VMS I/O User's Reference Manual: Part II

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This document contains the information necessary to interface directly with the communications I/O device drivers supplied as part of the VMS operating system. Several examples of programming techniques are included. This document does not contain information on I/O operations using VAX Record Management Services.

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Preface

Manual Objectives

This manual provides the information necessary to interface directly with I/O device drivers supplied as part of the VMS operating system. It is not the objective of this manual to provide information on all aspects of VMS input/output (I/O) operations.

Intended Audience

This manual is intended for system programmers who want to save time and space by using I/O devices directly. If you do not require such detailed knowledge of the I/O drivers, use the device-independent services described in the *VMS Record Management Services Manual.* Readers are expected to have some experience with VAX MACRO or another high-level assembly language.

Document Structure

This manual is organized into six chapters and one appendix, as follows:

- Chapters 1 through 6 describe the use of communications device drivers supported by VMS.
  - Chapter 1 discusses the DMC11/DMR11 interface driver.
  - Chapter 2 discusses the DMP11 and DMF32 interface drivers.
  - Chapter 3 discusses the DR11–W and DRV11-WA interface drivers.
  - Chapter 4 discusses the DR32 interface driver.
  - Chapter 5 discusses the Asynchronous DDCMP interface driver.
  - Chapter 6 discusses the Ethernet/802 device drivers.
- The appendix summarizes the function codes, arguments, and function modifiers used by these drivers.

Associated Documents

For additional information, refer to the following documents:

- *VMS System Services Reference Manual*
- *VAX Software Handbook*
- *PDP–11 Peripherals Handbook*
- *VAX FORTRAN User's Guide*
- *Guide to VMS Programming Resources*
- *VMS Record Management Services Manual*
- *VMS Networking Manual*
- *VAX–11 2780/3780 Protocol Emulator User's Guide*

- *VMS System Messages and Recovery Procedures Reference Volume*
- *VMS Device Support Manual*

Conventions

Convention	Meaning
RET	In examples, a key name (usually abbreviated) shown within a box indicates that you press a key on the keyboard; in text, a key name is not enclosed in a box. In this example, the key is the RETURN key. (Note that the RETURN key is not usually shown in syntax statements or in all examples; however, assume that you must press the RETURN key after entering a command or responding to a prompt.)
CTRL/C	A key combination, shown in uppercase with a slash separating two key names, indicates that you hold down the first key while you press the second key. For example, the key combination CTRL/C indicates that you hold down the key labeled CTRL while you press the key labeled C. In examples, a key combination is enclosed in a box.
$ SHOW TIME 05-JUN-1988 11:55:22	In examples, system output (what the system displays) is shown in black. User input (what you enter) is shown in red.
$ TYPE MYFILE.DAT . . .	In examples, a vertical series of periods, or ellipsis, means either that not all the data that the system would display in response to a command is shown or that not all the data a user would enter is shown.
input-file, . . .	In examples, a horizontal ellipsis indicates that additional parameters, values, or other information can be entered, that preceding items can be repeated one or more times, or that optional arguments in a statement have been omitted.
[logical-name]	Brackets indicate that the enclosed item is optional. (Brackets are not, however, optional in the syntax of a directory name in a file specification or in the syntax of a substring specification in an assignment statement.)
quotation marks apostrophes	The term quotation marks is used to refer to double quotation marks ("). The term apostrophe (') is used to refer to a single quotation mark.

Convention	Meaning

	Hyphens in coding examples indicate that additional arguments to the request are provided on the line that follows. For example:
	`CMDOFAB: $FAB    fac=put,fnm=sys$output:,-`
	`         mrs=132,rat=cr,rfm=var`
	`CMDORAB: $RAB    ubf=cmdbuf,usz=cmdbsz,-`
	`         fab=cmdofab`

numbers	Unless otherwise noted, all numbers in the text are assumed to be decimal. Nondecimal radixes—binary, octal, or hexadecimal—are explicitly indicated in the coding examples.

New and Changed Features

This revision of the *VMS I/O User's Reference Manual: Part II* reflects the technical changes since VMS Version 4.4. The following chapters contain new or changed information:

- Chapter 2 describes the DMP11 and DMF32 interface drivers only. Discussion of the asynchronous DDCMP interface driver has been moved to Chapter 5.
- Chapter 5 describes the asynchronous DDCMP interface driver. The DUP11 interface driver, which had been described in this chapter, is no longer supported.
- Chapter 6 describes the Ethernet/802 device drivers, that is, the drivers for the DEUNA, DEQNA, DELUA, DEBNA, DESVA, and DELQA.

1 DMC11/DMR11 Interface Driver

This chapter describes the use of the VMS DMC11 synchronous communications line interface driver. (The DMR11 synchronous communications line interface uses the same driver in DMC compatibility mode; references to the DMC11 driver also imply the use of the DMR11 driver operating in DMC11 compatibility mode.) The DMC11 provides a direct-memory-access (DMA) interface between two computer systems using the DIGITAL Data Communications Message Protocol (see Section 1.1.1). The DMC11 supports DMA data transfers of up to 16K bytes at rates of up to 1 million baud for local operation over coaxial cable and 56,000 baud for remote operation using modems. Both full- and half-duplex modes are supported.

The DMC11 is a message-oriented communications line interface used primarily to link two separate but cooperating computer systems.

1.1 Supported DMC11 Synchronous Line Interfaces

Table 1–1 lists the DMC11 options supported by the VMS operating system.

Table 1–1 Supported DMC11 Options

Type	Use
DMC11-AR with DMC11-FA DMC11-AR with DMC11-DA	Remote DMC11 and EIA or V35/DDS line unit
DMC11-AL with DMC11-MD DMC11-AL with DMC11-MA	Local DMC11 and 1M bps or 56 bps

1.1.1 DIGITAL Data Communications Message Protocol (DDCMP)

To ensure reliable data transmission, the DIGITAL Data Communications Message Protocol (DDCMP) has been implemented, using a high-speed microprocessor. For remote operations, a DMC11 can communicate with a different type of synchronous interface (or even a different type of computer), provided the remote system has implemented DDCMP.

DDCMP detects errors on the communication line interconnecting the systems using a 16-bit cyclic redundancy check (CRC). Errors are corrected, when necessary, by automatic message retransmission. Sequence numbers in message headers ensure that messages are delivered in the proper order with no omissions or duplications.

The DDCMP specification (Order No. AA-K175A-TC) provides more detailed information on DDCMP.

1.2 Driver Features and Capabilities

DMC11 driver capabilities include the following:

- A nonprivileged QIO interface to the DMC11 (allows use of the DMC11 as a raw-data channel)
- Unit attention conditions transmitted through attention ASTs and mailbox messages
- Both full- and half-duplex operation
- Interface design common to all communications devices supported by the VMS operating system
- Error logging of all DMC11 microprocessor and line unit errors
- Online diagnostics
- Separate transmit and receive quotas
- Assignment of several read buffers to the device

The following sections describe mailbox usage and I/O quotas.

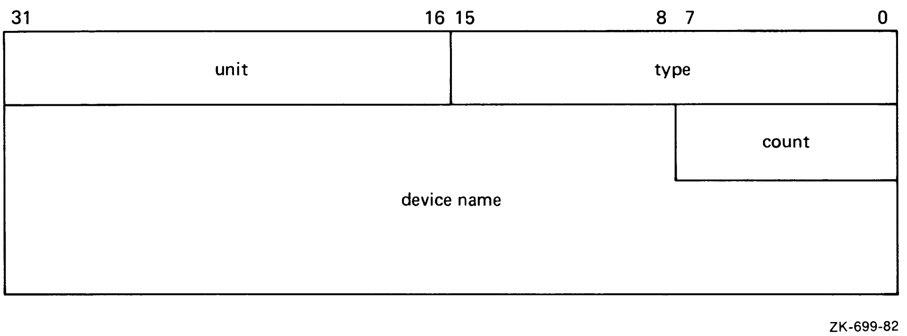
1.2.1 Mailbox Usage

The device owner process can associate a mailbox with a DMC11 by using the Assign I/O Channel ($ASSIGN) system service. (See the *VMS System Services Reference Manual.*) The mailbox is used to receive messages that signal attention conditions about the unit. As illustrated in Figure 1–1, these messages have the following content and format:

- Message type. This can be any one of the following:
  - MSG$_XM_DATAVL—Data is available.
  - MSG$_XM_SHUTDN—The unit has been shut down.
  - MSG$_XM_ATTN—A disconnect, timeout, or data check occurred.

  The $MSGDEF macro is used to define message types.
- Physical unit number of the DMC11
- Size (count) of the ASCII device name string
- Device name string

Figure 1–1 Mailbox Message Format



1.2.2 Quotas

Transmit operations are considered direct I/O operations and are limited by the process's direct I/O quota.

The quotas for the receive buffer free list (see Section 1.4.3.4) are the process's buffered I/O count and buffered I/O byte limit. After startup, the transient byte count and the buffered I/O byte limit are adjusted.

1.2.3 Power Failure

When a system power failure occurs, no DMC11 recovery is possible. The device is in a fatal error state and is shut down.

1.3 Device Information

You can obtain information on DMC11/DMR11 device characteristics by using the Get Device/Volume Information ($GETDVI) system service. (See the *VMS System Services Reference Manual*.)

$GETDVI returns DMC11/DMR11 device characteristics when you specify the item code DVI$_DEVCHAR. Table 1–2 lists these characteristics, which are defined by the $DEVDEF macro.

DVI$_DEVTYPE and DVI$_DEVCLASS return the device type and class names, which are defined by the $DCDEF macro. The device type for the DMC11 is DT$_DMC11; the device type for the DMR11 is DT$_ DMR11 (only after the device has been started once). The device class for the DMC11 is DC$_SCOM.

DVI$_DEVBUFSIZ returns the maximum message size. The maximum message size is the maximum send or receive message size for the unit. Messages greater than 512 bytes on modem-controlled lines are more prone to transmission errors and therefore may require more retransmissions.

Table 1–2 DMC11/DMR11 Device Characteristics

Characteristic[1]	Meaning
	Dynamic Bit (Conditionally Set)
DEV$M_NET	Network device
	Static Bits (Always Set)
DEV$M_ODV	Output device
DEV$M_IDV	Input device

[1]Defined by the $DEVDEF macro

DVI$_DEVDEPEND returns the DMC11/DMR11 unit characteristics bits, the unit and line status bits, and the error summary bits in a longword field, as shown in Figure 1–2.

Figure 1–2 DVI$_DEVDEPEND Returns

31 — 24	23 — 16	15 — 8	7 — 0
not used	error summary	unit and line status	unit characteristics

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The unit characteristics bits govern the DDCMP operating mode. They are defined by the $XMDEF macro and can be read or set. Table 1–3 lists the unit characteristics values and their meanings.

Table 1–3 DMC11/DMR11 Unit Characteristics

Characteristic	Meaning[1]
XM$M_CHR_MOP	DDCMP maintenance mode.
XM$M_CHR_SLAVE	DDCMP half-duplex slave station mode.
XM$M_CHR_HDPLX	DDCMP half-duplex mode.
XM$M_CHR_LOOPB	DDCMP loopback mode.
XM$M_CHR_MBX	The status of the mailbox associated with the unit. If this bit is set, the mailbox is enabled to receive messages signaling unsolicited data. (This bit can also be changed as a subfunction of read or write functions.)

[1]Section 1.1.1 describes DDCMP

The status bits show the status of the unit and the line. The values are defined by the $XMDEF macro. They can be read, set, or cleared as indicated. Table 1–4 lists the status values and their meanings.

Table 1–4 DMC11/DMR11 Unit and Line Status

Status	Meaning
XM$M_STS_ACTIVE	Protocol is active. This bit is set when IO$_SETMODE!IO$_STARTUP is complete and is cleared when the unit is shut down (read only).
XM$M_STS_TIMO	Timeout. If set, indicates that the receiving computer is unresponsive (read or clear).
XM$M_STS_ORUN	Data overrun. If set, indicates that a message was received but lost because there is no receive buffer (read or clear).
XM$M_STS_DCHK	Data check. If set, indicates that a retransmission threshold has been exceeded (read or clear).
XM$M_STS_DISC	Disconnect. If set, indicates that the data set ready (DSR) modem line went from on to off (read or clear).

The error summary bits are set only when the driver must shut down the DMC11 interface because a fatal error occurred. These are read-only bits that are cleared by any of the IO$_SETMODE functions (see Section 1.4.3). The XM$M_STS_ACTIVE status bit is clear if any error summary bit is set. Table 1–5 lists the error summary bit values and their meanings.

Table 1–5 DMC11/DMR11 Error Summary Bits

Error Summary Bit	Meaning
XM$M_ERR_MAINT	DDCMP maintenance message was received.
XM$M_ERR_START	DDCMP START message was received.
XM$M_ERR_LOST	Data was lost when a message was received that was longer than the specified maximum message size.
XM$M_ERR_FATAL	An unexpected hardware or software error occurred.

1.4 DMC11 Function Codes

The basic DMC11 function codes are read, write, and set mode. All three functions take function modifiers.

1.4.1 Read

The VMS operating system provides the following read function codes:

- IO$_READLBLK—Read logical block
- IO$_READPBLK—Read physical block
- IO$_READVBLK—Read virtual block

Received messages are multibuffered in system dynamic memory and then copied to the user's address space when the read operation is performed.

The read functions take the following two device/function-dependent arguments:

- P1—The starting virtual address of the buffer that is to receive data
- P2—The size of the receive buffer in bytes

The read functions can take the following function modifiers:

- IO$M_DSABLMBX—Disables use of the associated mailbox for unsolicited data notification
- IO$M_NOW—Completes the read operation immediately if no message is available

1.4.2 Write

The VMS operating system provides the following write function codes:

- IO$_WRITELBLK—Write logical block
- IO$_WRITEPBLK—Write physical block
- IO$_WRITEVBLK—Write virtual block

Transmitted messages are sent directly from the requesting process's buffer.

The write functions take the following device- or function-dependent arguments:

- P1—The starting virtual address of the buffer containing the data to be transmitted
- P2—The size of the buffer in bytes

The message size specified by P2 cannot be larger than the maximum send message size for the unit (see Section 1.3). If a message larger than the maximum size is sent, a status of SS$_DATAOVERUN is returned in the I/O status block.

The write functions can take the following function modifier:

- IO$M_ENABLMBX—Enable use of the associated mailbox

1.4.3 Set Mode

Set mode operations are used to perform protocol, operational, and program and driver interface operations with the DMC11. The VMS operating system defines the following types of set mode functions:

- Set mode
- Set characteristics
- Enable attention AST
- Set mode and shut down unit
- Set mode and start unit

1.4.3.1 Set Mode and Set Characteristics

The set mode and set characteristics functions set device characteristics such as maximum message size. The VMS operating system provides the following function codes:

- IO$_SETMODE—Set mode (no I/O privilege required)
- IO$_SETCHAR—Set characteristics (requires physical I/O privilege)

These two functions take the following device- or function-dependent argument:

- P1—The virtual address of the quadword characteristics buffer block if the characteristics are to be set. If this argument is zero, only the unit status and characteristics are returned in the I/O status block (see Section 1.5). Figure 1–3 shows the P1 characteristics block.

Figure 1–3 P1 Characteristics Block

31 24	23 16	15 8	7 0
maximum message size		type	class
TPI	error summary	status	characteristics

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In the buffer designated by P1 the device class is DC$_SCOM. Section 1.3 describes the device types. The maximum message size describes the maximum send or receive message size.

The second longword contains device- or function-dependent characteristics: unit characteristics, status, error summary bits, and transmit pipeline count (TPI). Any of the characteristics values and some of the status values can be set or cleared (see Tables 1–3, 1–4, and 1–5).

If the unit is active (XM$M_STS_ACTIVE is set), the action of a set mode or set characteristics function with a characteristics buffer is to clear the status bits or the error summary bits. If the unit is not active, the status bits or the error summary bits can be cleared, and the maximum message size, type, device class, unit characteristics, and transmit pipeline count can be changed.

1.4.3.2 Enable Attention AST

The enable attention AST function enables an AST to be queued when an attention condition occurs on the unit. An AST is queued when the driver sets or clears either an error summary bit or any of the unit status bits, or when a message is available and there is no waiting read request. The enable attention AST function is legal at any time, regardless of the condition of the unit status bits.

The VMS operating system provides the following function codes:

- IO$_SETMODE!IO$M_ATTNAST—Enable attention AST
- IO$_SETCHAR!IO$M_ATTNAST—Enable attention AST

Enable attention AST enables an AST to be queued one time only. After the AST occurs, it must be explicitly reenabled by the function before the AST can occur again. The function code is also used to disable the AST. The function is subject to AST quotas.

The enable attention AST functions take the following device- or function-dependent arguments:

- P1—Address of AST service routine or 0 for disable
- P2—Ignored
- P3—Access mode to deliver AST

The AST service routine is called with an argument list. The first argument is the current value of the device- or function-dependent characteristics longword shown in Figure 1–3. The access mode specified by P3 is maximized with the requester's access mode. (See the *VMS System Services Reference Manual* for an explanation of this concept.)

1.4.3.3 Set Mode and Shut Down Unit

The set mode and shut down unit function stops the operation on an active unit (XM$M_STS_ACTIVE must be set) and then resets the unit characteristics.

The VMS operating system provides the following function codes:

- IO$_SETMODE!IO$M_SHUTDOWN—Shut down unit
- IO$_SETCHAR!IO$M_SHUTDOWN—Shut down unit

These functions take the following device- or function-dependent argument:

- P1—The virtual address of the quadword characteristics block (Figure 1–3) if modes are to be set after shutdown. P1 is 0 if modes are not to be set after shutdown.

Both functions stop the DMC11 microprocessor and release all outstanding message blocks; any messages that have not been read are lost. The characteristics are reset after shutdown. Except for the sending of attention ASTs and mailbox messages, these functions act the same as the driver does when shutdown occurs because of a fatal error.

1.4.3.4 Set Mode and Start Unit

The set mode and start unit function sets the characteristics and starts the protocol on the associated unit. The VMS operating system provides the following function codes:

- IO$_SETMODE!IO$M_STARTUP—Start unit
- IO$_SETCHAR!IO$M_STARTUP—Start unit

These functions take the following device- or function-dependent arguments:

- P1—The virtual address of the quadword characteristics block (Figure 1–3) if the characteristics are to be set. Characteristics are set before the device is started.
- P2—Ignored.
- P3—The number of preallocated receive-message blocks to ensure the availability of buffers to receive messages.

The total quota taken from the process's buffered I/O byte count quota is the DMC11 work space plus the number of receive-message buffers specified by P3 times the maximum message size. For example, if six 200-byte buffers are required, the total quota taken is 1456 bytes:

```
  256  (DMC11 work space)
+ 1200  (number of buffers X buffer size)
  ----
  1456  (total quota taken)
```

This quota is returned to the process when shutdown occurs.

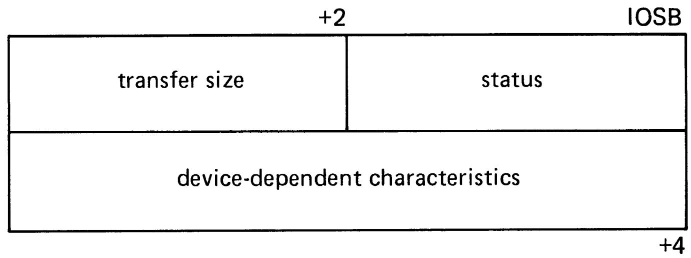
Receive-message blocks are used by the driver to receive messages that arrive independent of read request timing. When a message arrives, it is matched with any outstanding read requests. If there are no outstanding read requests, the message is queued, and an attention AST or mailbox message is generated. (IO$_SETMODE!IO$M_ATTNAST or IO$_SETCHAR!IO$M_ATTNAST must be set to enable an attention AST; IO$M_ENABLMBX must be used to enable a mailbox message.)

When read, the receive-message block is returned to the receive-message "free list" defined by P3. If the "free list" is empty, no receive messages are possible. In this case, a data lost condition can be generated if a message arrives. This nonfatal condition is reported by device-dependent data and an attention AST.

1.5 I/O Status Block

The I/O status block (IOSB) usage for all DMC11 functions is shown in Figure 1–4. Appendix A lists the status returns for these functions. (The *VMS System Messages and Recovery Procedures Reference Volume* provides explanations and suggested user actions for these returns.)

Figure 1–4 IOSB Contents



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In Figure 1–4, the transfer size at IOSB+2 is the actual number of bytes transferred. Table 1–3 lists the device-dependent characteristics returned at IOSB+4. These characteristics can also be obtained by using the Get Device/Volume Information ($GETDVI) system service (see Section 1.3).

1.6 Programming Example

The following sample program (Example 1–1) shows the typical use of QIO functions, such as transmitting and receiving data and checking for errors, in DMC11/DMR11 driver operations.

Example 1–1 DMC11/DMR11 Program Example

```
        .TITLE  EXAMPLE - DMC11/DMR11 Device Driver Sample Program
        .IDENT 'X00'

        $IODEF                  ; Define I/O functions and modes
        $XMDEF                  ; Define driver status flags
;
;  Macro definitions
;
        .macro  type    string,?L                       ;
        store   <string>                                ;
        movl    #$$.tmpx,cmdorab+rab$l_rbf              ;
        movw    #$$.tmpx1,cmdorab+rab$w_rsz             ;
        $put    rab=cmdorab                             ;
        blbs    r0,L                                    ;
        $exit_s                                         ;
L:                                                      ;
        .endm   type                                    ;
;
        .macro  store   string,pre
        .save
        .psect  $$$DEV
        $$.tmpx=.
        pre
        .ascii  %string%
        $$.tmpx1=.-$$.tmpx
        .restore
        .endm   store

CMDOFAB:        $FAB    fac=put,fnm=sys$output:,-  ; Output FAB
                mrs=132,rat=cr,rfm=var
CMDORAB:        $RAB    ubf=cmdbuf,usz=cmdbsz,-    ; Output RAB
                fab=cmdofab
CMDBUF::        .BLKB   256                     ; Command buffer
CMDBSZ=         .-CMDBUF                        ; Buffer size
FAOBUFDSC:      .LONG   CMDBSZ,CMDBUF           ; FAO buffer
                                                ; descriptor
FAOLEN:         .BLKL   1                       ; FAO output buffer
                                                ; length
P2BUF::         .BLKL   50                      ; P2 buffer
P2BUFSZ=        .-P2BUF                         ; P2 buffer size
P2BUFDSC:       .LONG   P2BUFSZ,P2BUF           ; P2 buffer descriptor
P1BUF::         .BLKQ   1                       ; P1 buffer
P1BUFSZ=        .-P1BUF                         ; P1 buffer size
CHNL::          .BLKL   1                       ; Channel number
IOSB::          .BLKQ   1                       ; I/O status block
DEVDSC:         .ASCID  'DEV'                   ; Device to assign
QIOREQDSC:      .LONG   QIOREQSZ,QIOREQ         ; QIO request status
QIOREQ:         .ASCII  'QIO completion status = !XL'
                .ASCII  'IOSB1 = !XL, IOSB2 = !XL'
QIOREQSZ=       .-QIOREQ                        ; Size of QIO status
                                                ; report
XMTBUFLEN=512                                   ; Size of transmit
                                                ; buffer
XMTBUF:         .REPEAT XMTBUFLEN
                .BYTE   ^X93                    ; Transmit data
                .ENDR
RCVBUF:         .BLKB   XMTBUFLEN
```

Example 1–1 Cont'd. on next page

Example 1–1 (Cont.) DMC11/DMR11 Program Example

```
;
; This is the start of the program section.
;
START:: .WORD    0
        $OPEN    FAB=CMDOFAB                    ; Open output
        BLBC     R0,EXIT                        ;
        $CONNECT RAB=CMDORAB                    ; Connect to output
        BLBC     R0,EXIT                        ;
        BRB      CONT                           ; Continue
EXIT:   $EXIT_S                                 ; Exit program

CONT:   TYPE     <DMC11/DMR11 Test Program>
        TYPE     <>
        $ASSIGN_S        DEVNAM=DEVDSC,CHAN=CHNL ; Assign unit
        BLBC     R0,EXIT                        ; Exit on error
;
; Initialize and start controller
;
        MOVZBL   #XM$M_CHR_LOOPB,P1BUF+4        ; Set P1 flags -
                                                ; Loopback
        MOVW     #XMTBUFLEN,P1BUF+2             ; Set P1 buffer size
        CLRL     P2BUFDSC                       ; Set zero length P2
                                                ; buffer
        BSBW     INIT                           ; Issue QIO
;
; Loopback data
;
        MOVZWL   #100,R9                        ; Loop device 100
                                                ; times
10$:    BSBW     XMIT                           ; Issue transmit
        BSBW     RECV                           ; Issue receive
        MOVAB    XMTBUF,R1                      ; Get address of xmit
                                                ; data
        MOVAB    RCVBUF,R2                      ; Get address of
                                                ; received data
        MOVZWL   #XMTBUFLEN,R3                  ; Get number of bytes
                                                ; to verify
20$:    CMPB     (R1)+,(R2)+                    ; Check data
        BNEQ     30$                            ;
        SOBGTR   R3,20$                         ;
        SOBGTR   R9,10$                         ;
        BRW      EXIT                           ; Exit

30$:    TYPE     <*** Loopback buffer comparison error ***>
        BRW      EXIT                           ; Exit
;
; Initialize controller QIO
;
INIT:   TYPE     <*** Initialize controller QIO ***>     ;
        $QIOW_S chan=chnl,func=#io$_setchar!io$m_startup,-
                 p1=p1buf,p2=#p2bufdsc,iosb=iosb,p3=#5   ;
        BRW      QIO_STATUS                     ;
```

Example 1–1 Cont'd. on next page

Example 1–1 (Cont.) DMC11/DMR11 Program Example

```
;
; Xmit data QIO
;
XMIT:   TYPE    <*** Transmit buffer QIO ***>   ;
        $QIO_S  chan=chnl,func=#io$writevblk,p1=xmtbuf,-
                p2=#xmtbuflen,iosb=iosb
        BRW     QIO_XMTST                       ;
;
; Receive data QIO
;
RECV:   TYPE    <*** Receive buffer QIO ***>    ;
        $QIOW_S chan=chnl,efn=#2,func=#io$_readvblk,-
                p1=rcvbuf,p2=#xmtbuflen,iosb=iosb
        .BRB    qio_status
        .ENABL  LSB
QIO_STATUS:                                     ; Check status of QIO
        BLBC    IOSB,10$                        ; Br if error on QIO
QIO_XMTST:                                      ; Check status of XMIT
        BLBC    R0,10$                          ; Br if error on
                                                ; request
        RSB                                     ; Else, return to
                                                ; caller

10$:    MOVZWL  IOSB,R1                         ; Get I/O status block
        PUSHL   R1                              ; Push I/O status block
        PUSHL   R0                              ; Push system service
                                                ; status
        PUSHAQ  FAOBUFDSC                       ; Push address of FAO
                                                ; buffer descriptor
        PUSHAW  FAOLEN                          ; Push address of
                                                ; output length
        PUSHAQ  QIOREQDSC                       ; Push address of
                                                ; input string
        CALLS   #5,@#SYS$FAO                    ; Get error message
        MOVAB   CMDBUF,CMDORAB+RAB$L_RBF        ; Get output buffer
                                                ; address
        MOVW    FAOLEN,CMDORAB+RAB$W_RSZ        ; Get output buffer
                                                ; length
        $PUT    CMDORAB                         ; Print error text
        BRW     EXIT                            ; Exit
        .DSABL  LSB

        .END    START
```

2 DMP11 and DMF32 Interface Drivers

This chapter describes the use of the VMS DMP11 multipoint communications line interface and DMF32 synchronous line interface drivers.

2.1 Supported Devices

The DMP11 multipoint communications line interface is a direct-memory-access (DMA) device that uses the DIGITAL Data Communications Message Protocol (DDCMP) to provide direct communication between a VAX processor and DDCMP-compatible devices, such as other DMP11s and some terminals (for example, the VT62). Up to 32 devices can be connected to the DMP11 through a single, multidrop, DDCMP-compatible line.

The logical connection between the DMP11 and a connected device is called a *tributary*. In multipoint configurations, the DMP11 functions as a multipoint control station, and the devices on the DDCMP line are located at tributary addresses. A controller operating in tributary mode on this line is called a *tributary station.*

In point-to-point configurations, one DMP11 is connected to one other controller. Controllers in this mode are called *point-to-point stations.*

The DMF32 synchronous line interface is a DMA communications device that uses a software implementation of DDCMP to provide an interface between a VAX processor and other DDCMP-compatible devices, such as a DMP11 or DMC11. The DMF32 supports both full- and half-duplex modes as well as tributary mode on a multidrop DDCMP-compatible line.

In a multipoint configuration, the DMF32 operates in tributary mode and is located at a tributary address on the DDCMP line.

In point-to-point configurations, one DMF32 is connected to a single other controller. Controllers in this mode are called point-to-point stations.

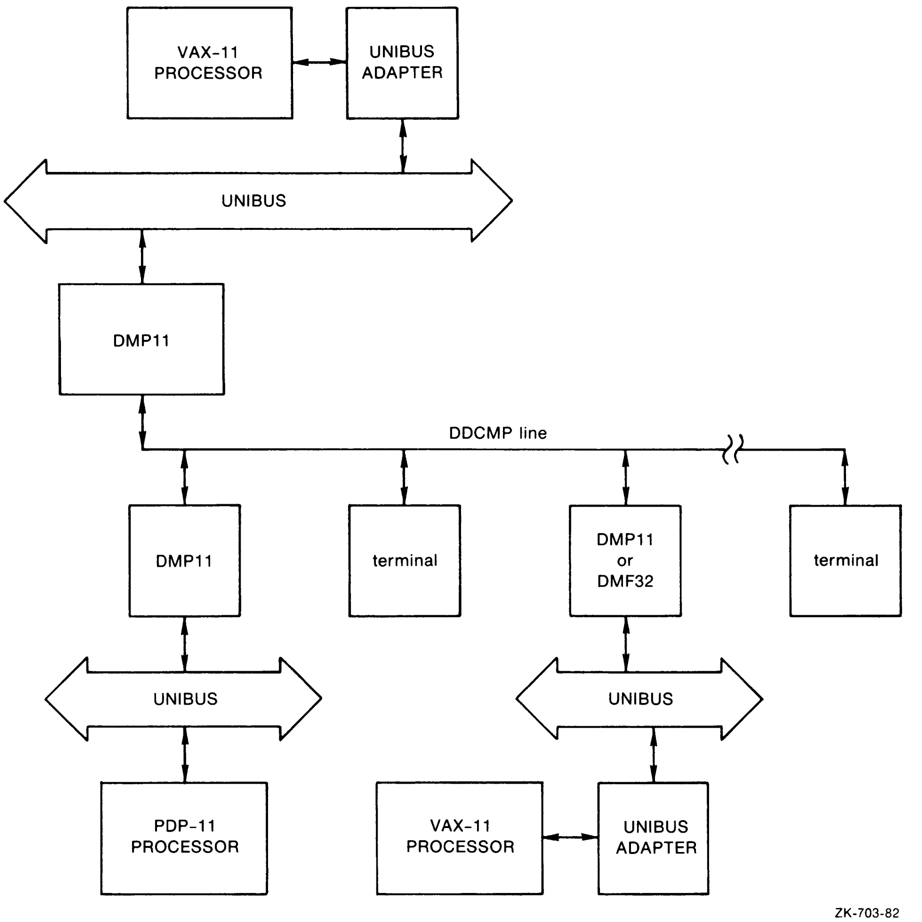
Figure 2–1 shows a typical DMP11/DMF32 multipoint configuration.

2.2 Driver Features and Capabilities

The DMP11 and DMF32 drivers provide the following capabilities:

- Multipoint operating mode in which the DMP11 functions as a control station connected to from 1 to 32 devices and tributary stations (not for the DMF32 driver)
- Multipoint operating mode in which the DMP11 or DMF32 functions as a tributary station
- Point-to-point operating mode in which the DMP11 or DMF32 is connected to a single other controller also operating in point-to-point mode

Figure 2–1 Typical DMP11/DMF32 Multipoint Configuration



- DMC11-compatible operating mode in which the DMP11 is connected to either a DMC11, a DMR11, another synchronous line interface using DDCMP, or another DMP11 running in DMC11-compatible mode (not for the DMF32 driver)
- Support for using the DMF32 in high-level data link control (HDLC) bit stuff mode
- Support for using a general character-oriented protocol over the DMF32
- A nonprivileged QIO interface to the DMP11 and DMF32 for using these devices as raw-data channels
- Tributary attention conditions transmitted through attention ASTs
- Full- and half-duplex operation
- Interface design common to all communications devices supported by the VMS operating system

- Separate transmit and receive queues
- Assignment of multiple read and write buffers to the device

2.2.1 Character-Oriented Protocols and HDLC Bit Stuff Mode

The DMF32 synchronous line unit supports character-oriented protocols and the high-level data link control (HDLC) bit stuff mode. The DMF32 driver can transmit and receive a framed message and also provide some modem control. General protocol handling for the character-oriented protocols is supported at the DMF32 driver level. However, the DMF32 driver provides an interface to the higher-level protocol so that receive messages are framed by the rules of the protocol. For HDLC mode, you can transmit and receive frame messages in full-duplex mode only.

Sections 2.4.3.2 through 2.4.3.5 describe these features of the DMF32 driver in greater detail.

2.2.2 Quotas

Transmit operations are direct (DMP11) or buffered (DMF32) I/O operations and are limited by the process's direct or buffered I/O quota.

The quotas for the receive buffer free list (see Section 2.4.3.1) are the process's buffered I/O quota and buffered I/O byte count quota.

2.2.3 Power Failure

If a system power failure occurs, no DMP11 or DMF32 recovery is possible. The driver is in a fatal error state and shuts down.

2.3 Device Information

You can obtain information on DMP11 or DMF32 characteristics by using the Get Device/Volume Information ($GETDVI) system service. (See the *VMS System Services Reference Manual*.) $GETDVI returns device characteristics when you specify the item code DVI$_DEVCHAR. Table 2–1 lists these characteristics, which are defined by the $DEVDEF macro.

DVI$_DEVCLASS returns the device class, which is DC$_SCOM. DVI$_DEFTYPE returns the device type, which is DT$_DMP11 for the DMP11 and DT$_DMF32 for the DMF32. The $DCDEF macro defines the device class and device type names.

DVI$_DEVBUFSIZ returns the maximum message size. The maximum message size is the maximum send or receive message size for the unit. Messages greater than 512 bytes on modem-controlled lines are more prone to transmission errors.

Table 2–1 DMP11 and DMF32 Device Characteristics

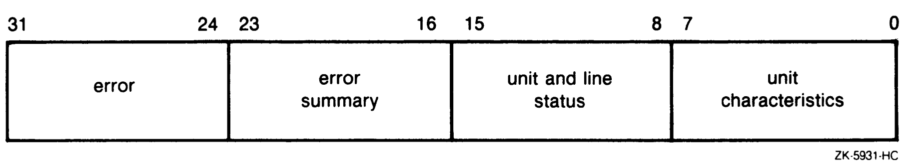
Characteristic[1]	Meaning
	Static Bits (Always Set)
DEV$M_NET	Network device. Set for terminal port if it is a network device.
DEV$M_AVL	Available device. Set when unit control block (UCB) is initialized.
DEV$M_ODV	Output device.
DEV$M_IDV	Input device.
DEV$M_SHR[2]	Shareable device.

[1]Defined by the $DEVDEF macro

[2]Only for DMP11

DVI$_DEVDEPEND returns the unit characteristics bits, the unit and line status bits, the error summary bits, and the specific errors in a longword field, as shown in Figure 2–2.

Figure 2–2 DVI$_DEVDEPEND Returns



Unit characteristics bits govern the DDCMP operating mode. They are defined by the $XMDEF macro and can be set by a set mode function (see Section 2.4.3.1) or can be read by a sense mode function (see Section 2.4.4). Table 2–2 lists the unit characteristics values and their meanings.

Table 2–2 DMP11 and DMF32 Unit Characteristics

Characteristic	Meaning
XM$M_CHR_MOP	Specifies DDCMP maintenance mode
XM$M_CHR_LOOPB	Specifies loopback mode
XM$M_CHR_HDPLX	Specifies half-duplex operation
XM$M_CHR_CTRL[1]	Specifies control station
XM$M_CHR_TRIB	Specifies tributary station
XM$M_CHR_DMC[1]	Specifies DMC11-compatible mode

[1]Only for DMP11

The status bits show the status of the unit and the line. These bits can only be set or cleared when the controller and tributary are not active.

Table 2–3 lists the status values and their meanings. The values are defined by the $XMDEF macro.

Table 2–3 DMP11 and DMF32 Unit and Line Status

Status	Meaning
XM$M_STS_ACTIVE	DDCMP protocol is active.
XM$M_STS_DISC	Modem line went from on to off. This bit will be returned in the field IRP$L_IOST2 if the driver has had a timeout while waiting for the CTS signal to be present on the device.
XM$M_STS_RUNNING[1]	Tributary is responding.
XM$M_STS_BUFFAIL	Receive buffer allocation failed.

[1]Only for DMP11

The error summary bits are set when an error occurs. If the error is fatal, the DMP11 or DMF32 is shut down. Table 2–4 lists the error summary bit values and their meanings.

Table 2–4 Error Summary Bits

Error Summary Bit[1]	Meaning
XM$M_ERR_MAINT	DDCMP maintenance message received
XM$M_ERR_START	DDCMP start message received
XM$M_ERR_FATAL	Hardware or software error occurred on controller
XM$M_ERR_TRIB	Hardware or software error occurred on tributary
XM$M_ERR_LOST	Data lost when a received message was longer than the specified maximum message size
XM$M_ERR_THRESH	Receive, transmit, or select threshold errors

[1]Read-only

Table 2–5 lists the errors that can be specified. These errors are mapped to the indicated codes.

Table 2–5 DMP11 and DMF32 Errors

Value[1] (octal)	Meaning	Code Set
2	Receive threshold error	XM$M_ERR_THRESH
4	Transmit threshold error	XM$M_ERR_THRESH
6	Select threshold error	XM$M_ERR_THRESH
10	Start received in run state	XM$M_ERR_START
12	Maintenance received in run state	XM$M_ERR_MAINT

[1]Not provided on the DMF32

Table 2–5 (Cont.) DMP11 and DMF32 Errors

Value[1] (octal)	Meaning	Code Set
14	Maintenance received in halt state	(none)
16	Start received in maintenance state	XM$M_ERR_START
22	Dead tributary	XM$M_STS_RUNNING[2] (cleared)
24	Running tributary	XM$M_STS_RUNNING[2] (set)
26	Babbling tributary	XM$M_ERR_TRIB
30	Streaming tributary	XM$M_ERR_TRIB
32	Ring detection	(none)
100–276	Internal procedure (software) errors	XM$M_ERR_TRIB
300	Buffer too small	XM$M_ERR_LOST
302	Nonexistent memory	XM$M_ERR_FATAL
304	Modem disconnected	XM$M_STS_DISC and XM$M_ERR_FATAL
306	Queue overrun	XM$M_ERR_FATAL[2]
310	Carrier lost on modem	XM$M_ERR_FATAL

[1]Not provided on the DMF32

[2]Not supported for the DMF32

2.4 DMP11 and DMF32 Function Codes

The DMP11 and DMF32 drivers can perform logical, virtual, and physical I/O operations. The basic functions are read, write, set mode, set characteristics, and sense mode. Table 2–6 lists these functions and their function codes. The sections that follow describe these functions in greater detail.

Table 2–6 DMP11 and DMF32 I/O Functions

Function Code and Arguments	Type[1]	Modifiers	Function
IO$_READLBLK P1,P2	L	IO$M_NOW	Read logical block.
IO$_READVBLK P1,P2	V	IO$M_NOW	Read virtual block.
IO$_READPBLK P1,-P2,[P6]	P	IO$M_NOW	Read physical block.
IO$_WRITELBLK P1,P2	L		Write logical block.

[1]V = virtual, L = logical, P = physical (There is no functional difference in these operations.)

Table 2–6 (Cont.) DMP11 and DMF32 I/O Functions

Function Code and Arguments	Type[1]	Modifiers	Function
IO$_WRITEVBLK P1,P2	V		Write virtual block.
IO$_WRITEPBLK P1,-P2,[P6]	P		Write physical block.
IO$_CLEAN	L		Complete outstanding requests (character-oriented protocols), and abort outstanding transmits (bit stuff mode).
IO$_SETMODE P1,-[P2],P3	L	IO$M_CTRL IO$M_SHUTDOWN IO$M_STARTUP IO$M_ATTNAST IO$M_SET_MODEM[2]	Set DMP11 and DMF32 characteristics and controller state for subsequent operations.
IO$_SETCHAR P1,-[P2],P3,[P6]	P	IO$M_CTRL IO$M_SHUTDOWN IO$M_STARTUP IO$M_ATTNAST IO$M_SET_MODEM[2]	Set DMP11 and DMF32 characteristics and controller state for subsequent operations.
IO$_SENSEMODE P1,P2	L	IO$M_CTRL IO$M_RD_MEM[2] IO$M_RD_MODEM IO$M_RD_COUNTS IO$M_CLR_COUNTS	Sense controller or tributary characteristics and return them in specified buffers.

[1]V = virtual, L = logical, P = physical (There is no functional difference in these operations.)

[2]Only for DMP11

Although the DMP11 and DMF32 drivers do not differentiate among logical, virtual, and physical I/O functions (all are treated identically), you must have the required privilege to issue a request.

2.4.1 Read

Read functions provide for the direct transfer of data into the user process's virtual memory address space. The VMS operating system provides the following function codes:

- IO$_READLBLK—Read logical block
- IO$_READVBLK—Read virtual block
- IO$_READPBLK—Read physical block

Received messages are multibuffered in system dynamic memory and then copied to the user's buffer.

The read functions take the following device- or function-dependent arguments:

- P1—The starting virtual address of the buffer that is to receive data.
- P2—The size of the receive buffer in bytes.
- P6—The address of a diagnostic buffer; only for physical I/O functions (optional). See Section 2.4.5.

The message size specified by P2 cannot be larger than the maximum receive-message size for the unit (see Section 2.3). If a message larger than the maximum size is received, a status of SS$_DATAOVERUN is returned in the I/O status block.

The read functions can take the following function modifier:

- IO$M_NOW—Complete the read operation immediately with a received message. (If no message is currently available, return a status of SS$_ENDOFFILE in the I/O status block.)

2.4.2 Write

Write functions provide for the direct transfer of data from the user process's virtual memory address space. The VMS operating system provides the following function codes:

- IO$_WRITELBLK—Write logical block
- IO$_WRITEVBLK—Write virtual block
- IO$_WRITEPBLK—Write physical block

Transmitted DMP11 messages are sent directly from the requesting process's buffer. DMF32 messages are copied into a system buffer before they are transmitted.

The write functions take the following device- or function-dependent arguments:

- P1—The starting virtual address of the buffer containing the data to be transmitted.
- P2—The size of the buffer in bytes.
- P6—The address of a diagnostic buffer; only for physical I/O functions (optional). See Section 2.4.5.

The message size specified by P2 cannot be larger than the maximum send-message size for the unit (see Section 2.3).

The write functions take no function modifiers.

2.4.3 Set Mode and Set Characteristics

Set mode operations are used to perform protocol, operational, and program/driver interface operations with the DMP11 or DMF32 drivers. The VMS operating system defines the following types of set mode functions:

- Set mode
- Set characteristics
- Set controller mode
- Set tributary mode
- Enable attention AST
- Shutdown controller
- Shutdown tributary

Used without function modifiers, set mode and set characteristics functions can modify an existing tributary. Used with certain function modifiers, they can perform DMP11 or DMF32 operations such as starting a tributary and requesting an attention AST. The VMS operating system provides the following function codes:

- IO$_SETMODE—Set mode (no I/O privilege required)
- IO$_SETCHAR—Set characteristics (requires physical I/O privilege)

The other five types of set mode functions, which use the two function codes with certain function modifiers, are described in the sections that follow.

To use the IO$_SETMODE and IO$_SETCHAR functions, you must assign the appropriate unit control block (UCB) with the Assign I/O Channel ($ASSIGN) system service.

2.4.3.1 Set Controller Mode

The set controller mode function sets the DMP11 or DMF32 controller state and activates the controller. The following combinations of function code and modifier are provided:

- IO$_SETMODE!IO$M_CTRL—Set controller characteristics
- IO$_SETCHAR!IO$M_CTRL—Set controller characteristics
- IO$_SETMODE!IO$M_CTRL!IO$M_STARTUP—Set controller characteristics and start the controller
- IO$_SETCHAR!IO$M_CTRL!IO$M_STARTUP—Set controller characteristics and start the controller

If the function modifier IO$M_STARTUP is specified, the controller is started and the modem is enabled. If IO$M_STARTUP is not specified, the specified characteristics are simply modified.

These codes take the following device- or function-dependent arguments:

- P1—The virtual address of a quadword characteristics buffer.
- P2—The address of a descriptor for an extended characteristics buffer (optional).

- P3—The number of preallocated receive-message blocks to allocate (referred to as the size of the "common receive pool"). (See the NMA$C_PCLI_BFN parameter ID in Table 2–8.)

Figure 2–3 shows the format of the P1 characteristics buffer. The maximum message size in the first longword specifies the maximum allowable transmit and receive-message length.

Table 2–7 lists the DMP11 and DMF32 characteristics that can be set in the second longword. The $XMDEF macro defines these values.

The P2 buffer consists of a series of six-byte entries. The first word contains the parameter identifier (ID), and the longword that follows it contains one of the values that can be associated with the parameter ID. Figure 2–4 shows the format for this buffer.

If both P1 and P2 characteristics are specified, the P2 characteristics supersede the P1 characteristics. For example, if P1 specifies XM$M_CHR_CTRL and P2 specifies NMA$C_PCLI_PRO with a value of NMA$C_LINPR_TRIB (that is, a tributary), the device is started as a tributary.

Figure 2–3 P1 Characteristics Buffer (Set Controller)

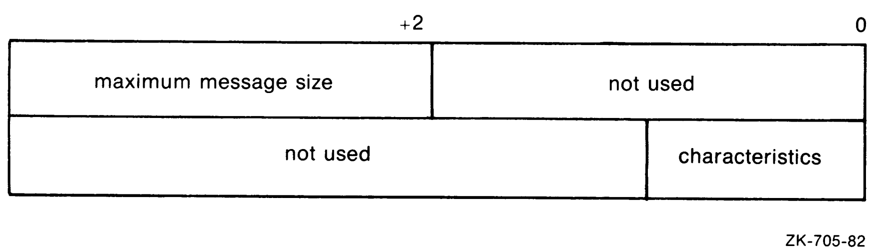


Table 2–7 DMP11 and DMF32 Characteristics

Characteristic	Meaning
XM$M_CHR_LOOPB	Sets loopback mode
XM$M_CHR_HDPLX	Sets half-duplex operation
XM$M_CHR_CTRL[1]	Specifies control station
XM$M_CHR_TRIB	Specifies tributary station
XM$M_CHR_DMC[1]	Specifies DMC11-compatible mode

[1]Only for DMP11

Figure 2–4 P2 Extended Characteristics Buffer (Set Controller)

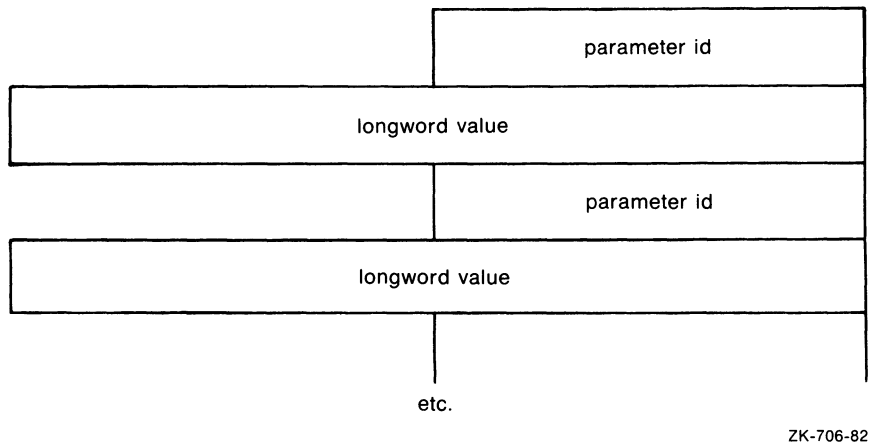


Table 2–8 lists the parameter IDs and values that can be specified in the P2 buffer. The $NMADEF macro defines these values.

