one of two, three, or four CPUs.

Any CPU can request connection to a UNIBUS run and receive the connection immediately if the requested UNIBUS run is in the neutral state (it is not connected to another CPU's UNIBUS). If the request is received when the UNIBUS run is connected to another CPU, an interrupt is generated, informing the connected CPU of the pending request, and a watchdog timer is started. The connected CPU normally acknowledges the request, indicating the UNIBUS is still in use. In this case, the UNIBUS remains connected to the CPU. However, if the CPU does not respond to the interrupt within the time limit imposed by the DT07's watchdog timer, the UNIBUS is switched to the requesting CPU. Thus, a CPU that is not operating remains connected to the UNIBUS only until another CPU requests the UNIBUS.

Each DT07 UNIBUS switch port functions as an isolation circuit. When its power is off, it does not affect any CPU operation.

23.1.2 UNIBUS Switch Driver

The UNIBUS switch driver permits the UNIBUS switch to be used in one of two ways:

1. A CPU retains the UNIBUS until the task issuing the directives that connected the UNIBUS to this CPU exits. This is normally accomplished when the task attaches the UNIBUS switch (IO.ATT function) and issues the connect function (IO.CON). When the task exits (for any reason), the system detaches the UNIBUS switch (IO.DET) and performs an implicit disconnect function (IO.DIS), releasing the UNIBUS switch for use by any other task.

The task that attaches the UNIBUS switch can be considered the manager of the UNIBUS switch until the task exits. The task can receive ASTs for certain conditions involving UNIBUS switching (see Section 23.3.1.1).

2. A CPU retains the UNIBUS until a task is executed that explicitly disconnects the UNIBUS. This is normally accomplished when a task issues the IO.CON function and no previous IO.ATT was issued. Once the UNIBUS is connected, the task exits. The UNIBUS then remains connected until either the CPU fails to respond to other CPU requests for the UNIBUS, or a task is executed that explicitly disconnects the UNIBUS. Note that when operating in this manner, no active task is required in order to retain the UNIBUS.

23.2 GET LUN INFORMATION MACRO

Word 2 of the buffer filled by the Get LUN Information system directive (the first characteristics word) contains all zeros. Words 3, 4 and 5 are undefined.

23.3 QIO MACRO

This section summarizes standard and device-specific QIO functions for UNIBUS switches.

23.3.1 Standard QIO Functions

Table 23-1 lists the standard functions of the QIO macro that are valid for UNIBUS switches.

Table 23-1
Standard QIO Functions for UNIBUS Switches

Format	Function
QIO$C IO.ATT,...,<[ast]>	Attach device
QIO$C IO.DET,...	Detach device
QIO$C IO.KIL,...	Cancel I/O requests.

where:

ast is the address of an optional AST routine which will be entered if certain conditions are detected (see Section 23.3.1.1)

IO.ATT does not connect the UNIBUS switch (see device-specific function IO.CON).

IO.DET detaches the UNIBUS switch from the task. If the UNIBUS switch was previously attached by the IO.CON function, an implied disconnect (IO.DIS) function is performed.

The only I/O requests that can be affected by the IO.KIL function are IO.CON and IO.DPT. When IO.KIL is issued during an IO.CON function, further retries are cancelled. When IO.KIL is issued during an IO.DPT function, the timeout count is changed, forcing timeout (IE.TMO) to occur.

23.3.1.1 **IO.ATT** - The IO.ATT QIO function attaches the UNIBUS switch to the task issuing the QIO directive. An optional AST address parameter can be specified. However, if it is specified, it must remain valid while the UNIBUS switch remains attached to the task.

The AST service routine for the UNIBUS switch is entered when one of the following conditions occur:

- The UNIBUS switch has become connected to another CPU because:

    1. The operator manually switched the UNIBUS to another CPU, or

    2. This CPU failed to respond to another CPUs request for the UNIBUS within the specified time (the CPU must acknowledge the request by servicing an interrupt, as described in Section 23.1.1).

  UNIBUS switch condition code 1 is passed to the AST routine via the stack indicating the cause of the AST.

- The UNIBUS switch has disconnected from the CPU because:

    1. A power failure occurred in this CPU (system power failure) and the UNIBUS switch driver was unable to reconnect the bus, or

    2. A power failure occurred on the connected UNIBUS causing the driver to automatically disconnect the UNIBUS

  UNIBUS switch condition code 2 (for a system power failure) or condition code 3 (for a UNIBUS power failure) is passed to the AST routine via the stack indicating the cause of the AST.

23.3.1.2 **IO.DET** - The IO.DET function detaches the issuing task from the UNIBUS switch, and in addition, performs an implied disconnect for the issuing task if that task had connected the UNIBUS switch. A detach function is generated by the Executive on behalf of an attached task if that task exits (normally or abnormally) without explicitly detaching the device. For a switched UNIBUS, this causes it to be disconnected if an attached, connected task faults in such a way as to cause it to exit.

23.3.1.3 **IO.KIL** - The IO.KIL function will cancel any outstanding IO.CON function that has a non-zero retry count and any outstanding IO.DPT function that has not yet timed out. Other QIO functions in progress are not affected by IO.KIL, and are automatically completed.

23.3.2 Device-Specific QIO Functions

The device-specific functions of the QIO macro that are valid for UNIBUS switches are shown in Table 23-2.

Table 23-2
Device-Specific QIO Functions for UNIBUS Switches

Format	Function
QIO$C IO.CON,...,<[rcnt],[cpu]>	Connect UNIBUS switch
QIO$C IO.DIS,...,<[tout],[port]>	Disconnect UNIBUS switch to specified CPU port
QIO$C IO.DPT,...,<[tout],[port]>	Disconnect UNIBUS switch to specified CPU port
QIO$C IO.SWI,...,<cpu>	Switch the UNIBUS from current CPU to specified CPU
QIO$C IO.CSR,...	Read UNIBUS switch CSR

where:

rcnt	is the number of additional times the connect will be attempted if the IO.CON fails to complete
cpu	is the ASCII letter designating the CPU to receive the UNIBUS switch
port	is the port number, ranging from 0 through 3, of the target CPU that must request the bus prior to the CPU that is currently connected to the UNIBUS actually completing the disconnect. The port number corresponds to the four MANUAL CONNECT switch positions (PORT 0 through PORT 3) marked on the DT07 control panel.
tout	is the maximum time (in seconds) allowed (253. maximum) for the function to be completed before an error condition is reported

Parameter details are included in the following sections.

23.3.2.1 **IO.CON** - The IO.CON (connect) function requests connection of a UNIBUS presently not connected to a specified CPU. It can be issued by either a task previously attached via the IO.ATT function or by a task that is not attached. The IO.CON function has four optional parameters. The use of each parameter is described as follows.