Section 2.4.3.2 lists the parameter IDs allowed for the character-oriented and HDLC bit stuff modes of operation.

Table 2–8 P2 Extended Characteristics Values

<table>
<tr><th>Parameter ID</th><th>Meaning</th></tr>
<tr><td>NMA$C_PCLI_PRO</td><td>Protocol mode. The following values can be specified:
<table>
<tr><th>Value</th><th>Meaning</th></tr>
<tr><td>NMA$C_LINPR_POI</td><td>DDCMP point-to-point (default)</td></tr>
<tr><td>NMA$C_LINPR_CON[1]</td><td>DDCMP control station</td></tr>
<tr><td>NMA$C_LINPR_TRI</td><td>DDCMP tributary</td></tr>
<tr><td>NMA$C_LINPR_DMC[1]</td><td>DDCMP DMC mode</td></tr>
<tr><td>NMA$C_LINPR_LAPB[2]</td><td>HLDC bit stuff mode</td></tr>
<tr><td>NMA$C_LINPR_BSY[2]</td><td>General character-oriented protocol mode</td></tr>
</table></td></tr>
<tr><td>NMA$C_PCLI_DUP</td><td>Duplex mode. The following values can be specified:
<table>
<tr><th>Value</th><th>Meaning</th></tr>
<tr><td>NMA$C_DPX_FUL</td><td>Full-duplex (default)</td></tr>
<tr><td>NMA$C_DPX_HAL</td><td>Half-duplex</td></tr>
</table></td></tr>
</table>

[1]Only for DMP11

[2]Only for DMF32

Table 2–8 (Cont.) P2 Extended Characteristics Values

Parameter ID	Meaning
NMA$C_PCLI_CON	Controller mode. The following values can be specified: **Value** — **Meaning** NMA$C_LINCN_NOR — Normal (default) NMA$C_LINCN_LOO — Loopback
NMA$C_PCLI_BFN	Number of receive buffers to preallocate. Must be provided here or as P3 argument.
NMA$C_PCLI_BUS	Maximum allowable transmit and receive message length (default = 512 bytes).
NMA$C_PCLI_NMS	Number of sync characters to precede message.
NMA$C_PCLI_SLT[1,3]	Number of milliseconds (msec) in the period of incrementing tributary priorities and the transmit delay (min = 50; default = 50).
NMA$C_PCLI_DDT[1,3]	Number of msec in the period of polling dead tributaries (default = 10000).
NMA$C_PCLI_DLT[1,3]	Number of msec between polls (default = 0).
NMA$C_PCLI_SRT[1,3]	Timer value used by control station and half-duplex point-to-point to establish that a tributary is streaming (default = 6000).

[1]Only for DMP11

[3]A global polling parameter. All timer values must be specified in milliseconds.

2.4.3.2 Additional Features of the DMF32 Driver

The character-oriented protocols and the HDLC bit stuff mode do not have the concept of line and circuit. Therefore, only $QIO requests that include the function modifier IO$M_CTRL are allowed. The VMS operating system does not acknowledge characteristics set in the P1 buffer for character-oriented and HDLC bit stuff modes of operation. You must have CMKRNL privilege to run the DMF32 in character-oriented mode. Only the parameters listed in Table 2–9 are relevant to the character-oriented and HDLC bit stuff modes of operation.

Table 2–9 P2 Extended Characteristics Values (DMF32 Driver)

Parameter ID	Meaning
NMA$C_PCLI_PRO	Must be set to NMA$C_LINPR_BSY to specify character-oriented mode of operation, or to NMA$C_LINPR_LAPB to specify HDLC bit stuff mode.

Table 2–9 (Cont.) P2 Extended Characteristics Values (DMF32 Driver)

Parameter ID	Meaning
NMA$C_PCLI_DUP	Requests full- or half-duplex mode of operation. (HDLC bit stuff mode supports full-duplex mode only.) If half-duplex mode is specified, the DMF32 driver sets the request to send (RTS) signal, waits for the clear to send (CTS) signal at the beginning of the transmit, and then drops RTS at the end of the transmit. The full-duplex mode value is NMA$C_DPX_FUL; the half-duplex mode value is NMA$C_DPX_HAL.
NMA$C_PCLI_BFN	The number of buffers the device can allocate for use as receive buffers. This value must be greater than 1. Default is 4.
NMA$C_PCLI_BUS	The size of the buffers to be allocated.
NMA$C_PCLI_CON	The state the controller is set to. If NMA$C_LINCN_NOR is specified, the device operates normally. If NMA$C_LINCN_LOO is specified, the device operates in internal loopback mode. Default is normal operation.
NMA$C_PCLI_SYC[1]	The sync character used by device. Defaults to 32 hexadecimal.
NMA$C_PCLI_NMS[1]	The number of sync characters to precede a transmit. Defaults to 8.
NMA$C_PCLI_BPC[1]	The number of bits per character (5,6,7, or 8). Defaults to 8.
NMA$C_PCLI_FRA[1]	The address of the protocol framing routine (in nonpaged pool). This parameter must be specified.
NMA$C_PCLI_STI1[1] NMA$C_PCLI_STI2[1]	These two parameters contain the initial value for the quadword of framing routine state information.
NMA$C_PCLI_MCL[1]	Determines whether modem signals should be turned off when a DEASSIGN operation is performed. The DMF32 driver always clears the modem signals on the last DEASSIGN. However, on all other DEASSIGN operations, the modem signals are cleared only if the value of NMA$C_PCLI_MCL is 0. If the value NMA$C_STATE_ON is specified, the data terminal ready (DTR) signal is dropped when DEASSIGN is performed. If the value NMA$C_STATE_OFF is specified, DTR is not dropped until the last DEASSIGN.
NMA$C_PCLI_TMO[1]	Specifies the timeout (in seconds) when waiting for CTS during transmit operations.

[1]Character-oriented mode only

2.4.3.3 Framing Routine Interface for Character-Oriented Protocols

In general, the character-oriented protocols each has its own rule for framing receive messages. To provide support for each protocol's special framing rule, the DMF32 driver has been extended to provide support for calling a special framing routine from the DMF32 driver's processing of receive messages. This routine is defined by the higher-level software using the DMF32 driver and is loaded by that same software into nonpaged pool. The address of this routine is passed to the driver when the device is started up. The purpose of the framing routine is to tell the driver how to frame each byte of the received data message and to tell the driver that the received message is complete and ready to be posted.

The address of the framing routine is kept in the DMF32 driver's internal buffer. The internal buffer also contains a quadword that is used by the framing routine for holding state information while it is framing the receive message. The framing routine is called by the driver at FORK IPL through a JSB instruction. The input and the output to the framing routine is described in the following tables.

Input	Contents
R0	Address of quadword of state information.
R1 bits 0-7	Character to examine. The high-order bit is set if this is the first character of a new frame.

<table>
<tr><th>Output</th><th colspan="2">Contents</th></tr>
<tr><td rowspan="4">R0</td><td colspan="2">Status information for the DMF32 driver. The following bits are defined:</td></tr>
<tr><td>Value</td><td>Meaning</td></tr>
<tr><td>XG$V_BUFFER_CHAR</td><td>If clear, buffer the character in the next position. If set, use bit XG$V_BUFFER_IN_PREV_POS.</td></tr>
<tr><td>XG$V_BUFFER_IN_PREV_POS</td><td>If clear, ignore the character. If set, buffer the character in the previous position; do not update the buffer pointer.</td></tr>
<tr><td></td><td>XG$V_COMPLETE_READ</td><td>If clear, ignore. If set, return the framed buffer to user (buffer character if required).</td></tr>
</table>

After the DMF32 driver has completed a framed receive data message, the driver resets the quadword of state information to the value passed when the device is started up. This means that the driver resets error information along with success information.

2.4.3.4 Use of the DMF32 Driver Transmitter Interface in Character-Oriented Mode

For write requests made through the QIO interface, the P4 parameter contains the address of a quadword buffer to be used to update the field in the DMF32 driver's internal buffer, which contains the state information for the framing routine. If this parameter is 0, the state information is not updated.

If the DMF32 driver has had a timeout error while waiting for the CTS signal to be present on the device, the bit XM$M_STS_DISC is returned in the field IRP$L_IOST2.

2.4.3.5 The IO$_CLEAN Function

The clean function either completes or aborts outstanding device requests. The VMS operating system provides the following function code:

- IO$_CLEAN

For character-oriented protocols, a clean function request results in the completion of all outstanding I/O requests pending on the device. For HDLC bit stuff mode, a clean function request results in the aborting of all outstanding transmit operations on the device. In both cases the status return is SS$_ABORT. Note that the modem registers are not cleared.

The clean function is not supported in DDCMP mode of operation.

2.4.3.6 Set Tributary Mode

The set tributary mode function either starts a tributary or modifies an existing one. The driver creates a circuit data block for a particular unit of the DMP11 device with the specified tributary address. The set tributary function must be performed before any communication can occur with the attached unit.

Because the DMF32 driver deals with only one tributary, the set tributary function starts both the tributary and the protocol. The data block describing the tributary has already been created.

The VMS operating system provides the following combinations of function code and modifier:

- IO$_SETMODE—Modify tributary characteristics
- IO$_SETCHAR—Modify tributary characteristics
- IO$_SETMODE!IO$M_STARTUP—Start tributary
- IO$_SETCHAR!IO$M_STARTUP—Start tributary

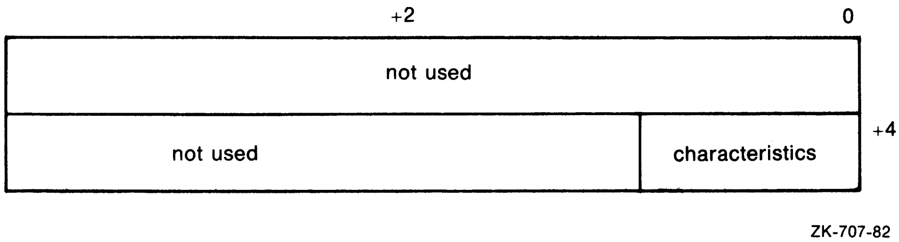
These codes take the following device- or function-dependent arguments:

- P1—The virtual address of a quadword characteristics buffer (optional)
- P2—The address of a descriptor for an extended characteristics buffer (optional)

Figure 2–5 shows the format of the P1 characteristics buffer. The following characteristic can be set in the second longword:

- XM$V_CHR_MOP—Set tributary to DDCMP maintenance mode

Figure 2–5 P1 Characteristics Buffer (Set Tributary)



The P2 buffer consists of a series of six-byte entries. The first longword contains the parameter identifier (ID), and the next longword contains one of the values that can be associated with the parameter ID. Figure 2–4 shows the format for this buffer.

Table 2–10 lists the parameter IDs and values that can be specified in the P2 buffer.

Table 2–10 P2 Extended Characteristics Values

<table>
<tr><th>Parameter ID</th><th>Meaning</th></tr>
<tr><td>NMA$C_PCCI_TRI</td><td>Tributary address. Because the maximum physical address that the DMP11 or DMF32 can recognize is 255, only the first byte is actually used. For the DMP11, this parameter must be set before the tributary is started, unless the controller was set to run in point-to-point or DMC-compatible mode. For the DMF32, the tributary address always defaults to 1. Accepted values are 1 to 255.</td></tr>
<tr><td>NMA$C_PCCI_MRB[1]</td><td>Maximum number of buffers allocated from common pool for receive messages; 255 indicates unlimited number (default is unlimited). Accepted values are 1 to 255.</td></tr>
<tr><td>NMA$C_PCCI_MST[1]</td><td>Maintenance state. The following values can be specified:
<table>
<tr><th>Value</th><th>Meaning</th></tr>
<tr><td>NMA$C_STATE_ON</td><td>On</td></tr>
<tr><td>NMA$C_STATE_OFF</td><td>Off (default)</td></tr>
</table></td></tr>
</table>

[1]Only for the DMP11

Table 2–10 (Cont.) P2 Extended Characteristics Values

Parameter ID	Meaning
NMA$C_PCCI_POL[1,2]	Latch polling state. The following values can be specified:

Value	Meaning
NMA$C_CIRPST_AUT	Automatic (default)
NMA$C_CIRPST_ACT	Active
NMA$C_CIRPST_INA	Inactive
NMA$C_CIRPST_DIE	Dying
NMA$C_CIRPST_DED	Dead

Parameter ID	Meaning
NMA$C_PCCI_TRT[1,2]	Transmit delay timer (default = 0).
NMA$C_PCCI_ACB[1,2]	Initial poll priority for active state of tributary (default = 255).
NMA$C_PCCI_ACI[1,2]	Rate of priority incrementing for active state of tributary (default = 0).
NMA$C_PCCI_IAB[1,2]	Initial poll priority for inactive state of tributary (default = 0).
NMA$C_PCCI_IAI[1,2]	Rate of priority incrementing for inactive state of tributary (default = 64).
NMA$C_PCCI_DYB[1,2]	Initial poll priority for dying state of tributary (default = 0).
NMA$C_PCCI_DYI[1,2]	Rate of priority incrementing for dying state of tributary (default = 16).
NMA$C_PCCI_IAT[1,2]	Number of no data message responses before changing state to inactive (default = 8).
NMA$C_PCCI_DYT[1,2]	Number of no responses before changing state to dying (default = 2).
NMA$C_PCCI_DTH[1,2]	Number of no responses before changing state to dead (default = 16).
NMA$C_PCCI_MTR[2]	Maximum number of abutting data messages that will be transmitted before deselecting the tributary (default = 4).
NMA$C_PCCI_BBT[1,2]	Timer value for tributary to indicate maximum amount of time for a selected tributary to transmit. If this value is exceeded, the tributary is babbling (default = 6000).
NMA$C_PCCI_RTT[2]	Retransmit timer for full-duplex point-to-point mode and selection timer for multipoint control and half-duplex point-to-point mode (default = 3000).

[1]Only for the DMP11

[2]A tributary-specific polling parameter (All timer values must be specified in milliseconds.)

If both P1 and P2 characteristics are specified, the P2 characteristics supersede the P1 characteristics. For example, if P1 specifies XM$M_CHR_MOP and

P2 specifies NMA$C_PCCI_MST with a value of NMA$C_STATE_OFF, the tributary is in the normal DDCMP or data mode.

On receipt of the QIO request, the DMP11 driver verifies that a tributary address has been specified and determines whether this address is currently in use. If the address is in use, the tributary is not restarted. However, modifications to the tributary state or polling parameters are performed. If the tributary does not already exist, a new tributary is started.

On receipt of the QIO request to a DMF32, the driver modifies the tributary parameters and starts the protocol. The tributary state and the protocol state are equal. The driver does not verify that a tributary address has been provided. If an address has not been provided, it defaults to 1.

2.4.3.7 Shutdown Controller

The shutdown controller function shuts down the controller and disables the modem line. On completion of a shutdown controller request, all tributaries have been halted (including those tributaries not explicitly halted), all tributary buffers returned, and the controller reinitialized. For the DMF32, this function halts the tributary, the protocol, and the line. The controller cannot be used again until another IO$_SETMODE!IO$M_CTRL!IO$M_STARTUP or IO$_SETCHAR!IO$M_CTRL!IO$M_STARTUP request has been issued (see Section 2.4.3.1).

The VMS operating system provides the following combinations of function code and modifier:

- IO$_SETMODE!IO$M_CTRL!IO$M_SHUTDOWN—Shutdown controller
- IO$_SETCHAR!IO$M_CTRL!IO$M_SHUTDOWN—Shutdown controller

The shutdown controller function takes no device- or function-dependent arguments.

2.4.3.8 Shutdown Tributary

The shutdown tributary function halts, but does not delete, the specified tributary. On completion of a shutdown tributary request, the tributary is halted, all buffers are returned, and all pending I/O requests and received messages are aborted. Although the tributary cannot be used again until another IO$_SETMODE!IO$M_STARTUP or IO$_SETCHAR!IO$M_STARTUP request has been issued (see Section 2.4.3.6), all previously defined tributary parameters remain set (applicable only to the DMP11). For the DMF32, this function halts the tributary and the protocol. The attached device cannot be used until the tributary is restarted.

The VMS operating system provides the following combinations of function code and modifier:

- IO$_SETMODE!IO$M_SHUTDOWN—Shutdown tributary
- IO$_SETCHAR!IO$M_SHUTDOWN—Shutdown tributary

The shutdown tributary function takes no device- or function-dependent arguments.

2.4.3.9 Enable Attention AST

The enable attention AST function requests that an attention AST be delivered to the requesting process when a status change occurs on the specified tributary. An AST is queued when the driver sets or clears either an error summary bit or any of the unit status bits (see Tables 2–3 and 2–4), or when a message is available and there is no waiting read request. The enable attention AST function is legal at any time, regardless of the condition of the unit status bits.

The VMS operating system provides the following combinations of function code and modifier:

- IO$_SETMODE!IO$M_ATTNAST—Enable attention AST
- IO$_SETCHAR!IO$M_ATTNAST—Enable attention AST

These codes take the following device- or function-dependent arguments:

- P1—The address of an AST service routine or 0 for disable
- P2—Ignored
- P3—Access mode to deliver AST

The enable attention AST function enables an attention AST to be delivered to the requesting process once only. After the AST occurs, it must be explicitly reenabled by the function before the AST can occur again. The function is also subject to AST quotas.

The AST service routine is called with an argument list. The first argument is the current value of the second longword of the I/O status block (see Section 2.5). The access mode specified by P3 is maximized with the requester's access mode.

2.4.4 Sense Mode

The sense mode function returns the controller or tributary characteristics in the specified buffers.

The VMS operating system provides the following function codes:

- IO$_SENSEMODE!IO$M_CTRL—Read controller characteristics
- IO$_SENSEMODE—Read tributary characteristics

These codes take the following device- or function-dependent arguments:

- P1—The address of a two-longword buffer into which the device characteristics are stored (optional). (Figure 2–3 shows the characteristics buffer for controllers; Figure 2–5 shows the characteristics buffer for tributaries.)
- P2—The address of a descriptor for a buffer into which the extended characteristics buffer is stored (optional). (Figure 2–4 shows the format of the extended characteristics buffer.)

All characteristics that fit into the buffer specified by P2 are returned. However, if all the characteristics cannot be stored in the buffer, the I/O status block returns the status SS$_BUFFEROVF. The second word of the I/O status block returns the size (in bytes) of the extended characteristics buffer returned by P2 (see Section 2.5).

2.4.4.1 Read Internal Counters

The read internal counters (IO$M_RD_COUNTS) subfunction reads the DDCMP internal counters. The VMS operating system provides the following combinations of function codes and modifiers:

- IO$_SENSEMODE!IO$M_RD_COUNTS—Read tributary counters (DDCMP only).
- IO$_SENSEMODE!IO$M_CLR_COUNTS—Clears tributary counters (DDCMP only).
- IO$_SENSEMODE!IO$M_RD_COUNTS!IO$M_CLR_COUNTS—Read and then clear tributary counters (DDCMP only).
- IO$_SENSEMODE!IO$M_CTRL!IO$M_RD_COUNTS—Read controller counters (DDCMP and LAPB only).
- IO$_SENSEMODE!IO$M_CTRL!IO$M_CLR_COUNTS—Clear controller counters (DDCMP and LAPB only).
- IO$_SENSEMODE!IO$M_CTRL!IO$M_RD_COUNTS!IO$M_CLR_COUNTS—Read and then clear controller counters (DDCMP and LAPB only).

These codes take the following device- or function dependent arguments:

- P1—Ignored.
- P2—The address of a buffer descriptor into which the counters will be returned (Figure 2–6 shows the format of the buffer). Table 2–11 lists the parameter ids that can be returned for DDCMP controllers, Table 2–12 lists parameter ids that can be returned for LAPB controllers, and Table 2–13 lists the parameter ids that can be returned for tributaries.

All counters that fit into the buffer specified by P2 are returned. However, if all the counters cannot be stored in the buffer, the I/O status block returns the status SS$_BUFFEROVF. The second word of the I/O status block returns the size, in bytes, of the extended characteristics buffer returned (see Section 2.5).

Figure 2–6 P2 Extended Characteristics Buffer (Sense Mode)

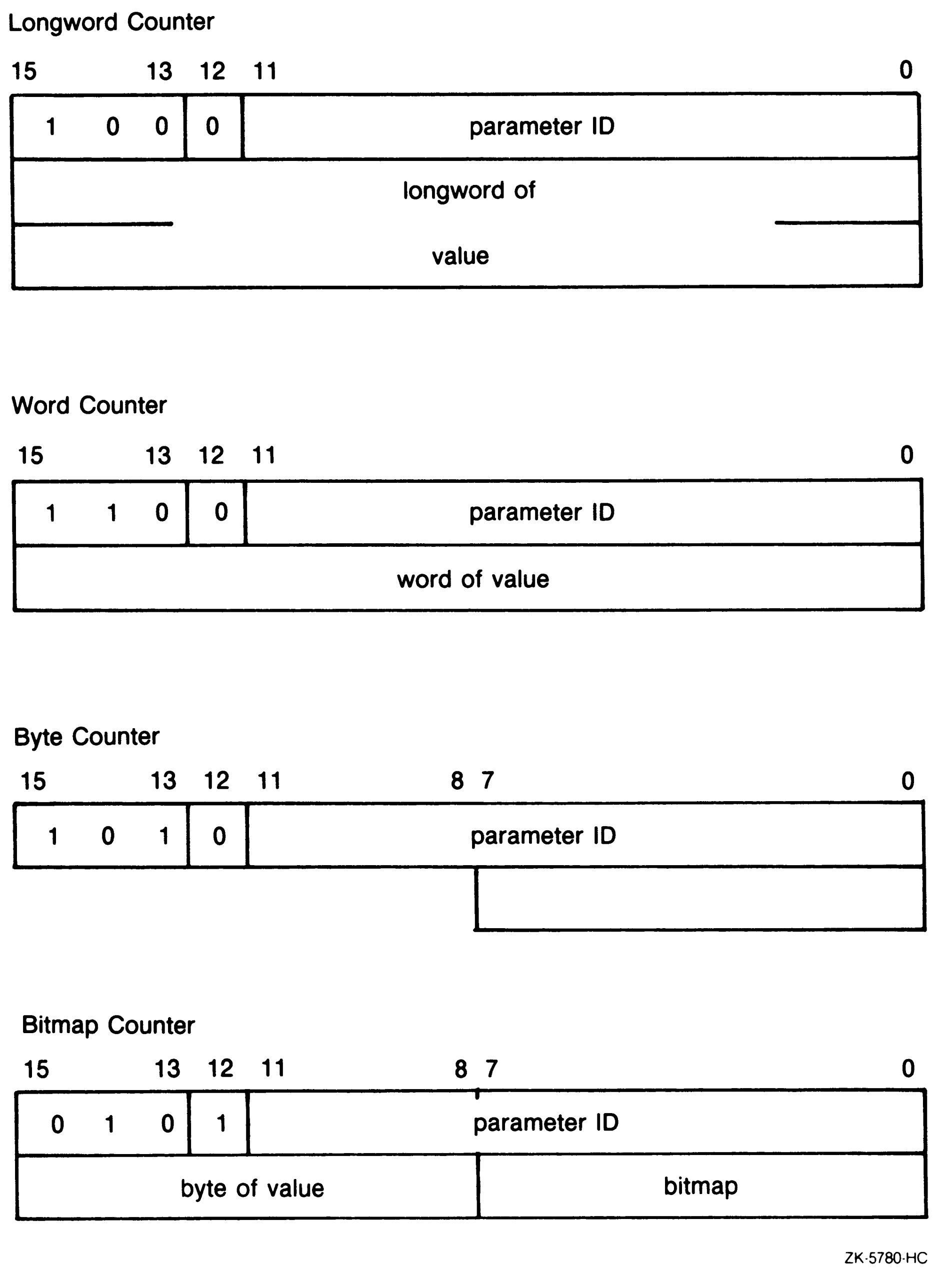


Table 2–11 DDCMP Controller Counter Parameter IDs

Parameter ID	Meaning
NMA$C_CTLIN_LPE	Number of local station errors bitmap counter.

Value	Meaning
1	Receive overrun SNAK set.
2	Receive overrun SNAK not set.
4	Transmitter underrun.
8	Message format error.

Parameter ID	Meaning
NMA$C_CTLIN_RPE	Number of remote station errors bitmap counter.

Value	Meaning
1	NAKs received due to receiver overrun.
2	NAKs received due to message format error.
4	SNAK set message format error.
8	Streaming tributary.

Table 2–12 LAPB Controller Counter Parameter IDs

Parameter ID	Meaning
NMA$C_CTCIR_DEI	Data errors inbound.

Table 2–13 Tributary Counter Parameter IDs

Parameter ID	Meaning
NMA$C_CTCIR_BRC	Number of bytes received by this station.
NMA$C_CTCIR_BSN	Number of bytes transmitted by station.
NMA$C_CTCIR_DBR	Number of messages received by this station.
NMA$C_CTCIR_DBS	Number of messages transmitted by this station.
NMA$C_CTCIR_SIE	Number of selection intervals elapsed.
NMA$C_CTCIR_RBE	Remote buffer error bitmap counters.

Value	Meaning
1	Remote buffer unavailable.
2	Remote buffer too small.

Table 2–13 (Cont.) Tributary Counter Parameter IDs

Parameter ID	Meaning	
NMA$C_CTCIR_LBE	Local buffer error bitmap counters.	
	Value	**Meaning**
	1	Local buffer unavailable.
	2	Local buffer too small.
NMA$C_CTCIR_SLT	Selection timeout bitmap counters.	
	Value	**Meaning**
	1	No attempt to respond was made.
	2	Attempt was made, but timeout still occurs.
NMA$C_CTCIR_RRT	Number of SACK settings when REP received.	
NMA$C_CTCIR_LRT	Number of SREP settings.	
NMA$C_CTCIR_DEI	Data error inbound bitmap counters.	
	Value	**Meaning**
	1	NAK transmitted header CRC error.
	2	NAK transmitted data CRC error.
	4	NAK transmitted REP response.
NMA$C_CTCIR_DEO	Data error outbound bitmap counters.	
	Value	**Meaning**
	1	NAK received header CRC error.
	2	NAK received data CRC error.
	4	NAK received REP response.

2.4.5 Diagnostic Support

The DMP11 and DMF32 drivers provide special capabilities for diagnostic support. The sections that follow describe these capabilities.

If a diagnostic buffer (P6) is specified with a physical I/O request, the eight one-byte device registers are dumped into it on completion of the request. (The DMF32 returns five one-word device registers.) The *DMP11 Technical Manual* and the *DMF32 Technical Manual* specify the contents of these registers. The P6 buffer does not return error counters.

2.4.5.1 Set Line Unit Modem Status

The set line unit modem status function sets the DMP11's line unit modem register. It is not supported for the DMF32. The VMS operating system provides the following combinations of function code and modifier:

- IO$_SETMODE!IO$M_SET_MODEM—Set line unit modem status
- IO$_SETCHAR!IO$M_SET_MODEM—Set line unit modem status

These codes take the following device- or function-dependent argument:

- P1—The address of a longword buffer that contains new modem status. One or more of the symbolic offsets listed in the following table can be set in the buffer.

Offset	Meaning
XM$V_MDM_STNDBY	Select standby used with EIA modems
XM$V_MDM_MAINT2	Maintenance mode 2 for remote loopback
XM$V_MDM_MAINT1	Maintenance mode 1 for local loopback
XM$V_MDM_FREQ	Select frequency
XM$V_MDM_RDY	Data terminal ready to receive or transmit data
XM$V_MDM_POLL	Select polling modem mode

2.4.5.2 Read Line Unit Modem Status

The read line unit modem status function reads the DMP11's line unit modem register. The VMS operating system provides the following combinations of function code and modifier:

- IO$_SENSEMODE!IO$M_RD_MODEM—Read line unit modem status
- IO$_SENSEMODE!IO$M_CTRL!IO$M_RD_MODEM—Read line unit modem status (DMF32)

These codes take the following device- or function-dependent argument:

- P1—The address of a longword buffer into which the line unit's modem status is stored. One or more of the bits listed in the following table can be set in the buffer.

Bit	Meaning
XM$V_MDM_CARRDET[1]	Receiver is active (Carrier Detect)
XM$V_MDM_MSTNDBY	STANDBY indication from modem
XM$V_MDM_CTS[1]	Data can be transmitted (CTS)
XM$V_MDM_DSR[1]	Modem is in service (DSR)
XM$V_MDM_HDX	Line unit is set to half-duplex mode
XM$V_MDM_RTS[1]	Request to send data from USART (RTS)
XM$V_MDM_DTR[1]	Line unit is available and online (DTR)
XM$V_MDM_RING[1]	Modem has just been dialed up (RING)
XM$V_MDM_MODTEST	Modem is in TEST MODE
XM$V_MDM_SIGQUAL	SIGNAL QUALITY from modem interface
XM$V_MDM_SIGRATE	SIGNAL RATE from modem interface

[1]Only for the DMF32

2.4.5.3 Read Device Status Slot

The read device status slot function reads a particular one-word memory location in a global or specified tributary status slot in the DMP11 controller. It is not supported for the DMF32. The VMS operating system provides the following combinations of function code and modifier:

- IO$_SENSEMODE!IO$M_RD_MEM!IO$M_CTRL—Read global status slot
- IO$_SENSEMODE!IO$M_RD_MEM—Read tributary status slot

These codes take the following device- or function-dependent arguments:

- P1—The address of a longword buffer where the status slot information is stored
- P2—The tributary status slot address (0–31)

2.5 I/O Status Block

The I/O status block (IOSB) for all DMP11 and DMF32 functions is shown in Figure 2–7. Appendix A lists the completion status returns for these functions. (The *VMS System Messages and Recovery Procedures Reference Volume* provides explanations and suggested user actions for these returns.)

Figure 2–7 IOSB Contents

	+2		0	
transfer size		completion status		
error number *	error summary	status	characteristics	+4

* only for DMP11

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The first longword of the IOSB returns, in addition to the completion status, either the size (in bytes) of the data transfer or the size (in bytes) of the extended characteristics buffer returned by a sense mode function. The second longword returns the unit characteristics listed in Table 2–2; the line status bits listed in Table 2–3; the error summary bits listed in Table 2–4; and, for the DMP11, the total number of errors accrued.

2.6 Programming Example

The following sample program (Example 2–1) shows the typical use of QIO functions in DMP11 and DMF32 driver operations such as starting the controller and tributary, and transmitting and receiving data.

To run this sample program on the first DMP11 in the system, enter the initial DCL command, ASSIGN XDA0: DEV.

Example 2–1 DMP11/DMF32 Program Example

```
        $ ASSIGN XDAO: DEV
        .TITLE  EXAMPLE - DMP11/DMF32  Device Driver Sample Program
        .IDENT  'X00'
        $IODEF                      ; Define I/O functions and modes
        $NMADEF                     ; Define Network Management symbols
        $XMDEF                      ; Define driver status flags

;
;  Macro definitions
;
        .macro  type      string,?l                ;
        store   <string>                           ;
        movl    #$$.tmpx,cmdorab+rab$l_rbf         ;
        movw    #$$.tmpx1,cmdorab+rab$w_rsz        ;
        $put    rab=cmdorab                        ;
        blbs    r0,1                               ;
        $exit_s                                    ;
l:                                                 ;
        .endm   type                               ;

        .macro  store     string,pre
        .save
        .psect  $$$dev
        $$.tmpx=.
        pre
        .ascii  %string%
        $$.tmpx1=.-$$.tmpx
        .restore
        .endm   store
CMDOFAB:        $FAB    fac=put,fnm=sys$output:,- ; Output FAB
                        mrs=132,rat=cr,rfm=var
CMDORAB:        $RAB    ubf=cmdbuf,usz=cmdbsz,- ; Output RAB
                        fab=cmdofab
CMDBUF::        .BLKB   256                     ; Command buffer
CMDBSZ=         .-CMDBUF                        ; Buffer size
FAOBUFDSC:      .LONG   CMDBSZ,CMDBUF           ; FAO buffer
                                                ; descriptor
FAOLEN:         .BLKL   1                       ; FAO output buffer
                                                ; length
P2BUF::         .BLKL   50                      ; P2 buffer
P2BUFSZ=        .-P2BUF                         ; P2 buffer size
P2BUFDSC:       .LONG   P2BUFSZ,P2BUF           ; P2 buffer descriptor
P1BUF::         .BLKQ   1                       ; P1 buffer
```

Example 2–1 Cont'd. on next page

Example 2–1 (Cont.) DMP11/DMF32 Program Example

```
P1BUFSZ=        .-P1BUF                              ; P1 buffer size
CHNL::          .BLKL   1                            ; Channel number
IOSB::          .BLKL   1                            ; I/O status block
DEVDSC:         .ASCID 'DEV'                         ; Device to assign
QIOREQDSC:      .LONG   QIOREQSZ,QIOREQ              ; QIO request status
QIOREQ:         .ASCII  'QIO completion status = !XL'
                .ASCII  'IOSB1 = !XL, IOSB2 = !XL'
QIOREQSZ=       .-QIOREQ                             ; Size of QIO status
                                                     ; report
XMTBUFLEN=512                                        ; Size of transmit
                                                     ; buffer
XMTBUF:         .REPEAT XMTBUFLEN
                .BYTE   ^X93                         ; Transmit data
                .ENDR
RCVBUF:         .BLKB   XMTBUFLEN

;
;  This is the start of the program section
;
START:: .WORD      0
        $OPEN      FAB=CMDOFAB                       ; Open output
        BLBC       R0,EXIT                           ;
        $CONNECT   RAB=CMDORAB                       ; Connect to output
        BLBC       R0,EXIT                           ;
        BRB        CONT                              ; Continue
EXIT:   $EXIT_S                                      ; Exit program

CONT:   TYPE       <DMP11/DMF32 Test Program>
        TYPE       <>
        $ASSIGN_S  DEVNAM=DEVDSC,CHAN=CHNL           ; Assign unit
        BLBC       R0,EXIT                           ; Exit on error

;
;  Initialize and start controller
;
        MOVZWL     #XM$M_CHR_LOOPB!XM$M_CHR_DMC,P1BUF+4 ; Set P1 flags,
                                                     ; loopback and DMC
                                                     ; compatible
        MOVW       #XMTBUFLEN,P1BUF+2                ; Set P1 buffer size
        CLRL       P2BUFDSC                          ; Set zero length P2
                                                     ; buffer
        BSBW       INIT                              ; Issue QIO
;
;  Establish and start tributary
;
        CLRQ       P1BUF                             ; Reset P1 buffer
        MOVAB      P2BUF,R7                          ; Get address of P2
                                                     ; buffer
        MOVW       #NMA$C_PCCI_TRI,(R7)+             ; Set parameter code
        MOVZBL     #1,(R7)+                          ; Store trib address
```

Example 2–1 Cont'd. on next page

Example 2–1 (Cont.) DMP11/DMF32 Program Example

```
        MOVZBL   #6,P2BUFDSC                       ; Store length of P2
                                                   ; buffer
        BSBW     ESTAB                             ; Issue QIO
;
;  Loopback data
;
        MOVZWL   #100,R9                           ; Loop device 100
                                                   ; times
10$:    BSBW     XMIT                              ; Issue transmit
        BSBW     RECV                              ; Issue receive
        MOVAB    XMTBUF,R1                         ; Get address of
                                                   ; transmit data
        MOVAB    RCVBUF,R2                         ; Get address of
                                                   ; received data
        MOVZWL   #XMTBUFLEN,R3                     ; Get number of bytes
                                                   ; to verify
20$:    CMPB     (R1)+,(R2)+                       ; Check data
        BNEQ     30$                               ;
        SOBGTR   R3,20$                            ;
        SOBGTR   R9,10$                            ;
        BRW      EXIT                              ; Exit

30$     TYPE     <*** Loopback buffer comparison error ***>
        BRW      EXIT                              ; Exit
;
;  Initialize controller QIO
;
INIT:   TYPE     <*** Initialize controller QIO ***>
        $QIO_S   chan=chnl,func=#io$_setchar!io$m_ctrl!io$m_startup,-
                 p1=p1buf,p2=#p2bufdsc,iosb=iosb,p3=#5
        BRW      QIO_STATUS                        ;

;
;  Start tributary QIO
;
ESTAB:  TYPE     <*** Startup tributary QIO ***>
        $QIO_S   chan=chnl,func=#io$_setchar!io$m_startup,-
                 p1=p1buf,p2=#p2bufdsc,iosb=iosb
        BRW      QIO_STATUS
;
;  Transmit data QIO
;
XMIT:   TYPE     <*** Transmit buffer QIO ***>
        $QIO_S   chan=chnl,func=#io$_writevblk,p1=xmtbuf,-
                 p2=#xmtbuflen,iosb=iosb
        BRW      QIO_XMTST
;
;  Receive data QIO
;
RECV:   TYPE     <*** Receive buffer QIO ***>
        $QIO_S   chan=chnl,efn=#2,func=#io$_readvblk,p1=rcvbuf,-
                 p2=#xmtbuflen,iosb=iosb
        .BRB     qio_status
        .ENABL   LSB
QIO_STATUS:                                        ; Check status of QIO
        BLBC     IOSB,10$                          ; Br if error on QIO
QIO_XMTST:                                         ; Check status of XMIT
        BLBC     R0,10$                            ; Br if error on
```

Example 2–1 Cont'd. on next page

Example 2–1 (Cont.) DMP11/DMF32 Program Example

```
        RSB                                     ; request, else return
                                                ; to caller

10$     MOVZWL  IOSB,R1                         ; Get I/O status block
        PUSHL   R1                              ; Push I/O status block
        PUSHL   R0                              ; Push system service
                                                ; status
        PUSHAQ  FAOBUFDSC                       ; Push address of FAO
                                                ; buffer descriptor
        PUSHAW  FAOLEN                          ; Push address of
                                                ; output length
        PUSHAQ  QIOREQDSC                       ; Push address of
                                                ; input string
        CALLS   #5,@#SYS$FAO                    ; Get error message
        MOVAB   CMDBUF,CMDORAB+RAB$L_RBF        ; Get output buffer
                                                ; address
        MOVW    FAOLEN,CMDORAB+RAB$W_RSZ        ; Get output buffer
                                                ; length
        $PUT    CMDORAB                         ; Print error test
        BRW     EXIT                            ; Exit
        .DSABL  LSB

        .END    START
```

3 DR11–W and DRV11–WA Interface Driver

This chapter describes the use of the DR11–W interface driver (XADRIVER). (The DRV11–WA uses the same driver; thus, unless otherwise stated, references to the DR11–W also apply to the DRV11–WA.)

3.1 Supported Devices

The DR11–W is a general-purpose, 16-bit, parallel, direct-memory-access (DMA) data interface. It is capable of being used either as an interface between memory and a user device or as an interprocessor link (non-DECnet) between two systems.

Because user devices of different or unknown capability can be connected to the interface that the XADRIVER presents, the VMS-supplied device driver might be either insufficient or significantly inefficient for the application. For this reason, VMS provides limited support for the DR11–W and DRV11–WA when connected to foreign devices, and provides the source code for XADRIVER in the VMS distribution kit as a template adding additional functionality.

Note that the driver is not supported if modifications are made to the source program. DIGITAL strongly recommends that any modifications to device drivers be attempted only by those who are extremely familiar with the internal operation of the operating system. For additional information, refer to the *DR11-W Direct Memory Interface Module User's Guide*, the *DRV11-WA General Purpose DMA Interface User's Guide*, and the *VMS Device Support Manual*.

The DRV11–WA is similar to the DR11–W. However, it operates as an interface device that uses the 22-bit Q-BUS rather than the UNIBUS. Unless otherwise indicated, the DRV11–WA driver performs the same QIO functions as the DR11–W driver; descriptions of DR11–W features also apply to the DRV11–WA. The DRV11–WA driver is supported for the MicroVAX II, but not the MicroVAX I.

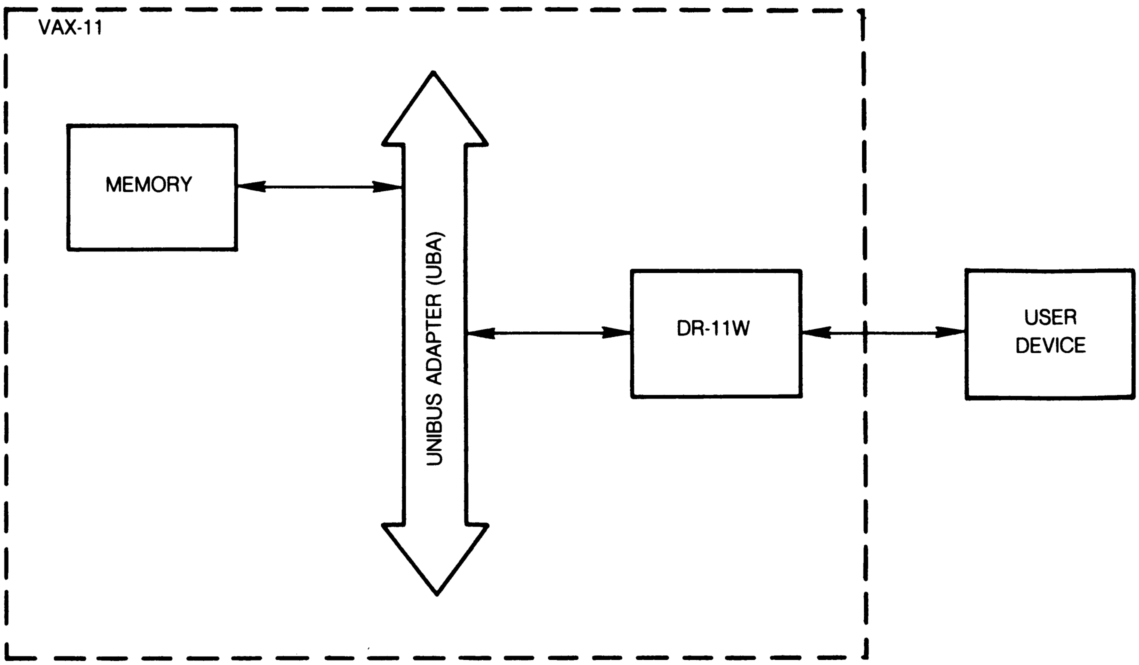
Note: **Etch Revision Level E boards must be configured to be compatible with earlier versions of the DRV11-WA by installing jumpers W2, W3, and W6. These restrictions do not apply to the DR11-W.**

You can link a DR11–W to another DR11–W, a DRV11–WA to another DRV11–WA, or a DR11–W to a DRV11–WA. The VMS operating system does not support interprocessor links. You must write the code for any interprocessor communications operations.

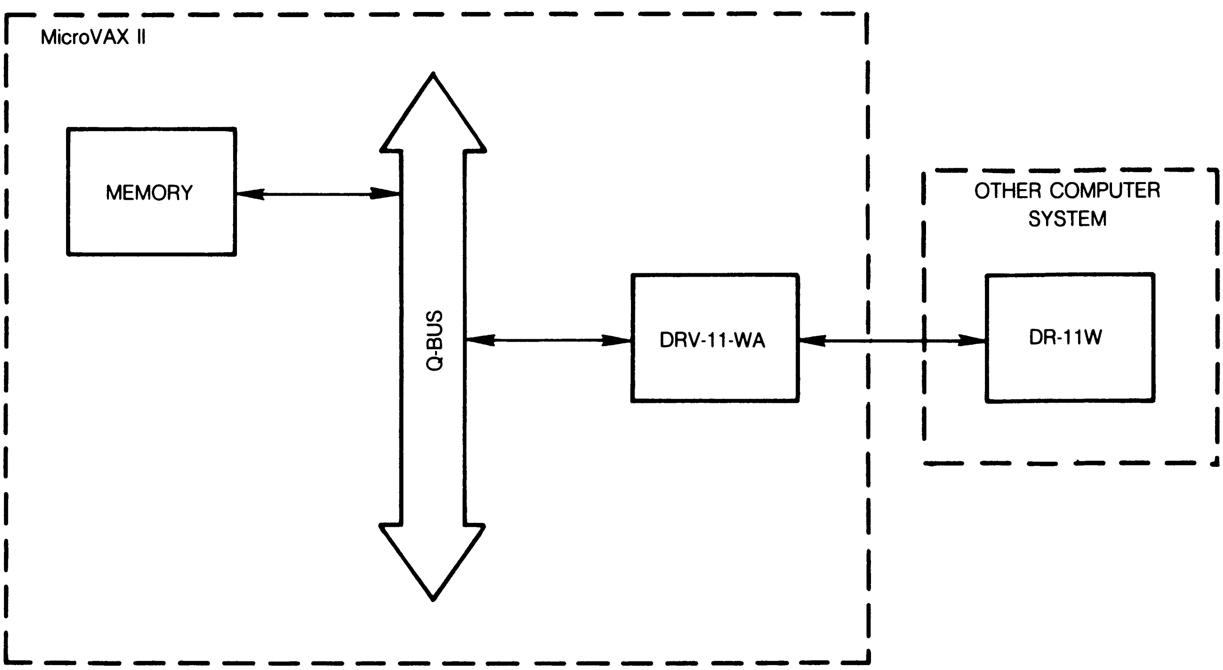
Figure 3–1 shows two typical applications of the DR11–W and DRV11–WA.

The driver (XADRIVER) allows general access to the features provided by the DR11–W and DRV11–WA devices. Function codes and modifiers are provided to control, and to transfer data between, the user device and the VMS operating system.

Figure 3–1 Typical DR11–W/DRV11–WA Device Configurations



a. Data Interface



b. Processor Link

ZK-709-82

3.1.1 Device Differences

The following differences between the DR11–W and the DRV11–WA affect the user at the QIO interface level; the referenced sections contain additional information about these differences:

- Unsolicited interrupts—The DRV11–WA driver does not acknowledge unsolicited interrupts (see Section 3.3).
- IO$M_WORD function modifier—The DRV11–WA driver does not perform word mode transfers (see Section 3.3).
- CSR error bit—The DRV11–WA driver detects some, but not all, hardware errors detected by the DR11–W driver (see Section 3.1.6).
- Error information register (EIR)—The DRV11–WA does not have an EIR (see Section 3.1.6).
- IO$M_RESET function modifier—The DRV11–WA cannot be reset in the same way as the DR11–W (see Section 3.3).
- IO$M_DATAPATH function modifier—The IO$M_DATAPATH function modifier is ignored for the DRV11–WA driver (see Section 3.3.3.1).

3.1.2 DRV11–WA Installation

In addition to the two installation considerations described in this section, follow the instructions in the hardware documentation when installing the DRV11–WA.

3.1.2.1 Type of Addressing

Bit 10 of the vector address selection switch is not used as part of the vector; it selects 18- or 22-bit addressing. Set the device to 22-bit addressing.

3.1.2.2 Device Address and Interrupt Vector Address Selection

Because the DRV11–WA is designed to be compatible with the DR11-B, the hardware documentation instructs you to set the device address and the interrupt vector address to those reserved for the DR11-B. However, the DRV11–WA is treated as much as possible like a DR11–W. Set the device address and interrupt vector address to those reserved for the DR11–W. (Set the device address to rank 19 and the interrupt vector address to rank 40, both in floating address space.) Use the VMS System Generation Utility CONFIGURE command to calculate exact addresses.

If you want to set up the device at the DR11-B address as described in the hardware documentation, configure the device using the following commands:

```
$run sys$system:sysgen
load sys$system:xadriver
connect xaa0 /adap=ub0/csr=%o772410/vector=%o124
exit
```

3.1.3 DR11–W and DRV11–WA Transfer Modes

The DR11–W transfers data in block mode and in word mode. (Word mode transfers are not supported with the DRV11–WA.) In block mode, all transfers are provided by the DMA facility. Each QIO request moves a single buffer of data between the user device and physical memory. One interrupt is generated on completion of the transfer. The transfer rate and transfer direction are controlled by the user device.

In block mode, the two types of UNIBUS or Q-BUS transfers are single cycle and burst. During single-cycle transfers the bus is arbitrated for each word (two bytes) of information exchanged. Both the DR11–W and the DRV11–WA have a single cycle mode supported by VMS.

Burst transfers result in the exchange of multiple words without arbitration of the bus. Two classes of burst mode transfers are possible, depending on the position of a switch on the module. On the DR11–W, the VMS operating system only permits the use of dual cycle mode (class 1) in which two words are transferred for each arbitration of the UNIBUS. On the DRV11–WA, the VMS operating system only permits the use of the 4-cycle mode in which four words are transferred for each arbitration of the Q-BUS. Use burst mode transfers with caution. They can provide greater performance, but can prevent use of the bus by other devices for what might be unacceptable periods. Both the DR11–W and the DRV11–WA also have an N-cycle burst mode that cannot be used on VMS systems. On DRV11–WA boards prior to CS Revision Level B and Etch Revision Level D, N-cycle is the only form of burst mode available, and there is no burst mode selection switch on the module.

In word mode, a single QIO request transfers a buffer of data, with an interrupt requested for each word. Word mode is usually used to exchange control information between the application program and the user device. Once the proper control information has been accepted, a block-mode transfer can be started to exchange data.

In both block- and word-mode transfers, the transfer size is indicated by the byte count value specified in the P2 argument. The DR11–W and DRV11–WA transfer information between main memory and the user device in one-word (two-byte) units; transfers are counted on a word-by-word basis. However, the VMS operating system counts information one byte at a time. Consequently, if the desired DR11–W or DRV11–WA transfer is 100 words, the P2 argument must specify 200 (bytes) for the transfer count value. If an odd number of bytes is specified for the transfer count, the driver rejects the QIO request.

Transfers to and from memory typically occur from sequentially increasing addresses. The user device can inhibit the increment to the next address.

During block mode transfers, the user device controls the transfer direction through signals exchanged with the driver. Neither the VMS operating system nor the application program has any control over the transfer direction. Consequently, a read or write request to the driver by the application program should be by convention, according to the intended action. An effect of this, regardless of whether a read or write QIO function is specified, is that the application program's data buffer is always checked for modify access (rather than read or write access) during block-mode transfers. In word mode, the transfer direction is controlled explicitly by the device driver.

Note: The meaning of the terms read and write can be misunderstood when discussing data transfers. This manual uses these terms for the application procedure running under the VMS operating system. A read operation involves the transfer of information from the user device to VAX memory. A write operation involves the transfer of information from VAX memory to the user device. Receive and input are synonymous with read operations; transmit and output are synonymous with write operations.

3.1.4 DR11–W and DRV11–WA Control and Status Register Functions

For each buffer of data transferred, the DR11–W or DRV11–WA driver allows for the exchange of an additional six bits of information: the function (FNCT) and status (STATUS) bits, which are included in the control and status register (CSR). These bits are accessible to an application process through the device driver QIO interface. The FNCT bits are labeled FNCT 1, FNCT 2, and FNCT 3. The STATUS bits are labeled STATUS A, STATUS B, and STATUS C.

The user device interfaced to the DR11–W or DRV11–WA interprets the value of the three FNCT bits. The QIO request that initiates the transfer specifies the IO$M_SETFNCT modifier to indicate a change in the value for the FNCT bits. The P4 argument of the request specifies this value. P4 bits 0 through 2 correspond to FNCT bits 1,2,3, respectively. Bits 3 through 31 are not used. If required, the FNCT bits must be set for each request. The FNCT bits set in the CSR are passed directly to the user device.

The DR11–W and DRV11–WA STATUS bits are available in bits 9 through 11 of the CSR, which correspond to STATUS bits C,B,A, respectively. On completion of all transfers, the STATUS bits are returned from the user device through the DR11–W or DRV11–WA to the IOSB. Neither the VMS operating system nor the DR11–W/ DRV11–WA modifies these bits in any way. Thus, both FNCT and STATUS fields are defined solely by the user device. Except when used as an interprocessor link, the DR11–W or DRV11–WA takes no special action based on the state of these fields, and the FNCT bits remain set until explicitly changed with the IO$M_ SETFNCT function modifier.

The DR11–W and DRV11–WA CSR STATUS bits should not be confused with the status values returned in the I/O status block.

The function modifier IO$M_CYCLE sets the CSR CYCLE bit for the transfer specified by the QIO request. In block mode, the CYCLE bit initiates the transfer of the first word of data. In word mode, IO$M_CYCLE has no effect.

Section 3.1.7 describes the special meaning given to the FNCT and STATUS bits by the DR11–W or DRV11–WA hardware and device driver when used as an interprocessor link.

3.1.5 Data Registers

Two registers are used to transfer information to and from the user device. The input data register (IDR) contains the last data value transferred into the DR11–W or DRV11–WA from the user device. The output data register (ODR) contains the last value transferred from the DR11–W or DRV11–WA to the user device. During block mode operations, these registers are controlled automatically and require no explicit action on the part of the application program. During word-mode write operations, the DR11–W driver loads the ODR with each successive data word; each word is then available to the user device. During word-mode read operations, the driver reads the IDR and stores the value in memory. Interrupts from the DR11–W synchronize reading and writing the IDR and ODR when in word mode.

3.1.6 Error Reporting

The error information register (EIR) is used for reporting certain error conditions to the application program at the completion of each request. As the result of a user device action, the device sets the ATTN bit in the CSR. The CSR ERROR bit is also set at this time. If ERROR is set during a block-mode transfer, the transfer is aborted. Table 3–5 in Section 3.4 lists the EIR and CSR bit assignments for the I/O status block.

The DRV11–WA detects some, but not all, types of errors detected by the DR11–W. Specifically, the error bit in the CSR (bit 15) for the DRV11–WA signals attention interrupts, nonexistent memory errors, and power failures at the remote device, but does not signal multicycle request errors or parity errors. The DRV11–WA does not have an EIR. The driver always returns zeros in place of the EIR in the fourth word of the IOSB when an I/O operation is completed.

3.1.7 Link Mode of Operation

The XADRIVER driver can control two DR11–Ws, two DRV11–WAs, or a DR11–W and a DRV11–WA connected as interprocessor links between two computer systems.

Note: **The DRV11-WA to DRV11-WA link mode of operation is not possible with earlier board versions. DIGITAL does not support the DRV11-WA to DRV11-WA link mode of operation.**

Control switches on the DR11–W and DRV11–WA modules are set to place the hardware in the link mode configuration. You must set these switches and use either the set mode or the set characteristics function to instruct the driver to function in link mode.

In link operations, two cooperating processes exchange data through the devices, which function as a memory-to-memory interface. This feature requires that the two processes agree on, and establish a basis for describing, the direction of the data transfer, the message sizes, and arbitrating use of the link.

In link operations, the FNCT and STATUS bits are given special meaning by the DR11–W or DRV11–WA hardware and the device driver. Proper operation of the DR11–W or DRV11–WA as an interprocessor link depends on the correct use of these bits. The driver does not enforce correct use of the FNCT and STATUS bits. When issuing a QIO request to the DR11–W or

DRV11–WA in link mode with IO$M_SETFNCT specified, the correct values and sequence of FNCT bits must be provided by the application image. Table 3–1 lists the FNCT and STATUS bits and what actions occur when the DR11–W or DRV11–WA is in link mode. (Table 3–5 lists the CSR bit assignments.)

Table 3–1 Control and Status Register FNCT and STATUS Bits (Link Mode)

Bit	Function
FNCT 1	Indicates whether the DR11–W or DRV11–WA at this end of the link is to transmit or receive data. If FNCT 1 is 0, the DR11–W or DRV11–WA transmits data from memory to the associated DR11–W or DRV11–WA at the other end of the link. If FNCT 1 is 1, the DR11–W or DRV11–WA receives data from the associated DR11–W or DRV11–WA and stores it in memory. (Note that two DRV11–WAs cannot be linked together.) For proper operation, one system must set FNCT 1 to 1 (for receive) and the associated system must set FNCT 1 to 0 (for transmit).
FNCT 2	Interrupts the remote processor. For proper operation, the driver must be set to operate as a link. When a set mode or set characteristics function is used to instruct the driver to perform a link operation, the driver does not leave FNCT 2 set. Instead, the driver sets and then immediately clears the bit to provide a pulse, rather than a level, to the associated system.
FNCT 3	Indicates whether the nonprocessor request (NPR) transfers that follow occur as single-cycle or burst-mode transfers. If FNCT 3 is 0, burst transfers are performed. If FNCT 3 is 1, single-cycle transfers are performed. Note that burst-mode transfers can occupy the UNIBUS or Q-BUS for long periods, to the exclusion of other devices on the same bus.
STATUS A	Returns the value of FNCT 3 set in the associated computer system. When an interrupt is returned from the associated computer denoting the need to exchange a message, STATUS A indicates whether the request that follows is to be set up for single-cycle or for burst operation.
STATUS B	Returns the value of FNCT 2 set in the associated system. Because the DR11–W driver, when configured as a link, never leaves FNCT 2 set, STATUS B is never read as a 1. When STATUS B is set, ATTENTION and, in turn ERROR, are set in the DR11–W or DRV11–WA. When the driver handles the resulting interrupt, it attempts to clear ATTENTION. If ATTENTION cannot be cleared, it indicates that the condition causing it was a level, held true by the associated system. Since ATTENTION can be set by conditions other than FNCT 2, for example, the error ACLO in the associated system, treating FNCT 2 as a pulse allows the receiving DR11–W to differentiate between an error and a normal processor interrupt request.
STATUS C	Returns the value of the FNCT 1 bit sent by the associated computer. STATUS C indicates whether the DMA transfer that follows is a transmit or a receive operation.

If a DR11–W in link configuration sets one or more of the three CSR FNCT bits, the other DR11–W will perform one or more of the following actions:

- Request an interrupt
- Specify the intended transfer direction for a block-mode transfer that follows
- Declare whether the transfer is to take place in burst or single-cycle operation

In each case, the value written into the FNCT bits of the first DR11–W is available and is read from the STATUS bits of the other DR11–W.

Since either process can initiate the data transfer, arbitration for the use of the link is automatic. If both processes want to write or both want to read, a timeout occurs. A timeout also occurs if either process neglects to specify the agreed-upon transfer direction or message size. Each process should specify a different timeout period or a different time before re-requesting the link after a timeout. These actions, which preclude a lockup of the link, are not enforced by the driver.

If an attention interrupt is generated, it indicates that either the DR11–W or DRV11–WA associated with the other system is initiating a transfer or that the other DR11–W or DRV11–WA is going off line because of a power failure. The DR11–W driver's ability to clear ATTENTION (see description of STATUS B in Table 3–1) allows a data transfer to be distinguished from a hardware error. If an error occurs and ATTENTION can be cleared, SS$_DRVERR is returned as the status. If ATTENTION cannot be cleared, SS$_CTRLERR is returned.

3.2 Device Information

You obtain information on DR11–W or DRV11–WA characteristics by using the Get Device/Volume Information ($GETDVI) system service. (See the *VMS System Services Reference Manual.*)

$GETDVI returns DR11–W- or DRV11–WA-specific characteristics when you specify the item codes DVI$_DEVCHAR and DVI$_DEVDEPEND. Tables 3–2 and 3–3 list these characteristics. The $DEVDEF macro defines the device-independent characteristics; the $XADEF macro defines the device-dependent characteristics.

DVI$_DEVTYPE and DVI$_DEVCLASS return the device type and device class names, which are defined by the $DCDEF macro. The device type for the DR11–W is DT$_DR11W; the device type for the DRV11–WA is DT$_XA_DRV11WA. The device class for both the DR11–W and DRV11–WA is DC$_REALTIME. DVI$_DEVBUFSIZ returns the default buffer size, which is 65,535.

Table 3–2 DR11–W and DRV11–WA Device-Independent Characteristics

Characteristic[1]	Meaning
	Dynamic Bits (Conditionally Set)
DEV$M_AVL	Device is online and available.

[1]Defined by the $DEVDEF macro.

Table 3–2 (Cont.) DR11–W and DRV11–WA Device-Independent Characteristics

Characteristic[1]	Meaning
	Dynamic Bits (Conditionally Set)
DEV$M_ELG	Error logging is enabled for this device.
	Static Bits (Always Set)
DEV$M_IDV	Input device.
DEV$M_ODV	Output device.
DEV$M_RTM	Real-time device.

[1]Defined by the $DEVDEF macro.

Table 3–3 DR11–W and DRV11–WA Device-Dependent Characteristics

Value[1]	Meaning
XA$M_DATAPATH	Describes which UNIBUS adapter data path is in use. 0 = direct data path; 1 = buffered data path. The initial state of this bit is 0. (Not applicable to the DRV11–WA.)
XA$M_LINK	Describes whether the DR11–W or DRV11–WA is used as a link or as a user device interface. 0 = user device interface; 1 = link. The initial state of this bit is 0.

[1]Defined by the $XADEF macro.

3.3 DR11–W and DRV11–WA Function Codes

The XADRIVER can perform logical, virtual, and physical I/O operations. The basic I/O functions are read, write, set mode, and set characteristics. Table 3–4 lists these functions and their function codes. The following sections describe these functions in greater detail.

Table 3–4 DR11–W Function Codes

Function Code and Arguments	Type[1]	Function Modifiers	Function
IO$_READLBLK P1,P2,- P3,P4,P5	L	IO$M_SETFNCT IO$M_WORD[2] IO$M_TIMED IO$M_CYCLE IO$M_RESET	Read logical block.

[1]V = virtual, L = logical, P = physical (There is no functional difference in these operations.)

[2]Not applicable to the DRV11–WA

Table 3–4 (Cont.) DR11–W Function Codes

Function Code and Arguments	Type[1]	Function Modifiers	Function
IO$_READVBLK P1,P2,-P3,P4,P5	V	IO$M_SETFNCT IO$M_WORD[2] IO$M_TIMED IO$M_CYCLE IO$M_RESET	Read virtual block.
IO$_READPBLK P1,P2,-P3,P4,P5	P	IO$M_SETFNCT IO$M_WORD[2] IO$M_TIMED IO$M_CYCLE IO$M_RESET	Read physical block.
IO$_WRITELBLK P1,P2,-P3,P4,P5	L	IO$M_SETFNCT IO$M_WORD[2] IO$M_TIMED IO$M_CYCLE IO$M_RESET	Write logical block.
IO$_WRITEVBLK P1,P2,-P3,P4,P5	V	IO$M_SETFNCT IO$M_WORD[2] IO$M_TIMED IO$M_CYCLE IO$M_RESET	Write virtual block.
IO$_WRITEPBLK P1,P2,-P3,P4,P5	P	IO$M_SETFNCT IO$M_WORD[2] IO$M_TIMED IO$M_CYCLE IO$M_RESET	Write physical block.
IO$_SETMODE P1,P3	L	IO$M_ATTNAST	Set DR11–W or DRV11–WA characteristics for subsequent operations.
IO$_SETCHAR P1,P3	P	IO$M_ATTNAST IO$M_DATAPATH	Set DR11–W or DRV11–WA characteristics for subsequent operations.

[1]V = virtual, L = logical, P = physical (There is no functional difference in these operations.)

[2]Not applicable to the DRV11–WA

Although the XADRIVER does not differentiate among logical, virtual, and physical I/O functions (all are treated identically), you must have the required privilege to issue a request.

The read and write functions take the following device- or function-dependent arguments:

- P1—The starting virtual address of the buffer that is to receive data for a read operation, or the virtual address of the buffer that is to send data to the DR11–W for a write operation. Modify access to the buffer, rather than read or write access, is checked for all block-mode read and write requests.

- P2—The size of the data buffer in bytes (the transfer count). Since the DR11–W performs word transfers, the transfer count must be an even value. The maximum transfer size is 65,534 bytes. If a larger number is specified, the high-order bits of this field are ignored.
- P3—The timeout period for this request (in seconds). The value specified must be equal to or greater than 2. IO$M_TIMED must be specified. The default timeout value for each request is 10 seconds.
- P4—The value of the DR11–W command and status register (CSR) function (FNCT) bits to be set. If IO$M_SETFNCT is specified, the low-order three bits of P4 (2:0) are written to the CSR FNCT bits 3:1 (respectively) at the time of the transfer.
- P5—The value (low two bytes) to be loaded into the DR11–W output data register (ODR). IO$M_SETFNCT must be specified and the transfer count (P2) must be 0.

If a direct data path (DDP) is used (see Section 3.3.3.1), the address specified by the P1 argument must be word-aligned. However, if a buffered data path (BDP) is used, byte alignment is allowed. All transfers through the BDP, which is only available on the UNIBUS, must occur from sequential, increasing addresses. If the user device interfaced to the DR11–W cannot conform to this requirement, the DDP must be used.

The transfer count specified by the P2 argument must be an even number of bytes. If an odd number is specified, an error (SS$_BADPARAM) is returned in the I/O status block (IOSB). If the transfer count is 0, the driver will transfer no data. However, if IO$M_SETFNCT is specified and P2 is 0, the driver will set the FNCT bits in the DR11–W CSR, load the low two bytes specified in P5 into the DR11–W ODR, and return the current CSR status bit values in the IOSB.

The read and write functions can take the following function modifiers:

- IO$M_SETFNCT—Sets the FNCT bits in the DR11–W CSR before the data transfer is initiated. The low-order three bits of the P4 argument specify the FNCT bits. The user device that interfaces with the DR11–W or DRV11–WA receives the FNCT bits directly, and their value is interpreted entirely by the device.

  Additionally, if the transfer count (P2) is 0, load the value specified in P5 into the device ODR.

  If a link operation is specified in the device-dependent characteristics (XA$M_LINK = 1), FNCT 2 will not be left set (that is, it will be set and immediately cleared) in the device CSR.
- IO$M_WORD—Performs the data transfer in word mode rather than in DMA block mode (not applicable to the DRV11–WA). In word mode an interrupt occurs for each word transferred. This allows the exchange of a small amount of data to establish the parameters for a block-mode data transfer that follows.

If IO$M_WORD is included in a write request, the first word in a user's buffer is loaded into the DR11–W ODR. The driver then waits for an interrupt before proceeding to load the next word or complete the request. If IO$M_WORD is included in a read request, the driver waits for an interrupt and then reads a word from the DR11–W IDR and stores it in the user's buffer.

Interrupts are initiated when either the user device or, when in link operation, the associated DR11–W sets ATTENTION.

If the DR11–W or DRV11–WA receives an unsolicited interrupt, no read or write request is posted. If the next request is for a word-mode read, the driver returns the word read from the DR11–W IDR and stores it in the first word of the user's buffer. In this case the driver does not wait for an interrupt.

The DRV11–WA does not respond to unsolicited interrupts from a remote device; the DRV11–WA only acknowledges interrupts when a DMA transfer is outstanding. Consequently, word-mode transfers are not possible on a DRV11–WA because the device does not acknowledge the interrupt that occurs when the I/O operation is completed; the QIO waits indefinitely or times out. (In some cases, you can work around this problem by causing the remote device to generate an interrupt, which makes the local DRV11–WA complete the I/O operation with an SS$_OPINCOMPL status.)

- IO$M_TIMED—Uses the timeout value in the P3 argument rather than the default timeout value of 10 seconds.
- IO$M_CYCLE—Sets the cycle bit in the DR11–W or DRV11–WA CSR for this request. In block mode, this initiates the first NPR cycle. For user devices, the application of the cycle bit is dependent on the specific device. In word mode, IO$M_CYCLE is ignored. In link operations, only the transmitting DR11–W or DRV11–WA must set CYCLE and then only after the companion DR11–W has its receive request initiated.
- IO$M_RESET—Performs a device reset to the DR11–W before any I/O operation is initiated. This function does not affect any other device on the system.

  The DRV11–WA can be reset only by initializing the Q-BUS and all other devices attached to the Q-BUS. Therefore, when the IO$M_RESET function modifier is used to reset the DRV11–WA, the XADRIVER simulates a reset by setting the word count register (WCR) to indicate one word left to be transferred and setting the CYCLE bit to complete the transfer. If the driver is not performing a transfer at the time of a reset, the reset is a NOOP.

On completion of each read or write request, including those requests with a zero transfer count, the current value of the DR11–W or DRV11–WA CSR and DR11–W EIR is returned in the I/O status block.

3.3.1 Read

Read functions provide for the direct transfer of data from the user device that interfaces with the DR11–W or DRV11–WA into the user process's virtual memory address space. The VMS operating system provides the following function codes:

- IO$_READLBLK—Read logical block
- IO$_READVBLK—Read virtual block
- IO$_READPBLK—Read physical block

Five function-dependent arguments and five function modifiers are used with these codes. These arguments and modifiers are described at the beginning of Section 3.3.

3.3.2 Write

Write functions provide for the direct transfer of data to the user device that interfaces with the DR11–W or DRV11–WA from the user process's virtual memory address space. The VMS operating system provides the following function codes:

- IO$_WRITELBLK—Write logical block
- IO$_WRITEVBLK—Write virtual block
- IO$_WRITEPBLK—Write physical block

Five function-dependent arguments and five function modifiers are used with these codes. These arguments and modifiers are described at the beginning of Section 3.3.

3.3.3 Set Mode and Set Characteristics

Set mode operations affect the operation and characteristics of the associated DR11–W or DRV11–WA. The VMS operating system defines two types of set mode functions: set mode and set characteristics. These functions allow the user process to set or change the device characteristics. The following function codes are provided:

- IO$_SETMODE—Set mode (no I/O privilege required)
- IO$_SETCHAR—Set characteristics (requires physical I/O privilege)

These functions take the following device- or function-dependent arguments:

- P1—The virtual address of a quadword characteristics buffer. If the function modifier IO$M_ATTNAST is specified, P1 is the address of the AST service routine. In this case, if P1 is 0, all attention ASTs are disabled.
- P3—The access mode to deliver the AST (maximized with the requester's access mode). If IO$M_ATTNAST is not specified, P3 is ignored.

Figure 3–2 shows the quadword P1 characteristics buffer for IO$_SETMODE and IO$_SETCHAR.

Figure 3–2 P1 Characteristics Buffer

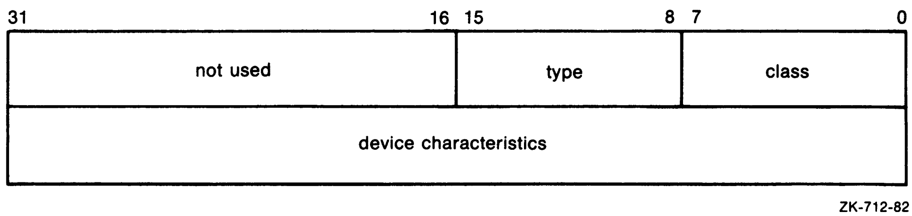


Table 3–3 lists the device characteristics for the set mode and set characteristics functions. The device class value is DC$_REALTIME. The device type value is DT$_DR11W or DT$_XA_DRV11WA. These values are defined by the $DCDEF macro.

3.3.3.1 Set Mode Function Modifiers

The IO$_SETMODE and IO$_SETCHAR function codes can take the following function modifier:

- IO$M_ATTNAST—Enable attention AST

This function modifier allows the user process to queue an attention AST for delivery when an asynchronous or unsolicited condition is detected by the DR11–W or DRV11–WA driver. Unlike ASTs for other QIO functions, use of this function modifier does not increment the I/O count for the requesting process or lock pages in memory for I/O buffers. Each AST is charged against the user's AST limit.

Attention ASTs are delivered when any of the following occur:

- Any block- or word-mode data transfer request is completed.
- An unsolicited interrupt from the DR11–W occurs. (The DRV11–WA does not respond to unsolicited interrupts.)
- An attention AST is queued and a previous unsolicited interrupt has not been acknowledged.
- A device timeout occurs.

The Cancel I/O on Channel ($CANCEL) system service is used to flush attention ASTs for a specific channel.

The enable attention AST function modifier enables an attention AST to be delivered to the requesting process once only. After the AST occurs, it must be explicitly reenabled by the function modifier before the AST can occur again. This function modifier does not update the device characteristics.

When the AST is delivered, the AST parameter contains the contents of the DR11–W or DRV11–WA CSR in the low two bytes and the value read from the DR11–W or DRV11–WA IDR in the high two bytes.

In addition to IO$M_ATTNAST, the IO$_SETCHAR function code can take the following function modifier:

- IO$M_DATAPATH—Use the data path specified by XA$M_DATAPATH in the P1 characteristics buffer

The IO$M_DATAPATH function modifier allows the user to specify either the direct data path (DDP) or a buffered data path (BDP) for block-mode transfers through the UNIBUS adapter.

The device-specific characteristic XA$M_DATAPATH is used to switch between use of the DDP and the BDP. If XA$M_DATAPATH is set, the BDP is used; if clear, the DDP is used. Regardless of the value of XA$M_DATAPATH, the choice of data path has no effect unless the function modifier IO$M_DATAPATH is also specified, which requires physical I/O privilege.

Note: **Use caution when specifying data transfers through the BDP. The user device has access to several hardware functions: C0 and C1, inhibit word count increment, and inhibit bus address increment. If these signals are used out of context of the expected UNIBUS adapter constraints for BDPs, the result is unpredictable.**

Unlike the UNIBUS, the Q-BUS does not provide a choice between a direct data path and a buffered data path; the IO$M_DATAPATH function modifier is ignored for the DRV11–WA.

3.4 I/O Status Block

The I/O status block (IOSB) for DR11–W or DRV11–WA read and write functions is shown in Figure 3–3. On completion of each read or write request, the I/O status block is filled with system and DR11–W or DRV11–WA status information.

Figure 3–3 IOSB Contents — Read and Write Functions

+2	IOSB
byte count	status
DR11-W EIR	DR11-W CSR

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The first longword of the I/O status block contains I/O status returns and the byte count. Appendix A lists the status returns for read and write functions. (The *VMS System Messages and Recovery Procedures Reference Volume* provides explanations and suggested user actions for these returns.) The byte count is the actual number of bytes transferred by the request. If the request ends in an error, the byte count might differ from the requested number of bytes. If a power failure, timeout, or the Cancel I/O on Channel ($CANCEL) system service stops the request, the value in the byte count field is not valid.

The third and fourth words of the I/O status block contain the values of the DR11–W CSR and EIR on completion of the request. (The DRV11–WA has a CSR but not an EIR; the driver always returns zeros in the fourth word of the IOSB when an I/O operation is completed.) Table 3–5 lists the bit assignments for these two words. The *DR11–W User's Manual* provides additional information on the EIR and CSR.

Table 3–5 EIR and CSR Bit Assignments

Word	Bit	Function
EIR	0	Register flag
	1–7	(not applicable)
	8	N-cycle burst
	9	Burst timeout (sets ERROR)
	10	PARITY (sets ERROR)
	11	ACLO (sets ERROR)
	12	Multicycle request (sets ERROR)
	13	ATTENTION (sets ERROR)
	14	Nonexistent memory (sets ERROR)
	15	ERROR (generates interrupt when set)
CSR	0	GO
	1	FNCT 1
	2	FNCT 2
	3	FNCT 3
	4	Extended bus address 16
	5	Extended bus address 17
	6	Interrupt enable
	7	READY
	8	CYCLE
	9	STATUS C
	10	STATUS B
	11	STATUS A
	12	Maintenance mode
	13	ATTENTION (sets ERROR)
	14	Nonexistent memory (sets ERROR)
	15	ERROR (generates interrupt when set)

3.5 Programming Example

A sample program residing in the SYS$EXAMPLES directory demonstrates how to perform transfers across a DR11–W to DRV11–WA or a DR11–W to DR11–W interprocessor link. The sample program includes the following modules:

- XALINK.MAR—Places the device in link mode
- XAMESSAGE.MAR—Performs the actual transfer of data
- XATEST.FOR—Solicits parameters for the transfer from the user and calls the XALINK.MAR and XAMESSAGE.MAR modules
- XATEST.COM—Compiles and links the sample program

Example 3–1, which consists of the module XAMESSAGE.MAR, shows how an actual memory-to-memory link might be implemented using the XADRIVER. All actions are invoked through the $QIO interface by a nonprivileged image.

Note: **XAMESSAGE.MAR is a demonstration program, not an application. The program may not work in all circumstances. See the template warning at the beginning of Example 3-1.**

XAMESSAGE.MAR includes the following features:

- Either system can function as the transmitter or the receiver. For any given exchange, one system must be the transmitter and one must be the receiver.
- Either the transmitter or the receiver can call XAMESSAGE first, which is made possible by the driver's ability to keep track of unsolicited attention interrupts. XAMESSAGE uses this feature for the following reasons:
  - To synchronize the DMA exchange
  - To ensure that the receiver issues the block-mode read request first
  - To ensure that the transmitter sets the CYCLE bit to initiate the first NPR transfer
- If either the transmitter or receiver specifies unequal transfer sizes or does not match the transfer direction, either a timeout occurs or one of the procedures returns an error. The caller must resolve these discrepancies.

Table 3–6 lists the main flow of the program. Note that paths for transmit and receive and for DR11–W and DRV11–WA are combined in the same module (XAMESSAGE).

The three parts of Table 3–6 describe the operation of XAMESSAGE in three different device configurations:

- A DRV11–WA transmitting a message to a DR11–W
- A DR11–W transmitting a message to a DRV11–WA
- A DR11–W transmitting a message to another DR11–W

The two right-hand columns describe the action taken by each device involved in the transfer. The leftmost column contains the name of the routine in XAMESSAGE that performs the respective action: MAIN refers to the main routine for XAMESSAGE, AST_GO refers to the AST routine by that name, AST_COM refers to the AST routine called AST_ COMPLETION, and ASYNC means that the action occurs asynchronously and is not controlled directly by any code in XAMESSAGE.

Table 3–6 XAMESSAGE Program Flow

DRV11–WA (Transmitter) to DR11–W (Receiver)

XAMESSAGE	DRV11–WA (Transmitter)	DR11–W (Receiver)
MAIN	1. Issue block mode read request.	1. Enable attention AST.
AST_GO		2. Execute attention AST as a result of interrupt from transmitter.
AST_GO		3. Issue block mode read request.
AST_GO	4. Complete block mode read request prematurely as a result of the interrupt at the beginning of the receiver's read request.	
AST_GO	5. Issue block mode write request.	
ASYNC	6. Perform DMA transfer.	6. Perform DMA transfer.
AST_COM	7. Execute completion AST, and check for errors.	7. Execute completion AST, and check for errors.

DR11–W (Transmitter) to DRV11–WA (Receiver)

XAMESSAGE	DRV11–WA (Receiver)	DR11–W (Transmitter)
MAIN	1. Issue block mode read.	1. Enable attention AST.
AST_GO		2. Execute attention AST as a result of interrupt from receiver.
AST_GO		3. Issue block mode write request.
ASYNC	4. Perform DMA transfer.	4. Perform DMA transfer.
AST_COM	5. Execute completion AST, and check for errors.	5. Execute completion AST, and check for errors.

Table 3–6 (Cont.) XAMESSAGE Program Flow

DR11–W (Transmitter) to DR11–W (Receiver)

XAMESSAGE	DR11–W (Receiver)	DR11–W (Transmitter)
MAIN	1. Enable attention AST.	1. Enable attention AST.
MAIN		2. Momentarily set the FNCT2 bit via a 0-length transfer to interrupt the receiver.
AST_GO	3. Execute attention AST as a result of interrupt from transmitter.	
AST_GO	4. Issue block mode read request.	
AST_GO		5. Execute attention AST as a result of interrupt from receiver.
AST_GO		6. Issue block mode write request.
ASYNC	7. Perform DMA transfer.	7. Perform DMA transfer.
AST_COM	8. Execute completion AST, and check for errors.	8. Execute completion AST, and check for errors.

Example 3–1 DR11–W/DRV11–WA Program Example (XAMESSAGE.MAR)

```
        .TITLE        XAMESSAGE
        .IDENT        'V04-001'

;*****************************************************************************
;*                                                                           *
;*  DIGITAL ASSUMES  NO  RESPONSIBILITY TO SUPPORT THE SOFTWARE DESCRIBED    *
;*  IN THIS MODULE, NOR TO ANSWER INQUIRIES ABOUT IT.                        *
;*                                                                           *
;*  THIS SOFTWARE MODULE IS PART OF A TEMPLATE WHICH MAY REQUIRE CUSTOMER    *
;*  MODIFICATIONS TO WORK IN ALL CIRCUMSTANCES.                              *
;*                                                                           *
;*****************************************************************************
;


;
;++
;
; ABSTRACT:
;
;       This module allows you to connect a DR11--W to a DRV11--WA; or
;       a DR11--W to another DR11--W in an interprocessor link and to
;       perform data transfers from one processor to the other.
;
```

Example 3–1 Cont'd. on next page

Example 3–1 (Cont.) DR11–W/DRV11–WA Program Example (XAMESSAGE.MAR)

```
;--
        .SBTTL          LOCAL DEFINITIONS AND STORAGE
;++
; XAMESSAGE ROUTINE
;
; CALLING SEQUENCE:
;
;        CALL (BUFFER_ADDRESS,BUFFER_SIZE,TRANSFER_DIRECTION,CHANNEL,-
;              EVENT_FLAG,TIME_OUT,STATUS_ADDRESS,LOCAL_DEVICE,REMOTE_DEVICE)
;
;                BUFFER_ADDRESS = ADDRESS OF DATA BUFFER TO TRANSFER
;                BUFFER_SIZE = SIZE IN BYTES OF DATA BUFFER TO TRANSFER.
;                  NOTE THAT RECEIVER AND TRANSMITTER MUST AGREE ON THE
;                  SIZE OF THE TRANSFER.
;                TRANSFER_DIRECTION = DIRECTION FOR DATA TO GO
;                        0 = TRANSMIT
;                        1 = RECEIVE
;                CHANNEL = CHANNEL ASSIGNED TO DEVICE (DR11--W OR DRV11--WA)
;                EVENT_FLAG = EVENT FLAG TO SET WHEN TRANSFER COMPLETE
;                TIME_OUT = I/O TIME-OUT VALUE IN SECONDS
;                STATUS_ADDRESS = ADDRESS OF 20 BYTE ARRAY TO RECEIVE
;                  FINAL STATUS - ONLY FILLED IN IF USER'S PARAMETERS ARE
;                  ALL VALID.
;                        IOSB - 8 BYTES
;                                I/O STATUS BLOCK FROM QUEUE I/O REQUEST
;                        ERROR - 4 BYTES - NOT USED - FOR COMPATIBILITY
;                                WITH OLD VERSIONS OF THIS MODULE.
;                        STATE - 4 BYTES
;                                THIS FIELD TRACKS WHICH QIO WAS THE LATEST
;                                ONE TO BE PERFORMED.
;                                01 - LAST QIO WAS ONE IN THE MAIN ROUTINE.
;                                02 - LAST QIO WAS ONE IN AST_GO.
;                        SSRV_STS - 4 BYTES
;                                VALUE OF RO RETURNED FROM THE LAST SYSTEM
;                                SERVICE EXECUTED.
;                LOCAL_DEVICE = TYPE OF DEVICE AT LOCAL END OF LINK.
;                        DR11_W = 1
;                        DRV11_WA = 2
;                REMOTE_DEVICE = TYPE OF DEVICE AT REMOTE END OF LINK.
;                        DR11_W = 1
;                        DRV11_WA = 2
;
;--

        $SSDEF
; PARAMETER OFFSETS.
BUFFER_P = 4
BUF_SIZE_P = 8
DIRECTION_P = 12
CHAN_P = 16
EFN_P = 20
TIME_P = 24
STS_ADDR_P = 28
LCL_DEVICE_P = 32
REM_DEVICE_P = 36
        .PSECT          XADATA,LONG
```

Example 3–1 Cont'd. on next page

Example 3–1 (Cont.) DR11–W/DRV11–WA Program Example (XAMESSAGE.MAR)

```
; SAVED PARAMETER VALUES.
BUFFER:         .LONG       0           ; SAVED BUFFER ADDRESS
BUF_SIZE:       .LONG       0           ; SAVED BUFFER SIZE
DIRECTION:      .LONG       0           ; DIRECTION OF TRANSFER
CHAN:           .LONG       0           ; SAVED CHANNEL ASSIGNED TO DR11--W
EFN:            .LONG       0           ; SAVED EVENT FLAG NUMBER
TIME:           .LONG       0           ; SAVED TIME-OUT VALUE
STS_ADDR:       .LONG       0           ; ADDRESS OF CALLERS STATUS VARIABLE

; DEFINE DEVICE TYPES AT BOTH ENDS OF INTERPROCESSOR LINK.

DR11_W = 1
DRV11_WA = 2
LCL_DEVICE:     .BLKL       1           ; TYPE OF DEVICE ON THIS SYSTEM.
REM_DEVICE:     .BLKL       1           ; TYPE OF DEVICE AT OTHER
                                        ;   END OF LINK.
AST:            .BLKL       1

; NOTE - ORDER IS ASSUMED FOR NEXT FOUR VARIABLES
IOSB:           .QUAD       0           ; QIO IOSB
ERROR:          .LONG       0           ; ERROR VALUE PARAMETER
STATE:          .LONG       0           ; STATE VARIABLE
SSRV_STS:       .LONG       0           ; SYSTEM SERVICE STATUS
        .PAGE
        .SBTTL  VALIDATE AND SAVE CALLER'S PARAMETERS
        .PSECT  XACODE,NOWRT

        .ENTRY  XAMESSAGE,^M<R2,R3,R4,R5>

; VALIDATE AND SAVE CALLER'S PARAMETERS
        CLRQ    W^IOSB                  ; CLEAR IOSB
        CLRL    W^ERROR                 ; CLEAR ERROR FIELD
        CLRL    W^SSRV_STS              ; CLEAR SYS SERVICE RETURN STATUS.
        CMPW    (AP),#9                 ; MUST HAVE 9 PARAMETERS
        BEQL    10$                     ; BR IF OKAY
        BRW     BADPARAM                ; BR TO SIGNAL ERROR
10$:    MOVL    BUFFER_P(AP),W^BUFFER   ; GET BUFFER ADDRESS
        MOVL    @BUF_SIZE_P(AP),W^BUF_SIZE ; GET BUFFER SIZE
        BNEQ    20$                     ; BR IF OKAY
        BRW     BADPARAM                ; TRANSFER SIZE IS NON ZERO -- ILLEGAL
20$:    MOVZBL  @DIRECTION_P(AP),W^DIRECTION ; GET TRANSFER DIRECTION FLAG
        CMPL    W^DIRECTION,#2          ; THE ONLY LEGAL VALUES ARE 0,1
        BLEQU   25$                     ; BR IF OKAY
        BRW     BADPARAM                ; ELSE BR TO SIGNAL ERROR
25$:    MOVL    @CHAN_P(AP),W^CHAN      ; FETCH CHANNEL
        MOVL    @EFN_P(AP),W^EFN        ; AND EVENT FLAG
        BEQL    BADPARAM                ; MUST SPECIFY EVENT FLAG
        MOVL    @TIME_P(AP),W^TIME      ; FETCH TIME-OUT VALUE
        BNEQ    30$                     ; IF NONZERO, USE IT.
        MOVZBL  #5,W^TIME               ; ELSE USE SOME "REASONABLE" VALUE
30$:    MOVL    STS_ADDR_P(AP),W^STS_ADDR ; GET ADDRESS OF STATUS ARRAY
        BEQL    BADPARAM                ; IF NOT SPECIFIED, ERROR
        CLRL    @W^STS_ADDR             ; INITIALIZE STATUS VALUE
        MOVZBL  @LCL_DEVICE_P(AP),W^LCL_DEVICE ; GET LOCAL DEVICE TYPE
        CMPL    #DRV11_WA,W^LCL_DEVICE  ; IS LOCAL DEVICE A DRV11--WA?
        BEQLU   35$                     ; BRANCH IF SO.
        CMPL    #DR11_W,W^LCL_DEVICE    ; IS LOCAL DEVICE A DR11--W?
        BNEQU   BADPARAM                ; ERROR IF IT'S NOT EITHER.
35$:    MOVZBL  @REM_DEVICE_P(AP),W^REM_DEVICE ; GET REMOTE DEVICE TYPE
```

Example 3–1 Cont'd. on next page

Example 3–1 (Cont.) DR11–W/DRV11–WA Program Example (XAMESSAGE.MAR)

```
        CMPL      #DRV11_WA,W^REM_DEVICE     ; IS REMOTE DEVICE A DRV11--WA?
        BEQLU     50$                        ; BRANCH IF SO.
        CMPL      #DR11_W,W^REM_DEVICE       ; IS REMOTE DEVICE A DR11--W?
        BNEQU     BADPARAM                   ; ERROR IF IT'S NOT EITHER.
50$:    $CLREF_S  EFN=EFN                    ; MAKE SURE EFN IS CLEAR
        BLBS      RO,100$                    ; BR IF NO SYS SERVICE ERROR
        RET
100$:   CMPL      #DRV11_WA,W^LCL_DEVICE     ; DISPATCH BASED ON LOCAL
                                             ;   DEVICE TYPE
        BEQL      DRV11_WA_START             ; LOCAL DEVICE IS DRV11--WA
        BRW       DR11_W_START               ; LOCAL DEVICE IS DR11--W

BADPARAM:
        MOVZWL    #SS$_BADPARAM,RO           ; ELSE RETURN ERROR.
        RET

        .PAGE
        .SBTTL    START MESSAGE PROCESSOR

DRV11_WA_START:                              ; THE LOCAL DEVICE IS A DRV11--WA
        BLBC      W^DIRECTION,10$            ; BRANCH IF IT'S A TRANSMIT
                                             ;   OPERATION
        MOVAL     W^AST_COMPLETION,W^AST     ; AST_COMPLETION IS THE AST FOR
                                             ;   RECEIVE
        BRB       20$
10$:    MOVAL     W^AST_GO,W^AST             ; AST_GO IS THE AST FOR TRANSMIT
                                             ;   OPERATION
20$:    MOVL      #01,W^STATE                ; STATE = 1 => LAST QIO WAS IN MAIN
                                             ;   ROUTINE.
        $QIO_S    CHAN=W^CHAN,-              ; BLOCK MODE READ - EVEN IF IT'S
                  FUNC=#<IO$_READLBLK!IO$M_TIMED!IO$M_SETFNCT>,- ; TRANSMIT
                  IOSB=W^IOSB,-
                  ASTADR=@W^AST,-
                  P1=@W^BUFFER,-             ; ADDRESS OF CALLER'S DATA BUFFER
                  P2=W^BUF_SIZE,-            ; LENGTH OF DATA BUFFER
                  P3=W^TIME,-                ; TIMEOUT VALUE
                  P4=#7                      ; INTERRUPT+READ
        BRW       MAIN_EXIT                  ; EXIT MAIN ROUTINE.
DR11_W_START:                                ; LOCAL DEVICE IS DR11--W
        MOVL      #01,W^STATE                ; STATE = 1 => LAST QIO WAS IN MAIN
                                             ;   ROUTINE.
        $QIO_S    CHAN=W^CHAN,-              ; QIO TO ENABLE AST'S
                  FUNC=#<IO$_SETMODE!IO$M_ATTNAST>,-
                  IOSB=W^IOSB,-
                  P1=W^AST_GO
        BLBC      RO,MAIN_EXIT               ; BRANCH ON ERROR - ALL DONE.
        BLBS      W^DIRECTION,MAIN_EXIT      ; BRANCH IF THIS IS A RECEIVE
                                             ;   OPERATION
        CMPL      #DR11_W,W^REM_DEVICE       ; IS REMOTE DEVICE A DR11--W?
        BNEQU     MAIN_EXIT                  ; BRANCH IF NOT.
        $QIO_S    CHAN=W^CHAN,-              ; PERFORM O-LENGTH QIO.  THIS
                  FUNC=#<IO$_WRITELBLK!IO$M_SETFNCT>,- ; SERVES TO SET THE
                  IOSB=W^IOSB,-              ; FNCT BITS (CONTAINED IN P4),
                  P1=@W^BUFFER,-             ; IN THE CSR, INTERRUPTING THE
                                             ;   REMOTE DR11--W.
                  P2=#0,-
                  P4=#2
MAIN_EXIT:
        MOVL      RO,W^SSRV_STS              ; SAVE QIO STATUS RETURN
```

Example 3–1 Cont'd. on next page

Example 3–1 (Cont.) DR11–W/DRV11–WA Program Example (XAMESSAGE.MAR)

```
        MOVC3     #20,W^IOSB,@W^STS_ADDR       ; RETURN STATUS TO THE USER
        BLBS      W^SSRV_STS,10$               ; IF SUCCESS, DON'T SET EVFLAG YET
        $SETEF_S  EFN=W^EFN                    ; IF ERROR, SET EVENT FLAG
                                               ;   -- ALL DONE.
10$:    MOVL      W^SSRV_STS,RO                ; RESTORE RO STATUS RETURN.
        RET

        .PAGE
        .SBTTL   AST_GO - AST WHICH INITIATES THE QIO TO PERFORM ACTUAL TRANSFER.
        .ENTRY   AST_GO,^M<R2,R3,R4,R5>

;
; This AST is called to perform the $QIO which begins the actual transfer
; of user data.  (Hence the name AST_GO.)
;
        BLBS     W^DIRECTION,AST_RECEIVE       ; BRANCH IF RECEIVE OPERATION

;
; On a DR11--W, this AST is delivered as a result of an interrupt from the
; remote device, so no status checking is necessary.  On a DRV11--WA, this AST
; is delivered as a result of an intentionally premature I/O completion, so
; we expect the status return to be SS$_OPINCOMPL.
;
AST_XMIT:
        CMPL     #DRV11_WA,W^LCL_DEVICE        ; IS LOCAL DEVICE A DRV11--WA?
        BNEQ     20$                           ; BRANCH IF NOT.
        CMPW     W^IOSB,#SS$_OPINCOMPL         ; STATUS SHOULD BE SS$_OPINCOMPL.
        BEQL     20$                           ; BR IF EXPECTED STATUS
        BRW      IO_DONE                       ; ELSE ERROR
20$:    MOVL     #02,W^STATE                   ; STATE = 2 => LAST QIO WAS IN
                                               ;   AST_GO.
        $QIO_S   CHAN=W^CHAN,-                 ; BLOCK MODE WRITE
                 FUNC=#<IO$_WRITELBLK!IO$M_TIMED!IO$M_SETFNCT!IO$M_CYCLE>,-
                 IOSB=W^IOSB,-
                 ASTADR=W^AST_COMPLETION,-
                 P1=@W^BUFFER,-                ; ADDRESS OF CALLER'S DATA BUFFER
                 P2=W^BUF_SIZE,-               ; LENGTH OF BUFFER
                 P3=W^TIME,-                   ; TIMEOUT VALUE
                 P4=#4                         ; FNCT BITS FOR CSR
        BLBS     RO,40$                        ; RETURN IF QIO STARTED OK
        BRW      IO_DONE                       ; ALL DONE IF ERROR OCCURRED.
40$:    RET                                    ; DISMISS THIS AST, AND
                                               ;   WAIT FOR AST_COMPLETION
;
; AST_RECEIVE is only used by the DR11--W, since the DRV11--WA initiates
; the actual data transfer from the main routine when it is the receiver.
;
AST_RECEIVE:
        MOVL     #02,W^STATE                   ; STATE = 2 => LAST QIO WAS IN
                                               ;   AST_GO.
        $QIO_S   CHAN=W^CHAN,-                 ; BLOCK MODE READ
                 FUNC=#<IO$_READLBLK!IO$M_TIMED!IO$M_SETFNCT>,-
                 IOSB=W^IOSB,-
                 ASTADR=W^AST_COMPLETION,-     ; ADDRESS OF AST FOR I/O COMPLETION
                 P1=@W^BUFFER,-                ; ADDRESS OF CALLER'S DATA BUFFER
                 P2=W^BUF_SIZE,-               ; LENGTH OF DATA BUFFER
                 P3=W^TIME,-                   ; TIMEOUT VALUE
                 P4=#7                         ; INTERRUPT+READ
        BLBS     RO,10$                        ; RETURN IF QIO STARTED OK
```

Example 3–1 Cont'd. on next page

Example 3–1 (Cont.) DR11–W/DRV11–WA Program Example (XAMESSAGE.MAR)

```
        BRW     IO_DONE                 ; ON ERROR, WE'RE ALL DONE.
10$:    RET

        .PAGE
        .SBTTL  AST_COMPLETION - COMPLETION ROUTINE FOR I/O TRANSFER.
        .ENTRY  AST_COMPLETION,^M<R2,R3,R4,R5>
;
; This AST is called when the actual transfer of data is complete.  Note that
; the status value in the IOSB must be checked by the caller when we're done.
; IO_DONE is also called when an error occurs and the handshaking sequence
; must be terminated.
;
IO_DONE:
        MOVC3   #20,W^IOSB,@W^STS_ADDR  ; RETURN STATUS TO THE USER
        $SETEF_S EFN=W^EFN              ; SET THE CALLER'S EVENT FLAG
        MOVZBL  #SS$_NORMAL,RO          ; SIGNAL SUCCESSFUL AST COMPLETION.
        RET
        .END
```

4 DR32 Interface Driver

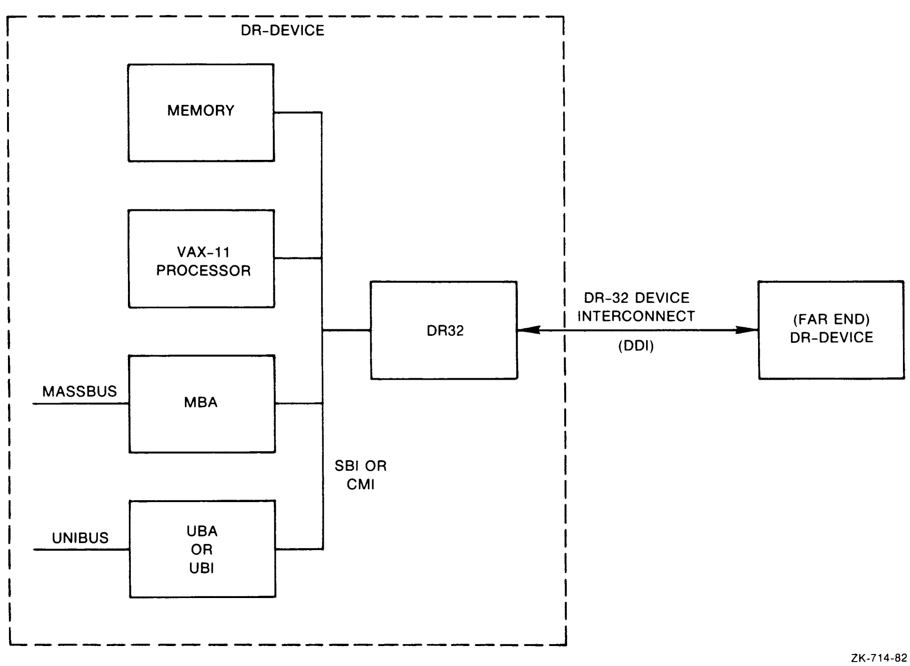
This chapter describes the use of the VMS DR32 interface driver.