Retry Count -- The retry count specifies the number of additional times the connect function will be attempted if the IO.CON fails to complete within the timeout period of the UNIBUS switch. Retry count parameters used in this manner are always nonzero positive values. The IO.CON function is not completed until either the retry count expires or the UNIBUS switch is successfully connected. Thus, the issuing task having a non-zero retry count wil not be checkpointed until the IO.CON function is completed.

When a retry count of zero is specified, the connect function attempts to connect the UNIBUS switch once (no retries) and immediately reports the directive status to the issuing task.

When a retry count of 177777 (-1) is specified, the connect function continues to retry the connection until a successful connection is made or an IO.KIL function is issued.

CPU -- The CPU parameter can only be used with closely coupled[1] multiprocessor systems to specify the CPU to which the UNIBUS switch should be connected. This function is used only when the UNIBUS switch is presently not connected (the IO.SWI function should be used to disconnect the UNIBUS switch from a connected CPU and connect it to a specified CPU). The CPU is specified by a single ASCII letter (A, B, C, or D).

23.3.2.2 **IO.DIS** - The IO.DIS function is used to disconnect the switched UNIBUS from the currently connected CPU.

NOTE

> It is the responsibility of the task issuing the IO.DIS or IO.DPT function to determine that all devices on the switched UNIBUS are inactive when the function is issued. The UNIBUS switch driver does not check for active devices on the UNIBUS before completing either the IO.DIS or IO.DPT function.

23.3.2.3 **IO.DPT** - The IO.DPT function is used in a loosely coupled[2] multiprocessor system to allow the UNIBUS to be connected to another CPU on a specified port if the CPU requests connection within a specified time interval. (Refer to the note at the end of Section 23.3.2.2.)

Timeout -- The timeout parameter specifies the maximum time allowed for the function to complete before an error is reported. Timeout specifications are positive, nonzero values ranging from 1 to 254 seconds. The default timeout value is 2 seconds. If the CPU parameter is included in the IO.DIS function, the driver waits for the specified CPU to request the UNIBUS up to the specified timeout value. If the CPU does not request the UNIBUS during this time, the UNIBUS remains connected and the IE.TMO status is returned to the issuing task.

If a timeout value of 0 is specified, the IO.DIS function will not complete until either the successful disconnect occurs, or an IO.KIL function is issued.

---

[1] A closely coupled system is one in which all memory resources are shared by more than one CPU.

[2] A loosely coupled system is one in which memory resources are not shared by more than one CPU.

Port -- The port parameter can only be used with loosely coupled multiprocessor systems to specify the port through which the UNIBUS switch should be connected to a CPU. The port is specified by a number ranging from 0 through 3.

23.3.2.4 **IO.SWI** - The IO.SWI function disconnects the UNIBUS switch from the currently connected CPU and connects it to the specified CPU in a closely coupled system. The CPU parameter is required.

IO.SWI is executed without the possibility of a third CPU taking control of the UNIBUS during the switching process.

The CPU parameter is used in closely coupled multiprocessor systems to specify the CPU to which the UNIBUS switch should be connected. The CPU is specified by a single ASCII letter (A, B, C, or D).

23.3.2.5 **IO.CSR** - The IO.CSR function reads maintenance information contained in the device CSR and returns it in the second word of the I/O status block. Information returned is valid only if the UNIBUS switch is connected. The use of this function should be limited to diagnostic applications.

23.4 POWERFAIL RECOVERY

23.4.1 System Powerfail Recovery

During powerfail recovery, the driver attempts to restore the state of the system prior to the actual power failure. If the UNIBUS switch is found to be disconnected during powerfail recovery, the driver attempts to reconnect the switched UNIBUS. If the first attempt to reconnect the UNIBUS is not successful, an entry is made in the error log and the attached task is notified of the UNIBUS switch state via the AST specified in the IO.ATT function (if previously issued).

If an IO.CON function was in progress when the power failure occurred and a retry count was pending, the UNIBUS switch driver attempts to successfully connect the UNIBUS switch until the retry count expires.

If an IO.DIS or IO.DPT function was in progress when the power failure occurred, the UNIBUS switch driver attempts to complete the operation.

23.4.2 UNIBUS Powerfail Recovery

If an interrupt is received from the UNIBUS switch indicating a power failure has occurred on the switched UNIBUS, the driver issues an immediate disconnect (IO.DIS). The attached task (if any) is notified via the AST. Note that the system may be corrupted if some of the I/O devices on the switched UNIBUS were active when the power failure occurred, since the drivers for those I/O devices may attempt to access the device registers after the switched UNIBUS (and I/O devices) has become disconnected.

23.5 STATUS RETURNS

Table 23-3 lists the error and status conditions that are returned by the UNIBUS switch driver.

Table 23-3
UNIBUS Switch Driver Status Returns

Code	Reason
IS.SUC	Successful completion The operation specified in the QIO directive was completed successfully
IS.PND	I/O request pending The operation specified in the QIO directive has not yet been executed. The I/O status block is filled with zeros
IE.ABO	Request aborted An I/O request was queued (not yet acted upon by the driver) when an IO.KIL was issued
IE.BAD	Bad parameters The parameters specified in the QIO macro where in error
IE.CNR	Connect rejected The connect function did not successfully connect the switched UNIBUS to the specified CPU, and the retry count, if specified, has expired
IE.DAA	Device already attached The device specified in an IO.ATT funcion was already attached by the issuing task. This code indicates that the issuing task has already attached the desired physical device unit, not that the unit was attached by another task
IE.DNA	Device not attached The physical device unit specified in an IO.DET function was not attached by the issuing task. This code has no bearing on the attachment status of other tasks
IE.IFC	Illegal function A function code was specified in an I/O request that is illegal for the UNIBUS switch driver

(continued on next page)

Table 23-3 (Cont.)
UNIBUS Switch Driver Status Returns

Code	Reason
IE.NOD	Insufficient buffer space Dynamic storage space has been depleted, resulting in insufficient buffer space available to allocate either the I/O packet or the device list buffer
IE.OFL	Device off-line The physical device unit associated with the LUN specified in the QIO directive (the UNIBUS switch) was not online, or the CPU specified in the IO.CON or IO.SWI was not online
IE.SPC	Illegal address space The buffer specified in the IO.CON function was partially or totally outside the address space of the issuing task
IE.TMO	Time out error The timeout count expired during an IO.DPT operation before the target CPU requested the UNIBUS. This error code is also returned when the DT03/DT07 hardware fails to respond to a request due to a hardware failure

23.6 FORTRAN USAGE

All of the QIO functions described for the UNIBUS switch driver can be used in FORTRAN tasks, except AST support is not provided (IO.ATT function with an AST address specified). A macro subroutine can be written for the FORTRAN task to call that specifies the AST address.