4.1 Supported Device

The DR32 is an interface adapter that connects the internal memory bus of a VAX processor to a user-accessible bus called the DR32 device interconnect (DDI). Two DR32s can be connected to form a VAX processor-to-processor link (non-DECnet). Figure 4–1 shows the relationship of the DR32 to a VMS system and the DR32 device interconnect (DDI).

As a general-purpose data port, the DR32 is capable of moving continuous streams of data to or from memory at high speed. Data from a user device to disk storage must go through an intermediate buffer in physical memory.

Figure 4–1 Basic DR32 Configuration



4.1.1 DR32 Device Interconnect

The DR32 device interconnect (DDI) is a bidirectional path for the transfer of data and control signals. Control signals sent over the DDI are asynchronous and interlocked; data transfers are synchronized with clock signals. Any connection to the DDI is called a *DR device*. The DDI provides a point-to-point connection between two DR devices, one of which must be a VAX processor. The DR device connected to the external end of the DDI is called the *far-end DR device*.

4.2 DR32 Features and Capabilities

The DR32 driver provides the following features and capabilities:

- 32-bit parallel data transfers
- High bandwidth (6 megabytes/second on the DDI with a VAX–11/780 or 3.12 megabytes/second on a VAX–11/750)
- Word or byte alignment of data
- Half-duplex operation
- Hardware-supported (I/O driver-independent) memory mapping
- Separate control and data interconnects
- Command and data chaining
- Direct software link between the DR32 and the user process
- Synchronization of the user program with DR32 data transfers
- Transfers initiated by an external device

The following sections describe command and data chaining, data transfers, power failure, and interrupts.

4.2.1 Command and Data Chaining

Command chaining is the execution of commands without software intervention for each command. Commands are chained in the sense that they follow each other on a queue. After a QIO function starts the DR32, any number of DR32 commands can be executed during that QIO operation. This process continues until either the transfer is halted (a command packet is fetched that specifies a halt command) or an error occurs. (Section 4.4.3 describes command packets.)

Command packets can specify data chaining. In data chaining, a number of physical memory buffers appear as one large buffer to the far-end DR device. Data chaining is completely transparent to this device; transfers are seen as a continuous stream of data. Chained buffers can be of arbitrary byte alignment and length. The length of a transfer appears to the far-end DR device as the total of all the byte counts in the chain, and since chains in the DR32 can be of unlimited length, the device interprets the byte count as potentially infinite.

4.2.2 Far-End DR Device-Initiated Transfers

For the far-end DR device, the DR32 provides the capability of initiating data transfers to memory (initiating random access mode). This mode is used when two DR-32s are connected to form a processor-to-processor link. Random access consists of data transfers to or from memory without notification of the VAX processor. Random access can be discontinued either by specifying a command packet with random access disabled or by an abort operation from either the controlling process or the far-end DR device.

4.2.3 Power Failure

If power fails on the DR32 interface but not on the system, the DR32 driver aborts the active data transfer and returns the status code SS$_POWERFAIL in the I/O status block. If a system power failure occurs, the DR32 driver completes the active data transfer when power is recovered and returns the status code SS$_POWERFAIL.

4.2.4 Interrupts

The DR32 interface can interrupt the DR32 driver for any of the following reasons:

- An abort has occurred. The QIO operation is completed.
- A DR32 power-down or power-up sequence has occurred.
- An unsolicited control message has been sent to the DR32. If this command packet's interrupt control field is properly set up, a packet AST interrupt occurs. The interrupt occurs after the command packet obtained from the free queue (FREEQ) is placed on the termination queue (TERMQ).
- The DR32 enters the halt state. The QIO operation is completed.
- A command packet that specifies an unconditional interrupt has been placed onto TERMQ. The result is a packet AST.
- A command packet with the "interrupt when TERMQ empty" bit set was placed on an empty TERMQ. The result is a packet AST.

4.3 Device Information

You can obtain information on DR32 characteristics by using the Get Device/Volume Information ($GETDVI) system service. (See the *VMS System Services Reference Manual.*)

$GETDVI returns DR32 characteristics when you specify the item code DVI$_DEVCHAR. Table 4–1 lists these characteristics, which are defined by the $DEVDEF macro.

DVI$_DEVTYPE and DVI$_DEVCLASS return the device type and class names, which are defined by the $DCDEF macro. The device type is DT$_DR780 for the DR780 and DT$_DR750 for the DR750. The device class for the DR32 is DC$_REALTIME. DVI$_DEVDEPEND returns a longword field in which the low-order byte contains the last data rate value loaded into the DR32 data rate register.

Table 4–1 DR32 Device Characteristics

Characteristic[1]	Meaning
	Dynamic Bit (Conditionally Set)
DEV$M_AVL	Device is available.
	Static Bits (Always Set)
DEV$M_IDV	Input device.
DEV$M_ODV	Output device.
DEV$M_RTM	Real-time device.

[1]Defined by the $DEVDEF macro.

4.4 Programming Interface

The DR32 interface is supported by a device driver, a high-level language procedure library of support routines, and a program for microcode loading.

After issuing an IO$_STARTDATA request to the DR32 driver, application programs communicate directly with the DR32 interface by inserting command packets onto queues. This direct link between the application program and the DR32 interface provides faster communication by avoiding the necessity of going through the I/O driver.

Two interfaces are provided for accessing the DR32: a QIO interface and a support routine interface. The QIO interface requires that the application program build command packets and insert them onto the DR32 queues. The support routine interface, on the other hand, provides procedures for these functions and, in addition, performs housekeeping functions, such as maintaining command memory.

The support routine interface was designed to be called from high-level languages, such as FORTRAN, where the data manipulation required by the QIO interface might be awkward. Note, however, that the user of the support routines interface must be as knowledgeable about the DR32 and the meaning of the fields in the command packets as the user of the QIO interface.

4.4.1 DR32—Application Program Interface

Application programs interface with the DR32 through two memory areas. These areas are called the *command block* and the *buffer block*. The addresses and sizes of the blocks are determined by the application program and are passed to the DR32 driver as arguments to the IO$_STARTDATA function, which starts the DR32 (see Section 4.4.5.2).

Both blocks are locked into memory while the DR32 is active. The buffer block defines the area of memory that is accessible to the DR32 for the transfer of data between the far-end DR device and the DR32. The command block contains the headers for the three queues that provide the communication path between the DR32 and the application program, and space in which to build command packets.

The interface between the DR32 and the application program contains three queues: the input queue (INPTQ), the termination queue (TERMQ), and the free queue (FREEQ). Information is transferred between the DR32 and the far-end DR device through command packets. The three queue structures control the flow of command packets to and from the DR32. The application program builds a command packet and inserts it onto INPTQ. The DR32 removes the packet, executes the specified command, enters some status information, and then inserts the packet onto TERMQ. Unsolicited input from the far-end DR device is placed in packets removed from FREEQ and inserted onto TERMQ.

The INPTQ, TERMQ, and FREEQ headers are located in the first six longwords of the command block. Since the queues are self-relative—meaning they use the VMS self-relative queue instructions (INSQHI, INSQTI, REMQHI, and REMQTI)—the headers must be quadword-aligned. The application program must initialize all queue headers. Figure 4–2 shows the position of the queue headers in the command block. Section 4.4.2 describes queue processing in greater detail.

4.4.2 Queue Processing

Three queue structures control the flow of command packets to and from the DR32:

- Input queue (INPTQ)
- Termination queue (TERMQ)
- Free queue (FREEQ)

The DR32 removes command packets from the heads of FREEQ and INPTQ and inserts command packets onto the tail of TERMQ. For command sequences initiated by the application program, the DR32 removes command packets from the head of INPTQ, processes them, and returns them to the tail of TERMQ. Queue processing is performed by the DR32 with the equivalent of the INSQTI and REMQHI instructions. To remove a packet from INPTQ, the DR32 executes the equivalent of REMQHI HDR, CMDPTR where CMDPTR is a DR32 register used as a pointer to the current command packet and HDR specifies the INPTQ header. To insert a packet onto TERMQ, the DR32 executes the equivalent of INSQTI CMDPTR, HDR. The user process

Figure 4–2 Command Block (Queue Headers)

input queue forward link (INPTQ head)	0
input queue backward link (INPTQ tail)	4
termination queue forward link (TERMQ head)	8
termination queue backward link (TERMQ tail)	12
free queue forward link (FREEQ head)	16
free queue backward link (FREEQ tail)	20
command packet space	

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performs similar operations with the queues, inserting packets onto the head or tail of INPTQ and normally removing packets from the head of TERMQ.

If any of the queues are currently being accessed by the DR32, the program's interlocked queue instructions will fail for either of the following reasons:

- The DR32 is currently removing a packet from INPTQ or FREEQ, or inserting a packet onto TERMQ, and the operation will be completed shortly.
- The DR32 detects an error condition, such as an unaligned queue, that prevents it from completing the queue operation. In this case, the transfer is aborted and the I/O status block contains the error that caused the abort.

To distinguish between these two conditions, the application program must include a queue retry mechanism that retries the queue operation a reasonable number of times (for example, 25) before determining that an error condition exists. An example of a queue retry mechanism is shown in the program example (Program B in Section 4.7).

If the DR32 discerns that any of the queues are interlocked, it retries the operation until it completes or the DR32 is aborted.

4.4.2.1 Initiating Command Sequences

If a command packet is inserted onto an empty INPTQ, the application program must notify the DR32 of this event. This is done by setting bit 0, the GO bit, in a DR32 register. The IO$_STARTDATA function returns the GO bit's address to the application program. After notification by the GO bit that there are command packets on its INPTQ, the DR32 continues to process the packets until INPTQ is empty.

The GO bit can be safely set at any time. While processing command packets, the DR32 ignores the GO bit. If the GO bit is set when the DR32 is idle, the DR32 will attempt to remove a command packet from INPTQ. If INPTQ is empty at this time, the DR32 clears the GO bit and returns to the idle state.

4.4.2.2 Device-Initiated Command Sequences

If the DR device that interfaces the far-end of the DDI is capable of transmitting unsolicited control messages, messages of this type can be transmitted to the local DR32. These messages are not synchronized to the application program command flow. Therefore, the DR32 uses a third queue, FREEQ, to handle unsolicited messages. Normally, the application program inserts a number of empty command packets onto FREEQ to allow the external device to transmit control messages.

If a control message is received from the far-end DR device, the DR32 removes an empty command packet from the head of FREEQ, fills the device message field of this packet with the control message and, when the transmission is completed, inserts the packet onto the tail of TERMQ. (The device message field in this command packet must be large enough for the entire message or a length error will occur.) The application program then removes the packet from TERMQ. If the command packet is from FREEQ, the XF$M_PKT_FREQPK bit in the DR32 status longword is set.

4.4.3 Command Packets

To provide for direct communication between the controlling process and the DR32, the DR32 fetches commands from user-constructed command packets located in physical memory. Command packets contain commands for the DR32, such as the direction of transfer, and messages to be sent to the far-end DR device. The DR32 is simply the conveyer of these messages; it does not examine or add to their content. The controlling process builds command packets and manipulates the three queues, using the four VAX self-relative queue instructions. Figure 4–3 shows the DR32 queue flow. Figure 4–4 shows the contents of a DR32 command packet.

Figure 4–3 DR32 Command Packet Queue Flow

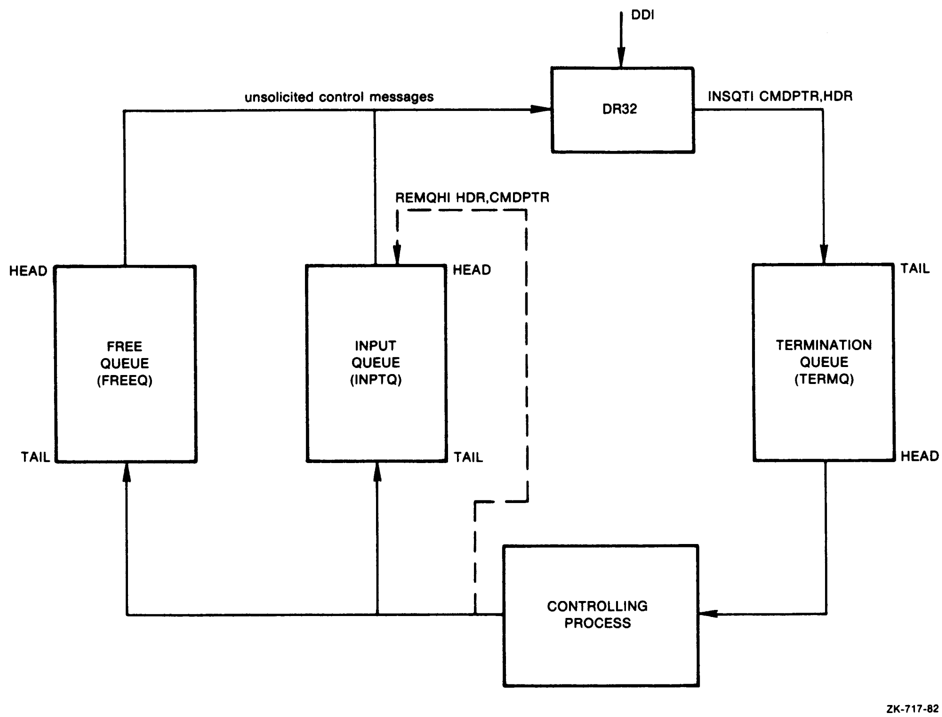
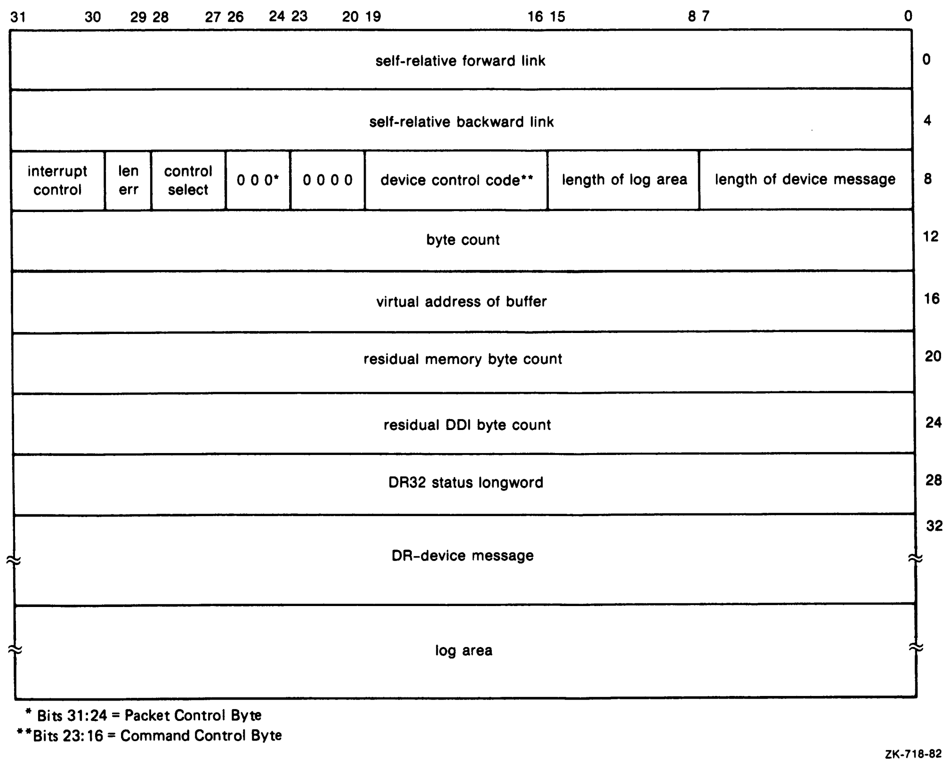
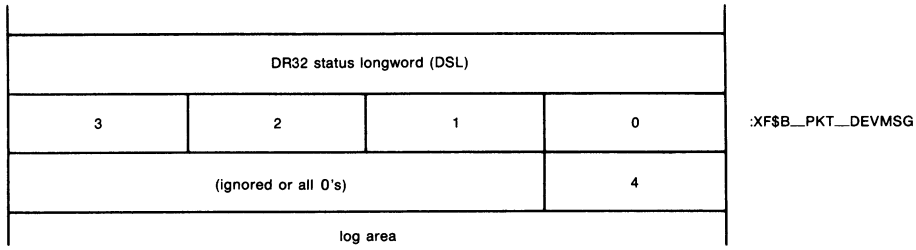


Figure 4–4 DR32 Command Packet



4.4.3.1 Length of Device Message Field

The length of device message field describes the length of the DR device message in bytes. The message length must be less than 256 bytes. Note, however, that the length of device message field itself must always be an integral number of quadwords long. For example, if the application program requires a five-byte device message, it must write a 5 in the length of device message field, but allocate eight bytes for the device message field itself. In this case, the last three bytes of the field are ignored by the DR32 when transmitting a message, or written as zeros when receiving a message.



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The symbolic offset for the length of device message field is XF$B_PKT_MSGLEN.

4.4.3.2 Length of Log Area Field

The length of log area field describes the length of the log area in bytes. The length specified must be less than 256 bytes. Note, however, that the length of log area field itself must be an integral number of quadwords long. For example, if the application program requires a five-byte log area field, it must write a 5 in the length of log area field but allocate eight bytes for the log area field itself. In this case, the last three bytes of the field are written as zeros when receiving a log message (log messages are always received). The symbolic offset for the length of log area field is XF$B_PKT_LOGLEN.

4.4.3.3 Device Control Code Field

The device control field describes the function performed by the DR32. The field occupies the lower half of the command control byte (bits 16 through 23). The VMS operating system defines the following values:

Symbol	Value	Function
XF$K_PKT_RD	0	Read device
XF$K_PKT_RDCHN	1	Read device chained
XF$K_PKT_WRT	2	Write device
XF$K_PKT_WRTCHN	3	Write device chained
XF$K_PKT_WRTCM	4	Write device control message
	5	(reserved)
XF$K_PKT_SETTST	6	Set self-test
XF$K_PKT_CLRTST	7	Clear self-test
XF$K_PKT_NOP	8	No operation
XF$K_PKT_DIAGRI	9	Diagnostic read internal
XF$K_PKT_DIAGWI	10	Diagnostic write internal
XF$K_PKT_DIAGRD	11	Diagnostic read DDI

Symbol	Value	Function
XF$K_PKT_DIAGWC	12	Diagnostic write control message
XF$K_PKT_SETRND	13	Set random enable
XF$K_PKT_CLRRND	14	Clear random enable
XF$K_PKT_HALT	15	Set halt

Table 4–2 describes the functions performed by the different device control codes.

Table 4–2 Device Control Code Descriptions

Function	Meaning
Read device	Specifies a data transfer from the far-end DR device to the DR32. The control select field (see Section 4.4.3.4) describes the information to be transferred prior to the initiation of the data transfer.
Read device chained	Specifies a data transfer from the far-end DR device to the DR32. The DR32 chains data to the buffer specified in the next command packet in INPTQ. A command packet that specifies the read device chained function must be followed by a command packet that specifies either the read device chained function or the read device function. All other device control codes cause an abort. If a read device chained function is specified, the chain continues. However, if a read device function is specified, that command packet is the last packet in the chain.
Write device and write device chained	Specify data transfers from the DR32 to the far-end DR device. Otherwise, they are similar to read device and read device chained functions.
Write device control message	Specifies the transfer of a control message to the far-end DR device. This message is contained in the device message field of this command packet. The write device control message function directs the controlling DR32 to ignore the byte count and virtual address fields in this command packet.
Set self-test	Directs the DR32 to set an internal self-test flag and to set a disable signal on the DDI. This signal informs the far-end DR device that the DR32 is in self-test mode. While in self-test mode, the DR32 can no longer communicate with the far-end DR device.
Clear self-test	Directs the DR32 to clear the internal self-test flag set by the set self-test function and to return to the normal mode of operation.
No operation	This function explicitly does nothing.

Table 4–2 (Cont.) Device Control Code Descriptions

Function	Meaning
Diagnostic read internal	Directs the DR32 to fill the memory buffer, which is described by the virtual address and byte count specified in the current command packet, with the data that is stored in the DR32 data silo. The buffer is filled in a cyclical manner. For example, on the DR780 every 128-byte section of the buffer receives the silo data. The amount of data stored in the buffer equals the DDI byte count minus the SBI byte count. The DDI byte count is equal to the original byte count. No data transmission takes place on the DDI for this function. On the DR780, the diagnostic read internal function destroys the first four bytes in the silo before storing the data in the buffer.
Diagnostic write internal	Together with the diagnostic read internal function, used to test the DR32 read and write capability. The diagnostic write internal function directs the DR32 to store data, which is contained in the memory buffer described by the current command packet, in the DR32 data silo, a FIFO-type buffer. No data transmission takes place on the DDI for this function. The diagnostic write internal function terminates when either of the following conditions occurs: • The memory buffer is empty (the SBI byte count is 0). • An abort has occurred. When the function terminates, the amount of data in the silo equals the DDI byte count minus the SBI memory byte count. (Sections 4.4.3.9 and 4.4.3.10 describe these values.)
Diagnostic read DDI	Tests transmissions over the data portion of the DDI. The DR32 must be in the self-test mode or an abort occurs. On the DR780, the diagnostic read DDI function transmits the contents of DR32 data silo locations 0 to 127 over the DDI and returns the data to the same locations. If data transmission is normal (without errors), the residual memory count is equal to the original byte count, the residual DDI count is 0, and the contents of the silo remain unchanged.

Table 4–2 (Cont.) Device Control Code Descriptions

Function	Meaning
Diagnostic write control message	Tests transmissions over the control portion of the DDI. The DR32 must be in self-test mode or an abort occurs. The diagnostic write control message function directs the DR32 to remove the command packet on FREEQ and check the length of message field. Then the first byte of the message in the command packet on INPTQ is transmitted and read back on the control portion of the DDI. This byte is then written into the message space of the packet from FREEQ. The updated packet from FREEQ is inserted onto TERMQ and is followed by the packet from INPTQ.
Set random enable and clear random enable	Directs the DR32 to accept read and write commands sent by the far-end DR device. Range-checking is performed to verify that all addresses specified by the far-end DR device for access are within the buffer block. Far-end DR device-initiated transfers to or from the VAX memory are conducted without notification of the VAX processor or the application program. The clear random enable function directs the DR32 to reject far-end DR device-initiated transfers. Random access mode must be enabled when the DR32 is used in a processor-to-processor link.
Set halt	Places the DR32 in a halt state. The set halt function always generates a packet interrupt regardless of the value in the interrupt control field (see Section 4.4.3.6). If an AST routine was requested on completion of the QIO function (see Sections 4.4.5.2 and 4.4.6.2), the routine is called after the command packet containing the set halt function has been processed by the DR32.

The following symbolic offsets are defined for the device control code field:

Symbol	Meaning
XF$B_PKT_CMDCTL	Byte offset from the beginning of the command packet
XF$V_PKT_FUNC	Bit offset from XF$B_PKT_CMDCTL
XF$S_PKT_FUNC	Size of the device control code bit field

4.4.3.4 Control Select Field

This field describes the part of the command packet that will be transmitted to the far-end DR device. The control select field is examined only for the read device, read device chained, write device, and write device chained functions;

for all others, it is ignored. The VMS operating system defines the following values:

Symbol	Value	Function
XF$K_PKT_NOTRAN	0	No transmission. Nothing is transmitted over the control portion of the DDI. However, if the command packet specifies a data transfer, data can be transmitted over the data portion of the DDI. The primary use of this code is during data chaining.
XF$K_PKT_CB	1	Command control byte (bits 23:16) only. This code directs the DR32 to transmit the contents of the command control byte, which includes the device control code field, to the far-end DR device. This code is used primarily at the start of data chain or nondata chain commands.
XF$K_PKT_CBDM	2	Command control byte and device message. This code directs the DR32 to transmit the command control byte, and then the device message. It is used primarily when an interface requires more than one byte of command.
XF$K_PKT_CBDMBC	3	Command control byte, device message, and byte count. This code directs the DR32 to transmit the command control byte, the byte count, and the device message (in that order). It is used primarily during processor-to-processor link operations. In this case the device message must be exactly four bytes in length and contain the virtual address of the buffer in the far-end processor's memory.

The following symbolic offsets are defined for the control select field:

Symbol	Meaning
XF$B_PKT_PKTCTL	Byte offset from the beginning of the command packet
XF$V_PKT_CISEL	Bit offset from XF$B_PKT_PKTCTL
XF$S_PKT_CISEL	Size of control select bit field

4.4.3.5 Suppress Length Error Field

The suppress length error field function prevents the DR32 from aborting if the data transfer on the DDI is terminated by the far-end DR device before the DDI byte counter has reached zero.

The following symbolic offsets are defined for the suppress length error field:

Symbol	Meaning
XF$B_PKT_PKTCTL	Byte offset from the beginning of the command packet
XF$V_PKT_SLNERR	Bit offset from XF$B_PKT_PKTCTL
XF$S_PKT_SLNERR	Size of the suppress length error bit field

4.4.3.6 Interrupt Control Field

The interrupt control field determines the conditions under which an interrupt is generated, on a packet-by-packet basis, when the DR32 places this command packet onto TERMQ. Depending on the conditions specified in the IO$_STARTDATA call, the interrupt can set an event flag or call an AST routine.

Symbol	Value	Function
XF$K_PKT_UNCOND	0	Interrupt unconditionally
XF$K_PKT_TMQMT	1	Interrupt only if TERMQ was previously empty
XF$K_PKT_NOINT	2,3	No interrupt

If the set halt function is active, the interrupt control field is ignored. The set halt function unconditionally causes a packet interrupt. The following symbolic offsets are defined for the interrupt control field:

Symbol	Meaning
XF$B_PKT_PKTCTL	Byte offset from the beginning of the command packet
XF$V_PKT_INTCTL	Bit offset from XF$B_PKT_PKTCTL
XF$S_PKT_INTCTL	Size of the interrupt control bit field

4.4.3.7 Byte Count Field

The byte count field specifies the size in bytes of the data buffer for this data transfer. Together with the virtual address of buffer field, this field describes the buffer in the buffer block that the DR32 will read from or write to.

The following symbolic offset is defined for the byte count field:

Symbol	Meaning
XF$B_PKT_BFRSIZ	Byte offset from the beginning of the command packet

4.4.3.8 Virtual Address of Buffer Field

The virtual address of buffer field specifies the virtual address of the data buffer for this data transfer. Together with the byte count field, this field describes the buffer in the buffer block that the DR32 will read from or write to.

The following symbolic offset is defined for the virtual address of buffer field:

Symbol	Meaning
XF$B_PKT_BFRADR	Byte offset from the beginning of the command packet

4.4.3.9 Residual Memory Byte Count Field

After completion of a read device, read device chained, write device, write device chained, diagnostic read internal, diagnostic write internal, or diagnostic read DDI function specified in this command packet, the DR32 places the packet onto TERMQ for return to the controlling process. At that time, this field will contain a byte count. The difference between the count specified in the byte count field and the count in this field is the number of bytes transferred to or from physical memory, depending on the direction of transfer.

The following symbolic offset is defined for the residual memory byte count field:

Symbol	Meaning
XF$L_PKT_RMBCNT	Byte offset from the beginning of the command packet

(See also the descriptions of the diagnostic read internal and diagnostic write internal functions in Table 4–2.)

4.4.3.10 Residual DDI Byte Count Field

After completion of a read device, read device chained, write device, write device chained, diagnostic read internal, diagnostic write internal, or diagnostic read DDI function specified in this command packet, the DR32 places the packet onto TERMQ for return to the controlling process. At this time, the residual DDI byte count field contains a byte count. The difference between the count specified in the byte count field and the count in this field is the number of bytes transferred to or from the far-end DR device over the DDI, depending on the direction of transfer.

The following symbolic offset is defined for the residual DDI byte count field:

Symbol	Meaning
XF$L_PKT_RDBCNT	Byte offset from the beginning of the command packet

(See also the descriptions of the diagnostic read internal and diagnostic write internal functions in Table 4–2.)

4.4.3.11 DR32 Status Longword (DSL)

The DR32 stores the final status for a command packet in the DR32 status longword before inserting the packet onto TERMQ. The longword contains two distinct status fields:

31 24	23 16	15 0
0	DDI status	16 bits of status

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Table 4–3 lists the names for the status bits returned in the DR32 status longword.

Table 4–3 DR32 Status Longword (DSL) Status Bits

Name	Meaning
	16 Status Bits
XF$V_PKT_SUCCESS XF$M_PKT_SUCCESS	If set, the command was performed successfully. If not set, one of the following bits must be set: XF$M_PKT_INVPTE XF$M_PKT_RNGERR XF$M_PKT_UNGERR XF$M_PKT_INVPKT XF$M_PKT_FREQMT XF$M_PKT_DDIDIS XF$M_PKT_INVDDI XF$M_PKT_LENERR XF$M_PKT_DRVABT XF$M_PKT_PARERR XF$M_PKT_DDIERR
XF$V_PKT_CMDSTD XF$M_PKT_CMDSTD	If set, the command specified in this packet was started.
XF$V_PKT_INVPTE XF$M_PKT_INVPTE	If set, the DR32 accessed an invalid page table entry.
XF$V_PKT_FREQPK XF$M_PKT_FREQPK	If set, this command packet was removed from FREEQ.
XF$V_PKT_DDIDIS XF$M_PKT_DDIDIS	If set, the far-end DR device is disabled.
XF$V_PKT_SLFTST XF$M_PKT_SLFTST	If set, the DR32 is in self-test mode.
XF$V_PKT_RNGERR XF$M_PKT_RNGERR	If set, a range error occurred; that is, a user-provided address was outside the command block or buffer block.
XF$V_PKT_UNQERR XF$M_PKT_UNQERR	If set, a queue element was not aligned on a quadword boundary.
XF$V_PKT_INVPKT XF$M_PKT_INVPKT	If set, this packet was not a valid DR32 command packet.
XF$V_PKT_FREQMT XF$M_PKT_FREQMT	If set, a message was received from the far-end DR device and FREEQ was empty.
XF$V_PKT_RNDENB XF$M_PKT_RNDENB	If set, random access mode is enabled.

Table 4–3 (Cont.) DR32 Status Longword (DSL) Status Bits

Name	Meaning
	16 Status Bits
XF$V_PKT_INVDDI XF$M_PKT_INVDDI	If set, a protocol error occurred on the DDI.
XF$V_PKT_LENERR XF$M_PKT_LENERR	If set, the far-end DR device terminated the data transfer before the required number of bytes was sent; or a message was received from the far-end DR device, and the device message field in the command packet at the head of FREEQ was not large enough to hold it.
XF$V_PKT_DRVABT XF$M_PKT_DRVABT	The I/O driver aborted the transfer. Usually the result of a Cancel I/O on Channel ($CANCEL) system service request.
XF$V_PKT_PARERR XF$M_PKT_PARERR	A parity error occurred on the data or control portion of the DDI.
	DDI Status
XF$V_PKT_DDISTS XF$S_PKT_DDISTS	DDI status. This field is the one-byte DDI register 0 of the far-end DR device. The following three bits are offsets to this field.
XF$V_PKT_NEXREG XF$M_PKT_NEXREG	An attempt was made to access a nonexistent register in the far-end DR device.
XF$V_PKT_LOG XF$M_PKT_LOG	The far-end DR device registers are stored in the log area.
XF$V_PKT_DDIERR XF$M_PKT_DDIERR	An error occurred on the far-end DR device.

4.4.3.12 Device Message Field

The device message field contains control information to be sent to the far-end DR device. It is used when more than one byte of command is required. The number of bytes in the device message is specified in the length of device message field (see Section 4.4.3.1). (The number of bytes allocated for the length of device message field must be rounded up to an integral number of quadwords.)

If the far-end DR device is a DR32 connected to another processor, a device message can be sent only if the function specified in the device control code field of this command packet is a read device, read device chained, write device, write device chained, or write device control message.

In the case of a write device control message, the data in the device message field is treated as unsolicited input and is written into the device message field of a command packet taken from the far-end DR32's FREEQ.

In the case of a read or write (either chained or unchained) function, the only message allowed is the address of the buffer in the far-end processor that either contains or will receive the data to be transferred. This device message must be exactly four bytes in length. In this case the device message is not stored in the command packet from the far-end DR32's FREEQ, but is used by the far-end DR32 to perform the data transfer.

The device message field is also used in command packets placed on FREEQ to convey unsolicited control messages from the far-end DR device.

The symbolic offset for the device message field is XF$B_PKT_DEVMSG.

4.4.3.13 Log Area Field

The log area field receives the return status and other information from the far-end DR device's DDI registers. Logging must be initiated by the far-end DR device. The presence of a log area does not automatically cause logging to occur.

If the DR32 is connected in a processor-to-processor configuration, the log area field is not used.

4.4.4 DR32 Microcode Loader

The DR32 microcode loader program XFLOADER must be executed prior to using the DR32. Running XFLOADER requires CMKRNL and LOG_IO privileges. Typically, a command to run XFLOADER is placed in the site-specific system startup file. XFLOADER locates the file containing the DR32 microcode in the following manner:

1. XFLOADER attempts to open a file using the logical name XFc$WCS, where "c" is the DR32 controller designator. For example, to load microcode on device XFA0, XFLOADER attempts to open a file with the logical name XFA$WCS.
2. If the opening procedure described in step 1 fails, XFLOADER attempts to open the file SYS$SYSTEM:XF780.ULD for a DR780, or SYS$SYSTEM:XF750.ULD for a DR750. This file specification describes the default location and filename for the DR32 microcode.

By default, XFLOADER attempts to load microcode into all DR32s on a system. To limit microcode loading to a subset of DR32s, define the logical name XF$DEVNAM using the device names of the DR32s as the equivalence names. XFLOADER searches for the translation using the LNM$FILE_DEV search list. For example, the following command tells XFLOADER to load microcode only in the first and third DR32s on the system:

```
$ DEFINE/SYSTEM XF$DEVNAM XFA0,XFC0
```

After loading microcode into all specified DR32s, XFLOADER either exits or hibernates, according to the following:

- If XFLOADER was run with an ordinary RUN command (that is, RUN XFLOADER), it exits after loading microcode.
- If XFLOADER was run as a separate process, as with the following command, it hibernates after loading microcode:

  ```
  RUN/UIC=[1,1]/PROCESS=XFLOADER SYS$SYSTEM:XFLOADER
  ```

  In this case, XFLOADER automatically reloads microcode into the DR32s after a power recovery.

XFLOADER performs a load microcode QIO to the DR32 driver.

4.4.5 DR32 Function Codes

The DR32 I/O functions are load microcode and start data transfer. Normally, the controlling process stops data transfers with a set halt command packet. However, the Cancel I/O on Channel ($CANCEL) system service can be used to abort data transfers and complete the I/O operation.

4.4.5.1 Load Microcode

The load microcode function resets the DR32 and loads an image of DR32 microcode. It also sets the DR32 data rate to the last specified value. Physical I/O privilege is required. The VMS operating system defines the following function code:

- IO$_LOADMCODE—Load microcode

The load microcode function takes the following device- or function-dependent arguments:

- P1—The starting virtual address of the microcode image that is to be loaded into the DR32
- P2—The number of bytes to be loaded (maximum of 5120 for the DR780)

If any data transfer requests are active when a load microcode request is issued, the load request is rejected and SS$_DEVACTIVE is returned in the I/O status block.

The microcode is verified by addressing each microword and checking for a parity error. (The microcode is not compared to the buffer image.) If there are no parity errors, the microcode was loaded successfully and the driver sets the microcode valid bit in one of the DR32 registers. If there is a parity error, SS$_PARITY is returned in the I/O status block. (The valid bit is cleared by the reset operation.)

In addition to SS$_PARITY, three other status codes can be returned in the I/O status block: SS$_NORMAL, SS$_DEVACTIVE, and SS$_POWERFAIL.

4.4.5.2 Start Data Transfer

The start data transfer function specifies a command table that holds the parameters required to start the DR32. In addition to several other parameters, the command table contains the size and address of the command and buffer blocks, and the address of a command packet AST routine. No user privilege is required. The VMS operating system defines the following function code:

- IO$_STARTDATA—Start data transfer

The start data transfer function takes the following function modifier:

- IO$M_SETEVF—Set event flag

If IO$M_SETEVF is included with the function code, the specified event flag is set when a command packet interrupt occurs and when the start data transfer QIO is completed. If IO$M_SETEVF is not specified, the event flag is set only when the QIO is completed.

IO$M_SETEVF should not be used with the $QIOW macro, because the $QIOW will return after the event flag is set the first time.

The start data transfer function takes the following device- or function-dependent arguments:

- P1—The starting virtual address of the data transfer command table in the user's process
- P2—The length in bytes (always 32) of the data transfer command table (the symbolic name is XF$K_CMT_LENGTH)

The format of the data transfer command table is shown in Figure 4–5 (offsets are shown in parentheses).

Figure 4–5 Data Transfer Command Table

			Offset
command block size (XF$L_CMT_CBLKSZ)			0
command block address (XF$L_CMT_CBLKAD)			4
buffer block size (XF$L_CMT_BBLKSIZ)			8
buffer block address (XF$L_CMT_BBLKAD)			12
command packet AST routine address (XF$L_CMT_PASTAD)			16
command packet AST parameter (XF$L_CMT_PASTPM)			20
	flags (XF$B_CMT_FLAGS)	data rate (XF$B_CMT_RATE)	24
address of the location to store the GO bit address (XF$L_CMT_GBITAD)			28

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Because the command block contains the queue headers for INPTQ, TERMQ, and FREEQ, its address in the second longword must be quadword-aligned.

The command packet AST routine specified in the fifth longword is called whenever the DR32 signals a command packet interrupt. A command packet AST should be distinguished from a QIO AST (**astadrs** argument). A command packet interrupt occurs whenever the DR32 completes a function and returns a packet that specifies an interrupt (see Section 4.4.3.6) by inserting it onto TERMQ. The **astadrs** argument address is called when the QIO is completed. If either the command packet AST address or the **astadrs** address is zero, the respective AST is not delivered. If the command packet specifies the set halt function, a command packet interrupt occurs regardless of the state of the packet interrupt bits.

The seventh longword contains the data rate byte and a flags byte. The data rate byte controls the DR32 clock rate. The data rate value is considered to be an unsigned integer.

For the DR780, the relationship between the value of the data rate byte and the actual data rate is given by the following formula:

$$Data\ rate\ (in\ megabytes/sec) = \frac{40}{256 - (value\ of\ data\ rate\ byte)}$$

For example, a data rate value of 236 corresponds to an actual data rate of 2.0 megabytes/second.

For the DR750, use the following formula:

$$Data\ rate\ (in\ megabytes/sec) = \frac{12.50}{256 - (value\ of\ data\ rate\ byte)}$$

For example, a data rate value of 236 corresponds to an actual data rate of 0.625 megabytes/second.

The maximum data rate byte values are 250 megabytes/second for the DR780 and 252 megabytes/second for the DR750.

The parameter XFMAXRATE set during system generation limits the maximum data rate that can be set. This parameter limits the maximum data rate because very high data rates on certain configurations can cause a processor timeout. If you attempt to set the data rate higher than the rate allowed by XFMAXRATE, the error status SS$_BADPARAM is returned in the I/O status block.

The VMS operating system defines the following flag bit values:

XF$V_CMT_SETRTE	If set, XF$B_CMT_RATE specifies the data rate. If clear, the data rate established by a previous $IO_STARTDATA function is used. The IO$_LOADMCODE function sets the data rate to the last value used. If the data rate has not been previously set, a value of 0 is used.
XF$V_CMT_DIPEAB	If set, parity errors on the data portion of the DDI do not cause device aborts. If clear, a parity error results in a device abort.

The eighth longword contains the address of a location to store the address of the GO bit. This bit must be set whenever the application program inserts a command packet onto an empty INPTQ. The GO bit register is mapped in system memory space and the address is returned to the user.

The IO$_STARTDATA function locks the command and buffer blocks into memory and starts the DR32. Whenever the DR32 interrupts with a command packet interrupt, the driver queues a packet AST (if an AST address is specified) and, if IO$M_SETEVF is specified, sets the event flag. The QIO remains active until one of the following events occur:

- A set halt command packet is processed by the DR32.
- The data transfer aborts.
- A Cancel I/O on Channel ($CANCEL) system service is issued on this channel.

If an abort occurs, the second longword of the I/O status block contains additional bits that identify the cause of the abort (see Section 4.5).

The start data transfer function can return the following twelve error codes in the I/O status block:

SS$_ABORT	SS$_BUFNOTALIGN	SS$_CANCEL
SS$_CTRLERR	SS$_DEVREQERR	SS$_EXQUOTA
SS$_INSFMEM	SS$_IVBUFLEN	SS$_MCNOTVALID
SS$_NORMAL	SS$_PARITY	SS$_POWERFAIL

4.4.6 High-Level Language Interface

The VMS operating system supports a set of program-callable procedures that provide access to the DR32. The formats of these calls are given here for VAX FORTRAN users; VAX MACRO users must set up a standard VMS argument block and issue the standard procedure CALL. (Optionally, VAX MACRO users can access the DR32 directly by issuing an IO$_STARTDATA function, building command packets, and inserting them onto INPTQ.) Users of other high-level languages can also specify the proper subroutine or procedure invocation.

Six high-level language procedures are provided by the VMS operating system for the DR32. They are contained in the default system library, STARLET.OLB. Table 4–4 lists these procedures. Procedure arguments are either input or output arguments, that is, arguments supplied by the user or arguments that will contain information stored by the procedure. Except for those that are indicated as output arguments, all arguments in the following call descriptions are input arguments. By default, all procedure arguments are integer variables unless otherwise indicated.

The VMS high-level language support routines for the DR32 do the following:

- Issue I/O requests
- Allocate and manage the command memory
- Build command packets, insert them onto INPTQ, and set the GO bit
- Remove command packets from TERMQ and return the information they contain to the controlling process
- Use action routines for program–DR32 synchronization

Table 4–4 VMS Procedures for the DR32

Subroutine	Function
XF$SETUP	Defines command and buffer areas and initializes queues
XF$STARTDEV	Issues an I/O request that starts the DR32

Table 4–4 (Cont.) VMS Procedures for the DR32

Subroutine	Function
XF$FREESET	Releases command packets onto FREEQ
XF$PKTBLD	Builds command packets and releases them onto INPTQ
XF$GETPKT	Removes a command packet from TERMQ
XF$CLEANUP	Deassigns the device channel and deallocates the command area

The VMS operating system also provides a FORTRAN parameter file, SYS$LIBRARY:XFDEF.FOR, that can be included in FORTRAN programs. This file defines many of (but not all) the symbolic names with the XF$ prefix described in this chapter. For example, SYS$LIBRARY:XFDEF.FOR contains symbolic definitions for function codes (that is, device control codes), interrupt control codes, command control codes, and masks for error bits set in the I/O status block and the DR32 status longword. To include these definitions in a FORTRAN program, insert the following statement in the source code:

```
INCLUDE 'SYS$LIBRARY:XFDEF.FOR'
```

4.4.6.1 XF$SETUP

The XF$SETUP subroutine defines memory space for the command and buffer areas, and initializes INPTQ, TERMQ, and FREEQ. The call to XF$SETUP must be made prior to any calls to other DR32 support routines.

The format of the XF$SETUP call is as follows:

```
CALL XF$SETUP(contxt,barray,bufsiz,numbuf,[idevmsg],
              [idevsiz],[ilogmsg],[ilogsiz],[cmdsiz],
              [status])
```

Argument descriptions are as follows:

contxt — A 30-longword user-supplied array that is maintained by the support routines and is used to contain context and status information concerning the current data transfer (see Section 4.4.6.5). The **contxt** array provides a common storage area that all support routines share. For increased performance, **contxt** should be longword-aligned.

barray — Specifies the starting virtual address of an array of buffers that, in the case of an output operation, contain information for transfer by the DR32, or in the case of an input operation, will contain information transferred by the DR32. For example, if **barray** is declared INTEGER*2 BARRAY (I,J), I is the size of each data buffer in words and J is the number of buffers. The lower bound on both indexes is assumed to be 1. All buffers in the array must be contiguous to each other and of fixed size.

bufsiz — Specifies the size in bytes of each buffer in the array. All buffers are the same size. If the **barray** argument is declared as stated in the preceding paragraph, **bufsiz** = I*2. The **bufsiz** argument length is one longword.

numbuf Specifies the number of buffers in the array. If the **barray** argument is declared as in the preceding paragraph, **numbuf** = J. The area of memory described by the **barray, bufsiz,** and **numbuf** arguments is used as the buffer block for DR32 data transfers. The **numbuf** argument length is one longword.

idevmsg Specifies an array, declared by the application program, that is used to store an unsolicited input device message from the far-end DR device. The DR32 stores unsolicited input in the device message field of a command packet from FREEQ and places that packet onto TERMQ. When XF$GETPKT removes such a packet from TERMQ, it copies the device message field into the **idevmsg** array. The calling program is then notified that information has been stored in the **idevmsg** array. The **idevmsg** argument is optional; the argument must be given if any unsolicited input is anticipated.

idevsiz Specifies the size in bytes of the **idevmsg** array. The maximum size of a device message is 256 bytes. The **idevsiz** argument is optional; if **idevmsg** is specified, **idevsiz** must be specified. The **idevsiz** argument length is one word.

ilogmsg Specifies an array, declared by the application program, that is used to store log information from the far-end DR device contained in the log area field of the command packet. Log information is hardware-dependent data that is returned by the far-end DR device. The XF$SETUP routine stores the address and size of the **ilogmsg** array; the log information is stored in the **ilogmsg** array by the XF$GETPKT routine. The **ilogmsg** argument is optional; the argument must be given if any log information is anticipated.

ilogsiz Specifies the size in bytes of the **ilogmsg** array. The maximum size of a log message is 256 bytes. The **ilogsiz** argument is optional. However, if **ilogmsg** is specified, **ilogsiz** must be specified. The **ilogsiz** argument length is one word.

cmdsiz Specifies the amount of memory space to be allocated from which command packets are to be built. Consider the following factors when deciding how much memory to allocate for this purpose:

1. The number of command packets that the application program will be using.
2. The device message and log area fields in command packets are rounded up to quadword boundaries.
3. The size of the command packet itself is rounded up to an eight-byte boundary.
4. **cmdsiz** will be rounded up to a page boundary.

The **cmdsiz** argument is optional; argument length is one longword. If defaulted, the allocated space is equal to the following, which is rounded up to a full page:

```
(numbuf)*(32+idevsiz+ilogsiz)*(3)
```

Memory space for command packets is obtained by calling LIB$GET_VM.

status — This output argument receives the VMS success or failure code of the XF$SETUP call:

SS$_NORMAL	Normal successful completion
SS$_BADPARAM	Invalid input argument

Error returns can be found in LIB$GET_VM.

The **status** argument is optional; argument length is one longword.

4.4.6.2 XF$STARTDEV

The XF$STARTDEV subroutine issues the I/O request that starts the DR32 data transfer.

The format of the XF$STARTDEV call is as follows:

```
CALL  XF$STARTDEV(contxt,devnam,[pktast],[astparm],[efn],-
              [modes],[datart],[status])
```

Argument descriptions are as follows:

contxt — Specifies the array that contains context and status information (see Section 4.4.6.1).

devnam — Specifies the device name (logical name or actual device name) of the DR32. All letters in the resultant string must be capitalized and the device name must terminate with a colon, for example, XFA0:. The **devnam** datatype is character string.

pktast — Specifies the address of an AST routine that is called each time a command packet that specifies an interrupt in its interrupt control field is returned by the DR32, that is, placed onto TERMQ (see Section 4.4.7.2). This AST routine is also called on completion of the I/O request. Normally, the AST routine would call XF$GETPKT to remove command packets from TERMQ until TERMQ is empty. The **pktast** argument is optional.

astparm — Specifies a longword parameter that is included in the call to the **pktast**-specified AST routine. The format used to call the AST routine is:

```
CALL  pktast(astparm)
```

The **astparm** argument is optional; argument length is one longword. If **astparm** is not specified, **pktast** is called with no parameter.

efn — If the event flag must be determined by the application program, **efn** specifies the number of the event flag that is set when a packet interrupt is delivered. Otherwise, it is not necessary to include this argument in an XF$STARTDEV call. If defaulted, **efn** is 21. The **efn** argument length is one word.

The event flag (either the default or the event flag specified by this argument) is set for every packet interrupt, and also when the QIO completes.

modes Specifies the mode of operation. The VMS operating system defines the following value:

2 = parity errors on the data portion of the DDI that do not cause the device to abort.

If defaulted, **modes** is 0 (a parity error causes the device to abort).

datart Specifies the data rate. The data rate controls the speed at which the transfer takes place. The data rate is considered to be an unsigned integer in the range 0 to 255. The relationship between the specified data rate value and the actual data rate for the DR780 and the DR750 is shown in Section 4.4.5.2.

If **datart** is defaulted, the previously set data rate is used. The **datart** argument length is one byte.

status This output argument receives the VMS success or failure code of the XF$STARTDEV call:

SS$_NORMAL	Normal successful completion
SS$_BADPARAM	Required parameter defaulted

Error returns can be obtained by issuing the Create I/O on Channel ($CREATE) and Queue I/O Request ($QIO) system services.

The **status** argument is optional; argument length is one longword.

4.4.6.3 XF$FREESET

The XF$FREESET subroutine releases command packets onto FREEQ. These packets are then available to the DR780 to store any unsolicited input from the far-end DR device. If unsolicited input from the far-end DR device is expected, the XF$FREESET call should be made before the XF$STARTDEV call is issued.

Idevsiz, the argument that specifies the size of the **idevmsg** array in the call to XF$SETUP, defines the size of the device message field in command packets inserted onto FREEQ. This occurs because unsolicited device messages are copied from the device message field of the command packet to the **idevmsg** array.

Note that the XF$FREESET subroutine may occasionally disable ASTs for a very short period.

The format of the XF$FREESET call is as follows:

```
CALL  XF$FREESET(contxt,[numpkt],[intctrl],[action],-
                 [actparm],[status])
```

Argument descriptions are as follows:

contxt Specifies the array that contains context and status information (see Section 4.4.6.1).

numpkt Specifies the number of command packets to be released onto FREEQ. The **numpkt** argument is optional; argument length is one word. If defaulted, **numpkt** is 1.

intctrl Specifies the conditions under which an AST is delivered (and the event flag set) when the DR32 places this command packet (or packets) on TERMQ (see Section 4.4.6.2). The VMS operating system defines the following values:

0 = unconditional AST delivery and event flag set
1 = AST delivery and event flag set only if TERMQ is empty
2 = no AST interrupt or event flag set

The **intctrl** argument is optional; argument length is one word. If defaulted, **intctrl** is 0.

action Specifies the address of a routine that is called when any command packet built by this call to XF$FREESET is removed from TERMQ by XF$GETPKT (see Section 4.4.7.3). The **action** argument is optional.

actparm A longword parameter that is passed to the action routine when the action routine is called (see Section 4.4.7.3). The **actparm** argument is optional.

status This output argument receives the VMS success or failure code of the XF$FREESET call:

SS$_NORMAL	Normal successful completion
SS$_BADQUEUEHDR	FREEQ interlock timeout
SS$_INSFMEM	Insufficient memory to build command packets
SHR$_NOCMDMEM	Command memory not allocated (usually because the data transfer has stopped and XF$CLEANUP has been called, or because XF$SETUP has not been called)

4.4.6.4 XF$PKTBLD

The XF$PKTBLD subroutine builds command packets and releases them onto INPTQ.

Note that the XF$PKTBLD subroutine may occasionally disable ASTs for a very short period.

The format of the XF$PKTBLD call is as follows:

```
CALL  XF$PKTBLD(contxt,func,[index],[size],
          [devmsg],[devsiz],[logsiz],[modes],
          [action],[actparm],[status])
```

Argument descriptions are as follows:

contxt Specifies the array that contains context and status information (see Section 4.4.6.1).

func Specifies the device control code. Device control codes describe the function the DR32 is to perform. The **func** argument length is one word. The VMS operating system defines the following values (Table 4–2 describes the functions in greater detail):

Symbol	Value	Function
XF$K_PKT_RD	0	Read device
XF$K_PKT_RDCHN	1	Read device chained
XF$K_PKT_WRT	2	Write device
XF$K_PKT_WRTCHN	3	Write device chained
XF$K_PKT_WRTCM	4	Write device control message
	5	(reserved)
XF$K_PKT_SETTST	6	Set self-test
XF$K_PKT_CLRTST	7	Clear self-test
XF$K_PKT_NOP	8	No operation
XF$K_PKT_DIAGRI	9	Diagnostic read internal
XF$K_PKT_DIAGWI	10	Diagnostic write internal
XF$K_PKT_DIAGRD	11	Diagnostic read DDI
XF$K_PKT_DIAGWC	12	Diagnostic write control message
XF$K_PKT_SETRND	13	Set random enable
XF$K_PKT_CLRRND	14	Clear random enable
XF$K_PKT_HALT	15	Set halt

index

Specifies the index of a data buffer specified by the **barray** argument (see Section 4.4.6.1). The specific index value given means that elements **barray** (1,index) through **barray** (size,index) will be transferred (one buffer full of data). The **index** argument is optional and is only used when the function specifies a data transfer (a read device, read device chained, write device, or write device chained function). The **index** argument length is one word.

size

Specifies a byte count to be transferred. This argument is optional and is only used when the function specifies a data transfer. If defaulted, the number of bytes to be transferred is assumed to be the size of the buffer (specified by the **bufsiz** argument in the call to XF$SETUP). If the **size** argument is given, the specified number of bytes of data **barray** (1,index) through **barray** (size,index) will be transferred. If **size** is defaulted and the function specifies a data transfer, **barray** (1,index) through **barray** (bufsiz,index) will be transferred. The **size** argument length is one longword.

devmsg

Specifies a variable that contains the device message to be sent to the far-end DR device. Provides additional control of the far-end DR device (see Section 4.4.3.12). The **devmsg** argument is optional.

devsiz

Specifies the size in bytes of the **devmsg** variable. If the **modes** argument specifies that a device message is to be sent over the control portion of the DDI, **devsiz** specifies the number of bytes of **devmsg** that will be sent to the far-end DR device.

logsiz Specifies the size of the log message expected from the far-end DR device. The **logsiz** argument is optional, argument length is one word. If defaulted, **logsiz** is 0.

modes Provides additional control of the transaction. The VMS operating system defines the following values:

Value	Meaning
+8	Only the function code is sent over the control portion of the DDI to the far-end DR device. Only for read device, read device chained, write device, and write device chained functions.
+16	The function code and the device message are sent over the control portion of the DDI to the far-end DR device. Only for read device, read device chained, write device, and write device chained functions.
+24	The function code, the device message, and the buffer size are sent over the control portion of the DDI to the far-end DR device. Only for read device, read device chained, write device, and write device chained functions.
	If none of the preceding three values is selected, nothing is transmitted over the control portion of the DDI to the far-end DR device.
+32	Length errors are suppressed. If not selected, a length error results in an abort.
+64	An AST should be delivered (and an event flag set) when this command packet is inserted onto TERMQ, provided TERMQ is empty.
+128	No AST is delivered or event flag set for this command packet.
	If both +64 and +128 are selected, +128 takes precedence.
	If neither of the preceding two values is selected, ASTs are delivered and the event flag is set unconditionally (whenever this command packet is placed onto TERMQ).
+256	Insert this command packet at the head of INPTQ. If not selected, insert the packet at the tail of INPTQ.

The **modes** argument default value is 0.

action Specifies the address of a routine that is called when XF$GETPKT removes this command packet from TERMQ. This occurs after the DR32 has completed the command specified in the packet (see Section 4.4.7.3). The **action** argument length is one longword.

actparm A longword parameter that is passed to the action routine when the action routine is called (see Section 4.4.7.3). The **actparm** argument is optional.

status This output argument receives the VMS success or failure code of the XF$PKTBLD call:

SS$_NORMAL	Normal successful completion
SS$_BADPARAM	Input parameter error
SS$_BADQUEUEHDR	INPTQ interlock timeout
SS$_INSFMEM	Insufficient memory to build command packets
SHR$_NOCMDMEM	Command memory not allocated (usually because the data transfer has stopped and XF$CLEANUP has been called, or because XF$SETUP has not been called)

4.4.6.5 XF$GETPKT

The XF$GETPKT subroutine removes a command packet from TERMQ.

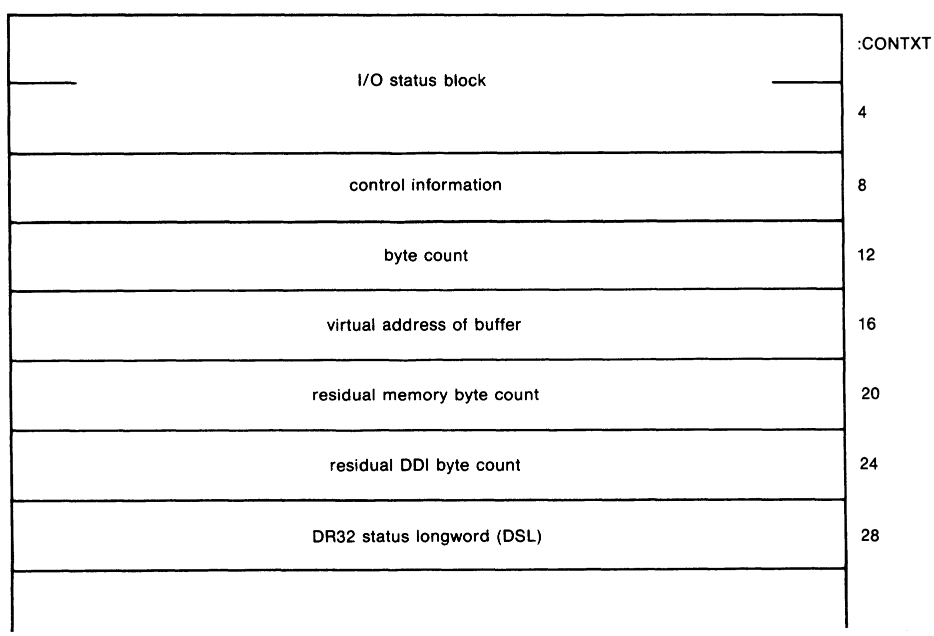
Note that the XF$GETPKT subroutine may occasionally disable ASTs for a very short period.

The format of the XF$GETPKT call is as follows:

```
CALL  XF$GETPKT(contxt,[waitflg],[func],[index],-
            [devflag],[logflag],[status])
```

Argument descriptions are as follows:

contxt Specifies the array that contains the context and status information (see Section 4.4.6.1). On return from XF$GETPKT, the first eight longwords of the **contxt** array are filled with the status of the data transfer:



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The first two longwords are the I/O status block. The next six longwords are copied directly from bytes 8 through 31 of the command packet.

This context and status information is returned by the DR32 as status in each command packet. With the exception of the I/O status block, the information is copied by XF$GETPKT into the **contxt** array whenever XF$GETPKT removes a command packet from TERMQ.

The I/O status block is stored only after the data transfer has halted and it contains the final status of the transfer. Section 4.5 describes the I/O status block.

(See Section 4.4.2 for a description of the remaining fields.)

waitflg — Specifies the consequences of an attempt by XF$GETPKT to remove a command packet from an empty TERMQ. If **waitflg** is 0 (default), XF$GETPKT waits for the event flag to be set and then removes a packet from TERMQ. If **waitflg** is 1, XF$GETPKT returns immediately with a failure status. Normally, **waitflg** is set to 1 (.TRUE.) for AST synchronization and set to 0 (.FALSE.) for event flag synchronization (see Section 4.4.7). The **waitflg** argument is optional.

func — This output argument receives the device control code specified in this command packet (see Section 4.4.6.4). The **func** argument is optional; argument length is one word.

index — If the current command packet specified a data transfer, this output argument receives the buffer index specified when this command packet was built by XF$PKTBLD (see Section 4.4.6.4). The **index** argument is optional; argument length is one word.

devflag — If set to .TRUE. (255), this output argument indicates that a device message was stored in the **idevmsg** array, which is described in the XF$SETUP call (see Section 4.4.6.1). The **devflag** argument is optional; argument length is one byte.

logflag — If set to .TRUE. (255), this output argument indicates that a log message was stored in the **ilogmsg** array, which is described in the XF$SETUP call (see Section 4.4.6.1). The **logflag** argument is optional; argument length is one byte.

status — This output argument receives the status of the XF$GETPKT call:

SS$_NORMAL	Normal successful completion
SS$_BADQUEUEHDR	TERMQ interlock timeout
SHR$_QEMPTY	TERMQ empty but transfer still in progress; only returned if **waitflg** is .TRUE
SHR$_HALTED	TERMQ empty, transfer complete, and I/O status block contains final status; XF$CLEANUP called automatically (Subsequent calls to XF$GETPKT return SHR$_NOCMDMEM.)
SHR$_NOCMDMEM	Command memory not allocated; usually indicates either: **1** XF$SETUP not called **2** XF$CLEANUP called

4.4.6.6 XF$CLEANUP

The XF$CLEANUP subroutine deassigns the channel and deallocates the command area allocated by XF$SETUP. If XF$GETPKT detects a TERMQ empty condition and the transfer has halted, it will automatically call XF$CLEANUP. However, if the transfer either terminates in an SS$_CTRLERR or SS$_BADQUEHDR error, or is intentionally terminated, XF$GETPKT might not detect these conditions and XF$CLEANUP should be called explicitly.

The format of the XF$CLEANUP call is as follows:

CALL XF$CLEANUP(contxt,[status])

Argument descriptions are as follows:

contxt Specifies the array that contains context and status information (see Section 4.4.6.1).

status This output argument receives the status of the XF$CLEANUP call:

SS$_NORMAL	Normal successful completion
SHR$_NOCMDMEM	The command memory not allocated; there are error returns from LIB$FREE_VM and $DASSIGN

4.4.7 User Program—DR32 Synchronization

Synchronization of high-level language application programs with the DR32 can be achieved in the following ways:

- Event flags
- AST routines
- Action routines

4.4.7.1 Event Flags

Event flags are synchronized by calling the XF$GETPKT routine (see Section 4.4.6.5) with the **waitflg** argument set to 0 (default). The **pktast** argument in the XF$STARTDEV routine (see Section 4.4.6.2) is normally set to its default value. If the XF$GETPKT routine is called and the termination queue is empty, the routine waits until the DR32 places a command packet on the queue and sets the event flag. The packet is then removed from the queue and returned to the caller.

4.4.7.2 AST Routines

If a call to the XF$STARTDEV routine includes the **pktast** argument, the specified AST routine is called each time an AST is delivered. AST delivery can be controlled on a packet-by-packet basis by using the **intctrl** argument in the XF$FREESET routine and by specifying appropriate values in the **modes** argument of the XF$PKTBLD routine (see Sections 4.4.6.3 and 4.4.6.4). For a particular command packet, ASTs can be delivered as follows:

- Unconditionally when the packet is placed onto TERMQ
- Only if TERMQ is empty when the packet is placed on it
- Not at all (that is, there is no AST when the packet is placed on TERMQ)

There is no guarantee that an AST will be delivered for every command packet, even when the **astctrl** argument indicates unconditional AST delivery. In particular, if packet interrupts are closely spaced, several packets can be placed onto TERMQ even though only one AST is delivered. Therefore, the AST routine should continue to call the XF$GETPKT routine until all command packets are removed from TERMQ.

4.4.7.3 Action Routines

The **action** argument specified in the XF$FREESET and XF$PKTBLD routines (see Sections 4.4.6.3 and 4.4.6.4) can be used for a more automated synchronization of the program with the DR32. Routines specified by **action** arguments can be used for both event flag and AST routine synchronization.

The address of the action routine is included in the command packet. This routine is automatically called by the XF$GETPKT routine when it removes that packet from TERMQ. This allows you to define, at the time the command packet is built, how it will be handled once it is removed from TERMQ. In addition to specifying different action routines for different types of command packets, you can also specify an action routine parameter (**actparm**) to further identify the command packet or the action to be taken when the command is completed. Figure 4–6 shows the use of action-specified routines for program synchronization.

An important difference between AST routine and action routine use is the number of times the respective routines are specified. Command packet AST routines are specified only once, in an XF$STARTDEV call; a single AST routine is implied. Action routines, however, are specified in each command packet. This allows a different action routine to be designed for each type of command packet.

Routines specified by the action argument are supplied by the user. The format of the calling interface is as follows:

```
CALL action-routine (contxt,actparm,devflag,logflag,func,index,status)
```

With the exception of **actparm**, all arguments are the same as those described for the XF$GETPKT routine. In effect, the action routine receives the same information XF$GETPKT optionally returns to its calling program, along with the **actparm** argument that was specified when the packet was built. If these variables are to be passed as inputs to the action routine, they must be supplied as output variables in the call to the XF$GETPKT routine.

4.5 I/O Status Block

The I/O status block for the load microcode and start data transfer QIO functions is shown in Figure 4–7. The I/O status block used in the first two longwords of the **contxt** array for high-level language calls also has the same format.

Figure 4–6 Action Routine Synchronization

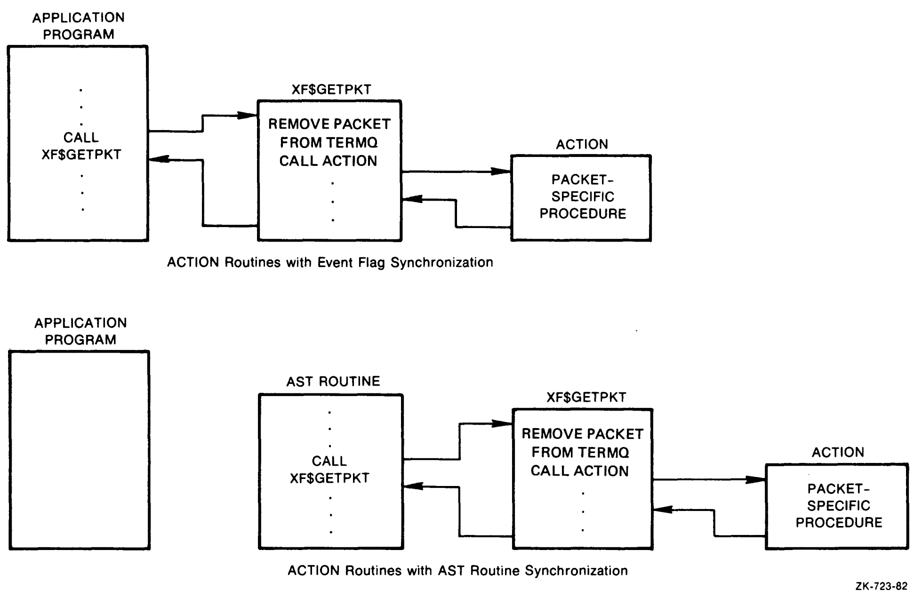
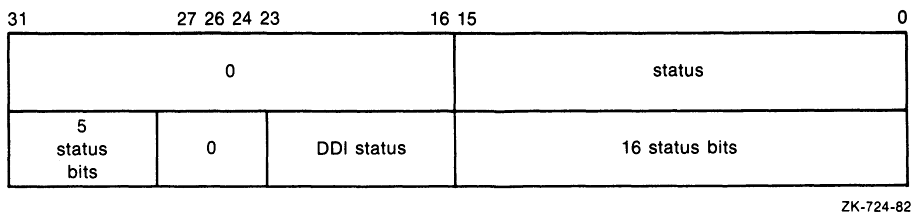


Figure 4–7 I/O Functions IOSB Contents



VMS status values are returned in the first longword. Appendix A lists these values. (The *VMS System Messages and Recovery Procedures Reference Volume* provides explanations and user actions for these returns.) If SS$_CTRLERR, SS$_DEVREQERR, or SS$_PARITY is returned in the status word, the second longword contains additional returns (device-dependent data). Table 4–5 lists these returns.

The I/O status block for an I/O function is returned after the function completes. Status is not stored on the completion of every command packet, because any number of packets can pass between the application program and the DR32 when a single QIO executes.

Table 4–5 Device-Dependent IOSB Returns for I/O Functions

Symbolic Name	Meaning
	16 Status Bits
XF$V_PKT_SUCCESS	The command was performed successfully.
XF$V_IOS_CMDSTD	The command specified in the command packet started.
XF$V_IOS_INVPTE	An invalid page table entry.
XF$V_IOS_FREQPK	This command packet came from FREEQ.
XF$V_IOS_DDIDIS	The far-end DR device is disabled.
XF$V_IOS_SLFTST	The DR32 is in self-test mode.
XF$V_IOS_RNGERR	The user-provided address is outside the command block range or the buffer block range.
XF$V_IOS_UNQERR	A queue element was not aligned on a quadword boundary.
XF$V_IOS_INVPKT	A packet was not a valid DR32 command packet.
XF$V_IOS_FREQMT	A message was received from the far-end DR device and FREEQ was empty.
XF$V_IOS_RNDENB	Random access mode is enabled.
XF$V_IOS_INVDDI	A protocol error occurred on the DDI.

Table 4–5 (Cont.) Device-Dependent IOSB Returns for I/O Functions

Symbolic Name	Meaning
	16 Status Bits
XF$V_IOS_LENERR	The far-end DR device terminated the data transfer before the required number of bytes was sent, or a message was received from the far-end DR device and the device message field in the command packet at the head of FREEQ was not large enough to hold it.
XF$V_IOS_DRVABT	The I/O driver aborted the DR32 function.
XF$V_PKT_PARERR	A parity error occurred on the data or control portion of the DDI.
	DDI Status
XF$V_IOS_DDISTS	The one-byte status register 0 for the far-end DR device. XFV_IOS_NEXREG, XFV_IOS_LOG, and XF$V_IOS_DDIERR are returns from this register.
XF$V_IOS_NEXREG	An attempt was made to access a nonexistent register on the far-end DR device.
XF$V_IOS_LOG	The far-end DR device registers are stored in the log area.
XF$V_IOS_DDIERR	An error occurred on the far-end DR device.
	5 Status Bits
XF$V_IOS_BUSERR	An error on the processor's internal CPU memory bus occurred.
XF$V_IOS_RDSERR	A noncorrectable memory error occurred (read) data substitute.
XF$V_IOS_WCSPE	Writable control store (WCS) parity error.
XF$V_IOS_CIPE	Control interconnect parity error. A parity error occurred on the control portion of the DDI.
XF$V_IOS_DIPE	Data interconnect parity error. A parity error occurred on the data portion of the DDI.

4.6 Programming Hints

This section contains information on important programming considerations relevant to users of the DR32 driver.

4.6.1 Command Packet Prefetch

The DR32 has the capability of prefetching command packets from INPTQ. While executing the command specified in one packet, the DR32 can prefetch the next packet, decode it, and be ready to execute the specified command at the first opportunity. When the command is executed depends on which command is specified. For example, if two read device or write device command packets are on INPTQ, the DR32 fetches the first packet, decodes the command, verifies that the transfer is legal, and starts the data transfer. While the transfer is taking place, the DR32 prefetches the next read device or write device command packet, decodes it, and verifies the transfer legality. The second transfer begins as soon as the first transfer is completed.

If the two command packets on INPTQ are read device (or write device) and write device control message, in that order, the DR32 prefetches the second packet and immediately executes the command, because control messages can be overlapped with data transfers. The DR32 then prefetches the next command packet. In an extreme case, the DR32 can send several control messages over the control portion of the DDI while a single data transfer takes place on the data portion of the DDI.

The prefetch capability and the overlapping of control and data transfers can cause unexpected results when programming the DR32. For instance, if the application program calls for a data transfer to the far-end DR device followed by notification of the far-end DR device that data is present, the program cannot simply insert a write device command packet and then a write control message command packet onto INPTQ—the control message might arrive before the data transfer completes.

A better way to synchronize the data transfer with notification of data arrival is to request an interrupt in the interrupt control field of the data transfer command packet. Then, when the data transfer command packet is removed from TERMQ, the application program can insert a write control message command packet onto INPTQ to notify the far-end DR device that the data transfer has completed.

Another consequence of command packet prefetching occurs, for example, when two write device command packets are inserted onto INPTQ. While the first data transfer takes place, the second command packet is prefetched and decoded. If an unusual event occurs and the application program must send an immediate control message to the far-end DR device, the application program might insert a write device control message packet onto INPTQ. However, this packet is not sent immediately because the second write device command packet has already been prefetched; the control message is sent after the second data transfer starts.

If the application program must send a control message with minimum delay, use one of the following techniques:

- Insert only one data transfer function onto INPTQ at a time. If this is done, a second transfer function will not be prefetched and a control message can be sent at any time.
- Use smaller buffers or a faster data rate to reduce the time necessary to complete a given command packet.
- Issue a Cancel I/O on Channel ($CANCEL) system service call followed by another IO$_STARTDATA function.

4.6.2 Action Routines

Action routines provide a useful DR32 programming technique. They can be used in application programs written in either assembly language or a high-level language. When a command packet is built, the address of a routine to be executed when the packet is removed from TERMQ is appended to the end of the packet. Then, rather than having to determine what action to perform for a particular packet when it is removed from TERMQ, the specified action routine is called.

4.6.3 Error Checking

Bits 0 through 23 in the second longword of the I/O status block correspond to the same bits in the DR32 status longword (DSL). Although the I/O status block is written only after the QIO function completes, the DSL is stored in every command packet. However, because there is no command packet in which to store a DSL for certain error conditions, such as FREEQ empty, some errors are reported only in the I/O status block. To check for an error under these conditions, examine the DSL in each packet for success or failure only. Then, if a failure occurs, the specific error can be determined from the I/O status block. The I/O status block should also be checked to verify that the QIO has not completed prior to a wait for the insertion of additional command packets onto TERMQ. In this way, the application program can detect asynchronous errors for which there is no command packet available.

4.6.4 Queue Retry Macro

When an interlocked queue instruction is included in the application program, the code should perform a retry if the queue is locked. However, the code should not execute an indefinite number of retries. Consequently, all retry loops should contain a maximum retry count. The macro programming example provided in Section 4.7 contains a useful queue retry macro.

4.6.5 Diagnostic Functions

The diagnostic functions listed in Table 4–2 can be used to test the DR32 without the presence of a far-end DR device. For the DR780, perform the following test sequence:

1. Insert a set self-test command packet onto INPTQ.
2. Insert a diagnostic write internal command packet that specifies a 128-byte buffer onto INPTQ. This packet copies 128 bytes from memory into the DR780 internal data silo.
3. Insert a diagnostic read DDI command packet onto INPTQ. This packet transmits the 128 bytes of data from the silo over the DDI and returns it to the silo.
4. Insert a diagnostic read internal command packet that specifies another 128-byte buffer in memory onto INPTQ. This packet copies 128 bytes of data from the silo into memory.

5 Compare the two memory buffers for equality. Note that on the DR780, the diagnostic read internal function destroys the first four bytes in the silo before storing the data in memory. Therefore, compare only the last 124 bytes of the two buffers.

6 Insert a clear self-test command packet onto INPTQ.

4.6.6 The NOP Command Packet

It is often useful to insert a NOP command packet onto INPTQ to test the state of the DDI disable bit (XF$M_PKT_DDIDIS in the DSL). By checking this bit before initiating a data transfer, an application program can determine whether the far-end DR device is ready to accept data.

4.6.7 Interrupt Control Field

As described in Section 4.4.3.6, the interrupt control field determines the conditions under which an interrupt is generated: unconditionally, if TERMQ was empty, or never. The following are general applications of this field:

- If a program performs five data transfers and requires notification of completion only after all five have completed, the first four command packets should specify no interrupt, and the fifth command packet should specify an unconditional interrupt.
- If a program performs a continuous series of data transfers, each command packet can specify an interrupt only if TERMQ was empty. Then, every time an event flag or AST notifies the program that a command packet was inserted onto TERMQ, the program removes and processes packets on TERMQ until it is empty.
- Command packets that specify no interrupt should never be mixed with command packets that specify an interrupt if TERMQ was empty.

4.7 Programming Examples

The programming examples in the following two sections use DR32 high-level language procedures and DR32 Queue I/O functions.

4.7.1 DR32 High-Level Language Program

The following program (Example 4–1) is an example of how the DR32 high-level language procedures perform a data transfer from a far-end DR device. The program reads a specified number of data buffers from an undefined far-end DR device, which is assumed to be a data source, into the VAX memory. The number of buffers is controlled by the NUMBUF parameter. The program contains examples of the read data chained function code and DR32 application program synchronization using AST routines and action routines.

Example 4–1 DR32 High-Level Language Program Example

```
*************************************************************************
C
C                 DR32 HIGH-LEVEL LANGUAGE PROGRAM
C
*************************************************************************

        INCLUDE 'XFDEF.FOR'                             ;DEFINE XF CONSTANTS
        PARAMETER       BUFSIZ = 1024                   !SIZE OF EACH BUFFER
        PARAMETER       NUMBUF = 8                      !NUMBER OF BUFFERS IN
                                                        !RING
        PARAMETER       ILOGSIZ = 4                     !SIZE OF INPUT LOG
                                                        !ARRAY
        PARAMETER       EFN = 0                         !EVENT FLAG SYNCHRON-
                                                        !IZING MAIN LEVEL WITH
                                                        !AST ROUTINE
        INTEGER*2       BUFARRAY(BUFSIZ,NUMBUF)         !THE RING OF BUFFERS
        INTEGER*2       INDEX                           !REFERS TO BUFFER
                                                        !IN BUFARRAY
        INTEGER*2       COUNT                           !COUNTS NUMBER OF
                                                        !BUFFERS FILLED
        INTEGER*2       DATART                          !DR32 CLOCK RATE

        INTEGER*4       CONTXT(30)      !CONTEXT ARRAY USED BY SUPPORT
        INTEGER*4       ILOGMSG(ILOGSIZ)!LOG MESSAGES FROM DEVICE
                                        !STORED HERE
        INTEGER*4       STATUS          !RETURNS FROM SUBROUTINES
        INTEGER*4       DEVMSG          !far-end DR device CODE

        EXTERNAL        ASTRTN          !AST ROUTINE
        EXTERNAL        AST$PROCBUF     !ACTION ROUTINE TO HANDLE
                                        !COMPLETION OF READ DATA
                                        !COMMAND PACKET

        EXTERNAL        AST$HALT        !ACTION ROUTINE TO HANDLE
                                        !COMPLETION OF A HALT
                                        !COMMAND PACKET

        COMMON  /MAIN_AST/      CONTXT, INDEX
        COMMON  /MAIN_ACTION/   BUFARRAY, ILOGMSG, COUNT
        EXTERNAL        SS$_NORMAL      !SUCCESS STATUS RETURN

*************************************************************************
C
C  THE CALL TO THE SETUP ROUTINE
C
*************************************************************************

        CALL XF$SETUP (CONTXT,BUFARRAY,BUFSIZ*2,NUMBUF,,,ILOGMSG,
        1               ILOGSIZ*4,,STATUS)
        IF (STATUS .NE. %LOC(SS$_NORMAL)) CALL LIB$STOP(%VAL(STATUS))

C
C  PRELOAD THE INPUT QUEUE BEFORE STARTING THE DR32 IN ORDER TO AVOID
C  A DELAY IN THE DATA TRANSFER
C
C

*************************************************************************
C
C  BUILD COMMAND PACKETS
C
*************************************************************************
```

Example 4–1 Cont'd. on next page

Example 4–1 (Cont.) DR32 High-Level Language Program Example

```
C  BUILD THE COMMAND PACKET THAT WILL INSTRUCT THE far-end DR device
C  TO START SAMPLING.  ARBITRARILY ASSUME THAT THE far-end DR device
C  WILL RECOGNIZE THIS DEVICE MESSAGE.  INSERT THIS PACKET ON THE
C  INPUT QUEUE (INPTQ).
C
        DEVMSG = 25                     !SIGNAL far-end DR device
                                        !"GO"
        CALL XF$PKTBLD (
        1       CONTXT,                 !THE CONTEXT ARRAY
        1       XF$K_PKT_WRTCM,         !WRITE CONTROL MESSAGE
                                        !FUNCTION
        1       ,,                      !NO INDEX OR SIZE
        1       DEVMSG,                 !SIGNAL "GO"
        1       4,                      !SIZE OF DEVMSG IN BYTES
        1       ILOGSIZ*4               !SPACE FOR INPUT LOG
                                        !MESSAGE
        1       XF$K_PKT_UNCOND         !MODES: UNCONDITIONAL
                                        !       INTERRUPT
        1       + XF$K_PKT_CBDM         !     : SEND FUNC AND DEVMSG
        1       + XF$K_PKT_INSTL        !     : INSERT PACKET AT INPTQ
                                        !       TAIL
        1       ,,                      !NO ACTION ROUTINE OR ACTPARM
        1       STATUS)
        IF (STATUS .NE. %LOC(SS$_NORMAL)) CALL LIB$STOP(%VAL(STATUS))

C
C  IN A LOOP, BUILD THE COMMAND PACKETS THAT WILL PERFORM THE CHAINED
C  READ TO INITIALLY FILL THE BUFFERS
C
        DO 10   INDEX = 1, NUMBUF       !FOR ALL BUFFERS DO
                CALL XF$PKTBLD(
        1       CONTXT,                 !THE CONTEXT ARRAY
        1       XF$K_PKT_RDCHN,         !READ DATA CHAINED
        1       INDEX,                  !IDENTIFIES BUFFER
        1       ,,,                     !NO SIZE, DEVMSG, OR DEVSIZ
        1       ILOGSIZ*4,              !SPACE FOR INPUT LOG MESSAGE
        1       XF$K_PKT_UNCOND         !MODES: UNCONDITIONAL
                                        !       INTERRUPT
        1       + XF$K_PKT_CB           !     : SEND FUNCTION CODE
        1       + XF$K_PKT_INSTL,       !     : INSERT PACKET AT INPTQ
                                        !       TAIL
        1       AST$PROCBUF,            !ACTION ROUTINE
        1       ,                       !NO ACTPARM
        1       STATUS)
        IF (STATUS .NE. %LOC(SS$_NORMAL)) CALL LIB$STOP(%VAL(STATUS))
10      CONTINUE

C
C  THE INPUT QUEUE IS LOADED
C
***********************************************************************
C
C  START THE DR32
C
***********************************************************************
```

Example 4–1 Cont'd. on next page

Example 4–1 (Cont.) DR32 High-Level Language Program Example

```
        DATART = 0                          !DATA TRANSFER RATE
        COUNT = 0                           !NUMBER OF BUFFERS THAT HAVE
                                            !BEEN FILLED
        CALL SYS$CLREF (%VAL(EFN))          !CLEAR EVENT FLAG BEFORE START

        CALL XF$STARTDEV (CONTXT,'XFAO:',ASTRTN,,,,DATART,STATUS)
        IF (STATUS .NE. %LOC(SS$_NORMAL)) CALL LIB$STOP(%VAL(STATUS))

C
C  FROM THIS POINT, ROUTINES AT THE AST LEVEL ASSUME CONTROL.  WAIT
C  FOR THEM TO SIGNAL COMPLETION OF THE SAMPLING SWEEP.
C
        CALL SYS$WAITFR (%VAL(EFN))

        STOP
        END
*************************************************************************
C
C  AST ROUTINES
C
*************************************************************************
        SUBROUTINE      ASTRTN (ASTPARM)

        INCLUDE 'XFDEF.FOR/NOLIST'
        INTEGER*2       ASTPARM                 !UNUSED PARAMETER

        INTEGER*4       CONTXT(30)              !CONTEXT ARRAY
        INTEGER*4       STATUS                  !FOR CALL TO XF$GETPKT

        LOGICAL*1       WAITFLG                 !INPUT TO XF$GETPKT
        LOGICAL*1       LOGFLAG                 !INPUT TO XF$GETPKT

        COMMON  /MAIN_AST/      CONTXT, INDEX

        EXTERNAL        SS$_NORMAL

C
C  CALL XF$GETPKT IN A LOOP UNTIL TERMQ IS EMPTY.  XF$GETPKT WILL CALL
C  THE APPROPRIATE ACTION ROUTINE FOR EACH COMMAND PACKET.
C
        WAITFLG = .TRUE.                    !DO NOT WAIT FOR EVENT FLAG
        LOGFLAG = .TRUE.                    !REQUEST NOTIFICATION IF LOG
                                            !MESSAGE IS IN PACKET

10      CALL XF$GETPKT (CONTXT,WAITFLG,,INDEX,,LOGFLAG,STATUS)
        IF (STATUS .EQ. %LOC(SS$_NORMAL))       !PACKET FROM TERMQ
        1       GOTO 10
        IF (STATUS .EQ. SHR$_QEMPTY)        !TERMQ EMPTY - TRANSFER
        1       GOTO 20                     !STILL IN PROGRESS
        IF (STATUS .EQ. SHR$_HALTED .OR. STATUS .EQ. SHR$_NOCMDMEM)
        1       GOTO 20                     !TRANSFER COMPLETE.  NO MORE
                                            !COMMAND PACKETS. ASTS MAY
                                            !STILL BE DELIVERED

        CALL LIB$STOP (%VAL(STATUS))        !ERROR IN XF$GETPKT

20      RETURN
        END
```

Example 4–1 Cont'd. on next page

Example 4–1 (Cont.) DR32 High-Level Language Program Example

```
************************************************************************
C
C  ACTION ROUTINE
C
************************************************************************

        SUBROUTINE      AST$PROCBUF (CONTXT,ACTPARM,DEVFLAG,LOGFLAG,
        1                           FUNC,INDEX,STATUS)

C
C  THIS IS THE ACTION ROUTINE CALLED BY XF$GETPKT WHEN IT REMOVES A
C  COMMAND PACKET FROM TERMQ.  THIS PACKET HAS JUST COMPLETED A READ
C  DATA OPERATION FROM THE BUFFER SPECIFIED BY INDEX.  THE BUFFER IS
C  PROCESSED, AND IF MORE DATA IS REQUIRED, THAT IS, BUFCOUNT .LE.
C  MAXCOUNT), ANOTHER PACKET IS BUILT.  THE BUFFER IN THIS PACKET IS
C  THEN REFILLED AND THE PACKET IS INSERTED ONTO INPTQ.
C  IF BUFCOUNT .GT. MAXCOUNT, THE SAMPLING SWEEP IS FINISHED AND A
C  HALT PACKET IS INSERTED ONTO INPTQ.
C
        INCLUDE         'XFDEF.FOR/NOLIST'
        PARAMETER       MAXCOUNT = 10    !NUMBER OF BUFFERS IN SWEEP
        PARAMETER       ILOGSIZ = 4      !SIZE OF INPUT LOG MESSAGE ARRAY
        PARAMETER       BUFSIZ = 1024    !SIZE OF EACH BUFFER (IN WORDS)
        PARAMETER       NUMBUF = 8       !NUMBER OF BUFFERS

        INTEGER*2       INDEX            !REFERS TO A BUFFER IN BUFARRAY
        INTEGER*2       FUNC             !FUNCTION CODE FROM PACKET
        INTEGER*2       BUFCOUNT         !COUNTS NUMBER OF BUFFERS FILLED
        INTEGER*2       BUFARRAY(BUFSIZ,NUMBUF) !THE ARRAY OF BUFFERS
        INTEGER*4       ACTPARM          !ACTION PARAMETER (NOT USED)
        INTEGER*4       STATUS           !STATUS OF XF$GETPKT (NOT USED)
        INTEGER*4       STAT             !STATUS OF CALL TO XF$PKTBLD
        INTEGER*4       CONTXT(30)       !CONTEXT ARRAY USED BY SUPPORT
        INTEGER*4       ILOGMSG(ILOGSIZ)!STORES LOG MESSAGES FROM DEVICE

        LOGICAL*1       DEVFLAG          !NOT USED IN THIS EXAMPLE
        LOGICAL*1       LOGFLAG          !SIGNALS LOG MESSAGE PRESENT

        COMMON  /MAIN_ACTION/   BUFARRAY,ILOGMSG,BUFCOUNT

        EXTERNAL        SS$_NORMAL
        EXTERNAL        AST$HALT
C
C  PROCESS THE BUFFER
C
        DO 10   I = 1, BUFSIZ
************************************************************************
C
C  AT THIS POINT INSERT THE CODE TO PROCESS ELEMENT (I,INDEX) OF
C  BUFARRAY
C
************************************************************************
10      CONTINUE
```

Example 4–1 Cont'd. on next page

Example 4–1 (Cont.) DR32 High-Level Language Program Example

```
************************************************************************
C
C  AT THIS POINT INSERT THE CODE TO LOOK AT THE LOG MESSAGE
C
************************************************************************

C
C  IS THIS THE LAST BUFFER IN THE SWEEP?
C
BUFCOUNT = BUFCOUNT + 1
        IF (BUFCOUNT .LT. MAXCOUNT) THEN         !BUILD A PACKET TO
                                         !REFILL THE BUFFER
        CALL FAKE$PKTBLD (               !NEED INTERVENING ROUTINE
        1        CONTXT,                 !THE CONTEXT ARRAY
        1       XF$K_PKT_RDCHN,          !READ DATA CHAINED
        1       INDEX,                   !BUFFER INDEX
        1       ,,,                      !NO SIZE, DEVMSG, OR DEVSIZ
        1       ILOGSIZ*4,               !SPACE FOR LOG MESSAGE
        1       XF$K_PKT_UNCOND          !MODES: UNCONDITIONAL
                                         !       INTERRUPT
        1       + XF$K_PKT_CB            !     : SEND CONTROL BYTE
        1       + XF$K_PKT_INSTL,        !     : INSERT AT TAIL
        1       ,,                       !ACTION GIVEN IN FAKE$PKTBLD
        1       STAT)
        IF (STAT .NE. %LOC(SS$_NORMAL)) CALL LIB$STOP (%VAL(STAT))
        ELSE IF (BUFCOUNT .EQ. MAXCOUNT) THEN   !END OF CHAIN
                CALL FAKE$PKTBLD (       !NEED INTERVENING ROUTINE
        1       CONTXT,                  !THE CONTEXT ARRAY
        1       XF$K_PKT_RD,             !READ DATA FUNCTION
        1       INDEX,                   !BUFFER INDEX
        1       ,,,                      !NO SIZE, DEVMSG, OR DEVSIZ
        1       ILOGSIZ*4,               !SPACE FOR LOG MESSAGE
        1       XF$K_PKT_UNCOND          !MODES: UNCONDITIONAL
                                         !       INTERRUPT
        1       + XF$K_PKT_CB            !     : SEND CONTROL BYTE
        1       + XF$K_PKT_INSTL,        !     : INSET AT TAIL
        1       ,,                       !ACTION GIVEN IN FAKE$PKTBLD
        1       STAT)
        IF (STAT .NE. %LOC(SS$_NORMAL)) CALL LIB$STOP (%VAL(STAT))
        ELSE                             !BUILD A HALT PACKET
                CALL XF$PKTBLD (
        1       CONTXT,                  !THE CONTEXT ARRAY
        1       XF$K_PKT_HALT,           !ALL DONE
        1       ,,,,                     !DEFAULT VALUES
        1       ILOGSIZ*1,               !SPACE FOR INPUT LOG MESSAGE
        1       AST$HALT,                !ACTION ROUTINE
        1       ,                        !NO ACTPARM
        1       STAT)
        IF (STAT .NE. %LOC(SS$_NORMAL)) CALL LIB$STOP (%VAL(STAT))

        END IF

        RETURN
        END
```

Example 4–1 Cont'd. on next page

Example 4–1 (Cont.) DR32 High-Level Language Program Example

```
***************************************************************************
C
C  PASS ADDRESS OF ACTION ROUTINE TO COMMAND PACKET
C
***************************************************************************

        SUBROUTINE      FAKE$PKTBLD(A,B,C,D,E,F,G,H,I,J,K)

C
C  AST$PROCBUF CALLS THIS SUBROUTINE IN ORDER TO PASS THE ADDRESS OF
C  AST$PROCBUF TO XF$PKTBLD.  (AST$PROCBUF CANNOT REFER TO ITSELF
C  WITHIN THE SCOPE OF AST$PROCBUF)
C

        EXTERNAL        AST$PROCBUF

        CALL XF$PKTBLD (A,B,C,D,E,F,G,H,AST$PROCBUF,J,K)

        RETURN
        END
***************************************************************************
C
C  HALT ACTION ROUTINE
C
***************************************************************************

        SUBROUTINE      AST$HALT (CONTXT,ACTPARM,DEVFLAG,LOGFLAG,
                                        FUNC,INDEX,STATUS)
C
C  THIS IS THE ACTION ROUTINE CALLED BY XF$GETPKT WHEN IT REMOVES A
C  HALT PACKET FROM TERMQ.  THIS ROUTINE PRINTS STATUS INFORMATION,
C  CALLS XF$CLEANUP TO PERFORM FINAL HOUSEKEEPING FUNCTIONS, AND SETS
C  THE EVENT FLAG THAT SIGNALS THE TRANSFER IS COMPLETE.
C
        PARAMETER       EFN = 0

        INTEGER*2       FUNC            !NOT USED
        INTEGER*2       INDEX           !NOT USED

        INTEGER*4       ACTPARM         !NOT USED
        INTEGER*4       STATUS          !NOT USED
        INTEGER*4       STAT            !RETURN FROM XF$CLEANUP
        INTEGER*4       CONTXT(30)      !CONTEXT ARRAY USED BY SUPPORT

        LOGICAL*1       DEVFLAG         !NOT USED
        LOGICAL*1       LOGFLAG         !SIGNALS LOG MESSAGE

        EXTERNAL        SS$_NORMAL      !SUCCESS STATUS RETURN
C
C  PRINT FINAL STATUS
C
        PRINT *,  'FINAL STATUS IN I/O STATUS BLOCK'
        PRINT *,  CONTXT(1), CONTXT(2)

C
C  CLEAN UP
C

        CALL XF$CLEANUP (CONTXT,STAT)
        IF (STAT .NE. %LOC(SS$_NORMAL)) CALL LIB$STOP (%VAL(STAT))

        CALL SYS$SETEF (%VAL(EFN))

        RETURN
        END
```

4.7.2 DR32 Queue I/O Functions Program

The following sample program (Example 4–2) uses Queue I/O functions to send a device message to the far-end DR device and then waits for a message returned in a command packet on FREEQ. The returned message is copied into another command packet, and that packet writes a data buffer to the far-end DR device.