APPENDIX A

SUMMARY OF I/O FUNCTIONS

This appendix summarizes legal I/O functions for all device drivers described in this manual. Both devices and functions are listed alphabetically. The meanings of the five parameters represented by the ellipsis (...) are described in Section 1.5.1. The meanings of the function-specific parameters shown below are discussed in the appropriate driver chapters. The user may reference these functions symbolically by invoking the system macros FILIO$ (standard I/O functions) and SPCIO$ (special I/O functions), or by allowing them to be defined at task build time from the system object library.

A.1 ANALOG-TO-DIGITAL CONVERTER DRIVERS

IO.KIL,...	Cancel I/O requests
IO.RBC,...,<stadd,size,stcnta>	Initiate an A/D conversion

A.2 CARD READER DRIVER

IO.ATT,...	Attach device
IO.DET,...	Detach device
IO.KIL,...	Cancel I/O requests
IO.RDB,...,<stadd,size>	Read logical block (binary)
IO.RLB,...,<stadd,size>	Read logical block (alphanumeric)
IO.RVB,...,<stadd,size>	Read virtual block (alphanumeric)

A.3 CASSETTE DRIVER

IO.ATT,...	Attach device
IO.DET,...	Detach device
IO.EOF,...	Write end-of-file gap
IO.KIL,...	Cancel I/O requests
IO.RLB,...,<stadd,size>	Read logical block
IO.RVB,...,<stadd,size>	Read virtual block

IO.RWD,...	Rewind tape
IO.SPB,...,<nbs>	Space blocks
IO.SPF,...,<nes>	Space files
IO.WLB,...,<stadd,size>	Write logical block
IO.WVB,...,<stadd,size>	Write virtual block

A.4 COMMUNICATION DRIVERS (MESSAGE-ORIENTED)

IO.ATT,...	Attach device
IO.DET,...	Detach device
IO.FDX,...	Set device to full duplex mode
IO.HDX,...	Set device to half-duplex mode
IO.INL,...	Initialize device and set device characteristics
IO.KIL,...	Cancel I/O requests
IO.RLB,...,<stadd,size>	Read logical block, stripping sync characters
IO.RNS,...,<stadd,size>	Read logical block, transparent mode
IO.SYN,...,<syn>	Specify sync character
IO.TRM,...	Terminate communication, disconnecting from physical channel
IO.WLB,...,<stadd,size>	Write logical block with sync leader
IO.WNS,...,<stadd,size>	Write logical block, no sync leader

A.5 DECTAPE DRIVER

IO.RLB,...,<stadd,size,,,lbn>	Read logical block (forward)
IO.RLV,...,<stadd,size,,,lbn>	Read logical block (reverse)
IO.RVB,...,<stadd,size,,,lbn>	Read virtual block (forward)
IO.WLB,...,<stadd,size,,,lbn>	Write logical block (forward)
IO.WLV,...,<stadd,size,,,lbn>	Write logical block (reverse)
IO.WVB,...,<stadd,size,,,lbn>	Write virtual block (forward)

A.6 DECTAPE II DRIVER

IO.ATT...	Attach device
IO.DET,...	Detach device

IO.KIL,...	Cancel I/O requests
IO.RLB,...,<stadd,size,,,lbn>	Read logical block
IO.WLB,...,<stadd,size,,,lbn>	Write logical block
IO.WLC,...,<stadd,size,,,lbn>	Write logical block with check
IO.RLC,...,<stadd,size,,,lbn>	Read logical block with check
IO.BLS,...,<lbn>	Position tape
IO.DGN,...	Run internal diagnostics

A.7 DISK DRIVER

IO.RLB,...,<stadd,size,,blkh,blkl>	Read logical block
IO.RPB,...,<stadd,size,,,pbn>	Read physical block
IO.RVB,...,<stadd,size,,blkh,blkl>	Read virtual block
IO.SEC,...,<stadd,size,pbn>	Sense characteristics (RX02) only
IO.SMD,...,<density,,>	Set media density (RX02 only)
IO.WDD,...,<stadd,size,,,pbn>	Write physical block (with deleted data mark)
IO.WLB,...,<stadd,size,,blkh,blkl>	Write logical block
IO.WLC,...,<stadd,size,,blkh,blkl>	Write logical block followed by write check
IO.WPB,...,<stadd,size,,,pbn>	Write physical block
IO.WVB,...,<stadd,size,,blkh,blkl>	Write virtual block

A.8 GRAPHICS DISPLAY DRIVER

IO.ATT,...	Attach device
IO.CON,...,<stadd,size,lpef,lpast>	Connect to graphics device
IO.CNT,...	Continue (restart display-processing unit)
IO.DET,...	Detach device
IO.DIS,...	Disconnect from graphics device
IO.KIL,...	Cancel I/O requests
IO.STP,...	Stop (halt display-processing unit)

A.9 INDUSTRIAL CONTROL SUBSYSTEMS

All I/O functions listed below apply to the ICS/ICR subsystem. The five functions supported by the DSS/DRS11 subsystem driver are marked by (D).

IO.CCI,...,<stadd,sizb,tevf>	Connect a buffer to digital interrupts
IO.CTI,...,<stadd,sizb,tevf,arv>	Connect a buffer to counter interrupts
IO.CTY,...,<stadd,sizb,tevf>	Connect a buffer to terminal interrupts
IO.DCI,...	Disconnect a buffer from digital interrupts
IO.DTI,...	Disconnect a buffer from counter interrupts
IO.DTY,...	Disconnect a buffer from terminal interrupts
IO.FLN,...	Set controller offline
IO.ITI,...,<mn,ic>	Initialize a counter
IO.LDI,...,<tname,[,tevf],pn,csm>	Link task to digital interrupts (D)
IO.LKE,...,<tname,[,tevf]>	Link task to error interrupts
IO.LTI,...,<tname,[,tevf],cn[,arv]>	Link task to counter interrupts
IO.LTY,...,<tname,[,tevf]>	Link task to remote terminal interrupts
IO.MLO,...,<opn,pp,dp>	Open or close bistable digital output points (D)
IO.MSO,...,<opn,dp>	Pulse single-shot digital output points
IO.NLK,...,<tname>	Unlink a task from all interrupts (D)
IO.NLN,...	Place ICR controller online
IO.RAD,...,<stadd>	Read activating data (D)
IO.RBC,...,<stadd,size,stcnta>	Initiate multiple A/D conversions
IO.SAO,...,<chn,vout>	Perform analog output
IO.UDI,...,<tname>	Unlink a task from digital interrupts (D)
IO.UER,...,<tname>	Unlink a task from error interrupts
IO.UTI,...,<tname>	Unlink a task from counter interrupts

IO.UTY,...,<tname>	Unlink a task from terminal interrupts
IO.WLB,...,<staddb,sizb>	Transmit data to the ICR remote terminal

A.10 LABORATORY PERIPHERAL ACCELERATOR DRIVER

IO.CLK,...,<mode,ckcsr,preset>

IO.INI,...,<irbuf,278.>

IO.LOD,...,<mbuf,2048.>

IO.STA,...,<bufptr,40.>

IO.STP,...,<userid>

A.11 LABORATORY PERIPHERAL SYSTEMS DRIVERS

IO.ADS,...,<stadd,size,pnt, ticks,bufs,chna>	Perform A/D sampling
IO.HIS,...,<stadd,size,pnt, ticks,bufs>	Perform histogram sampling
IO.KIL,...	Cancel I/O requests
IO.LED,...,<int,num>	Display number in LED lights
IO.MDA,...,<stadd,size,pnt, ticks,bufs,chnd>	Perform D/A output
IO.MDI,...,<stadd,size,pnt, ticks,bufs,mask>	Perform digital input sampling
IO.MDO,...,<stadd,size,pnt, ticks,bufs,mask>	Perform digital output
IO.REL,...,<rel,pol>	Latch output relay
IO.SDI,...,<mask>	Read digital input register
IO.SDO,...,<mask,data>	Write digital output register
IO.STP,...,<stadd>	Stop in-progress request

A.12 LINE PRINTER DRIVER

IO.ATT,...	Attach device
IO.DET,...	Detach device
IO.KIL,...	Cancel I/O requests
IO.WLB,...,<stadd,size,vfc>	Write logical block
IO.WVB,...,<stadd,size,vfc>	Write virtual block

A.13 MAGNETIC TAPE DRIVER

IO.ATT,...	Attach device
IO.DET,...	Detach device
IO.EOF,...	Write end-of-file (tape mark)
IO.KIL,...	Cancel I/O requests
IO.RLB,...,<stadd,size>	Read logical block
IO.RLV,...,<stadd,size>	Read logical block reverse
IO.RVB,...,<stadd,size>	Read virtual block
IO.RWD,...	Rewind tape
IO.RWU,...	Rewind and turn unit off-line
IO.SEC,...	Read tape characteristics
IO.SMO,...,<cb>	Mount tape and set tape characteristics
IO.SPB,...,<nbs>	Space blocks
IO.SPF,...,<nes>	Space files
IO.STC,...,<cb>	Set tape characteristics
IO.WLB,...,<stadd,size>	Write logical block
IO.WVB,...,<stadd,size>	Write virtual block

A.14 PAPER TAPE READER/PUNCH DRIVERS

IO.ATT,...	Attach device
IO.DET,...	Detach device
IO.KIL,...	Cancel I/O Requests
IO.RLB,...,<stadd,size>	Read logical block (reader only)
IO.RVB,...,<stadd,size>	Read virtual block (reader only)
IO.WLB,...,<stadd,size>	Write logical block (punch only)
IO.WVB,...,<stadd,size>	Write virtual block (punch only)

A.15 PARALLEL COMMUNICATION LINK DRIVERS

A.15.1 Transmitter Driver Functions

IO.ATX,...,<stadd,size,flagwd, id,retries,retadd>	Attempt message transmission

IO.STC,...,<stadd,size,[state] [mode],,retadd>	Set master section characteristics
IO.SEC,...,	Sense master section status

A.15.2 Receiver Driver Functions

IO.CRX,...,<tef>	Correct for reception
IO.ATF,...,<stadd,size,retadd>	Accept transfer
IO.RTF,...	Reject transfer
IO.DRX,...	Disconnect from reception

A.16 TERMINAL DRIVER

IO.ATA,...,<ast[,parameter2] [,ast2]>	Attach device, specify unsolicited-character AST[1]
IO.ATT,...	Attach device
IO.CCO,...,<stadd,size,vfc>	Write logical block, cancel CTRL/O
IO.DET,...	Detach device
SF.GMC,...,<stadd,size>	Get multiple characteristics
IO.GTS,...,<stadd,size>	Get terminal support
IO.KIL,...	Cancel I/O requests
IO.RAL,...,<stadd,size[,tmo]>	Read logical block and pass all bits[1]
IO.RLB,...,<stadd,size[,tmo]>	Read logical block[1]
IO.RNE,...,<stadd,size[,tmo]>	Read logical block and do not echo[1]
IO.RPR,...,<stadd,size,[tmo], pradd,prsize,vfc>	Read after prompt[1]
IO.RST,...,<stadd,size[,tmo]>	Read with special terminators
IO.RTT,...,<stadd,size,[tmo], table>	Read logical block ended by specified special terminator[2]
IO.RVB,...,<stadd,size[,tmo]>	Read virtual block[1]
SF.SMC,...,<stadd,size>	Set multiple characteristics
IO.WAL,...,<stadd,size,vfc>	Write logical block and pass all bits

[1] "ast2", "parameter2", and "tmo" parameters are available for full-duplex driver functions only

[2] Function is available for full duplex driver only

IO.WBT,...,<stadd,size,vfc>	Write logical block and break through any ongoing I/O
IO.WLB,...,<stadd,size,vfc>	Write logical block
IO.WVB,...,<stadd,size,vfc>	Write virtual block

Subfunction bits for terminal-driver functions:

TF.AST	Unsolicited-input-character AST
TF.BIN	Binary prompt
TF.CCO	Cancel CTRL/O
TF.ESQ	Recognize escape sequences
TF.NOT	Unsolicited input AST notification[1]
TF.RAL	Read, pass all bits
TF.RCU	Restore cursor position[1]
TF.RNE	Read with no echo
TF.RST	Read with special terminators
TF.TMO	Read with timeout[1]
TF.WAL	Write, pass all bits
TF.WBT	Break-through write
TF.XCC	CTRL/C starts a command line interpreter[1]
TF.XOF	Send XOFF

A.17 UNIBUS SWITCH DRIVER

IO.ATT,...,<[ast]>	Attach device
IO.DET,...	Detach device
IO.KIL,...	Cancel I/O requests
IO.CON,...,<[rcnt],[cpu]>	Connect UNIBUS switch
QIO$C IO.DIS,...,	Disconnect UNIBUS switch
IO.DPT,...,<[tout],[port]>	Disconnect UNIBUS switch and connect to specified CPU port
IO.SWI,...,<cpu>	Switch UNIBUS from current CPU to specified CPU
IO.CSR,...	Read UNIBUS switch CSR