Example 4–2 DR32 Queue I/O Functions Program Example

```
; ******************************************************************
;
;                    DR32 QUEUE I/O FUNCTIONS PROGRAM
;
; ******************************************************************
        .TITLE  DR32 PROGRAMMING EXAMPLE
        .IDENT  /01/

;
; DEFINE SYMBOLS
;
        $XFDEF
;
;
; QRETRY - THIS MACRO EXECUTES AN INTERLOCKED QUEUE INSTRUCTION AND
;          RETRIES THE INSTRUCTION UP TO 25 TIMES IF THE QUEUE IS
;          LOCKED.
;
; INPUTS:
;
;       OPCODE = OPCODE NAME: INSQHI,INSQTI,REMQHI,REMQTI
;       OPERAND1 = FIRST OPERAND FOR OPCODE
;       OPERAND2 = SECOND OPERAND FOR OPCODE
;       SUCCESS = LABEL TO BRANCH TO IF OPERATION SUCCEEDS
;       ERROR = LABEL TO BRANCH TO IF OPERATION FAILS
;
; OUTPUTS:
;
;       R0 = DESTROYED
;
;       C-BIT = CLEAR IF OPERATION SUCCEEDED
;               SET IF OPERATION FAILED - QUEUE LOCKED
;               (MUST BE CHECKED BEFORE V-BIT OR Z-BIT)
;
;       REMQTI OR REMQHI:
;
;               V-BIT = CLEAR IF AN ENTRY REMOVED FROM QUEUE; SET
;                       IF NO ENTRY REMOVED FROM QUEUE.
;
;       INSQTI OR INSQHI:
```

Example 4–2 Cont'd. on next page

Example 4–2 (Cont.) DR32 Queue I/O Functions Program Example

```
;
;               Z-BIT = CLEAR IF ENTRY IS NOT FIRST IN QUEUE; SET
;                       IF ENTRY IS FIRST IN QUEUE.
;
        .MACRO  QRETRY  OPCODE,OPERAND1,OPERAND2,SUCCESS,ERROR,?LOOP,
                        ?OK
        CLRL    R0
LOOP:
        OPCODE  OPERAND1,OPERAND2
        .IF     NB      SUCCESS
        BCC     SUCCESS
        .IFF
        BCC     OK
        .ENDC
        AOBLSS  #25,R0,LOOP
        .IF     NB      ERROR
        BRW     ERROR
        .ENDC
OK:
        .ENDM   QRETRY

;
; ALLOCATE STORAGE FOR DATA STRUCTURES
;
        .PSECT  DATA,QUAD
CMDBLK:                                 ; COMMAND BLOCK

INPTQ:  .BLKQ   1                       ; INPUT QUEUE
TERMQ:  .BLKQ   1                       ; TERMINATION QUEUE
FREEQ:  .BLKQ   1                       ; FREE QUEUE
MSGPKT:                                 ; THIS PACKET SENDS A 12-BYTE
                                        ; DEVICE MESSAGE
        .BLKQ   1                       ; QUEUE LINKS
        .BYTE   12                      ; LENGTH OF DEVICE MESSAGE
        .BYTE   0                       ; LENGTH OF LOG AREA
        .BYTE   XF$K_PKT_WRTCM          ; COMMAND  = WRITE CONTROL
                                        ; MESSAGE
        .BYTE   XF$K_PKT_NOINT@-        ; PACKET CONTROL = NO
                                        ; INTERRUPT
                XF$V_PKT_INTCTL
        .BLKL   1                       ; BYTE COUNT
        .BLKL   1                       ; BUFFER ADDRESS
        .BLKL   2                       ; RESIDUAL MEMORY AND DDI BYTE
                                        ; COUNTS
        .BLKL   1                       ; DR32 STATUS LONGWORD
        .LONG   11111,22222,33333       ; DEVICE MESSAGE
        .LONG   0                       ; EXTEND DEVICE MESSAGE TO
                                        ; QUADWORD LENGTH
        .ALIGN  QUAD
```

Example 4–2 Cont'd. on next page

Example 4–2 (Cont.) DR32 Queue I/O Functions Program Example

```
WRTPKT:                                 ; THIS PACKET DOES A WRITE
                                        ; DEVICE
        .BLKQ   1                       ; QUEUE LINKS
        .BYTE   4                       ; LENGTH OF DEVICE MESSAGE
        .BYTE   0                       ; LENGTH OF LOG AREA
        .BYTE   XF$K_PKT_WRT            ; COMMAND = WRITE
        .BYTE   <XF$K_PKT_CBDMBC@-      ; PACKET CONTROL = SEND
                                        ; COMMAND BYTE,
                XF$V_PKT_CISEL>!-       ; DEVICE MESSAGE, AND BYTE
                                        ; COUNT
                <XF$K_PKT_NOINT@-       ; AND NO INTERRUPT
                XF$V_PKT_INTCTL>
        .LONG   1000                    ; BYTE COUNT
        .LONG   WRTBFR                  ; BUFFER ADDRESS
        .BLKL   2                       ; RESIDUAL MEMORY AND DDI BYTE
                                        ; COUNTS
        .BLKL   1                       ; DR32 STATUS LONGWORD

WDVMSG: .BLKQ   1                       ; SPACE FOR DEVICE MESSAGE

        .ALIGN  QUAD
HLTPKT:                                 ; THIS PACKET HALTS THE DR32
        .BLKQ   1                       ; QUEUE LINKS
        .BYTE   0,0,XF$K_PKT_HALT,0     ; COMMAND = HALT
        ,BLKL   5                       ; UNUSED FIELDS IN THIS PACKET

        .ALIGN QUAD
FREPKT:                                 ; PACKET FOR FREE QUEUE
        .BLKQ   1                       ; QUEUE LINKS
        .BYTE   4,0,0,0                 ; LENGTH OF DEVICE MESSAGE
                                        ; FIELD
        .BLKL   4                       ; UNUSED FIELDS IN THIS PACKET
        .BLKL   1                       ; DR32 STATUS LONGWORD
        .BLKQ   1                       ; SPACE FOR DEVICE MESSAGE
CMDBLKSIZ=.-CMDBLK

BFRBLK:                                 ; BUFFER BLOCK

WRTBFR: .BLKB   1000

BFRBLKSIZ=.-BFRBLK

CMDTBL: .LONG   CMDBLKSIZ               ; COMMAND BLOCK SIZE
        .LONG   CMDBLK                  ; COMMAND BLOCK ADDRESS
        .LONG   BFRBLKSIZ               ; BUFFER BLOCK SIZE
        .LONG   BFRBLK                  ; BUFFER BLOCK ADDRESS
        .LONG   PKTAST                  ; PACKET AST ADDRESS
        .LONG   0                       ; PACKET AST PARAMETER
        .BYTE   236,XF$M_CMT_SETRTE,0,0 ; DATA RATE (2.0 MBYTES/SEC)
        .LONG   GOBITADR                ; ADDRESS TO STORE THE GO
                                        ; BIT ADDRESS
GOBITADR:
        .BLKL   1

XFIOSB: .BLKL   2                       ; I/O STATUS BLOCK

XFNAMEDSC:
        .LONG   XFNAMESIZ               ; NAME DESCRIPTOR
        .LONG   XFNAME

XFCHAN: .BLKW   1                       ; CHANNEL NUMBER
```

Example 4–2 Cont'd. on next page

Example 4–2 (Cont.) DR32 Queue I/O Functions Program Example

```
XFNAME: .ASCII  /XFAO/
XFNAMESIZE=.-XFNAME

; *********************************************************************
;
; PROGRAM STARTING POINT
;
; *********************************************************************

        .PSECT  CODE,NOWRT

        .ENTRY  DREXAMPLE,M<R2,R3>

        $ASSIGN_S DEVNAM = XFNAMEDSC,-   ; ASSIGN A CHANNEL TO DR32
                  CHAN = XFCHAN
        BLBS    RO,10$                   ; SUCCESSFUL ASSIGN
        BRW     ERROR
10$:    MOVAB   CMDBLK,R2
        CLRQ    (R2)+                    ; INITIALIZE INPTQ
        CLRQ    (R2)+                    ; INITIALIZE TERMQ
        CLRQ    (R2)                     ; INITIALIZE FREEQ

;
; INSERT COMMAND PACKET ONTO FREEQ FOR RETURN MESSAGE
;

        QRETRY  ERROR=BADQUEUE,-
        INSQTI  FREPKT,FREEQ

;
; START DEVICE
;

        $QIO_S  FUNC = #IO$_STARTDATA,-
                CHAN = XFCHAN,-
                IOSB = XFIOSB,-
                EFN = #1,-
                P1 = CMDTBL,-
                P2 = #XF$K_CMT_LENGTH
        BLBC    RO,ERROR
;
; SEND MESSAGE TO far-end DR device
;

        QRETRY  ERROR=BADQUEUE,-
        INSQTI  MSGPKT,INPTQ
        MOVL    #1,@GOBITADR             ; SET GO BIT
        $WAITFR_S #1                     ; WAIT UNTIL QIO COMPLETES
;
; CHECK FOR SUCCESSFUL COMPLETION
;
        MOVZWL  XFIOSB,RO
        BEQL    BADQUEUE                  ; I/O NOT DONE YET - BAD QUEUE
                                          ; ERROR IN AST ROUTINE
        BLBC    RO,ERROR                  ; ERROR
        RET                               ; SUCCESSFUL COMPLETION

BADQUEUE:
        MOVZWL  #SS$_BADQUEUEHDR,RO
```

Example 4–2 Cont'd. on next page

Example 4–2 (Cont.) DR32 Queue I/O Functions Program Example

```
;
; AN ERROR HAS OCCURRED.  NORMALLY, YOU MIGHT PERFORM MORE
; EXTENSIVE ERROR CHECKING AT THIS POINT.  IN PARTICULAR, IF THE ERROR
; IS SS$_CTRLERR, SS$_DEVREQERR, OR SS$_PARITY, THE SECOND LONGWORD
; OF THE I/O STATUS BLOCK CAN PROVIDE ADDITIONAL INFORMATION.  IN THIS
; EXAMPLE, THE PROGRAM EXITS WITH THE ERROR STATUS IN RO.
;
;
; COMMAND PACKET AST ROUTINE
;

PKTAST: .WORD   0
NXTPKT: QRETRY  ERROR=70$,-             ; GET NEXT PACKET FROM QUEUE
        REMQHI  TERMQ,R1
        BVC     10$                     ; PACKET OBTAINED FROM QUEUE
        RET                             ; QUEUE IS EMPTY
10$:    BLBC    XF$L_PKT_DSL(R1),50$    ; RETURN IF PACKET ERROR
        BBC     #XF$V_PKT_FREQPK,-      ; RETURN IF PACKET NOT FROM
                XF$L_PKT_DSL(R1),50$    ; FREEQ

;
; COMMAND PACKET OBTAINED FROM FREEQ.  COPY DEVICE MESSAGE AND QUEUE
; WRITE PACKET.
;

        MOVL    XF$B_PKT_DEVMSG(R1),WDVMSG
        QRETRY  ERROR=70$,-
        INSQTI  WRTPKT,INPTQ
        QRETRY  ERROR=70$,-
        INSQTI  HLTPKT,INPTQ
        MOVL    #1,@GOBITADR            ; SET GO BIT
50$:    RET

;
; BAD QUEUE ERROR IN AST ROUTINE - WAKE UP MAIN LEVEL.  QIO MAY
; OR MAY NOT HAVE COMPLETED.
;

70$:    $SETEF_S  #1                    ; WAKE UP MAIN LEVEL
        RET

        .END    DREXAMPLE
```

5 Asynchronous DDCMP Interface Driver

This chapter describes the use of the VMS Asynchronous DDCMP interface driver.

5.1 Supported Devices

Asynchronous DDCMP is supported for DECnet–VAX using software DDCMP over terminal ports. This enables all VMS-supported terminal devices to provide a DDCMP interface between two VAX processors using terminal ports. Asynchronous DDCMP supports full-duplex, point-to-point lines.

5.2 Driver Features and Capabilities

The asynchronous DDCMP driver provides the following capabilities:

- Point-to-point operating mode in which the asynchronous DDCMP port is connected to a single other controller also operating in point-to-point mode
- A nonprivileged QIO interface to the asynchronous DDCMP for using this device as a raw-data channel
- Full duplex operation
- Interface design common to all communications devices supported by the VMS operating system
- Separate transmit and receive queues
- Assignment of multiple read and write buffers to the device

5.2.1 Quotas

Transmit operations are buffered and I/O operations and are limited by the process's buffered I/O quota.

The quotas for the receive buffer free list are the process's buffered I/O quota and buffered I/O byte count quota.

5.2.2 Power Failure

If a system power failure occurs, no asynchronous DDCMP recovery is possible. The driver is in a fatal error state and shuts down.

5.3 Device Information

You can obtain information on asynchronous DDCMP characteristics by using the Get Device/Volume Information ($GETDVI) system service. (See the *VMS System Services Reference Manual.*)

$GETDVI returns device characteristics when you specify the item code DVI$_DEVCHAR. Table 5–1 lists these characteristics, which are defined by the $DEVDEF macro.

DVI$_DEVCLASS returns the device class, which is DC$_SCOM. DVI$_DEFTYPE returns the device type, which is the terminal ports device type. The $DCDEF macro defines the device class and device type names.

DVI$_DEVBUFSIZ returns the maximum message size. The maximum message size is the maximum send or receive message size for the unit. Messages greater than 512 bytes on modem-controlled lines are more prone to transmission errors.

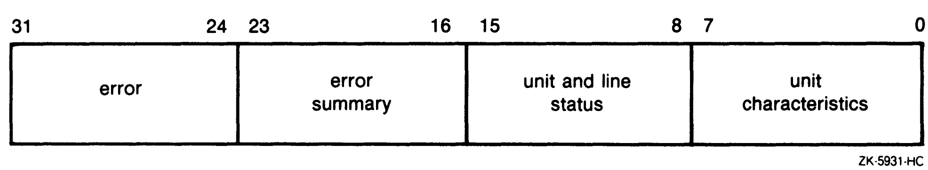
Table 5–1 Device Characteristics

Characteristic[1]	Meaning
	Static Bits (Always Set)
DEV$M_NET	Network device. Set for terminal port if it is a network device.
DEV$M_AVL	Available device. Set when unit control block (UCB) is initialized.
DEV$M_ODV	Output device.
DEV$M_IDV	Input device.

[1]Defined by the $DEVDEF macro

DVI$_DEVDEPEND returns the unit characteristics bits, the unit and line status bits, the error summary bits, and the specific errors in a longword field as shown in Figure 5–1.

Figure 5–1 DVI$_DEVDEPEND Returns



Unit characteristics bits govern the DDCMP operating mode. They are defined by the $XMDEF macro and can be set by a set mode function (see Section 5.4.3.1) or can be read by a sense mode function (see Section 5.4.4).

The status bits show the status of the unit and the line. These bits can only be set or cleared when the controller and tributary are not active.

Table 5–2 lists the status values and their meanings. The values are defined by the $XMDEF macro.

Table 5–2 Asynchronous DDCMP Unit and Line Status

Status	Meaning
XM$M_STS_ACTIVE	DDCMP protocol is active.
XM$M_STS_DISC	Modem line went from on to off. This bit will be returned in the field IRP$L_IOST2 if the driver has had a timeout while waiting for the CTS signal to be present on the device.
XM$M_STS_BUFFAIL	Receive buffer allocation failed.

The error summary bits are set when an error occurs. They are read-only bits. If the error is fatal, the asynchronous DDCMP for that port is shut down. Table 5–3 lists the error summary bit values and their meanings.

Table 5–3 Error Summary Bits

Error Summary Bit	Meaning
XM$M_ERR_MAINT	DDCMP maintenance message received
XM$M_ERR_START	DDCMP start message received
XM$M_ERR_FATAL	Hardware or software error occurred on controller
XM$M_ERR_TRIB	Hardware or software error occurred on tributary
XM$M_ERR_LOST	Data lost when a received message was longer than the specified maximum message size
XM$M_ERR_THRESH	Receive, transmit, or select threshold errors

Table 5–4 lists the errors that can be specified. These errors are mapped to the indicated codes.

Table 5–4 Asynchronous DDCMP Errors

Value (octal)	Meaning	Code Set
2	Receive threshold error	XM$M_ERR_THRESH
4	Transmit threshold error	XM$M_ERR_THRESH
6	Select threshold error	XM$M_ERR_THRESH
10	Start received in run state	XM$M_ERR_START
12	Maintenance received in run state	XM$M_ERR_MAINT
14	Maintenance received in halt state	(none)
16	Start received in maintenance state	XM$M_ERR_START
100–276	Internal procedure (software) errors	XM$M_ERR_TRIB
300	Buffer too small	XM$M_ERR_LOST
302	Nonexistent memory	XM$M_ERR_FATAL
304	Modem disconnected	XM$M_STS_DISC

5.4 Asynchronous DDCMP Function Codes

The asynchronous DDCMP driver can perform logical, virtual, and physical I/O operations. The basic functions are read, write, set mode, set characteristics, and sense mode. Table 5–5 lists these functions and their function codes. The sections that follow describe these functions in greater detail.

Table 5–5 Asynchronous DDCMP I/O Functions

Function Code and Arguments	Type[1]	Modifiers	Function
IO$_READLBLK P1,-P2	L	IO$M_NOW	Read logical block.
IO$_READVBLK P1,-P2	V	IO$M_NOW	Read virtual block.
IO$_READPBLK P1,-P2	P	IO$M_NOW	Read physical block.
IO$_WRITELBLK P1,P2	L		Write logical block.
IO$_WRITEVBLK P1,P2	V		Write virtual block.
IO$_WRITEPBLK P1,P2	P		Write physical block.
IO$_SETMODE P1,-[P2],P3	L	IO$M_CTRL IO$M_SHUTDOWN IO$M_STARTUP IO$M_ATTNAST	Set asynchronous DDCMP characteristics and controller state for subsequent operations.
IO$_SETCHAR P1,-[P2],P3	P	IO$M_CTRL IO$M_SHUTDOWN IO$M_STARTUP IO$M_ATTNAST	Set asynchronous DDCMP characteristics and controller state for subsequent operations.
IO$_SENSEMODE P1,P2	L	IO$M_CTRL IO$M_CLR_COUNTS IO$M_RD_COUNTS	Sense controller or tributary characteristics and return them in specified buffers.

[1]V = virtual, L = logical, P = physical (There is no functional difference in these operations.)

Although the asynchronous DDCMP driver does not differentiate among logical, virtual, and physical I/O functions (all are treated identically), you must have the required privilege to issue a request. (Logical I/O functions require no I/O privilege.)

5.4.1 Read

Read functions provide for the direct transfer of data into the user process's virtual memory address space. The VMS operating system provides the following function codes:

- IO$_READLBLK—Read logical block
- IO$_READVBLK—Read virtual block
- IO$_READPBLK—Read physical block

Received messages are multibuffered in system dynamic memory and then copied to the user's buffer.

The read functions take the following device- or function-dependent arguments:

- P1—The starting virtual address of the buffer that is to receive data
- P2—The size of the receive buffer in bytes

The message size specified by P2 cannot be larger than the maximum receive-message size for the unit (see Section 5.3). If a message larger than the maximum size is received, a status of SS$_DATAOVERUN is returned in the I/O status block.

The read functions can take the following function modifier:

- IO$M_NOW—Complete the read operation immediately with a received message. (If no message is currently available, return a status of SS$_ENDOFFILE in the I/O status block.)

5.4.2 Write

Write functions provide for the direct transfer of data from the user process's virtual memory address space. The VMS operating system provides the following function codes:

- IO$_WRITELBLK—Write logical block
- IO$_WRITEVBLK—Write virtual block
- IO$_WRITEPBLK—Write physical block

Asynchronous DDCMP messages are copied into a system buffer before they are transmitted.

The write functions take the following device- or function-dependent arguments:

- P1—The starting virtual address of the buffer containing the data to be transmitted
- P2—The size of the buffer in bytes

The message size specified by P2 cannot be larger than the maximum send-message size for the unit (see Section 5.3).

The write functions take no function modifiers.

5.4.3 Set Mode and Set Characteristics

Set mode operations are used to perform protocol, operational, and program and driver interface operations with the asynchronous DDCMP driver. The VMS operating system defines the following types of set mode functions:

- Set mode
- Set characteristics
- Set controller mode
- Set tributary mode
- Enable attention AST
- Shutdown controller
- Shutdown tributary

Used without function modifiers, set mode and set characteristics functions can modify an existing tributary. Used with certain function modifiers, they can perform asynchronous DDCMP operations such as starting a tributary and requesting an attention AST. The VMS operating system provides the following function codes:

- IO$_SETMODE—Set mode (no I/O privilege required)
- IO$_SETCHAR—Set characteristics (requires physical I/O privilege)

The other five types of set mode functions, which use the two function codes with certain function modifiers, are described in the sections that follow.

To use the IO$_SETMODE and IO$_SETCHAR functions, assign the appropriate unit control block (UCB) with the Assign I/O Channel ($ASSIGN) system service.

5.4.3.1 Set Controller Mode

The set controller mode function sets the asynchronous DDCMP controller state and activates the controller. The first occurrence of an IO$_SETMODE function creates a buffer for the driver to use. (Part of the buffer created by IO$_SETMODE!IO$M_CTRL!IO$M_STARTUP is allocated for the protocol operation to use.) The following combinations of function code and modifier are provided:

- IO$_SETMODE!IO$M_CTRL—Set controller characteristics
- IO$_SETCHAR!IO$M_CTRL—Set controller characteristics
- IO$_SETMODE!IO$M_CTRL!IO$M_STARTUP—Set controller characteristics and start the controller

- IO$_SETCHAR!IO$M_CTRL!IO$M_STARTUP—Set controller characteristics and start the controller

If the function modifier IO$M_STARTUP is specified, the controller is started and the modem is enabled. If IO$M_STARTUP is not specified, the specified characteristics are simply modified.

These codes take the following device- or function-dependent argument:

- P2—The address of a descriptor for a characteristics buffer (optional)

The P2 buffer consists of a series of six-byte entries. The first word contains the parameter identifier (ID), and the longword that follows contains one of the values that can be associated with the parameter ID. Figure 5–2 shows the format for this buffer.

Figure 5–2 P2 Characteristics Buffer (Set Controller)

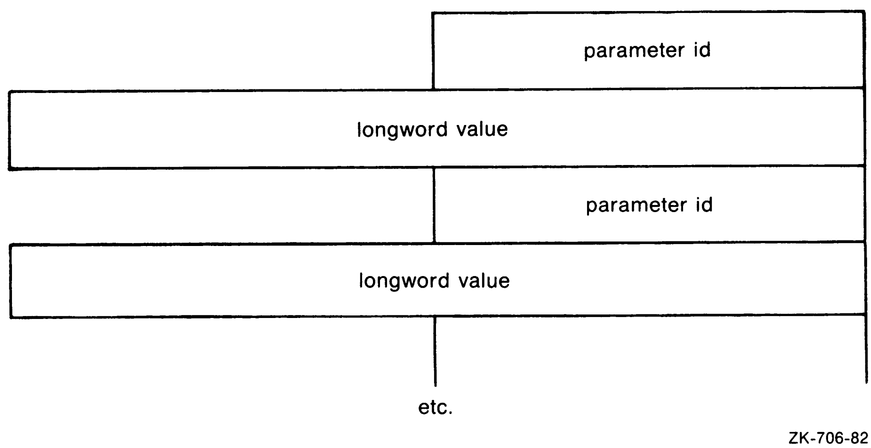


Table 5–6 lists the parameter IDs and values that can be specified in the P2 buffer. The $NMADEF macro defines these values.

Table 5–6 P2 Characteristics Values (Set Controller)

Parameter ID	Meaning
NMA$C_PCLI_PRO	Protocol mode. Only the following value can be specified: **Value** — **Meaning** NMA$C_LINPR_POI — DDCMP point-to-point (default)
NMA$C_PCLI_DUP	Duplex mode. Only the following value can be specified: **Value** — **Meaning** NMA$C_DPX_FUL — Full-duplex (default)

Table 5–6 (Cont.) P2 Characteristics Values (Set Controller)

Parameter ID	Meaning
NMA$C_PCLI_CON	Controller mode. Only the following value can be specified: **Value** — **Meaning** NMA$C_LINCN_NOR — Normal (default)
NMA$C_PCLI_BFN	Number of receive buffers to preallocate.
NMA$C_PCLI_BUS	Maximum allowable transmit and receive message length (default = 512 bytes).

5.4.3.2 Set Tributary Mode

The set tributary mode function either starts a tributary or modifies an existing one. This function must be performed before any communication can occur with the attached unit.

Because the asynchronous DDCMP driver deals with only one tributary, the set tributary function starts both the tributary and the protocol. The data block that describes the tributary has already been created.

The VMS operating system provides the following combinations of function code and modifier:

- IO$_SETMODE—Modify tributary characteristics
- IO$_SETCHAR—Modify tributary characteristics
- IO$_SETMODE!IO$M_STARTUP—Start tributary
- IO$_SETCHAR!IO$M_STARTUP—Start tributary

These codes take the following device- or function-dependent argument:

- P2—The address of a descriptor for a characteristics buffer (optional)

The P2 buffer consists of a series of six-byte entries. The first longword contains the parameter identifier (ID), and the longword that follows contains one of the values that can be associated with the parameter ID. Figure 5–2 shows the format for this buffer.

Table 5–7 lists the parameter IDs and values that can be specified in the P2 buffer.

Table 5–7 P2 Characteristics Values (Set Tributary)

Parameter ID	Meaning
NMA$C_PCCI_TRT[1]	Transmit delay timer (default = 0).
NMA$C_PCCI_RTT[1]	Retransmit timer for full-duplex point-to-point mode and selection timer for multipoint control and half-duplex point-to-point mode (default = 3000).

[1] A global polling parameter. All timer values must be specified in milliseconds.

On receipt of the QIO request for asynchronous DDCMP, the driver modifies the tributary parameters and starts the protocol. The tributary state and the protocol state are equal. The driver does not verify that a tributary address has been provided. If an address has not been provided, it defaults to 1.

5.4.3.3 Shutdown Controller

The shutdown controller function shuts down the controller and disables the modem line. On completion of a shutdown controller request, all tributaries have been halted (including those tributaries not explicitly halted), all tributary buffers returned, and the controller reinitialized. This function halts the tributary, the protocol, and the line. The controller cannot be used again until another IO$_SETMODE!IO$M_CTRL!IO$M_STARTUP or IO$_SETCHAR!IO$M_CTRL!IO$M_STARTUP request has been issued (see Section 5.4.3.1).

The VMS operating system provides the following combinations of function code and modifier:

- IO$_SETMODE!IO$M_CTRL!IO$M_SHUTDOWN—Shutdown controller
- IO$_SETCHAR!IO$M_CTRL!IO$M_SHUTDOWN—Shutdown controller

The shutdown controller function takes no device- or function-dependent arguments.

5.4.3.4 Shutdown Tributary

The shutdown tributary function halts, but does not delete, the specified tributary. On completion of a shutdown tributary request, the tributary and the protocol are halted, all buffers are returned, and all pending I/O requests and received messages are aborted. Neither the tributary nor the attached device can be used again until another IO$_SETMODE!IO$M_STARTUP or IO$_SETCHAR!IO$M_STARTUP request has been issued (see Section 5.4.3.2).

The VMS operating system provides the following combinations of function code and modifier:

- IO$_SETMODE!IO$M_SHUTDOWN—Shutdown tributary
- IO$_SETCHAR!IO$M_SHUTDOWN—Shutdown tributary

The shutdown tributary function takes no device- or function-dependent arguments.

5.4.3.5 Enable Attention AST

The enable attention AST function requests that an attention AST be delivered to the requesting process when a status change occurs on the specified tributary. An AST is queued when the driver sets or clears either an error summary bit or any of the unit status bits (see Tables 5–2 and 5–3), or when a message is available and there is no waiting read request. The enable attention AST function is legal at any time, regardless of the condition of the unit status bits.

The VMS operating system provides the following combinations of function code and modifier:

- IO$_SETMODE!IO$M_ATTNAST—Enable attention AST
- IO$_SETCHAR!IO$M_ATTNAST—Enable attention AST

These codes take the following device- or function-dependent arguments:

- P1—The address of an AST service routine or 0 for disable
- P2—Ignored
- P3—Access mode to deliver AST

The enable attention AST function enables an attention AST to be delivered to the requesting process once only. After the AST occurs, it must be explicitly reenabled by the function before the AST can occur again. The function is also subject to AST quotas.

The AST service routine is called with an argument list. The first argument is the current value of the second longword of the I/O status block (see Section 5.5). The access mode specified by P3 is maximized with the requester's access mode.

5.4.4 Sense Mode

The sense mode function returns the controller or tributary characteristics in the specified buffers.

The VMS operating system provides the following function codes:

- IO$_SENSEMODE!IO$M_CTRL—Read controller characteristics
- IO$_SENSEMODE—Read tributary characteristics

These codes take the following device- or function-dependent argument:

- P2—The address of a descriptor for a buffer into which the characteristics buffer is stored (optional). (Figure 5–2 shows the format of the characteristics buffer.)

All characteristics that fit into the buffer specified by P2 are returned. However, if all the characteristics cannot be stored in the buffer, the I/O status block returns the status SS$_BUFFEROVF. The second word of the I/O status block returns the size (in bytes) of the characteristics buffer returned by P2 (see Section 5.5).

5.4.4.1 Read Internal Counters

The read internal counters (IO$M_RD_COUNTS) subfunction reads the DDCMP internal counters. The VMS operating system provides the following combinations of function codes and modifiers:

- IO$_SENSEMODE!IO$M_RD_COUNTS—Read tributary counters.
- IO$_SENSEMODE!IO$M_CLR_COUNTS—Clear tributary counters.
- IO$_SENSEMODE!IO$M_RD_COUNTS!IO$M_CLR_COUNTS—Read and then clear tributary counters.
- IO$_SENSEMODE!IO$M_CTRL!IO$M_RD_COUNTS—Read controller counters.
- IO$_SENSEMODE!IO$M_CTRL!IO$M_CLR_COUNTS—Clear controller counters.

- IO$_SENSEMODE!IO$M_CTRL!IO$M_RD_COUNTS!IO$M_CLR_COUNTS—Read and then clear controller counters.

These codes take the following device- or function dependent arguments:

- P1—Ignored.
- P2—The address of a buffer descriptor into which the counters will be returned. Figure 5–3 shows the format of the buffer. Table 5–8 lists the parameter ids that can be returned for asynchronous DDCMP. Table 5–9 lists the parameter ids that can be returned for tributaries.

All counters that fit into the buffer specified by P2 are returned. However, if all the counters cannot be stored in the buffer, the I/O status block returns the status SS$_BUFFEROVF. The second word of the I/O status block returns the size, in bytes, of the extended characteristics buffer returned (see Section 5.5).

Figure 5–3 P2 Extended Characteristics Buffer (Sensemode)

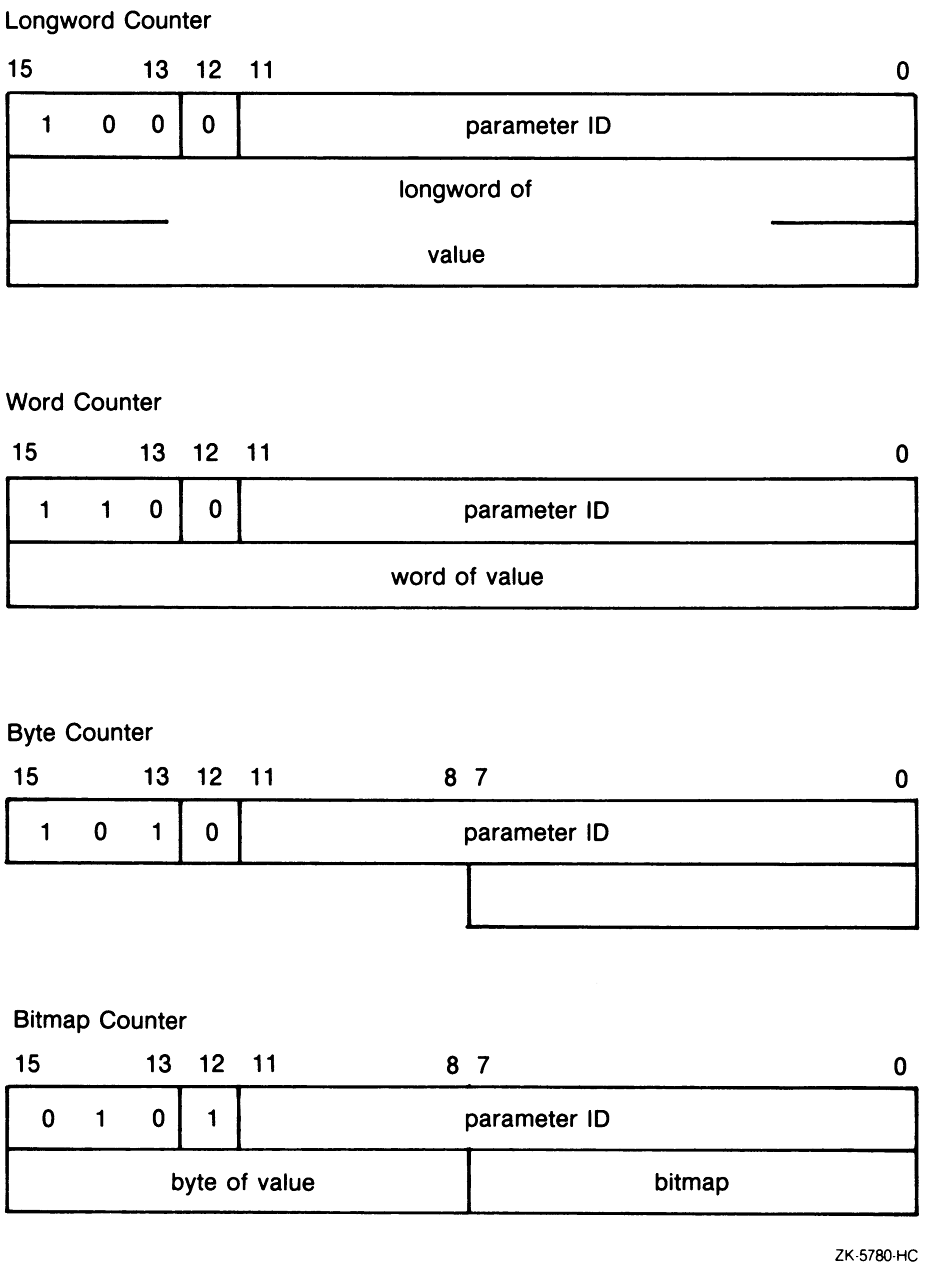


Table 5–8 Controller Counter Parameter IDs

Parameter ID	Meaning
NMA$C_CTLIN_LPE	Number of local station errors bitmap counter.

Value	Meaning
1	Receive overrun SNAK set.
2	Receive overrun SNAK not set.
4	Transmitter underrun.
8	Message format error.

Parameter ID	Meaning
NMA$C_CTLIN_RPE	Number of remote station errors bitmap counter.

Value	Meaning
1	NAKs received due to receiver overrun.
2	NAKs received due to message format error.
4	SNAK set message format error.
8	Streaming tributary.

Table 5–9 Tributary Counter Parameter IDs

Parameter ID	Meaning
NMA$C_CTCIR_BRC	Number of bytes received by this station.
NMA$C_CTCIR_BSN	Number of bytes transmitted by station.
NMA$C_CTCIR_DBR	Number of messages received by this station.
NMA$C_CTCIR_DBS	Number of messages transmitted by this station.
NMA$C_CTCIR_SIE	Number of selection intervals elapsed.
NMA$C_CTCIR_RBE	Remote buffer error bitmap counters.

Value	Meaning
1	Remote buffer unavailable.
2	Remote buffer too small.

Parameter ID	Meaning
NMA$C_CTCIR_LBE	Local buffer error bitmap counters.

Value	Meaning
1	Local buffer unavailable.
2	Local buffer too small.

Table 5–9 (Cont.) Tributary Counter Parameter IDs

Parameter ID	Meaning
NMA$C_CTCIR_SLT	Selection timeout bitmap counters. **Value** / **Meaning** 1 — No attempt to respond was made. 2 — Attempt was made, but timeout still occurs.
NMA$C_CTCIR_RRT	Number of SACK settings when REP received.
NMA$C_CTCIR_LRT	Number of SREP settings.
NMA$C_CTCIR_DEI	Data error inbound bitmap counters. **Value** / **Meaning** 1 — NAK transmitted header CRC error. 2 — NAK transmitted data CRC error. 4 — NAK transmitted REP response.
NMA$C_CTCIR_DEO	Data error outbound bitmap counters. **Value** / **Meaning** 1 — NAK received header CRC error. 2 — NAK received data CRC error. 4 — NAK received REP response.

5.5 I/O Status Block

The I/O status block (IOSB) for all asynchronous DDCMP functions is shown in Figure 5–4. Appendix A lists the completion status returns for these functions. (The *VMS System Messages and Recovery Procedures Reference Volume* provides explanations and suggested user actions for these returns.)

Figure 5–4 IOSB Contents

		+2		0	
transfer size		completion status			
error number *	error summary	status	characteristics		+4

* only for DMP11

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In addition to the completion status, the first longword of the IOSB returns either the size (in bytes) of the data transfer or the size (in bytes) of the characteristics buffer returned by a sense mode function. The second longword returns the line status bits listed in Table 5–2 and the error summary bits listed in Table 5–3.

6 Ethernet/802 Device Drivers

This chapter describes the QIO interface of the communication devices listed in Table 6–1.

Table 6–1 Supported Communication Devices

Device	Driver
DIGITAL Ethernet UNIBUS Network Adapter (DEUNA)	XEDRIVER
DIGITAL Ethernet Q-BUS Network Adapter (DEQNA)	XQDRIVER
DIGITAL Ethernet LSI UNIBUS Adapter (DELUA)	XEDRIVER
DIGITAL Ethernet BI-Bus Network Adapter (DEBNA)	ETDRIVER
DESVA	ESDRIVER
DIGITAL Ethernet LSI Q-BUS Adapter (DELQA)	XQDRIVER

All drivers support Ethernet and Institution for Electrical and Electronic Engineers (IEEE) 802 standards, except where otherwise indicated. Section 6.1.3 describes the specific IEEE 802 features supported by the drivers.

6.1 Ethernet/802 Characteristics

The Ethernet/802 controllers are direct-memory-access (DMA) devices that, along with additional external hardware, implement the Ethernet specification. A single Ethernet/802 controller, which is a piece of peripheral equipment of the system bus, communicates with the local system and with remote systems implementing the Ethernet or IEEE specifications. The Ethernet specification is described in *The Ethernet–Data Link Layer and Physical Layer Specification (Number AA-K759B-TK).*

The Ethernet/802 controllers use a single multi-access channel with carrier sense and collision detection (CSMA/CD) to provide direct communication between a VAX processor and the Ethernet. The Ethernet is that group of DIGITAL products that implement Intel™ , Xerox® , and DIGITAL intercompany Ethernet specifications. A *port* in an Ethernet configuration consists of a protocol type, a Service Access Point (SAP), or a protocol identifier and a controller. There are as many ports on an Ethernet/802 controller as there are protocol types, SAPs, and protocol identifiers. Each port is independent of other ports running on the same Ethernet/802 controller.

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Application programs use the Ethernet/802 driver's QIO interface to perform I/O operations to and from other nodes on the Ethernet. This chapter describes the QIO interface. Figure 6–1 shows the relationship of the Ethernet/802 controllers (except the DESVA) to the processor and the user application program. The DESVA uses ThinWire to connect to the Ethernet.

6.1.1 Driver Initialization and Operation

DIGITAL recommends that you perform the following sequence to initialize and start a port on an Ethernet/802 device driver:

1. Assign an I/O channel to XEc0 (for DEUNA and DELUA), XQc0 (for DEQNA and DELQA), ETc0 (for DEBNA), or ESc0 (for DESVA) with the Assign I/O Channel ($ASSIGN) system service, where c is the controller through which the data transfer will occur. $ASSIGN creates a new unit control block (UCB) to which the channel for the port is assigned.
2. Start up the port with the set mode function and start up function modifier (see Section 6.4.3.1). You must supply the required P2 buffer parameters.
3. Perform read, write, and sense mode operations as desired.
4. Shut down the port with the set mode function and shut down function modifier (see Section 6.4.3.4).
5. Deassign the I/O channel with the Deassign I/O Channel ($DASSGN) system service.

Sections 6.6.2 and 6.6.3 provide sample programs.

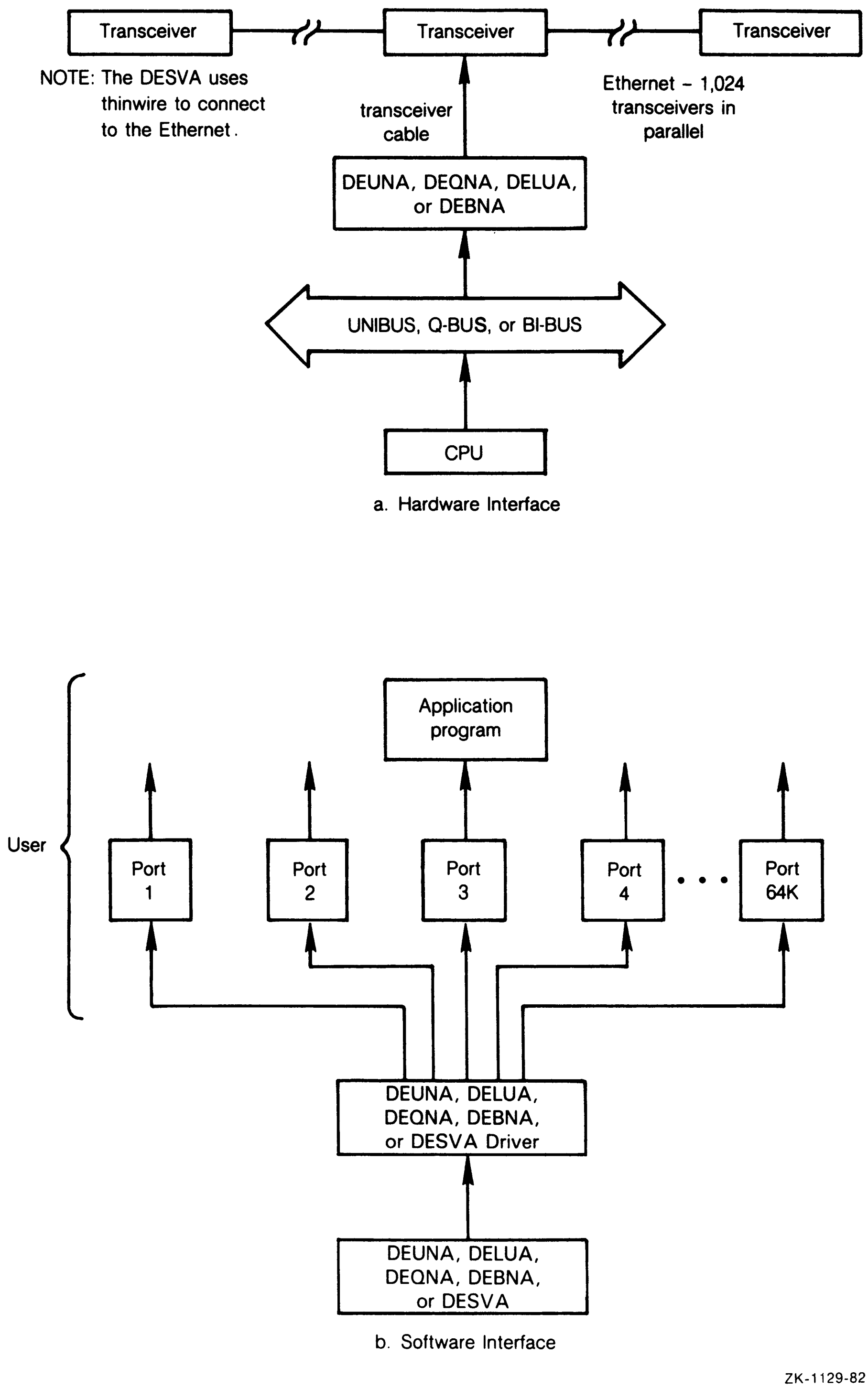
6.1.2 Ethernet Addresses

The Ethernet is a medium for creating a network; it is not a network by itself. The Ethernet/802 controller and the local system constitute a node. Nodes on Ethernet lines are identified by unique Ethernet addresses. A message can be sent to one, several, or all nodes on an Ethernet line simultaneously, depending on the Ethernet address used. You do not have to specify the Ethernet address of your own node to communicate with other nodes on the same Ethernet. However, you do need to know the Ethernet address of the node with which you want to communicate.

6.1.2.1 Format of Ethernet Addresses

An Ethernet address is 48 bits in length. Ethernet addresses are represented by the Ethernet standard as six pairs of hexadecimal digits (six bytes), separated by hyphens (for example, AA-01-23-45-67-FF). The bytes are displayed from left to right in the order in which they are transmitted; bits within each byte are transmitted from right to left. In the example, byte AA is transmitted first; byte FF is transmitted last. (See the description of NMA$C_PCLI_PHA in Table 6–6 for the internal representation of addresses.)

Figure 6–1 Typical Ethernet Configuration



Upon application, Xerox Corporation assigns a block of addresses to a producer of Ethernet interfaces. Thus, every manufacturer has a unique set of addresses to use. Normally, one address out of the assigned block of physical addresses is permanently associated with each controller (usually in read-only memory). This address is known as the Ethernet hardware address of the controller. Each individual controller has a unique Ethernet hardware address.

6.1.2.2 Ethernet Address Classifications

An Ethernet address can be a physical address of a single node or a multicast address, depending on the value of the low-order bit of the first byte of the address (this bit is transmitted first). Following are the two types of node addresses:

- Physical address—The unique address of a single node on an Ethernet. The least significant bit of the first byte of an Ethernet physical address is 0. (For example, in physical address AA-00-03-00-FC-00, byte AA in binary is 1010 1010, and the value of the low-order bit is 0.)
- Multicast address—A multidestination address of one or more nodes on a given Ethernet. The least significant bit of the first byte of a multicast address is 1. (For example, in the multicast address AB-22-22-22-22-22, byte AB in binary is 1010 1011, and the value of the low-order bit is 1.)

Contrary to the Ethernet specification and the IEEE 802.3 standard, the broadcast address (FF-FF-FF-FF-FF-FF) must be enabled as a multicast address in order to receive messages addressed to it.

6.1.2.3 Selecting an Ethernet Physical Address

DIGITAL's interface to the Ethernet/802 controllers allows you to set the physical address of the controller. All users of the controller must agree on this address. The first user of the controller chooses the physical address; any additional users of the controller must specify either the same physical address or no physical address. When all channels to the controller are shut down, the next user to start a channel chooses the physical address. The contoller's physical address is always chosen on the first successful startup when there are no active channels. If the address is not chosen at this time, the controller's hardware address is used as the physical address.

6.1.2.4 DIGITAL Ethernet Physical and Multicast Address Values

DIGITAL physical addresses are in the range AA-00-00-00-00-00 through AA-00-04-FF-FF-FF. The following are DIGITAL multicast addresses assigned for use in cross-company communications:

Value	Meaning
FF-FF-FF-FF-FF-FF	Broadcast
CF-00-00-00-00-00	Loopback assistance

The following DIGITAL multicast addresses are assigned to be received by other DIGITAL nodes on the same Ethernet:

Value	Meaning
AB-00-00-01-00-00	Dump/load assistance
AB-00-00-02-00-00	Remote console
AB-00-00-03-00-00	Level 1 and Level 2 routers
AB-00-00-04-00-00	All end nodes
09-00-2B-02-00-00	Level 2 routers
AB-00-00-05-00-00 through AB-00-03-FF-FF-FF	Reserved for future use
AB-00-03-00-00-00	LAT
AB-00-04-00-00-00 through AB-00-04-00-FF-FF	For use by DIGITAL customers for their own applications
AB-00-04-01-00-00 through AB-00-04-01-FF-FF	Local area VAXcluster
AB-00-04-02-00-00 through AB-00-04-FF-FF-FF	Reserved for future use
09-00-2B-01-00-00	DIGITAL Bridge management
09-00-2B-01-00-01	DIGITAL Bridge hello multicast

6.1.3 IEEE 802 Support

The Ethernet/802 drivers support the following IEEE 802 features:

- IEEE 802.2 packet format and IEEE 802.3 packet format
- IEEE 802.2 Class I service including the UI, XID, and TEST commands and the XID and TEST responses

  (Class II service must be provided by the user.)
- Six-byte destination and source address fields

  The IEEE 802.3 Standard states that the size of the destination and source addresses may be two or six bytes, as decided by the manufacturer. DIGITAL's Ethernet/802 drivers and controllers do not support two-byte address fields.
- Physical layer identified as type 10BASE5 (10 megabits/second baseband medium with maximum segment length of 500 meters)

Contrary to the IEEE 802.2 standard, the Global DSAP (FF) must be enabled as a Group SAP in order to receive messages with the Global DSAP in the destination SAP field.

6.2 Packet Formats

DIGITAL's Ethernet/802 controllers can transmit and receive both Ethernet and 802.2/802.3 packets. Each channel on a controller is able to transmit and receive either Ethernet or 802 packets. Ethernet and 802 channels can be assigned on the same controller at the same time.

At the time each channel on the controller is started, one of three packet formats can be specified: Ethernet (default), standard 802 (referred to as 802 packet format), and extended 802. If no format is specified, the default format is used.

Each channel on the controller must be unique on that controller. For each packet format, there is a parameter that distinguishes the channel from all other channels with the same packet format. For Ethernet packet format channels, the 2-byte protocol type parameter defines the channel. For 802 packet format channels, the 1-byte SAP defines the channel. For extended 802 format channels, the 5-byte protocol identifier defines the channel.

Sections 6.2.1, 6.2.2, and 6.2.3 describe the three packet formats and characteristics unique to each format.

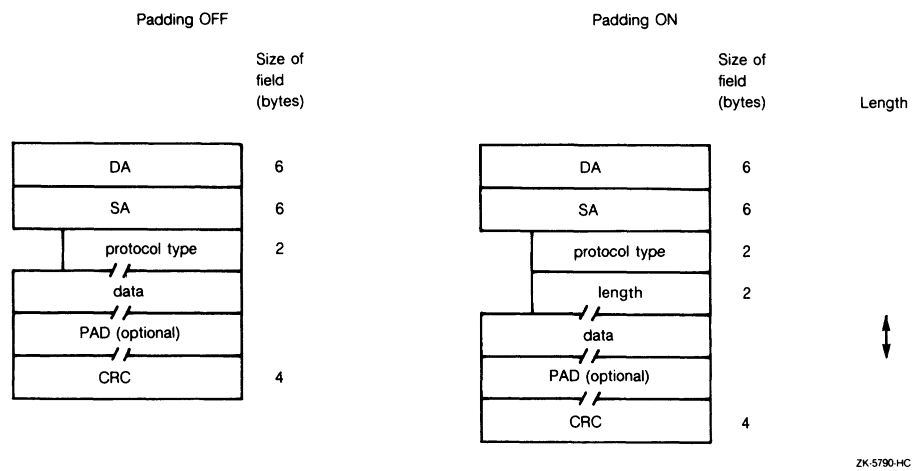
6.2.1 Ethernet Packet Format

The Ethernet packet format is determined by whether the channel has padding on or padding off. Ethernet packet padding is described in Section 6.2.1.2. Figure 6–2 shows the two formats.

The field definitions for the Ethernet packet are as follows:

- DA—Destination address
- SA—Source address
- Protocol type—16-bit protocol field
- LENGTH—Length of user data (excluding padding) when padding is on
- DATA—User-supplied data
- PAD—Sufficient padding to make the data, header, and CRC equal 64 bytes
- CRC—Cyclic Redundancy Check value

Figure 6–2 Ethernet Packet Format



6.2.1.1 Ethernet Protocol Types

Every Ethernet frame has a 2-byte protocol type field. This field is used to allow multiple users of Ethernet at a single station. Protocol types are independent of addresses; Xerox Corporation is also responsible for assigning unique protocol designations to interested parties. Whenever an Ethernet user at a particular station turns on an Ethernet channel, that user must specify the protocol type to be used on that channel. Messages sent over that channel always have the protocol type attached to them by the device driver, and messages received with that protocol type are delivered to the starter of that channel. DIGITAL's protocol types are in the ranges 60-00 through 60-09 and 80-38 through 80-42. Valid protocol types are in the range 05-DD through FF-FF.

Following is the cross-company protocol type:

Value	Meaning
90-00	Loopback assistance

DIGITAL's protocol types are as follows:

Value	Meaning
60-00	Reserved for DIGITAL
60-01	Dump/load assistance
60-02	Remote console
60-03	DECnet
60-04	LAT
60-05	Diagnostics
60-06	For use by DIGITAL customers for their own applications
60-07	Local area VAXcluster
60-08	Reserved for DIGITAL
60-09	Reserved for DIGITAL
80-38	DIGITAL Bridge
80-39 through 80-42	Reserved for DIGITAL

6.2.1.2 Ethernet Packet Padding

This section describes the PAD (padding) parameter (NMA$C_PCLI_PAD), which is used only in the Ethernet packet format.

All packets on the line must be at least 64 bytes in length. For Ethernet packets, this includes the Ethernet header, the user data, and the CRC. If the user data, CRC, and Ethernet header together are less than 64 bytes, null padding bytes are inserted between the user data and the CRC to make a 64-byte packet. This packet padding cannot be turned off.

The PAD parameter allows the Ethernet/802 drivers to place a packet-size field in the packet between the standard Ethernet header and the user data. If padding is on (NMA$C_STATE_ON is specified), the packet format is changed slightly, as shown in Figure 6–2.

If the PAD parameter is off (NMA$C_STATE_OFF is specified), Ethernet packets have the following characteristics:

- Packets transmitted are padded with null bytes as needed.
- Packets transmitted do not include the size field.
- The length of user data in the packets received is always between 46 and 1500 bytes. For example, if a 10-byte packet is transmitted, it is received as 46 bytes because the driver cannot determine the amount of user data in the packet—only the amount of user data plus padded null bytes.

If the PAD parameter is on (NMA$C_STATE_ON is specified), Ethernet packets have the following characteristics:

- Packets transmitted are padded with null bytes as needed.
- Packets transmitted include the size field.
- The length of user data in the packets received is always between 0 and 1498 bytes. The driver uses the size field to determine the amount of user data in the packet.

6.2.1.3 Protocol Type Sharing

Protocol types are usually nonshareable. The problems inherent in sharing a protocol type include the multiplexing and demultiplexing of messages to and from remote nodes, and the ability to change the characteristics of a protocol type. However, the protocol access parameter (NMA$C_PCLI_ACC) allows a protocol type to be opened in either of two shareable modes: shared-default (NMA$C_ACC_SHR) and shared-with-destination (NMA$C_ACC_LIM). The Ethernet/802 drivers also provide the nonshareable exclusive mode (NMA$C_ACC_EXC). (See Table 6–6.) The following paragraphs describe the rules and requirements for each mode:

- The exclusive mode is the default if no access mode is supplied as a P2 buffer parameter. This mode of operation does not allow the protocol to be shared by other users. Any attempt to start up another protocol of the same type results in an error status of SS$_BADPARAM.
- The shared-with-destination mode is a protocol type/destination address pairing that allows multiple users to share a protocol type and to communicate with a different node.

  For a given shared protocol type, there can be many "shared-with-destination" users; each user communicates with a different destination address. Any attempt to start up a channel with a destination address that is in use results in an error status of SS$_BADPARAM.

  When a "shared-with-destination" user passes the set mode P2 buffer, the buffer must contain a destination address in the NMA$C_PCLI_DES parameter. This destination address is used as the destination address in all messages transmitted, and the user receives messages only from this address.

  The "shared-with-destination" user is not allowed to enable multicast addresses. Any attempt to do so results in an error status of SS$_BADPARAM. A "shared-with-destination" user can only transmit to multicast addresses and the user's "shared-with-destination" address.
- The shared-default mode is the default user of a shared protocol type. There can be only one such user for each shared protocol type. It is not required that a "shared-default" user exist if a protocol type is shared, but there can be no more than one such user per shared protocol type.

  The "shared-default" user receives all messages for the shared protocol type, not for any of the "shared-with-destination" users. The "shared-default" user also receives all messages matching both the shared protocol type and any multicast address enabled by the "shared-default" user.

  The "shared-default" user can only transmit to multicast addresses and physical addresses that are not enabled by any of the "shared-with-destination" users sharing the same protocol type.

If there is no "shared-default" user of a protocol type, incoming messages from nodes not among the "shared-with-destination" users for that protocol type are ignored.

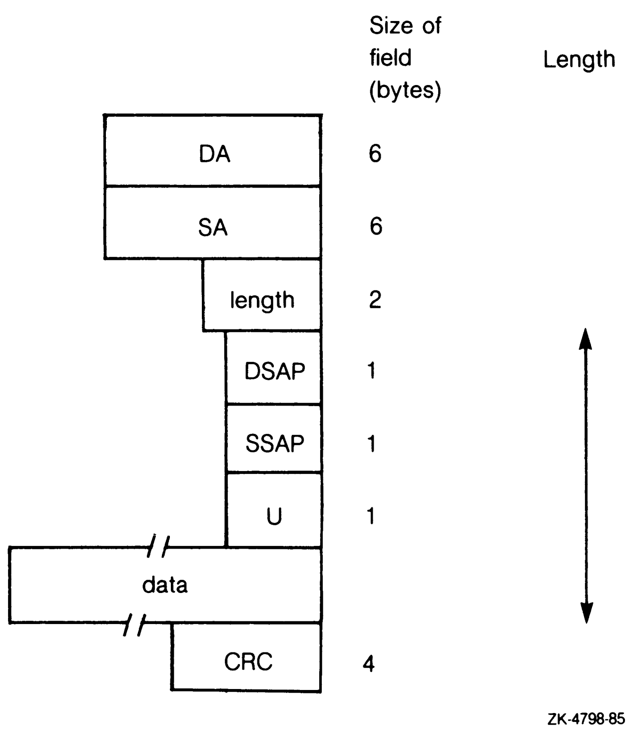
6.2.2 IEEE 802 Packet Format

The IEEE 802 packet formats accepted for a channel depend on the service enabled on that channel.

6.2.2.1 Class I Service Packet Format

For Class I service, only three packet formats are transmitted and received: UI, XID, and TEST. Figure 6–3 shows the format of these packets.

Figure 6–3 Class I Service Packet Format



The field definitions for the Class I service packet are as follows:

- DA—Destination address
- SA—Source address
- LENGTH—Length of the 802.3 frame (excluding padding)
- DSAP—Destination service access point (SAP)
- SSAP—Source SAP
- U—Unnumbered control field command/response

- DATA—User-supplied data plus padding
- CRC—Cyclic Redundancy Check value

The unnumbered control field (U), which is always one byte in length, is passed by the P4 argument of the write QIO and can be one of the following binary values:

- UI command (00000011)

  This is the unnumbered information command. It is the method used to transmit data from one user to another and is the most widely used control field value.

  The UI command can be specified by using NMA$C_CTLVL_UI.

- XID command (101p1111)

  This is the exchange identification command. It is used to convey information about the port. The "p" bit is the poll bit and may be either 0 or 1. This command can be specified by using NMA$C_CTLVL_XID for a "0" poll bit or NMA$C_CTLVL_XID_P for a "1" poll bit.

- XID response (101f1111)

  The XID response is a response to an XID command. The "f" bit is the final bit and will match the poll bit from the XID command.

- TEST command (111p0011)

  The TEST command is used to test a connection. The "p" bit is the poll bit and may be either 0 or 1. This command can be specified by using NMA$C_CTLVL_TEST for a "0" poll bit or NMA$C_CTLVL_TEST_P for a "1" poll bit.

- TEST response (111f0011)

  The TEST response is a response to a TEST command. The "f" bit is the final bit and will match the poll bit from the TEST command.

See the IEEE 802.2 standard for more information on these control field values and response messages.

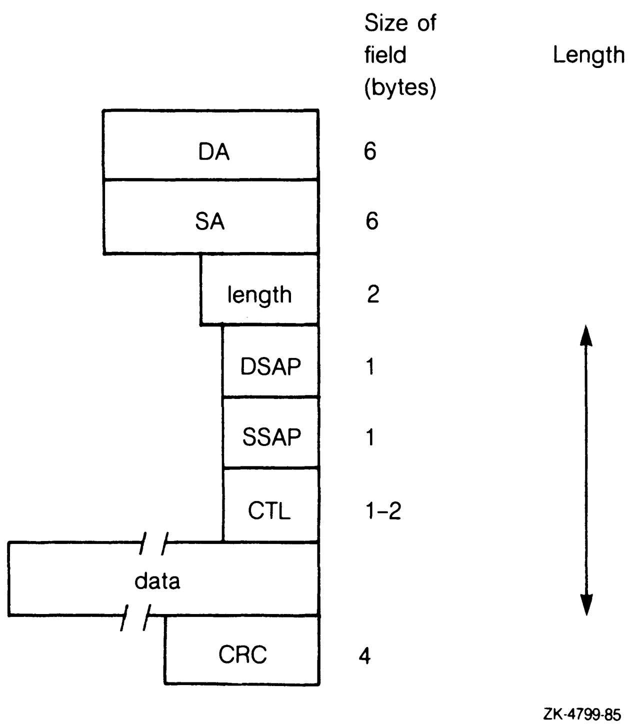
6.2.2.2 User-Supplied Service Packet Format

Figure 6–4 shows the packet format for user-supplied service.

The field definitions for the user-supplied service packet are as follows:

- DA—Destination address
- SA—Source address
- LENGTH—Length of the 802.3 frame (excluding padding)
- DSAP—Destination SAP
- SSAP—Source SAP
- CTL—Control field
- DATA—User-supplied data plus padding
- CRC—Cyclic Redundancy Check value

Figure 6–4 User-Supplied Service Packet Format

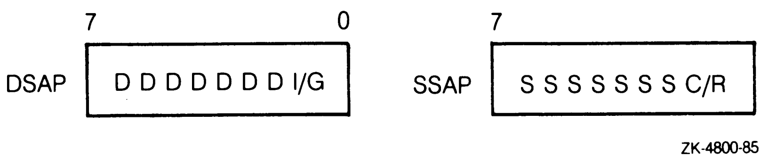


The user provides the control field values, which are documented in the IEEE 802.2 Standard. The user-supplied packet format is the generic packet format as specified in the IEEE 802.2 Standard. Class I packets (see Section 6.2.2.1) are a subset of this generic packet format. Therefore, if the control field value of the user-supplied packet is UI, XID, or TEST, the packet is the same as a Class I packet. Note that Class II packets, as defined in the IEEE 802.2 Standard, include the UI, XID, and TEST command/response formats.

6.2.2.3 Service Access Point (SAP) Use and Restrictions

The IEEE 802.2 Standard places restrictions on both user SAPs and SAPs used as source SAPs (SSAP). All SAPs are eight bits long. Figure 6–5 shows the format of DSAPs and SSAPs.

Figure 6–5 DSAP and SSAP Format



Definition of the least significant bit depends on whether the SAP is a source SAP (SSAP) or a destination SAP (DSAP). For a DSAP field, the least significant bit distinguishes group SAPs (bit 0 = 1) from individual SAPs (bit 0 = 0). For an SSAP field, the least significant bit distinguishes commands (bit 0 = 0) from responses (bit 0 = 1). Because these two bits are located at the same bit position within the SAP field, a group SAP cannot be used as an SSAP. If this were allowed, a group SAP would be interpreted as an individual SAP with the command/response bit set to 1, thus implying a response.

The IEEE 802.2 Standard reserves for its own definition all SAP addresses with the second least significant bit set to 1. It is suggested that you use these SAP values for their intended purposes, as defined in the IEEE 802.2 Standard.

Up to four group SAPs can be enabled on each 802 channel. The group SAPs enabled on a controller do not have to be unique for each channel; for example, two 802 format channels can have the same group SAP enabled. This allows a single packet coming into the controller to be duplicated and passed to each channel on the controller that has the group SAP enabled—assuming the packet has a DSAP value that is a group SAP. If the received packet has an individual SAP for a DSAP, the packet goes to at most one channel.

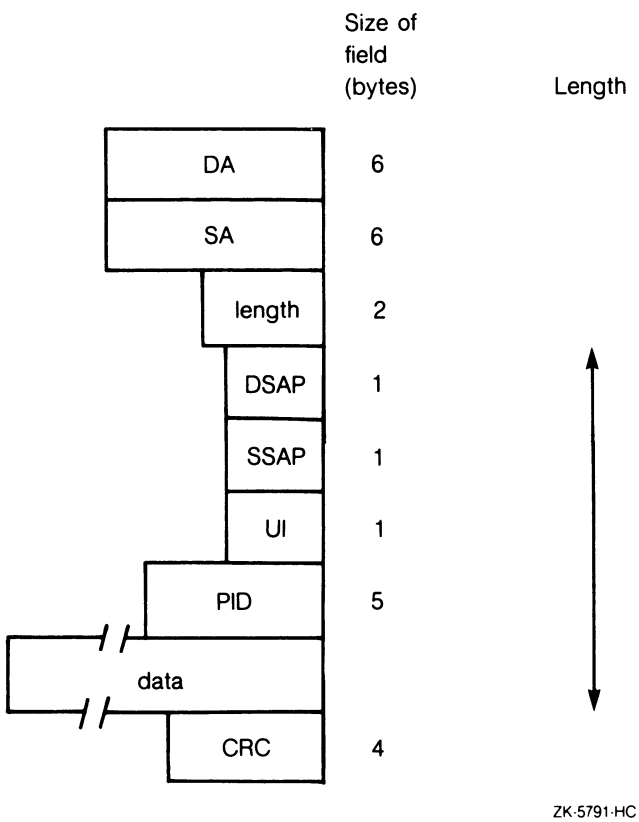
6.2.3 IEEE 802 Extended Packet Format

The 802 extended packet format is shown in Figure 6–6.

The field definitions for the 802 extended packet are as follows:

- DA—Destination address
- SA—Source address
- LENGTH—Length of the 802.3 frame (excluding padding)
- DSAP—Destination service access point (SAP) (always the SNAP SAP)
- SSAP—Source SAP (always the SNAP SAP)
- UI—Control field value is always unnumbered information

Figure 6–6 IEEE 802 Extended Packet Format



- PID—Channel's 5-byte protocol identifier
- DATA—User-supplied data plus padding
- CRC—Cyclic Redundancy Check value

The SNAP SAP value is a special SAP value reserved for 802 extended format packets. The SNAP SAP value distinguishes an 802 packet from an 802 extended packet. The only valid control field value for 802 extended packets is UI (unnumbered information).

6.3 Device Information

You can obtain information on controller characteristics by using the Get Device/Volume Information ($GETDVI) system service. (See the *VMS System Services Reference Manual.*)

$GETDVI returns controller characteristics when you specify the item code DVI$_DEVCHAR. Table 6–2 lists these characteristics, which are defined by the $DEVDEF macro.

Table 6–2 Ethernet Controller Device Characteristics

Characteristic	Meaning
	Static Bits (Always Set)
DEV$M_AVL	Device is available
DEV$M_IDV	Input device
DEV$M_NET	Network device
DEV$M_ODV	Output device

DVI$_DEVTYPE and DVI$_DEVCLASS return the device type and device class names, which are defined by the $DCDEF macro. The device type is DT$_DEUNA for the DEUNA, DT$_DEQNA for the DEQNA, DT$_XQ_DELQA for the DELQA, DT$_DELUA for the DELUA, DT$_ES_LANCE for the DESVA, and DT$_ET_DEBNA for the DEBNA. The device class for all Ethernet controllers is DC$_SCOM.

DVI$_DEVBUFSIZ returns the maximum message size. The maximum send or receive message size depends on the packet format and whether padding (NMA$C_PCLI_PAD) is enabled (see Sections 6.4.1 and 6.4.2).

DVI$_DEVDEPEND returns the unit and line status bits and the error summary bits in a longword field as shown in Figure 6–7.

Figure 6–7 DVI$_DEVDEPEND Returns

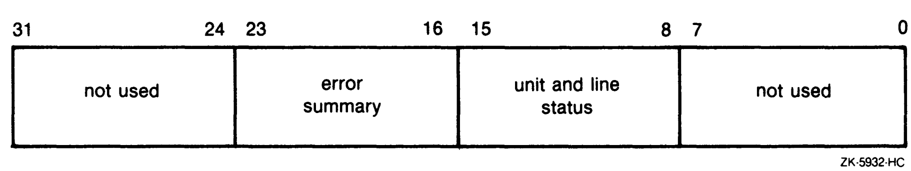


Table 6–3 lists the status values and their meanings. These values are defined by the $XMDEF macro. XM$M_STS_ACTIVE is set when the channel is started. XM$M_STS_BUFFAIL and XM$M_STS_TIMO are dynamically set and cleared by the Ethernet/802 driver.

Table 6–3 Ethernet Controller Unit and Line Status

Status	Meaning
XM$M_STS_ACTIVE	Channel is active.
XM$M_STS_BUFFAIL	Attempt to allocate a system receive buffer failed.
XM$M_STS_TIMO	Timeout occurred.

The error summary bits are set when an error occurs. They are read-only bits. If an error is fatal, the Ethernet port is shut down. Table 6–4 lists the error summary bit values and their meanings.

Table 6–4 Error Summary Bits

Error Summary Bit	Meaning
XM$M_ERR_FATAL	Hardware or software error occurred on controller port.

6.4 Ethernet/802 Function Codes

The Ethernet/802 drivers can perform logical, virtual, and physical I/O operations. The basic functions are read, write, set mode, set characteristics, sense mode, and sense characteristics. Table 6–5 lists these functions and their codes. The following sections describe these functions in greater detail.

Table 6–5 Ethernet/802 I/O Functions

Function Code and Arguments	Type[1]	Function Modifiers	Function
IO$_READLBLK P1,P2,-[P5]	L	IO$M_NOW	Read logical block.
IO$_READVBLK P1,P2,-[P5]	V	IO$M_NOW	Read virtual block.
IO$_READPBLK P1,P2,-[P5]	P	IO$M_NOW	Read physical block.
IO$_WRITELBLK P1,P2,-[P4],P5	L	IO$M_RESPONSE	Write logical block.
IO$_WRITEVBLK P1,P2,-[P4],P5	V	IO$M_RESPONSE	Write virtual block.
IO$_WRITEPBLK P1,P2,-[P4],P5	P	IO$M_RESPONSE	Write physical block.
IO$_SETMODE P1,[P2],-P3[2]	L	IO$M_CTRL IO$M_STARTUP IO$M_SHUTDOWN IO$M_ATTNAST	Set controller characteristics and controller state for subsequent operations.
IO$_SETCHAR P1,[P2],-P3[2]	P	IO$M_CTRL IO$M_STARTUP IO$M_SHUTDOWN IO$M_ATTNAST	Set controller characteristics and controller state for subsequent operations.
IO$_SENSEMODE [P1],-[P2]	L	IO$M_CTRL	Sense controller characteristics and return them in specified buffers.

[1]V = virtual, L = logical, P = physical (There is no functional difference in these operations.)

[2]The P1 and P3 arguments are only for attention AST QIOs.

Table 6–5 (Cont.) Ethernet/802 I/O Functions

Function Code and Arguments	Type[1]	Function Modifiers	Function
IO$_SENSECHAR [P1],-[P2]	P	IO$M_CTRL	Sense controller characteristics and return them in specified buffers.

[1]V = virtual, L = logical, P = physical (There is no functional difference in these operations.)

Although the Ethernet/802 device drivers do not differentiate among logical, virtual, and physical I/O functions (all are treated identically), you must have the required privilege to issue the request. (Logical I/O functions require no I/O privilege.)

6.4.1 Read

Read functions provide for the direct transfer of data from another port on the Ethernet into the user process's virtual memory address space. The VMS operating system provides the following function codes:

- IO$_READLBLK—Read logical block
- IO$_READVBLK—Read virtual block
- IO$_READPBLK—Read physical block

Received messages are multibuffered in system-dynamic memory and then copied to the user's buffer when a read operation is performed.

The read functions take the following device- or function-dependent arguments:

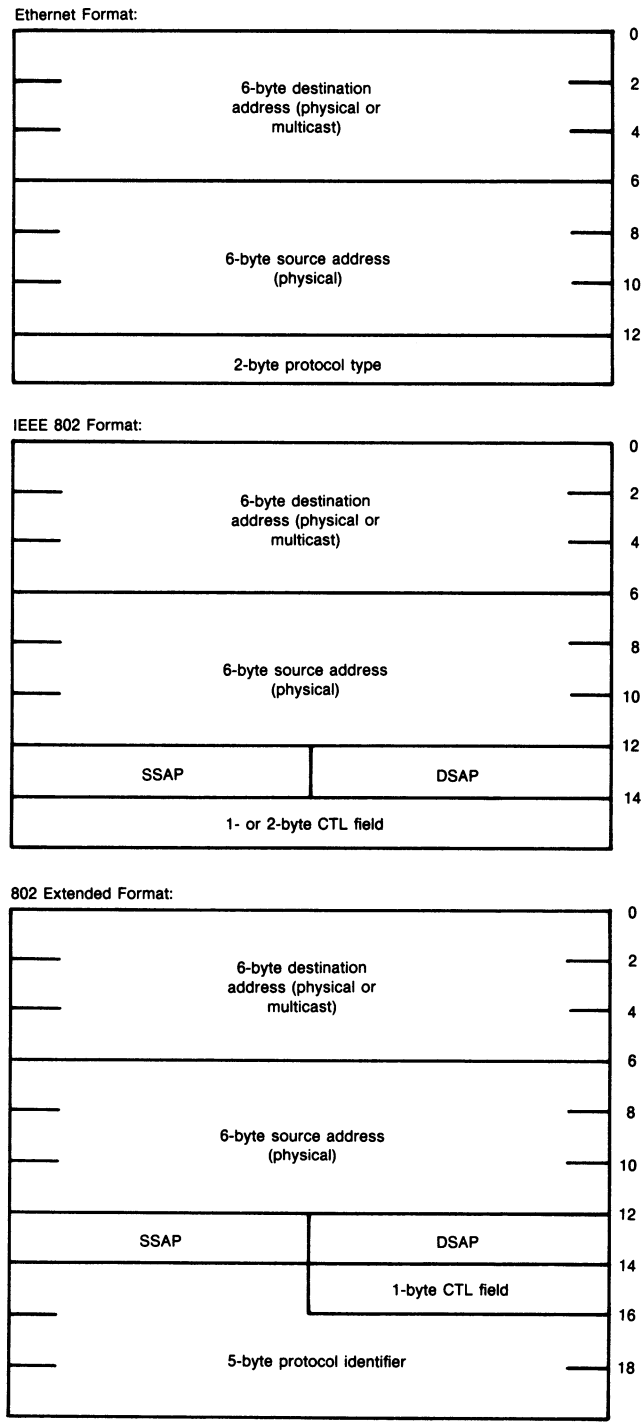
- P1—The starting virtual address of the buffer that is to receive data.
- P2—The size of the receive buffer in bytes.
- P5—The address of a buffer where the Ethernet/802 driver returns packet header information. This is an optional parameter. The information returned depends on the packet format enabled with the set mode QIO. The size of the buffer must be 14 bytes for an Ethernet format packet, 16 bytes for an IEEE 802 format packet, and 20 bytes for an 802 extended format packet. Note that the information returned is not the entire packet header but the header information less any length or size fields. The IOSB, if specified, is where the packet length information is returned.

  If promiscuous mode (NMA$C_PCLI_PRM; see Table 6–6) is enabled, the P5 buffer must be 20 bytes.

  Figure 6–8 shows the format of the three buffers.

The P1 and P2 arguments must always be specified; the P5 argument is optional. However, if P5 is not specified, you will be unable to determine the source of the received message.

Figure 6–8 Read Function P5 Buffer



If the size of the user data in a receive message is larger than the value of the NMA$C_PCLI_BUS parameter, the message is not given to the user, even if there is sufficient space in the user's receive buffer.

If the size of the user data in a receive message is larger than the size specified in P2 (and less than or equal to the value of the NMA$C_PCLI_BUS parameter), the P1 buffer is filled and SS$_DATAOVERUN is returned in the I/O status block.

The following user data sizes are the maximum that can be received:

Ethernet format without padding - 1500 bytes
Ethernet format with padding - 1498 bytes
802 format with a 1-byte CTL field - 1497 bytes
802 format with a 2-byte CTL field - 1496 bytes
802 extended format - 1492 bytes

For 802 format packets, the P5 buffer always contains the DSAP and SSAP in the bytes at offset 12 and 13. The next one or two bytes (offsets 14 and 15) following the SSAP contain the control field value. For Class I service, the control field value is always one byte in length and will always be placed in the byte at offset 14 of this buffer. For user-supplied service, you have to determine the length of the control field value according to the IEEE 802.2 Standard.

The read functions can take the following function modifier:

- IO$M_NOW—Complete the read operation immediately with a received message (if no message is currently available, return a status of SS$_ENDOFFILE in the I/O status block).

6.4.2 Write

Write functions provide for the direct transfer of data from the user process's virtual memory address space to another port on the Ethernet. The VMS operating system provides the following function codes:

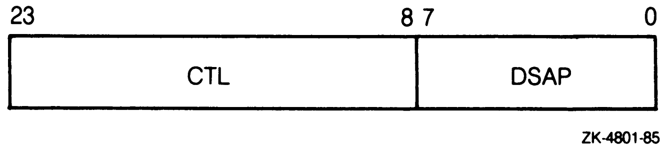
- IO$_WRITELBLK—Write logical block
- IO$_WRITEVBLK—Write virtual block
- IO$_WRITEPBLK—Write physical block

Transmitted messages are copied from the requesting process's buffer to a system buffer for transmission.

The write function takes the following device- or function-dependent arguments:

- P1—The starting virtual address of the buffer containing the data to be transmitted.
- P2—The size of the buffer in bytes.
- P4—The address of a quadword descriptor that points to a buffer that contains the DSAP and CTL field values (optional). (See Section 6.2.2.3.) The first longword of the descriptor is the buffer length; the second

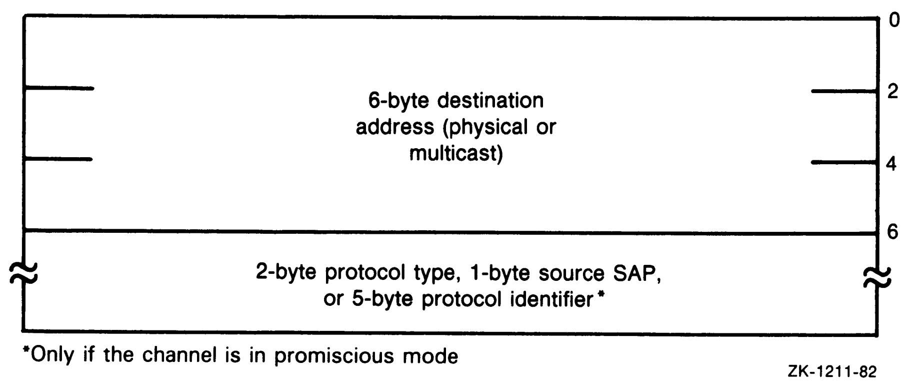
longword is the address of the buffer. This argument is used only for channels with the 802 packet format. The format of the buffer is:



- P5—The address of a six-byte buffer that contains the destination address (either physical or multicast).

  If the device is in promiscuous mode (NMA$C_PCLI_PRM; see Table 6–6), you must pass a larger buffer with additional information positioned after the destination address. For Ethernet packet format, the buffer must be 8 bytes with the 2-byte protocol type following the destination address. For 802 packet format, the buffer must be 7 bytes with the 1-byte source SAP following the destination address. For 802 extended packet format, the buffer must be 11 bytes with the 5-byte protocol identifier following the destination address. The individual Source SAP cannot be a group SAP or the SNAP SAP. Figure 6–9 shows the format of the P5 buffer.

Figure 6–9 Write Function P5 Buffer



The maximum message sizes specified by P2 are as follows:

Ethernet format without padding - 1500 bytes
Ethernet format with padding - 1498 bytes
802 format with a 1-byte CTL field - 1497 bytes
802 format with a 2-byte CTL field - 1496 bytes
802 extended format - 1492 bytes

If P2 specifies a message size larger than that allowed, the I/O status block returns the status SS$_IVBUFLEN.

If the P4 buffer is specified, it must be at least three bytes long. The first byte is always the DSAP; the next two bytes are used to determine the CTL field value. The DSAP value cannot be the SNAP SAP.

The CTL field value is either a one-byte or two-byte value. If the two least significant bits of the low-order byte of the CTL field contain the bit values 11, just the low order byte of the CTL field is used as the CTL field value. Otherwise, both bytes of the CTL field are used as the CTL field value.

Even if the driver only uses the low-order byte of the CTL field, you still must pass at least a three-byte buffer. In this case, the driver uses the low-order byte of the CTL field and ignores the high-order byte.

If Class I service is enabled, only one-byte CTL field values can be passed. If user-supplied service is enabled, then both one- and two-byte CTL field values are valid. If Class I service is enabled, the CTL field value must be one of the three command values: UI, XID, or TEST.

You can receive packets for the SAP enabled with the IO$_SETMODE or IO$_SETCHAR QIOs and can transmit packets destined for a different SAP. This would be similar to an Ethernet channel receiving packets for one protocol type and transmitting packets with a different protocol type (which is not possible with the current Ethernet $QIO interface). It is expected that most 802 format applications will only want to process receive packets from a source SAP that matches the SAP enabled on their channel. To do this, the read function (see Section 6.4.1) has been enhanced to return the source SAP to you. To verify that the source SAP of an incoming packet matches the SAP enabled on the channel, you need only match the source SAP returned by the read function with the SAP enabled on the channel.

The write functions can take the following function modifier:

- IO$M_RESPONSE—Transmit a response packet (sets the low-order bit in the SSAP field). Allows users with user-supplied service enabled to respond to certain 802 format command packets. IO$M_RESPONSE can only be specified when you have the 802 packet format enabled. 802 packet format channels with Class I service enabled result in an error if you attempt to transmit a response message with a CTL field value of UI.

6.4.3 Set Mode and Set Characteristics

Set mode operations are used to perform mode, operational, and program/driver interface operations with the controller. The VMS operating system defines the following types of set mode functions:

- Start up Ethernet port or set controller mode
- Enable attention AST
- Shut down Ethernet port

The set mode functions perform controller operations, such as starting a controller port and requesting an attention AST, which are described in the sections that follow. The VMS operating system provides the following function codes:

- IO$_SETMODE—Set mode (no I/O privilege required)
- IO$_SETCHAR—Set characteristics (requires physical I/O privilege)

6.4.3.1 Set Controller Mode

The set controller mode function sets the Ethernet/802 controller state and characteristics, and activates the controller port. The following combinations of function code and modifier are provided:

- IO$_SETMODE!IO$M_CTRL—Set controller characteristics
- IO$_SETCHAR!IO$M_CTRL—Set controller characteristics
- IO$_SETMODE!IO$M_CTRL!IO$M_STARTUP—Set controller characteristics and start the controller port
- IO$_SETCHAR!IO$M_CTRL!IO$M_STARTUP—Set controller characteristics and start the controller port

If the function modifier IO$M_STARTUP is specified, the Ethernet/802 port is started. If IO$M_STARTUP is not specified, the specified characteristics are simply modified.

This function takes the following device- or function-dependent argument:

- P2—The address of a quadword descriptor for an extended characteristics buffer. The first longword of the descriptor is the buffer length; the second longword is the address of the buffer. The P2 argument is optional.

The P2 buffer consists of a series of six-byte or counted string entries. The first word of each entry contains the parameter identifier (ID) followed by either a longword that contains one of the (binary) values that can be associated with the parameter ID or a counted string. Counted strings consist of a word that contains the size of the character string followed by the character string. Figure 6–10 shows the format for this buffer.

Figure 6–10 P2 Extended Characteristics Buffer

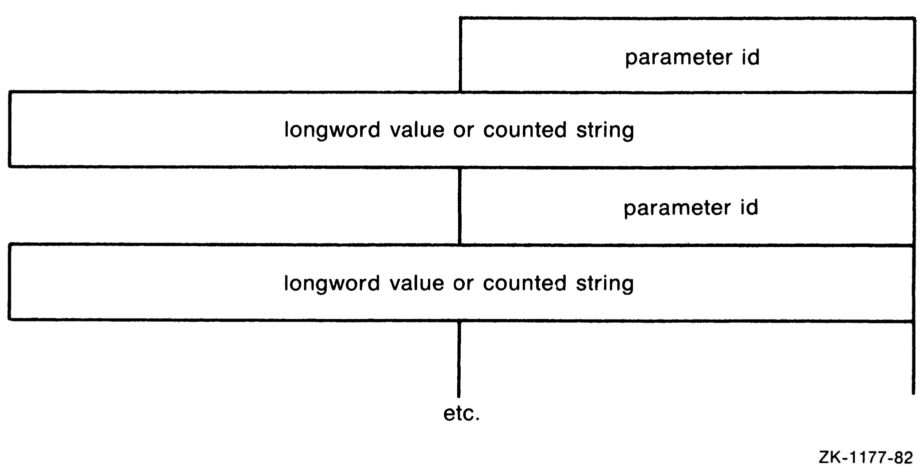


Table 6–6 is an alphabetic listing of the parameter IDs and values that can be specified in the P2 buffer. These parameter IDs are applicable to all Ethernet/802 controllers, except where otherwise noted. The $NMADEF macro defines these values. The $NMADEF macro is included in the macro library SYS$LIBRARY:LIB.MLB. (Table 6–7 lists the parameters that can be used with each of the packet formats, and indicates which are required, which are optional, and which generate the SS$_BADPARAM error.)

If the status SS$_BADPARAM is returned in the first word of the I/O status block, the second longword contains the parameter ID of the parameter in error.

Table 6–6 P2 Extended Characteristics Values

Parameter ID	Meaning
NMA$C_PCLI_ACC	Protocol access mode. This optional parameter determines the access mode for the protocol type. NMA$C_PCLI_ACC is valid only for channels using Ethernet packet format. One of the following values can be specified: NMA$C_ACC_EXC — Exclusive mode (default) NMA$C_ACC_SHR — Shared-default user mode NMA$C_ACC_LIM — Shared-with-destination mode Section 6.2.1.3 provides a description of protocol type sharing. NMA$C_PCLI_ACC is passed as a longword value.
NMA$C_PCLI_BFN	Number of receive buffers to preallocate (default = 1). This optional parameter is specified on a per-port basis. NMA$C_PCLI_BFN is passed as a longword value. NMA$C_PCLI_BFN represents the number of receive messages the Ethernet/802 driver will hold for a channel when the channel has no read QIOs posted to the driver.
NMA$C_PCLI_BSZ	Device buffer size. This optional parameter is used by the first user of the device to set the hardware buffer size. If the device is already running, this parameter is not used to set the hardware buffer size. Normally, the buffer size should not be changed from the default value (1500). The NMA$C_PCLI_BSZ parameter affects all users of the controller. It is passed as a longword value.

Table 6–6 (Cont.) P2 Extended Characteristics Values

Parameter ID	Meaning
NMA$C_PCLI_BUS	Maximum allowable channel receive buffer size, that is, message length (default = 512 bytes). This optional parameter is specified on a per-port basis. It is passed as a longword value. Any message received for this port that is larger than this parameter value is not used to complete a read QIO. If data chaining (NMA$C_PCLI_DCH) is OFF for this port, this value cannot be larger than the device buffer size being used by the device. If data chaining is ON for this port, this value cannot be larger than twice the device buffer size being used by the device.
NMA$C_PCLI_CON[1]	Controller mode. This optional parameter determines whether transmit packets are to be looped back at the controller. One of the following values can be specified: NMA$C_LINCN_NOR — Normal mode (default) NMA$C_LINCN_LOO — Loopback mode The only messages looped back are those acceptable to the controller as receive messages, that is, those messages that possess at least one of the following characteristics: • Matching physical address (see Section 6.1.2) • Matching multicast address (see Section 6.1.2) • Promiscuous mode (NMA$C_PCLI_PRM) is in the ON state • Destination address is a multicast address and all multicasts are enabled (NMA$C_PCLI_MLT is in the ON state) NMA$C_PCLI_CON affects all channels on a single controller. It is passed as a longword value.

[1]If the Ethernet/802 controller is active and you do not specify this parameter, the parameter defaults to the current setting. If the Ethernet/802 controller is not active, this parameter defaults to the default value indicated.

Table 6–6 (Cont.) P2 Extended Characteristics Values

Parameter ID	Meaning
	For the DELUA, DEBNA, and DESVA, the following list shows the maximum amount of user data that can be looped: Ethernet format without padding–18 bytes Ethernet format with padding–16 bytes 802 format with 1-byte CTL field–15 bytes 802 format with 2-byte CTL field–14 bytes 802 extended format–10 bytes When the DEUNA is in loopback mode the driver always enables echo mode (NMA$C_PCLI_EKO is in the ON state).
NMA$C_PCLI_CRC[1]	CRC generation state for transmitted messages (optional). One of the following values can be specified: NMA$C_STATE_ON — Controller generates a CRC (default). NMA$C_STATE_OFF — Controller does not generate a CRC. NMA$C_PCLI_CRC affects all channels on a single controller. There is no effect on checking a receive message's CRC (it is always checked). NMA$C_PCLI_CRC is passed as a longword value. If NMA$C_PCLI_CRC is turned off, all users of the controller must supply the 4-byte CRC value for all messages transmitted. The CRC is passed at the end of the P1 transmit buffer; the additional 4 bytes are included in the size of the P1 buffer. The CRC value is not checked for correctness. For the DEQNA and the DELQA, the NMA$C_PCLI_CRC parameter cannot be turned off.

[1]If the Ethernet/802 controller is active and you do not specify this parameter, the parameter defaults to the current setting. If the Ethernet/802 controller is not active, this parameter defaults to the default value indicated.

Table 6–6 (Cont.) P2 Extended Characteristics Values

Parameter ID	Meaning
NMA$C_PCLI_DCH	Data chaining state (optional). One of the following values can be specified: NMA$C_STATE_ON — Allows data chaining on received messages NMA$C_STATE_OFF — Does not allow data chaining (default) NMA$C_PCLI_DCH affects single channels on a single controller. It is passed as a longword value. Data chaining allows the driver to receive packets in more than one receive buffer, but only if the receive buffer size is less than the maximum size. If the NMA$C_PCLI_BSZ parameter is left at its default value of 1500, there is no reason to enable data chaining. The user process is never aware that a data chaining operation was required in the driver.
NMA$C_PCLI_DES	Shared protocol destination address. Passed as a counted string that consists of a modifier word (NMA$C_LINMC_SET or NMA$C_LINMC_CLR) followed by a 6-byte (48-bit) physical destination address. The size of the counted string must always be 8. NMA$C_PCLI_DES only has meaning when protocol access (NMA$C_PCLI_ACC) is defined as shared-with-destination mode (NMA$C_ACC_LIM). The destination address specified must be a physical address—not a multicast address—and it must be unique among all channels sharing the same protocol type. NMA$C_PCLI_DES is required when the access mode is defined as "shared-with-destination." NMA$C_PCLI_DES should not be specified on a channel where the 802 or 802E packet format is selected (NMA$C_PCLI_FMT is set to NMA$C_LINFM_802 or NMA$C_LINFM_802E). For 802 packet format the concept of shared protocol type is handled by using group SAPs. Section 6.2.1.3 provides a description of protocol type sharing.

Table 6–6 (Cont.) P2 Extended Characteristics Values

Parameter ID	Meaning
NMA$C_PCLI_EKO[1]	Echo mode. Applicable only to the DEUNA device driver. If echo mode is on, transmitted messages are returned to the sender. This optional parameter controls the condition of the half-duplex bit in the DEUNA mode register. One of the following values can be specified: NMA$C_STATE_ON — Echoes transmit messages NMA$C_STATE_OFF — Does not echo transmit messages (default) If NMA$C_STATE_ON is specified, the only transmitted messages echoed are those acceptable to the DEUNA as receive messages, that is, those messages that have at least one of the following characteristics: • Matching physical address (see Section 6.1.2) • Matching multicast address (see Section 6.1.2) • Promiscuous mode (NMA$C_PCLI_PRM) is in the ON state • Destination address is a multicast address and all multicasts are enabled (NMA$C_PCLI_MLT is in the ON state) If the DEUNA is placed in loopback mode (NMA$C_LINCN_LOO is specified in the NMA$C_PCLI_CON parameter), the driver enables echo mode. NMA$C_PCLI_EKO affects all channels on a single controller. It is passed as a longword value.
NMA$C_PCLI_FMT	Packet format. This optional parameter specifies the packet format as either Ethernet, IEEE 802, or 802 extended. This characteristic is passed as a longword value and affects single channels on a single controller. One of the following values can be specified: NMA$C_LINFM_ETH — Ethernet packet format (default) NMA$C_LINFM_802 — 802 packet format NMA$C_LINFM_802E — 802 extended packet format

[1]If the Ethernet/802 controller is active and you do not specify this parameter, the parameter defaults to the current setting. If the Ethernet/802 controller is not active, this parameter defaults to the default value indicated.

Table 6–6 (Cont.) P2 Extended Characteristics Values

Parameter ID	Meaning
	NMAC_PCLI_PTY, NMAC_PCLI_ACC, and NMA$C_PCLI_DES should only be specified on those channels where the Ethernet packet format (NMA$C_LINFM_ETH) is selected. NMAC_PCLI_SRV, NMAC_PCLI_SAP, and NMA$C_PCLI_GSP should only be specified on those channels where the 802 packet format (NMA$C_LINFM_802) is selected. NMA$C_PCLI_PID should only be specified on those channels where the 802 extended packet format (NMA$C_LINFM_802E) is selected.
NMA$C_PCLI_GSP	Group SAP. This is an optional parameter if the 802 packet format is selected (NMA$C_PCLI_FMT is set to NMA$C_LINFM_802). If the Ethernet or 802 extended packet format is selected, NMA$C_PCLI_GSP cannot be specified. Group SAPs can be shared among multiple channels on the same controller. If the 802 packet format is selected, NMA$C_PCLI_GSP defines up to four 802 group SAPs that are to be enabled for matching incoming packets to complete read operations on this channel. By default, no group SAPs are enabled. NMA$C_PCLI_GSP is passed as a longword value and is read as four 8-bit unsigned integers. Each integer must be either a group SAP or zero. To enable a single group SAP on a channel, you need only specify the group SAP value to be enabled in one of the four integers and place a value of zero in the three remaining integers. To disable group SAPs on the channel, you need only place a value of zero in all four integers. If this characteristic is correctly specified, any group SAPs that were previously enabled on the channel are now replaced by the SAPs specified by the current IO$_SETMODE or IO$_SETCHAR function.
NMA$C_PCLI_ILP[1]	Internal loopback mode. This optional parameter places the DELUA, DEBNA, or DESVA in internal loopback mode (not for the DEUNA, DEQNA, or DELQA devices). One of the following values can be specified: NMA$C_STATE_ON — Internal loopback mode NMA$C_STATE_OFF — Not in internal loopback mode (default)

[1]If the Ethernet/802 controller is active and you do not specify this parameter, the parameter defaults to the current setting. If the Ethernet/802 controller is not active, this parameter defaults to the default value indicated.

Table 6–6 (Cont.) P2 Extended Characteristics Values

Parameter ID	Meaning
	If NMA$C_STATE_ON is specified, the NMA$C_PCLI_CON parameter must be in loopback (NMA$C_LINCN_LOO) mode. When the controller is in loopback mode (generally for testing), it can loop packets in external loopback or internal loopback. This parameter places the controller in one of these loopback modes. NMA$C_PCLI_ILP is passed as a longword value and affects all channels on the controller.
NMA$C_PCLI_MCA	Multicast address (optional). Passed as a counted string that consists of a modifier word followed by a list of 6-byte (48-bit) multicast addresses. The value specified in the modifier word determines whether the addresses are set or cleared. If NMA$C_LINMC_CAL is specified, all multicast addresses in the list are ignored. The following mode values can be specified in the low byte of the modifier word: NMA$C_LINMC_SET — Set the multicast addresses. NMA$C_LINMC_CLR — Clear the multicast addresses. NMA$C_LINMC_CAL — Clear all multicast addresses. The driver filters all multicast addresses on a per-channel basis. Therefore, only messages received with the controller's physical address or the multicast addresses enabled on the channel are used to complete the user's read operations. Note that the DEUNA, DELUA, DEQNA, and DELQA devices support a limited number of multicast addresses. If this limit is exceeded, the Ethernet driver enables the "accept all multicast" feature on the controller and all multicast packets on the Ethernet must be filtered by the Ethernet driver. This may cause a minor performance loss. NMA$C_PCLI_MCA is specified on a per-channel basis.