[1] Full duplex driver only

A.18 UNIVERSAL DIGITAL CONTROLLER DRIVER

IO.CCI,...,<stadd,sizb,tevf>	Connect a buffer to contact interrupts
IO.CTI,...,<stadd,sizb,tevf,arv>	Connect a buffer to timer interrupts
IO.DCI,...	Disconnect a buffer from contact interrupt
IO.DTI,...	Disconnect a buffer from timer interrupts
IO.ITI,...,<mn,ic>	Initialize a timer
IO.KIL,...	Cancel I/O requests
IO.MLO,...,<opn,pp,dp>	Open or close latching digital output points
IO.RBC,...,<stadd,size,stcnta>	Initiate multiple A/D conversions

A.19 VIRTUAL TERMINAL DRIVER

IO.ATT,...	Attach device
IO.DET,...	Detach device
IO.KIL,...	Cancel I/O request
IO.RLB,...,<stadd,size>	Read logical block
IO.RVB,...,<stadd,size>	Read virtual block
IO.WLB,...,<stadd,size,stat>	Write logical block
IO.WVB,...,<stadd,size,stat>	Write virtual block
IO.STC,...,<cb,sw2,sw1>	Set terminal characteristics (enable/disable intermediate buffering, or return I/O completion status)

APPENDIX B

I/O FUNCTION AND STATUS CODES

This appendix lists the numeric codes for all I/O functions, directive status returns, and I/O completion status returns. Lists are organized in the following sequence:

- I/O completion status codes
- Directive status codes
- Device-independent I/O function codes
- Device-dependent I/O function codes

Device-dependent function codes are listed by device. Both devices and codes are organized in alphabetical order.

For each code, the symbolic name is listed in form IO.xxx, IE.xxx, or IS.xxx. A brief description of the error or function is also included. Both decimal and octal values are provided for all codes.

B.1 I/O STATUS CODES

This section lists error and success codes which can be returned in the I/O status block on completion of an I/O function. The codes below may be referenced symbolically by invoking the system macro IOERR$.

B.1.1 I/O Status Error Codes

Name	Decimal	Octal	Meaning
IE.ABO	-15	177761	Operation aborted
IE.ALN	-34	177736	File already open
IE.BAD	-01	177777	Bad parameter
IE.BBE	-56	177710	Bad block
IE.BCC	-66	177676	Block check error or framing error
IE.BLK	-20	177754	Illegal block number
IE.BYT	-19	177755	Byte-ligned buffer specified

I/O FUNCTION AND STATUS CODES

Name	Decimal	Octal	Meaning
IE.CNR	-73	177667	Connection rejected
IE.CON	-22	177752	UDC connect error
IE.DAA	-08	177770	Device already attached
IE.DAO	-13	177763	Data overrun
IE.DNA	-07	177771	Device not attached
IE.DNR	-03	177775	Device not ready
IE.DUN	-09	177767	Device not attachable
IE.EOF	-10	177766	End-of-file encountered
IE.EOT	-62	177702	End-of-tape encountered
IE.EOV	-11	177765	End-of-volume encountered
IE.FHE	-59	177705	Fatal hardware error
IE.FLG	-89	177647	Event flag already specified
IE.FLN	-81	177657	ICS/ICR controller already offline
IE.IEF	-97	177637	Invalid event flag
IE.IES	-82	177656	Invalid escape sequence
IE.IFC	-2	177776	Illegal function
IE.MOD	-21	177753	Invalid UDC or ICS/ICR module
IE.NLK	-79	177661	Task not linked to specified ICS/ICR interrupts
IE.NLN	-37	177733	File not open
IE.NOD	-23	177751	No dynamic memory available to allocate a secondary control block
IE.NST	-80	177660	Task specified in ICS/ICR Link or Unlink request is not installed
IE.NTR	-87	177651	Task not triggered
IE.OFL	-65	177677	Device off-line
IE.ONP	-05	177773	Illegal subfunction
IE.OVR	-18	177756	Illegal read overlay request
IE.PES	-83	177655	Partial escape sequence
IE.PRI	-16	177760	Privilege violation
IE.REJ	-88	177650	Transfer rejected

Name	Decimal	Octal	Meaning
IE.NOD	-23	177751	No dynamic memory available
IE.RSU	-17	177757	Nonsharable resource in use
IE.SPC	-06	177772	Illegal address space
IE.TMO	-74	177666	Timeout error
IE.VER	-04	177774	Unrecoverable error
IE.WCK	-86	177652	Write check error
IE.WLK	-12	177764	Write-locked device

B.1.2 I/O Status Success Codes

Name	Decimal Bytes	Octal Word	Meaning
IS.CR	Byte 0: 1 Byte 1: 15	006401	Successful completion with carriage return
IS.CC	Byte 0: 1 Byte 1: 3	001401	Successful completion on read terminated by CTRL/C
IS.ESC	Byte 0: 1 Byte 1: 33	015401	Successful completion with ESCape
IS.ESQ	Byte 0: 1 Byte 1. 233	115401	Successful completion with an escape sequence
IS.PND	+00	000000	I/O request pending
IS.RDD	+02	000002	Deleted data mark read
IS.SUC	+01	000001	Successful completion
IS.TMO	+02	000002	Successful completion on read terminated by timeout
IS.TNC	+02	000002	Successful transfer but message truncated (receiver buffer too small)

B.2 DIRECTIVES CODES

This section lists error and success codes which can be returned in the directive status word at symbolic location $DSW when a QIO directive is issued.

B.2.1 Directive Error Codes

Name	Decimal	Octal	Meaning
IE.ADP	-98	177636	Invalid address
IE.IEF	-97	177637	Invalid event flag number
IE.ILU	-96	177640	Invalid logical unit number
IE.SDP	-99	177635	Invalid DIC number or DPB size
IE.ULN	-05	177773	Unassigned LUN
IE.UPN	-01	177777	Insufficient dynamic storage

B.2.2 Directive Success Codes

Name	Decimal	Octal	Meaning
IS.SUC	+01	000001	Directive accepted

B.3 I/O FUNCTION CODES

This section lists octal codes for all standard and device-dependent I/O functions.

B.3.1 Standard I/O Function Codes

Symbolic Name	Word Equivalent	Code (High Byte)	Subcode (Low Byte)	Meaning
IO.ATT	001400	3	0	Attach device
IO.DET	002000	4	0	Detach device
IO.KIL	000012	0	12	Cancel I/O requests
IO.RLB	001000	2	0	Read logical block
IO.RVB	010400	21	0	Read virtual block
IO.WLB	000400	1	0	Write logical block
IO.WVB	011000	22	0	Write virtual block

B.3.2 Specific A/D Converter I/O Function Codes

Symbolic Name	Word Equivalent	Code (High Byte)	Subcode (Low Byte)	Meaning
IO.RBC	003000	6	0	Initiate an A/D conversion

B.3.3 Specific Card Reader I/O Function Codes

Symbolic Name	Word Equivalent	Code (High Byte)	Subcode (Low Byte)	Meaning
IO.RDB	001200	2	200	Read logical block (binary)

B.3.4 Specific Cassette I/O Function Codes

Symbolic Name	Word Equivalent	Code (High Byte)	Subcode (Low Byte)	Meaning
IO.EOF	003000	6	0	Write end-of-file gap
IO.RWD	002400	5	0	Rewind tape
IO.SPB	002420	5	20	Space blocks
IO.SPF	002440	5	40	Space files

B.3.5 Specific Communication (Message-Oriented) I/O Function Codes

Symbolic Name	Word Equivalent	Code (High Byte)	Subcode (Low Byte)	Meaning
IO.FDX	003020	6	20	Set device to full-duplex mode
IO.HDX	003010	6	10	Set device to half-duplex mode
IO.INL	002400	5	0	Initialize device and set device characteristics
IO.RNS	001020	2	20	Read logical block, transparent mode
IO.SYN	003040	6	40	Specify sync character
IO.TRM	002410	5	10	Terminate communication, disconnecting from physical channel
IO.WNS	000420	1	20	Write logical block with no sync leader

B.3.6 Specific DECtape I/O Function Codes

Symbolic Name	Word Equivalent	Code (High Byte)	Subcode (Low Byte)	Meaning
IO.RLV	001100	2	100	Read logical block (reverse)
IO.WLV	000500	1	100	Write logical block (reverse)

B.3.7 Specific DECtape II I/O Function Codes

Symbolic Name	Word Equivalent	Code (High Byte)	Subcode (Low Byte)	Meaning
IO.WLC	420	1	20	Write logical block with check
IO.RLC	1020	2	20	Read logical block with check
IO.BLS	4010	10	10	Position tape
IO.DGN	4150	10	150	Run internal diagnostics

B.3.8 Specific Disk I/O Function Codes

Symbolic Name	Word Equivalent	Code (High Byte)	Subcode (Low Byte)	Meaning
IO.RPB	001040	2	40	Read physical block (RX01, RL01, RL02 only)
IO.SEC	002520	5	120	Sense characteristics (RX02 only)
IO.SMD	002500	5	100	Set media density (RX02 only)
IO.WDD	001140	1	140	Write physical block with deleted data mark (RX02 only)
IO.WLC	001020	1	20	Write logical block followed by write check (all except RX01, RX02)
IO.WPB	000440	1	40	Write physical block (RX01, RX02, RL01, RL02 only)

B.3.9 Specific Graphics Display I/O Function Codes

Symbolic Name	Word Equivalent	Code (High Byte)	Subcode (Low Byte)	Meaning
IO.CON	015400	33	00	Connect to graphics device
IO.CNT	017000	36	00	Continue DPU
IO.DIS	016000	34	00	Disconnect from graphics device
IO.STP	016400	35	00	Stop DPU

B.3.10 Specific ICS/ICR, DSS/DR I/O Function Codes

Symbolic Name	Word Equivalent	Code (High Byte)	Subcode (Low Byte)	Meaning
IO.CCI	014000	30	0	Connect a buffer to digital interrupt input
IO.CTI	015400	33	0	Connect a counter
IO.CTY	003400	7	0	Connect a remote terminal
IO.DCI	014400	31	0	Disconnect a buffer from digital interrupt input
IO.DTI	016000	34	0	Disconnect a buffer from counter input
IO.DTY	006400	15	0	Disconnect a buffer from terminal input
IO.FLN	012400	25	0	Place selected unit offline
IO.ITI	017000	36	0	Initialize a counter
IO.LDI	007000	16	0	Link a task to digital interrupts
IO.LKE	012000	24	0	Link a task to error interrupts
IO.LTI	007400	17	0	Link a task to counter interrupts
IO.LTY	010000	20	0	Link a task to terminal interrupts
IO.MLO	006000	14	0	Open or close bistable digital output points

Symbolic Name	Word Equivalent	Code (High Byte)	Subcode (Low Byte)	Meaning
IO.MSO	005000	12	0	Pulse single-shot digital output points
IO.NLK	011400	23	0	Unlink a task from all unsolicited interrupts
IO.ONL	017400	37	0	Place selected unit online
IO.RAD	010400	21	0	Read task activation data
IO.RBC	003000	6	0	Initiate multiple A/D conversions
IO.SAO	004000	10	0	Perform analog output to specified channel
IO.UDI	011410	23	10	Unlink a task from digital interrupts
IO.UER	011440	23	40	Unlink a task from error interrupts
IO.UTI	011420	23	20	Unlink a task from counter interrupts
IO.UTY	011430	23	30	Unlink a task from terminal interrupts
IO.WLB	000400	1	0	Output to remote terminal

B.3.11 Specific LPA11-K I/O Function Codes

Symbolic Name	Word Equivalent	Code (High Byte)	Subcode (Low Byte)	Meaning
IO.CLK	015000	32	0	Start clock
IO.INI	014400	31	0	Initialize LPA11-K
IO.LOD	014000	30	0	Load microcode
IO.STA	015400	33	1	Start transfer
IO.STP	016400	35	0	Stop request

B.3.12 **Specific LPS I/O Function Codes**

Symbolic Name	Word Equivalent	Code (High Byte)	Subcode (Low Byte)	Meaning
IO.ADS	014000	30	0	Initialize A/D sampling
IO.HIS	015000	32	0	Initialize histogram sampling
IO.LED	012000	24	0	Display number in LED lights
IO.MDA	016000	34	0	Initialize D/A output
IO.MDI	014400	31	0	Initialize digital input sampling
IO.MDO	015400	33	0	Initialize digital output
IO.REL	013400	27	0	Latch output relay
IO.SDI	013000	26	0	Read digital input register
IO.SDO	012400	25	0	Write digital output register
IO.STP	016400	35	0	Stop in-progress request

B.3.13 **Specific Magtape I/O Function Codes**

Symbolic Name	Word Equivalent	Code (High Byte)	Subcode (Low Byte)	Meaning
IO.EOF	003000	6	0	Write end-of-file gap
IO.RLV	001100	2	100	Read logical block (reverse)
IO.RWD	002400	5	0	Rewind tape
IO.RWU	002540	5	140	Rewind and unload
IO.SEC	002520	5	120	Sense characteristics
IO.SMO	002560	5	160	Mount and set characteristics
IO.SPB	002420	5	20	Space blocks
IO.SPF	002440	5	40	Space files
IO.STC	002500	5	100	Set characteristics

B.3.14 Specific Parallel Communications Link I/O Function Codes

B.3.14.1 Transmitter Driver Functions

Symbolic Name	Word Equivalent	Code (High Byte)	Subcode (Low Byte)	Meaning
IO.ATX	000400	1	0	Attempt message transmission
IO.STC	002500	5	100	Set master section characteristics
IO.SEC	002520	5	120	Sense master section status

B.3.14.2 Receiver Driver Functions

Symbolic Name	Word Equivalent	Code (High Byte)	Subcode (Low Byte)	Meaning
IO.CRX	014400	31	0	Conneect for reception
IO.ATF	001000	2	0	Accept transfer
IO.RTF	015400	33	0	Reject transfer
IO.DRX	001500	32	0	Disconnect from reception

B.3.15 Specific Terminal I/O Function Codes

Symbolic Name	Word Equivalent	Code (High Byte)	Subcode (Low Byte)	Meaning
IO.ATA	001410	3	10	Attach device, specify unsolicited-input-cha racter AST
IO.CCO	000440	1	40	Write logical block and cancel CTRL/O
SF.GMC	002560	5	160	Get multiple characteristics
IO.GTS	002400	5	00	Get terminal support
IO.RAL	001010	2	10	Read logical block and pass all bits
IO.RNE	001020	2	20	Read with no echo
IO.RPR	004400	11	00	Read after prompt
IO.RST	001001	2	1	Read with special terminators

Symbolic Name	Word Equivalent	Code (High Byte)	Subcode (Low Byte)	Meaning
IO.RTT	005001	12	1	Read logical block ended by specified special terminator (Full-duplex driver only)
SF.SMC	002440	5	40	Set multiple characteristics
IO.WAL	000410	1	10	Write logical block and pass all bits
IO.WBT	000500	1	100	Write logical block and break through ongoing I/O

Subfunction Bits:

With IO.RLB, IO.RPR:

TF.RST	1
TF.BIN	2
TF.RAL	10
TF.RNE	20
TF.XOF	100

With IO.WLB:

TF.WAL	10
TF.CCO	40
TF.WBT	100

With IO.ATT:

TF.AST	10
TF.ESQ	20

B.3.16 **Specific UDC I/O Function Codes**

Symbolic Name	Word Equivalent	Code (High Byte)	Subcode (Low Byte)	Meaning
IO.CCI	014000	30	0	Connect a buffer to contact interrupt digital input
IO.CTI	015400	33	0	Connect a timer
IO.DCI	014400	31	0	Disconnect a buffer from contact interrupt digital input

Symbolic Name	Word Equivalent	Code (High Byte)	Subcode (Low Byte)	Meaning
IO.DTI	016000	34	0	Disconnect a timer
IO.ITI	017000	36	0	Initialize a timer
IO.MLO	006000	14	0	Open or close latching digital output points
IO.RBC	003000	6	0	Initiate multiple A/D conversions

B.3.17 Specific UNIBUS Switch I/O Function Codes

Symbolic Name	Word Equivalent	Code (High Byte)	Subcode (Low Byte)	Meaning
IO.CON	15400	33	0	Connect UNIBUS switch
IO.DIS	16000	34	0	Disconnect UNIBUS switch
IO.DPT	16010	34	10	Disconnect UNIBUS switch and connect to specified CPU port
IO.SWI	16400	35	0	Switch UNIBUS from current CPU to specified CPU
IO.CSR	15000	32	0	Read UNIBUS switch CSR

B.3.18 Specific Virtual Terminal I/O Function Codes

Symbolic Name	Word Equivalent	Code (High Byte)	Subcode (Low Byte)	Meaning
IO.STC	002500	5	100	Set terminal characteristics

APPENDIX C

RSX-11M PROGRAMMING EXAMPLE

```
MESSAGE TRANSFER        MACRO M0710  10-OCT-74 10:19  PAGE 1

                .TITLE MESSAGE TRANSFER
                .IDENT  /01/

        ;
        ; COPYRIGHT  1974, DIGITAL  EQUIPMENT  CORP.,  MAYNARD,  MASS.
        ;
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        ;
        ; VERSION 01
        ;
        ;               5-SEP-74
        ;
        ; DEMONSTRATION OF USE OF RSX-11M I/O
        ;
        ; MACRO LIBRARY CALLS
        ;

                .MCALL  ALUN$S,QIO$S,WTSE$S,WSIG$S

        ;
        ; LOCALLY DEFINED MACROS
        ;

                .MACRO  CALL SUBR       ;DEFINITION FOR SUBROUTINE CALLS
                JSR     PC,SUBR
                .ENDM

                .MACRO  RETURN          ;SUBROUTINE RETURN MACRO
                RTS     PC
                .ENDM

        ;
        ; LOCAL DATA
        ;


        ;
```

```
                    ; READ-RELATED STORAGE
                    ;

   000000  000000   RDSTS:  .WORD   0               ;READ STATUS BLOCK
   000002  000000           .WORD   0

                    ;
                    ; WRITE-RELATED STORAGE
                    ;

   000004  000000   WRSTS:  .WORD   0               ;WRITE STATUS BLOCK


MESSAGE TRANSFER        MACRO M0710  10-OCT-74 10:19  PAGE 1-1

   000006  000000           .WORD   0

                    ;
                    ; BUFFER STORAGE
                    ;

   000010           BUF1:   .BLKB   82.             ;BUFFER 1
   000132           BUF2:   .BLKB   82.             ;BUFFER 2

                    ;+
                    ; **-$XFER-DEMONSTRATE USE OF RSX-11M I/O BY OUTPUTTING RECORDS
                    ; FROM TI: (USER'S TERMINAL) TO LINE PRINTER. REQUESTS ARE DOUBLE
                    ; BUFFERED TO DEMONSTRATE HOW OPERATIONS MAY BE OVERLAPPED.
                    ;-

   000254           $XFER:: ALUN$S  #1,#"TI,#0      ;LUN 1 IS TI: DEVICE
   000274                   ALUN$S  #2,#"LP         ;LUN 2 IS LP0:
                    ;
                    ; READ A LINE FROM INPUT DEVICE, LUN 1
                    ;
   000314           10$:    QIO$S   #IO.RLB,#1,#1,,#RDSTS,,<#BUF1,#80.>
   000366  103003           BCC     20$             ;IF DISPATCHED OK, CONTINUE
   000370                   CALL    STCHK           ;CHECK STATUS
   000374  000747           BR      10$             ;IF RECOVERABLE ERROR, TRY AGAIN

   000376           20$:    WTSE$S  #1              ;WAIT UNTIL 1 COMPLETE
   000410  126727           CMPB    RDSTS,#IS.SUC   ;READ SUCCESSFUL?
           177364
           000000G
   000416  001402           BEQ     30$             ;CONTINUE IF SUCCESSFUL
   000420  000167           JMP     100$            ;TERMINATE IF NOT SUCCESSFUL
           000440

   000424  016701   30$:    MOV     RDSTS+2,R1      ;GET ACTUAL BYTE COUNT IN R1
           177352
                    ;
                    ; BEGIN TO FILL SECOND BUFFER
                    ;
   000430           40$:    QIO$S   #IO.RLB,#1,#2,,#RDSTS,,<#BUF2,#80.>
   000502  103003           BCC     50$             ;CONTINUE IF DISPATCH OK
   000504                   CALL    STCHK           ;CHECK STATUS
   000510  000747           BR      40$             ;TRY AGAIN

                    ;
                    ; START BUFFER 1 OUT
                    ;

   000512           50$:    QIO$S   #IO.WLB,#2,#1,,#WRSTS,,<#BUF1,R1,#40>
   000564  103003           BCC     60$             ;CONTINUE IF NO DISPATCH ERROR
   000566                   CALL    STCHK           ;CHECK STATUS
   000572  000747           BR      50$             ;TRY AGAIN

                    ;
                    ; THIS IS A SYNCHRONIZATION POINT. BOTH FUNCTIONS MUST COMPLETE
                    ; BEFORE ANYTHING ELSE BEGINS.
                    ;

```

```
MESSAGE TRANSFER        MACRO M0710  10-OCT-74 10:19  PAGE 1-2

    000574            60$:    WTSESS  #2                  ;WAIT FOR 2 TO FILL
    000606  126727            CMPB    RDSTS,#IS.SUC       ;SUCCESSFUL?
            177166
            000000G
    000614  001123            BNE     100$                ;IF NOT, CRASH
    000616  016702            MOV     RDSTS+2,R2          ;GET COUNT FOR BUFFER 2
            177160
    000622                    WTSESS  #1                  ;WAIT FOR 1 TO EMPTY
    000634  126727            CMPB    WRSTS,#IS.SUC       ;SUCCESSFUL?
            177144
            000000G
    000642  001110            BNE     100$                ;IF NOT, CRASH
                      ;
                      ; FILL BUFFER 1, EMPTY BUFFER 2
                      ;
    000644            70$:    QIO$S   #IO.RLB,#1,#1,,#RDSTS,,<#BUF1,#80.>
    000716  103003            BCC     80$                 ;IF OK, CONTINUE
    000720                    CALL    STCHK               ; CHECK STATUS
    000724  000747            BR      70$                 ;TRY AGAIN

    000726            80$:    QIO$S   #IO.WLB,#2,#2,,#WRSTS,,<#BUF2,R2,#40>
    001000  103003            BCC     90$                 ;CONTINUE IF SUCCESSFUL
    001002                    CALL    STCHK               ;CHECK STATUS IF NOT SUCCESSFUL
    001006  000747            BR      80$                 ;RETURN

                      ;
                      ; THIS IS ALSO A SYNCHRONIZATION POINT
                      ;

    001010            90$:    WTSESS  #1                  ;WAIT FOR 1 TO FILL
    001022  126727            CMPB    RDSTS,#IS.SUC       ;SUCCESSFUL?
            176752
            000000G
    001030  001015            BNE     100$                ;IF NOT, CRASH
    001032  016701            MOV     RDSTS+2,R1          ;GET ACTUAL BYTE COUNT IN R1
            176744
    001036                    WTSESS  #2                  ;WAIT FOR BUFFER 2 TO EMPTY
    001050  126727            CMPB    WRSTS,#IS.SUC       ;SUCCESSFUL?
            176730
            000000G
    001056  001002            BNE     100$                ;TERMINATE IF NOT
    001060  000167            JMP     40$                 ;BACK INTO LOOP
            177344

                      ;
                      ; DON'T ATTEMPT TO RECOVER ERRORS
                      ;

    001064  000004    100$:   IOT                         ;CRASH TASK

                      ;+
                      ; **- STCHK - ATTEMPT TO RECOVER DIRECTIVE DISPATCH ERROR ONLY IF
                      ; IT INVOLVES DYNAMIC MEMORY ALLOCATION - OTHERWISE TERMINATE.
                      ;
                      ;       INPUTS:
                      ;
                      ;               (SP)=RETURN ADDRESS
```

```
MESSAGE TRANSFER        MACRO MØ71Ø  1Ø-OCT-74 1Ø:19  PAGE 1-3

                                ;
                                ;       OUTPUTS:
                                ;
                                ;               NONE
                                ;-

    ØØ1Ø66  126727  STCHK:  CMPB    $DSW,#IE.UPN    ;BUFFER ALLOCATION FAILURE?
            ØØØØØØG
            ØØØØØØG
    ØØ1Ø74  ØØ1ØØ4          BNE     1Ø$             ;IF NOT TERMINATE
    ØØ1Ø76                  WSIG$S                  ;AWAIT SIGNIFICANT EVENT
    ØØ11Ø4                  RETURN                  ;TRY AGAIN

    ØØ11Ø6  ØØØØØ4  1Ø$:    IOT                     ;CRASH TASK

            ØØØ254'         .END    $XFER
```

```
MESSAGE TRANSFER        MACRO MØ71Ø  1Ø-OCT-74 1Ø:19  PAGE 1-4
SYMBOL TABLE

BJF1    ØØØØ1ØR         IO.WLB= ****** GX       WRSTS   ØØØØØ4R
BJF2    ØØØ132R         IS.SUC= ****** GX       $DSW  = ****** GX
IE.JPN= ****** GX       RDSTS   ØØØØØØR         $XFER   ØØØ254RG
IO.RLB= ****** GX       STCHK   ØØ1Ø66R         $$$ARG= ØØØØØ2

. ABS.  ØØØØØØ     ØØØ
        ØØ111Ø     ØØ1
ERRORS DETECTED:  Ø

FREE CORE:  3586. WORDS
,MSG/LI:TTM=MSG.ØØ1
```

RSX-11M/M-PLUS
I/O Drivers
Reference Manual
AA-H269A-TC

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