Table 6–6 (Cont.) P2 Extended Characteristics Values

Parameter ID	Meaning
NMA$C_PCLI_MLT	Multicast address state. This optional parameter instructs the controller hardware whether to accept all multicast addresses. One of the following values can be specified: NMA$C_STATE_ON — Accept all multicast addresses. NMA$C_STATE_OFF — Do not accept all multicast addresses (default). NMA$C_PCLI_MLT can be enabled on more than one channel. It only affects those channels on which it is enabled. NMA$C_PCLI_MLT allows you to receive all multicast address packets that also match the channel's protocol type, SAP, or protocol identifier. Generally, you enable only your individual set of multicast addresses using the NMA$C_PCLI_MCA parameter, and leave the NMA$C_PCLI_MLT parameter in the off state. There could be a minor performance loss when the NMA$C_PCLI_MLT parameter is in the ON state because the Ethernet/802 driver has to process all multicast addresses on the Ethernet line; the number of multicast addresses on the line determines the amount of processing required. The NMA$C_PCLI_MLT parameter is passed as a longword value.
NMA$C_PCLI_PAD	Use message size field on transmit and receive messages (optional). One of the following values can be specified: NMA$C_STATE_ON — Insert message size field (default) NMA$C_STATE_OFF — No size field

Table 6–6 (Cont.) P2 Extended Characteristics Values

Parameter ID	Meaning
	NMA$C_PCLI_PAD affects only the protocol type that issued the set mode request. It is passed as a longword value. If padding is enabled on Ethernet format packets, the driver adds a 2-byte count field to the transmitted data. This allows short packets (packets fewer than 46 bytes long) to be received with the proper length returned by the driver. The minimum Ethernet packet is 46 bytes of user data. If fewer than 46 bytes were sent, the hardware would pad the data and the receiver would always receive packets greater than 45 bytes. When padding is enabled, the maximum message size for transmit or receive operations is 1498 bytes. See Section 6.2.1.2 for additional information. NMA$C_PCLI_PAD should be specified only on a channel where the Ethernet packet format is selected (NMA$C_PCLI_FMT is set to NMA$C_LINFM_ETH). Note that NMA$C_PCLI_PAD is not the padding described in the *DEUNA User's Guide*.
NMA$C_PCLI_PHA[1]	Physical port address (optional). It is passed as a counted string that consists of a modifier word followed by the 48-bit physical address. If the request is to clear the physical port address or to set the physical port address to the DECnet default address, the physical address (if present) is not read. One of the following mode values can be specified in the low byte of the modifier word: NMA$C_LINMC_SET — Set the string value. NMA$C_LINMC_CLR — Clear the physical address. NMA$C_LINMC_SDF — Set the physical port address to the DECnet default address. The DECnet default address is constructed by appending the low-order word of the SYSGEN parameter SCSSYSTEMID to the constant DECnet header (AA-00-04-00). If SCSSYSTEMID is zero, and NMA$C_LINMC_SDF is specified, NMA$C_PCLI_PHA is ignored. The default is the current address set by a previous set mode function on this controller, or the hardware address if no address was defined by a previous set mode function.

[1]If the Ethernet/802 controller is active and you do not specify this parameter, the parameter defaults to the current setting. If the Ethernet/802 controller is not active, this parameter defaults to the default value indicated.

Table 6–6 (Cont.) P2 Extended Characteristics Values

Parameter ID	Meaning
	The physical address must be passed as a 6-byte (48-bit) quantity. The first byte is the least significant byte. A return value of -1 on a sense mode request implies that a physical address is not defined. The NMA$C_PCLI_PHA parameter affects all protocol types on a single controller.
NMA$C_PCLI_PID	Protocol identifier. This parameter is required for, and valid only on, channels that use 802 extended format packets. NMA$C_PCLI_PID is passed as a counted 5-byte string, which is the unique protocol identifier required for each 802 extended format user. All protocol idientifiers specified on a controller must be unique on that controller. Therefore, the protocol identifier specified using the NMA$C_PCLI_PID parameter will be checked for uniqueness on the controller.
NMA$C_PCLI_PRM	Promiscuous mode (optional). One of the following values can be specified: NMA$C_STATE_ON — Promiscuous mode enabled NMA$C_STATE_OFF — Promiscuous mode disabled (default) Only one channel on each controller can be active with promiscuous mode enabled. Enabling promiscuous mode requires PHY_IO privilege. The NMA$C_PCLI_PRM parameter is passed as a longword value. DIGITAL does not recommend promiscuous mode for normal usage. See Section 6.6.1 for additional information.
NMA$C_PCLI_PTY	Protocol type. This value is read as a 16-bit unsigned integer and must be different from other protocol types running on the same controller except when the protocol type is being shared. For Ethernet format channels, this required parameter is specified on a per-UCB basis; there is a UCB associated with every protocol type. Valid protocol types are in the range 05-DD through FF-FF. NMA$C_PCLI_PTY should only be specified on a channel where the Ethernet packet format is selected (NMA$C_PCLI_FMT is set to NMA$C_LINFM_ETH). NMA$C_PCLI_PTY is passed as a longword value. However, only the low-order word is used.

Table 6–6 (Cont.) P2 Extended Characteristics Values

Parameter ID	Meaning
NMA$C_PCLI_RES	Restart. This optional parameter allows the user to enable the automatic channel restart feature of the Ethernet drivers. One of the following values can be specified: NMA$C_LINRES_DIS — Disable automatic restart (default) NMA$C_LINRES_ENA — Enable automatic restart The VMS Ethernet drivers shut down all users of a controller if there is a fatal error on the controller or if the Ethernet driver determines that the controller has stopped functioning. All outstanding I/O operations on the Ethernet driver are completed with either an SS$_ABORT or SS$_TIMEOUT status. All channels that have the NMA$C_PCLI_RES parameter enabled (set to NMA$C_LINRES_ENA) have the channel automatically restarted by the Ethernet driver approximately 3 seconds after it has been shut down due to a fatal error. If the user issues read or write QIOs to the channel during the time the channel is shut down, the Ethernet driver completes the QIOs with an SS$_OPINCOMPL status. All channels that have the automatic restart feature disabled must be restarted by the application program when the channel is shut down by the Ethernet driver. The application program must wait approximately 5 seconds to allow the Ethernet driver to stabilize. Note that it is unusual to have fatal errors on an Ethernet controller or to have an Ethernet driver detect that an Ethernet controller has stopped functioning. Having the ability to automatically restart a user's channel makes the program easier to design because the program does not have to take into account the possibility of the Ethernet driver shutting down the channel permanently.
NMA$C_PCLI_SAP	802 format SAP. This parameter is required if the 802 packet format is selected (NMA$C_PCLI_FMT is set to NMA$C_LINFM_802). NMA$C_PCLI_SAP defines an 802 SAP and is read as an eight-bit unsigned integer. The least significant bit of the SAP must be zero and the SAP cannot be the NULL SAP (all eight bits equal zero) or the SNAP SAP.

Table 6–6 (Cont.) P2 Extended Characteristics Values

Parameter ID	Meaning
	NMA$C_PCLI_SAP is passed as a longword value. However, only the low-order byte is used. The SAP specified by NMA$C_PCLI_SAP is the SAP used to match incoming packets to complete read requests. It is used as the source SAP (SSAP) in all transmissions (write QIOs). Because it is illegal to transmit using a group SAP as the source SAP, the SAP specified by this NMA$C_PCLI_SAP cannot be a group SAP. NMA$C_PCLI_GSP describes how to set up group SAPs on a channel. All individual SAPs specified on a controller must be unique on that controller. Therefore, the SAP specified using the NMA$C_PCLI_SAP parameter is checked for uniqueness on the controller. The Ethernet concept of a shared protocol type is accomplished on an 802 channel by setting up a group SAP on the channels that need to share a SAP. Group SAPs can be shared among multiple channels on the same controller.
NMA$C_PCLI_SRV	Channel service. This optional parameter specifies the service supplied by the driver for the channel. It can only be specified if the 802 packet format is selected (NMA$C_PCLI_FMT is set to NMA$C_LINFM_802). This characteristic is passed as a longword value. One of the following values can be specified: NMA$C_LINSR_USR — User-supplied service (default) NMA$C_LINSR_CLI — Class I service See Section 6.2.2.1 for a description of Class I service and Section 6.2.2.2 for a description of user-supplied service.

6.4.3.2 Set Mode Parameters for Packet Formats

Table 6–7 summarizes the use of the set mode parameters for the Ethernet, 802, and 802 extended (802E) packet formats.

Table 6–7 Set Mode Parameters for Packet Formats

Parameter ID	Ethernet	IEEE 802	802E
FMT	DEF	REQ	REQ
PTY	REQ	E	E
SAP	E	REQ	E
PID	E	E	REQ
ACC	OPT	E	E
DES	OPT	E	E
PAD	OPT	E	E
SRV	E	OPT	E
GSP	E	OPT	E
BFN,BSZ, BUS,CON, CRC,DCH, EKO,ILP, MCA,MLT, PHA,PRM, RES	OPT	OPT	OPT

Legend:

DEF—Default. If not specified, this is the default parameter for this packet format.
REQ—Required. This parameter must be specified for this packet format.
OPT—Optional. This parameter is optional for this packet format; it may be specified.
E—Error. This parameter cannot be specified for this packet format. If the parameter is specified, it generates an SS$_BADPARAM error.

6.4.3.3 Set Mode Parameter Validation

When starting an Ethernet/802 channel, the Ethernet/802 driver checks that the mode of the new channel is compatible with the mode of the Ethernet/802 channels started previously. There are two sets of compatibility checks: one for channels running in shared mode and one for all channels.

The following parameters must match for all channels on the same controller:

NMA$C_PCLI_CON
NMA$C_PCLI_CRC
NMA$C_PCLI_EKO
NMA$C_PCLI_ILP
NMA$C_PCLI_PHA

The following parameters must match for all "shared-default" and "shared-with-destination" users of the same protocol type:

NMA$C_PCLI_BFN
NMA$C_PCLI_BUS
NMA$C_PCLI_DCH
NMA$C_PCLI_MLT
NMA$C_PCLI_PAD
NMA$C_PCLI_PTY
NMA$C_PCLI_RES

Once a channel is started, only the following parameters can be changed:

NMA$C_PCLI_GSP
NMA$C_PCLI_MCA

6.4.3.4 Shutdown Controller

The shutdown controller function shuts down the Ethernet port. On completion of a shutdown request all buffers are returned. This port cannot be used again until another startup request has been issued (see Section 6.4.3.1).

The following combinations of function code and modifier are provided:

- IO$_SETMODE!IO$M_CTRL!IO$M_SHUTDOWN—Shut down port
- IO$_SETCHAR!IO$M_CTRL!IO$M_SHUTDOWN—Shut down port

The shutdown controller function takes no device- or function-dependent arguments.

The driver aborts all pending I/O requests for the port on receipt of the shutdown controller request.

6.4.3.5 Enable Attention AST

This function requests that an attention AST be delivered to the requesting process when a status change occurs on the assigned channel. An AST is queued when a message is available and there is no waiting read request. The enable attention AST function is legal at any time, regardless of the condition of the unit status bits.

The following combinations of function code and modifier are provided:

- IO$_SETMODE!IO$M_ATTNAST—Enable attention AST
- IO$_SETCHAR!IO$M_ATTNAST—Enable attention AST

This function takes the following device- or function-dependent arguments:

- P1—The address of an AST service routine or 0 for disable
- P2—Ignored
- P3—Access mode to deliver AST

The enable attention AST function enables an attention AST to be delivered to the requesting process once only. After the AST occurs, it must be explicitly reenabled by the function before the AST can occur again. The function is subject to AST quotas.

The AST service routine is called with an argument list. The first argument is the current value of the second longword of the I/O status block (see Section 6.5). The access mode specified by P3 is maximized with the requester's access block.

6.4.4 Sense Mode and Sense Characteristics

The sense mode function returns the controller and channel characteristics in the specified buffers. These characteristics include the device characteristics described in Section 6.3 and, with the exceptions noted below, the extended characteristics listed in Table 6–6.

The following combinations of function code and modifier are provided:

- IO$_SENSEMODE!IO$M_CTRL—Read characteristics
- IO$_SENSECHAR!IO$M_CTRL—Read characteristics

These functions take the following device- or function-dependent arguments:

- P1—The address of a two-longword buffer where the device characteristics are stored. (Figure 6–11 shows the format for, and Section 6.3 describes the contents of, the P1 buffer.) The P1 argument is optional.
- P2—The address of a quadword descriptor where the extended characteristics buffer is stored. The first longword of the descriptor is the buffer length; the second longword is the address of the buffer. The P2 argument is optional.

  The P2 buffer is not read by the Ethernet/802 driver. The driver stores the channel's parameters in the buffer, which contains multiple entries. The format of each entry depends on whether a longword or a counted string is returned, as shown in Figure 6–12. The parameter ID for the buffer contains a string indicator bit (bit 12) that describes whether the data item is a string or a longword.

Except for the following differences, P2 returns the same extended characteristics as those listed in Table 6–6:

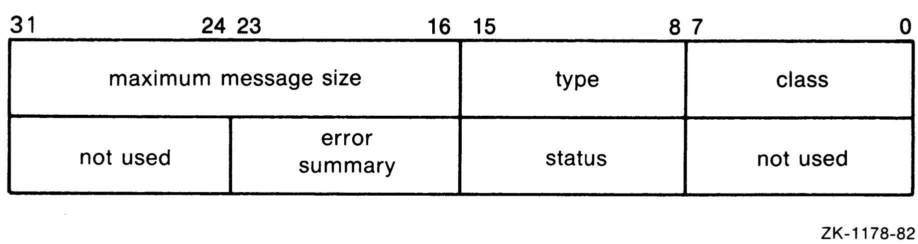
- All parameters that are valid for the enabled packet format are returned (see Table 6–7).
- The sense-mode P2 buffer does not return the modifier word for the NMAC_PCLI_PHA, NMAC_PCLI_MCA, and NMA$C_PCLI_DES parameter IDs.

- The NMA$C_PCLI_DES parameter is only returned on Ethernet channels whose access mode is set to "shared with destination."
- In addition to the parameter IDs listed in Table 6–6, the sense-mode P2 buffer returns the following parameter IDs:

Parameter ID	Meaning
NMA$C_PCLI_HWA	Hardware address. Describes the value for the hardware address. The hardware address is the default physical address when no physical address has been specified and there are no active users on the controller. NMA$C_PCLI_HWA is returned in the same format as NMA$C_PCLI_PHA.
NMA$C_PCLI_MBS	Maximum buffer size. Describes the maximum size buffer that can be transmitted or received on the channel, based on the channel's current parameter values. The following list shows the possible values that can be returned:

NMA$C_PCLI_FMT Value	NMA$C_PCLI_MBS Value
NMA$C_LINFM_ETH (padding is OFF)	1500
NMA$C_LINFM_ETH (padding is ON)	1498
NMA$C_LINFM_802	1497
NMA$C_LINFM_802E	1492

Figure 6–11 Sense Mode P1 Characteristics Buffer

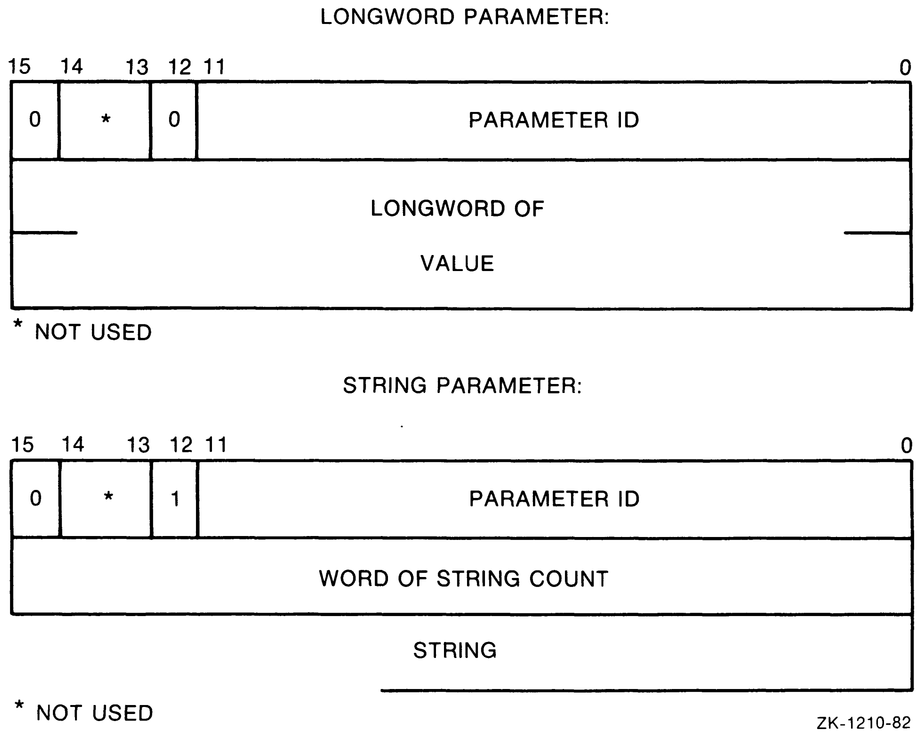


Currently, the minimum size that should be used for the P2 buffer is 130 bytes. This assumes that no multicast addresses are enabled. If multicast addresses are enabled, add 6 bytes for each multicast address.

Note: The minimum size of the P2 buffer might change with the addition of new functionality.

All characteristics that fit into the buffer specified by P2 are returned. However, if all the characteristics cannot be stored in the buffer, the I/O status block returns the status SS$_BUFFEROVF. The second word of the I/O status block returns the size (in bytes) of the extended characteristics buffer returned by P2 (see Section 6.5).

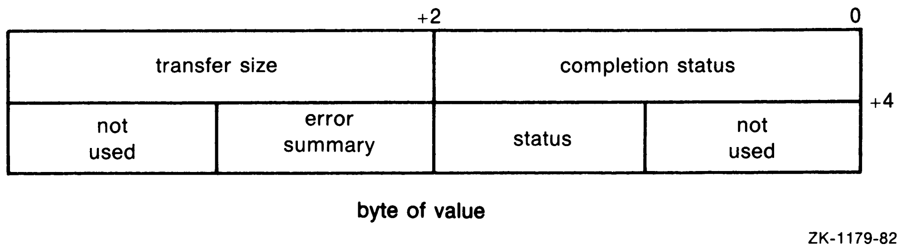
Figure 6–12 Sense Mode P2 Extended Characteristics Buffer



6.5 I/O Status Block

The I/O status block (IOSB) for all Ethernet/802 driver functions is shown in Figure 6–13. Appendix A lists the completion status returns for these functions. (The *VMS System Messages and Recovery Procedures Reference Volume* provides explanations and suggested user actions for these returns.)

Figure 6–13 IOSB Contents



The first longword of the IOSB returns, in addition to the completion status, either the size (in bytes) of the data transfer or the size (in bytes) of the extended characteristics buffer (P2) returned by a sense mode function. The second longword returns the unit and line status bits listed in Table 6–3 and the error summary bits listed in Table 6–4.

6.6 Application Programming Notes

This section contains information to assist you in writing application programs that use the Ethernet/802 device drivers. Section 6.6.1 discusses the additional rules required for application programs that you intend to run in promiscuous mode. Sections 6.6.2 and 6.6.3 provide Ethernet and 802 sample programs.

6.6.1 Promiscuous Mode

The Ethernet/802 drivers allow only one channel per controller to start with promiscuous mode enabled (NMA$C_PCLI_PRM specified as NMA$C_STATE_ON). Any channel running in promiscuous mode usually places an additional load on the CPU because the Ethernet/802 driver processes every packet on the Ethernet line for the promiscuous user. If there is no promiscuous channel on a controller, the controller performs most of the filtering required for the packets on the Ethernet line.

Table 6–8 details additional rules for channels running in promiscuous mode.

Table 6–8 Rules for Promiscuous Mode Operation

I/O Function	Rule
IO$_SETMODE IO$_SETCHAR	It is not necessary to specify a unique identifier (a protocol type, SAP, or protocol identifier parameter ID) in the P2 buffer. The channel cannot be running in shared mode.
IO$_WRITE	The user can only transmit packets in the packet format previously enabled with a set mode QIO. The unique identifier for the packet format must be included in the P5 buffer following the destination address (see Section 6.4.2).
IO$_READ	The Ethernet/802 driver completes the promiscuous user's read requests with Ethernet, IEEE 802, and 802 extended packets. Because any packet format can be used to complete a read request, the P5 parameter (if specified) must be 20 bytes in length. All Ethernet format packets are processed as if they have no size word specified after the protocol type. Therefore, Ethernet packets are always returned with 46 to 1500 bytes of data. If the Ethernet packet contains a size word, it is returned as part of the user data in the first word of the P1 buffer. The promiscuous user should use the information returned in the P5 buffer to determine the packet format. If the application program first filled the P5 buffer with zeros, the program should be able to determine the format of the packet received by scanning the P5 buffer after a read request is completed.

6.6.2 Ethernet Programming Example

The following sample program (Example 6–1) shows the typical use of QIO functions in driver operations such as establishing the protocol type, starting the channel, and transmitting and receiving data. This program does not illustrate DECnet operations because it is intended to show only basic QIO functions. The program sends a LOOPBACK packet and waits for the packet to be looped back.

Example 6–1 Ethernet Program Example

```
        .TITLE  EXAMPLE         ETHERNET SAMPLE TEST PROGRAM
        .IDENT  /X01/

; This Ethernet test program will send a LOOPBACK message to another system
; and wait for a response.  Since LOOPBACK forwarding is handled by the
; controller or the driver at the other node, you should always get a response
; as long as the other node exists.
;
; Note that this test will try to use the device defined by the logical
; ETH as the Ethernet device.  If this does not work, then it will try
; to use one of the currently known Ethernet devices.  To use a device
; other than one of XEA0, XQA0, ESA0, or ETA0, define ETH to be the
; device you would like to run this test on.
;
; Note that if you have service enabled on a DECnet circuit enabled on the
; Ethernet controller you wish to test, this program will get a fatal error
; when trying to start its channel.  This is expected because DECnet will
; start its own channel for the LOOPBACK protocol.

        .LIBRARY        "SYS$LIBRARY:LIB.MLB"

        $IODEF                          ; Define I/O functions and modifiers
        $NMADEF                         ; Define Network Management parameters

; Local definitions

        RCVBUFLEN = 512                 ; Size of receive buffer
        XMTBUFLEN = 20                  ; Size of transmit buffer

; Setmode parameter buffer.  For Ethernet, you are required to state only the
; unique protocol type value.  However, you will also state the packet format.
; Since the LOOPBACK protocol does not include a LENGTH word following the
; protocol type, you have to explicitly turn OFF padding since the default is
; ON.

SETPARM:
        .WORD   NMA$C_PCLI_FMT          ; Packet format
                .LONG   NMA$C_LINFM_ETH
        .WORD   NMA$C_PCLI_PTY          ; Our Protocol type
                .LONG   ^X0090
        .WORD   NMA$C_PCLI_PAD          ; Padding
                .LONG   NMA$C_STATE_OFF

        SETPARMLEN = .-SETPARM

SETPARMDSC:
        .LONG           SETPARMLEN
        .ADDRESS        SETPARM

; Sensemode parameter buffer.  This will be used to get our node's physical
; address to put into the loopback message.

SENSEBUF:
        .BLKB   150

SENSELEN=.-SENSEBUF
SENSEDSC:
        .LONG           SENSELEN
        .ADDRESS        SENSEBUF

; P2 transmit data buffer
```

Example 6–1 Cont'd. on next page

Example 6–1 (Cont.) Ethernet Program Example

```
XMTBUF:
        .WORD   00                          ; Skip count
        .WORD   02                          ; Forward request
FORW:   .BLKB   6                           ; You will put our address here
        .WORD   01                          ; Reply request
        .WORD   00

XMTBUFLEN = .-XMTBUF

; P5 transmit destination address
;
; Set this value to be a node on your Ethernet that supports LOOPBACK.

XMTP5:
        .BYTE   ^XAA,^X00,^X04,^X00,^X6F,^X4C

; P2 receive data buffer

RCVBUF:
        .BLKB   RCVBUFLEN

; P5 receive header buffer

RCVP5:
RCVDA:  .BLKB   6
RCVSA:  .BLKB   6
RCVPTY: .BLKB   2

; Messages used to display status of this program.

GMSG:   .ASCID  "Successful test"
BMSG:   .ASCID  "Received packet was not what was expected"
LMSG:   .ASCID  "Packet lost or node not responding"
EMSG:   .ASCID  "Error occurred while running test"
DMSG:   .ASCID  "No Ethernet device found - please define ETH correctly"

; Miscellaneous data structures

TRY:    .WORD   0                           ; Number of times you have tried
                                            ; the READ QIO (start at 0)
IOSB:   .BLKQ   1                           ; I/O status block
ETHDSC1:.ASCID  'ETH'                       ; Units to use for test
ETHDSC2:.ASCID  'ESA0'
ETHDSC3:.ASCID  'XQA0'
ETHDSC4:.ASCID  'ETA0'
ETHDSC5:.ASCID  'XEA0'
ETHCHAN:.BLKL   1                           ; Returned Ethernet channel number

;**********************************************************************
;
; Start of code
;
;**********************************************************************

        .ENTRY  START,^M<>

; Assign a channel to the Ethernet device.  If ETH does not work, try each
; of the currently known Ethernet devices.
```

Example 6–1 Cont'd. on next page

Example 6–1 (Cont.) Ethernet Program Example

```
ASSIGN1:
        $ASSIGN_S DEVNAM=ETHDSC1,CHAN=ETHCHAN
        BLBS    RO,ASSIGN_OK1
        CMPW    RO,#SS$_NOSUCHDEV
        BNEQ    ASSIGN_ERROR

ASSIGN2:
        $ASSIGN_S DEVNAM=ETHDSC2,CHAN=ETHCHAN
        BLBS    RO,ASSIGN_OK1
        CMPW    RO,#SS$_NOSUCHDEV
        BEQL    ASSIGN3

ASSIGN_ERROR:
        BRW     ERROR
ASSIGN_OK1:
        BRW     ASSIGN_OK

ASSIGN3:
        $ASSIGN_S DEVNAM=ETHDSC3,CHAN=ETHCHAN
        BLBS    RO,ASSIGN_OK
        CMPW    RO,#SS$_NOSUCHDEV
        BNEQ    ASSIGN_ERROR

ASSIGN4:
        $ASSIGN_S DEVNAM=ETHDSC4,CHAN=ETHCHAN
        BLBS    RO,ASSIGN_OK
        CMPW    RO,#SS$_NOSUCHDEV
        BNEQ    ASSIGN_ERROR

ASSIGN5:
        $ASSIGN_S DEVNAM=ETHDSC5,CHAN=ETHCHAN
        BLBS    RO,ASSIGN_OK
        CMPW    RO,#SS$_NOSUCHDEV
        BNEQ    ASSIGN_ERROR

; You could not find an Ethernet device to assign a channel to.

        PUSHAB  DMSG
        BRW     EXIT

ASSIGN_OK:

; Set up the channel's characteristics.

        $QIOW_S FUNC=#<IO$_SETMODE!IO$M_CTRL!IO$M_STARTUP>,-
                CHAN=ETHCHAN,IOSB=IOSB,-
                P2=#SETPARMDSC
        BLBS    RO,STARTUP_REQ_OK
        BRW     ERROR

STARTUP_REQ_OK:

        MOVZWL  IOSB,RO
        BLBS    RO,STARTUP_IO_OK
        BRW     ERROR

STARTUP_IO_OK:

; Now issue the SENSEMODE QIO so that you can get our physical address and
; put it in the LOOPBACK message you are about to transmit.
```

Example 6–1 Cont'd. on next page

Example 6–1 (Cont.) Ethernet Program Example

```
        $QIOW_S FUNC=#<IO$_SENSEMODE!IO$M_CTRL>,-
                CHAN=ETHCHAN,IOSB=IOSB,-
                P2=#SENSEDSC
        BLBS    R0,SENSE_REQ_OK
        BRW     ERROR

SENSE_REQ_OK:

        MOVZWL  IOSB,R0
        BLBS    R0,SENSE_IO_OK
        BRW     ERROR

SENSE_IO_OK:

; Now you have to locate the PHA parameter in the SENSEMODE buffer and copy
; it into our LOOPBACK transmit message.  You will scan the return buffer
; for a string parameter.  If you find a string parameter, you will check if
; it's the PHA parameter.

        MOVAB   SENSEBUF,R0             ; Start at beginning of buffer

10$:    BBS     #^XC,(R0),20$           ; If this is a string parameter,
                                        ; goto 20$

; Skip over the longword parameter.

        ADDL    #6,R0                   ; Skip 2-byte type and 4-byte value
        BRB     10$                     ; Check next parameter

; This is a string parameter.  Check if it's the PHA parameter.

20$:    BICW    #^XF000,(R0)            ; Clear flag bits in type field
        CMPW    #NMA$C_PCLI_PHA,(R0)    ; Is this the PHA parameter?
        BEQL    30$                     ; If EQL, yes

; Skip over this string parameter.

        ADDL    #2,R0                   ; Skip 2-byte type
        MOVZWL  (R0)+,R1                ; Convert string size to longword
                                        ; and skip it
        ADDL    R1,R0                   ; Skip string
        BRB     10$                     ; Check next parameter

; You have located the PHA parameter.  Move it into the LOOPBACK transmit
; buffer.

30$:    MOVL    4(R0),FORW              ; Move 1st four bytes
        MOVW    8(R0),FORW+4            ; Move last two bytes

; Now transmit our TEST message.

        $QIOW_S FUNC=#IO$_WRITEVBLK,CHAN=ETHCHAN,IOSB=IOSB,-
                P1=XMTBUF,P2=#XMTBUFLEN,P5=#XMTP5
        BLBS    R0,XMIT_REQ_OK
        BRW     ERROR

XMIT_REQ_OK:

        MOVZWL  IOSB,R0
        BLBS    R0,XMIT_IO_OK
        BRW     ERROR
```

Example 6–1 Cont'd. on next page

Example 6–1 (Cont.) Ethernet Program Example

```
XMIT_IO_OK:

; Now try to receive the response.  You will use the NOW function modifier
; on the READ so that you don't hang here waiting forever if there is no
; response.  You will attempt to receive the message 1000 times.  If there
; is no response by then, you will declare the response lost.

RECV:
        $QIOW_S FUNC=#IO$_READVBLK!IO$M_NOW,CHAN=ETHCHAN,IOSB=IOSB,-
                P1=RCVBUF,P2=#RCVBUFLEN,P5=#RCVP5
        BLBS    RO,RECV_REQ_OK
        BRW     ERROR

RECV_REQ_OK:

        MOVZWL  IOSB,RO
        BLBS    RO,RECV_IO_OK
        CMPW    RO,#SS$_ENDOFFILE         ; Was there just no message available?
        BEQL    10$                       ; Branch if so to try again
        IRW    ERROR

; If you are able to post 1000 reads and not receive the response packet, then
; you will assume the packet is lost.

10$:    CMPW    TRY,#1000                 ; Have you tried enough?
        BGTR    LOST                      ; If GTR, yes, so message is lost
        INCW    TRY                       ; Try again
        BRB     RECV

RECV_IO_OK:

; You received a message.  Check that the Source Address matches the place we
; sent the message.

        CMPL    XMTP5,RCVSA
        BNEQ    RECV_BAD
        CMPW    XMTP5+4,RCVSA+4
        BEQL    RECV_OK

; There was something wrong with the message received.

RECV_BAD:
        PUSHAB  BMSG
        BRB     EXIT

; The test went fine.  Print a success message.

RECV_OK:
        PUSHAB  GMSG
        BRB     EXIT

; You lost the message.  Print a message stating so.

LOST:
        PUSHAB  LMSG
        BRB     EXIT

; There was an error while running the test.  Print a message stating so.

ERROR:
        PUSHAB  EMSG
        BRB     EXIT
```

Example 6–1 Cont'd. on next page

Example 6–1 (Cont.) Ethernet Program Example

```
; The test is done.  You will call LIB$PUT_OUTPUT to display the status of
; this test.  The message that will be displayed has its descriptor on the
; stack.  That descriptor will be used by the LIB$PUT_OUTPUT routine.

EXIT:
        CALLS   #1,G^LIB$PUT_OUTPUT
        $EXIT_S

        .END    START
```

6.6.3 IEEE 802 Programming Example

The following sample program (Example 6–2) shows how to initialize an IEEE 802 channel and how to send and receive packets on that channel. This program sends a TEST packet and waits for the TEST response.

Example 6–2 IEEE 802 Programming Example

```
        .TITLE  EXAMPLE                 802 SAMPLE TEST PROGRAM
        .IDENT  /X01/

; This 802 test program will send a TEST message to another system and
; wait for a response.  Since you will be sending the message to the
; MAC Sublayer on the other node, you should always get a response as
; long as the other node exists.
;
; Note that this test will try to use the device defined by the logical
; ETH as the Ethernet device.  If this does not work, then it will try
; to use one of the currently known Ethernet devices.  To use a device
; other than one of XEAO, XQAO, ESAO, or ETAO, define ETH to be the
; device you would like to run this test on.

        .LIBRARY        "SYS$LIBRARY:LIB.MLB"

        $IODEF                          ; Define I/O functions and modifiers
        $NMADEF                         ; Define Network Management parameters

; Local definitions

        RCVBUFLEN = 512                 ; Size of receive buffer
        XMTBUFLEN = 20                  ; Size of transmit buffer

; Setmode parameter buffer.  For 802, you are required to state the packet
; format and our unique SAP value.

SETPARM:
        .WORD   NMA$C_PCLI_FMT          ; Packet format
                .LONG   NMA$C_LINFM_802
        .WORD   NMA$C_PCLI_SAP          ; Our individual SAP address
                .LONG   2

        SETPARMLEN = .-SETPARM

SETPARMDSC:
        .LONG           SETPARMLEN
        .ADDRESS        SETPARM

; P2 transmit data buffer
```

Example 6–2 Cont'd. on next page

Example 6–2 (Cont.) IEEE 802 Programming Example

```
XMTBUF:
        .BYTE   00,01,02,03,04,05,06,07,08,09
        .BYTE   10,11,12,13,14,15,16,17,18,19

; P4 transmit DSAP and CTL field values

XMTP4:
        .BYTE   0                       ; DSAP for transmit is the MAC
                                        ; Sublayer SAP (zero)
        .WORD   NMA$C_CTLVL_TEST        ; The CTL field value is TEST

; P4 transmit descriptor

XMTP4DSC:
        .LONG           3               ; P4 is always 3 bytes in size
        .ADDRESS        XMTP4           ; Address of buffer

; P5 transmit destination address
;
; Set this value to be a node on your Ethernet that supports 802 packet
; format.

XMTP5:
        .BYTE   ^XAA,^X00,^X04,^X00,^X6F,^X4C

; P2 receive data buffer

RCVBUF:
        .BLKB   RCVBUFLEN

; P5 receive header buffer

RCVP5:
RCVDA:  .BLKB   6
RCVSA:  .BLKB   6
RCVDSAP:.BLKB   1
RCVSSAP:.BLKB   1
RCVCTL: .BLKB   2

; Messages used to display status of this program.

GMSG:   .ASCID  "Successful test"
BMSG:   .ASCID  "Received packet was not what was expected"
LMSG:   .ASCID  "Packet lost or node not responding"
EMSG:   .ASCID  "Error occurred while running test"
DMSG:   .ASCID  "No Ethernet device found - please define ETH correctly"

; Miscellaneous data structures

TRY:    .WORD   0                       ; Number of times you have tried
                                        ; the READ QIO (start at 0)
IOSB:   .BLKQ   1                       ; I/O status block
ETHDSC1:.ASCID  'ETH'                   ; Units to use for test
ETHDSC2:.ASCID  'ESA0'
ETHDSC3:.ASCID  'XQA0'
ETHDSC4:.ASCID  'ETA0'
ETHDSC5:.ASCID  'XEA0'
ETHCHAN:.BLKL   1                       ; Returned Ethernet channel number
```

Example 6–2 Cont'd. on next page

Example 6–2 (Cont.) IEEE 802 Programming Example

```
;************************************************************************
;
; Start of code
;
;************************************************************************

        .ENTRY  START,^M<>

; Assign a channel to the Ethernet device.  If ETH does not work, try each
; of the currently known Ethernet devices.

ASSIGN1:
        $ASSIGN_S DEVNAM=ETHDSC1,CHAN=ETHCHAN
        BLBS    RO,ASSIGN_OK1
        CMPW    RO,#SS$_NOSUCHDEV
        BNEQ    ASSIGN_ERROR

ASSIGN2:
        $ASSIGN_S DEVNAM=ETHDSC2,CHAN=ETHCHAN
        BLBS    RO,ASSIGN_OK1
        CMPW    RO,#SS$_NOSUCHDEV
        BEQL    ASSIGN3

ASSIGN_ERROR:
        BRW     ERROR
ASSIGN_OK1:
        BRW     ASSIGN_OK

ASSIGN3:
        $ASSIGN_S DEVNAM=ETHDSC3,CHAN=ETHCHAN
        BLBS    RO,ASSIGN_OK
        CMPW    RO,#SS$_NOSUCHDEV
        BNEQ    ASSIGN_ERROR

ASSIGN4:
        $ASSIGN_S DEVNAM=ETHDSC4,CHAN=ETHCHAN
        BLBS    RO,ASSIGN_OK
        CMPW    RO,#SS$_NOSUCHDEV
        BNEQ    ASSIGN_ERROR

ASSIGN5:
        $ASSIGN_S DEVNAM=ETHDSC5,CHAN=ETHCHAN
        BLBS    RO,ASSIGN_OK
        CMPW    RO,#SS$_NOSUCHDEV
        BNEQ    ASSIGN_ERROR

; You could not find an Ethernet device to assign a channel to.

        PUSHAB  DMSG
        BRW     EXIT

ASSIGN_OK:

; Set up the channel's characteristics.

        $QIOW_S FUNC=#<IO$_SETMODE!IO$M_CTRL!IO$M_STARTUP>,-
                CHAN=ETHCHAN,IOSB=IOSB,-
                P2=#SETPARMDSC
        BLBS    RO,STARTUP_REQ_OK
        BRW     ERROR

STARTUP_REQ_OK:
```

Example 6–2 Cont'd. on next page

Example 6–2 (Cont.) IEEE 802 Programming Example

```
        MOVZWL  IOSB,R0
        BLBS    R0,STARTUP_IO_OK
        BRW     ERROR

STARTUP_IO_OK:

; Now transmit our TEST message.

        $QIOW_S FUNC=#IO$_WRITEVBLK,CHAN=ETHCHAN,IOSB=IOSB,-
                P1=XMTBUF,P2=#XMTBUFLEN,P4=#XMTP4DSC,P5=#XMTP5
        BLBS    R0,XMIT_REQ_OK
        BRW     ERROR

XMIT_REQ_OK:

        MOVZWL  IOSB,R0
        BLBS    R0,XMIT_IO_OK
        BRW     ERROR

XMIT_IO_OK:

; Now try to receive the response.  You will use the NOW function modifier
; on the READ so that you don't hang here waiting forever if there is no
; response.  You will attempt to receive the message 1000 times.  If there
; is no response by then, you will declare the response lost.

RECV:
        $QIOW_S FUNC=#IO$_READVBLK!IO$M_NOW,CHAN=ETHCHAN,IOSB=IOSB,-
                P1=RCVBUF,P2=#RCVBUFLEN,P5=#RCVP5
        BLBS    R0,RECV_REQ_OK
        BRW     ERROR

RECV_REQ_OK:

        MOVZWL  IOSB,R0
        BLBS    R0,RECV_IO_OK
        CMPW    R0,#SS$_ENDOFFILE       ; Was there just no message available?
        BEQL    10$                     ; Branch if so to try again
        BRW     ERROR

; If you are able to post 1000 reads and not receive the response packet, then
; you will assume the packet is lost.

10$:    CMPW    TRY,#1000               ; Have you tried enough?
        BGTR    LOST                    ; If GTR, yes, so message is lost
        INCW    TRY                     ; Try again
        BRB     RECV

RECV_IO_OK:

; You received a message.  Check that the Source Address matches the place we
; sent the message.

        CMPL    XMTP5,RCVSA
        BNEQ    RECV_BAD
        CMPW    XMTP5+4,RCVSA+4
        BNEQ    RECV_BAD

; Check that the data received was the correct size.

        CMPW    #XMTBUFLEN,IOSB+2
        BNEQ    RECV_BAD

; Check that the data received matches the data you sent.
```

Example 6–2 Cont'd. on next page

Example 6–2 (Cont.) IEEE 802 Programming Example

```
        MOVZBL  #XMTBUFLEN,R0
        MOVAB   XMTBUF,R1
        MOVAB   RCVBUF,R2
10$:    CMPB    (R1)+,(R2)+
        BNEQ    RECV_BAD
        SOBGTR  R0,10$
        BRB     RECV_OK                 ; All bytes matched

; There was something wrong with the message received.

RECV_BAD:
        PUSHAB  BMSG
        BRB     EXIT

; The test went fine.  Print a success message.

RECV_OK:
        PUSHAB  GMSG
        BRB     EXIT

; You lost the message.  Print a message stating so.

LOST:
        PUSHAB  LMSG
        BRB     EXIT

; There was an error while running the test.  Print a message stating so.

ERROR:
        PUSHAB  EMSG
        BRB     EXIT

; The test is done.  You will call LIB$PUT_OUTPUT to display the status of
; this test.  The message that will be displayed has its descriptor on the
; stack.  That descriptor will be used by the LIB$PUT_OUTPUT routine.

EXIT:
        CALLS   #1,G^LIB$PUT_OUTPUT
        $EXIT_S

        .END    START
```

A I/O Function Codes

This appendix lists the function codes and function modifiers defined in the $IODEF macro. The arguments for these functions are also listed.

A.1 DMC11/DMR11 Interface Driver

Functions	Arguments	Modifiers
IO$_READLBLK IO$_READVBLK IO$_READPBLK	P1 - buffer address P2 - message size	IO$M_DSABLMBX IO$M_NOW
IO$_WRITELBLK IO$_WRITEVBLK IO$_WRITEPBLK	P1 - buffer address P2 - message size	IO$M_ENABLMBX[1]
IO$_SETMODE IO$_SETCHAR	P1 - characteristics buffer address	
IO$_SETMODE!IO$M_ATTNAST IO$_SETMODE!IO$M_ATTNAST	P1 - AST service routine address P2 - (ignored) P3 - AST access mode	
IO$_SETMODE!IO$M_SHUTDOWN IO$_SETCHAR!IO$M_SHUTDOWN	P1 - characteristics block address	
IO$_SETMODE!IO$M_STARTUP IO$_SETCHAR!IO$M_STARTUP	P1 - characteristics block address P2 - (ignored) P3 - receive message blocks	

[1]Only for IO$_WRITELBLK and IO$_WRITEPBLK

QIO Status Returns		
SS$_ABORT	SS$_BADPARAM	SS$_DATAOVERUN
SS$_DEVACTIVE	SS$_DEVOFFLINE	SS$_ENDOFFILE
SS$_NORMAL		

A.2 DMP11 and DMF32 Interface Drivers

Functions	Arguments
IO$_READLBLK[!IO$M_NOW] IO$_READVBLK[!IO$M_NOW] IO$_READPBLK[!IO$M_NOW] IO$_WRITELBLK IO$_WRITEVBLK IO$_WRITEPBLK	P1- buffer address P2 - buffer size P6 - diagnostic buffer address (optional)
IO$_SETMODE IO$_SETCHAR IO$_SETMODE!IO$M_CTRL IO$_SETCHAR!IO$M_CTRL IO$_SETMODE!IO$M_CTRL!IO$M_STARTUP IO$_SETCHAR!IO$M_CTRL!IO$M_STARTUP IO$_SETMODE!IO$M_STARTUP IO$_SETCHAR!IO$M_STARTUP IO$_SETMODE!IO$M_SHUTDOWN IO$_SETCHAR!IO$M_SHUTDOWN IO$_SETMODE!IO$M_CTRL!IO$M_SHUTDOWN IO$_SETCHAR!IO$M_CTRL!IO$M_SHUTDOWN	P1 - characteristics buffer address (optional) P2 - extended characteristics buffer descriptor address (optional) P3 - receive message blocks (optional) P6 - diagnostic buffer address (optional)
IO$_SETMODE!IO$M_ATTNAST IO$_SETCHAR!IO$M_ATTNAST	P1 - AST service routine address P2 - (ignored) P3 - access mode to deliver AST
IO$_SETMODE!IO$M_SET_MODEM[1] IO$_SETCHAR!IO$M_SET_MODEM[1] IO$_SENSEMODE!IO$M_RD_MODEM IO$_SENSEMODE!IO$M_CTRL !IO$M_RD_MODEM[1]	P1 - modem status buffer address
IO$_SENSEMODE IO$_SENSEMODE!IO$M_CTRL	P1 - characteristics buffer address (optional) P2 - extended characteristics buffer descriptor address (optional)
IO$_SENSEMODE!IO$M_RD_COUNTS[2] IO$_SENSEMODE!IO$M_CLR_COUNTS[2] IO$_SENSEMODE!IO$M_RD_COUNTS !IO$M_CLR_COUNTS[2] IO$_SENSEMODE!IO$M_CTRL !IO$M_RD_COUNTS[3] IO$_SENSEMODE!IO$M_CTRL !IO$M_CLR_COUNTS[3] IO$_SENSEMODE!IO$M_CTRL !IO$M_RD_COUNTS !IO$M_CLR_COUNTS[3]	P1 - (ignored) P2 - counter buffer descriptor address

[1]Only for DMP11

[2]Only for DDCMP

[3]Only for DDCMP and LAPB

Functions	Arguments
IO$_SENSEMODE!IO$M_RD_MEM[1] IO$_SENSEMODE!IO$M_RD_MEM !IO$M_CTRL[1]	P1 - status slot buffer address P2 - tributary status slot address
IO$_CLEAN	(none)

[1]Only for DMP11

QIO Status Returns		
SS$_ABORT	SS$_BADPARAM	SS$_BUFFEROVF
SS$_CANCEL	SS$_DEVACTIVE	SS$_DEVICEFULL
SS$_DEVINACT	SS$_DEVOFFLINE	SS$_ENDOFFILE
SS$_NORMAL		

A.3 DR11–W/DRV11–WA Interface Driver

Functions	Arguments	Modifiers
IO$_READLBLK IO$_READVBLK IO$_READPBLK IO$_WRITELBLK IO$_WRITEVBLK IO$_WRITEPBLK	P1 - buffer address P2 - buffer size P3 - timeout period P4 - CSR value P5 - ODR value	IO$M_SETFNCT IO$M_WORD[1] IO$M_TIMED IO$M_CYCLE IO$M_RESET
IO$_SETMODE IO$_SETCHAR	P1 - characteristics buffer address P3 - access mode	IO$M_ATTNAST IO$M_DATAPATH[2]

[1]Not applicable to DRV11–WA

[2]Only for IO$_SETCHAR

QIO Status Returns		
SS$_BADPARAM	SS$_CANCEL	SS$_CTRLERR
SS$_DEVACTIVE	SS$_DRVERR	SS$_EXQUOTA
SS$_NOPRIV	SS$_NORMAL	SS$_OPINCOMPL
SS$_PARITY	SS$_TIMEOUT	

A.4 DR32 Interface Driver

Functions	Arguments	Modifiers
IO$_LOADMCODE	P1 - starting address of microcode to be loaded P2 - load byte count	
IO$_STARTDATA	P1 - starting address of data transfer command table P2 - length of the data transfer command table	IO$M_SETEVF

High-Level Language	Function
XF$SETUP	Defines command and buffer areas; initializes queues
XF$STARTDEV	Issues a request that starts the DR32
XF$FREESET	Releases command packets onto FREEQ
XF$PKTBLD	Builds command packets; releases them onto INPTQ
XF$GETPKT	Removes a command packet from TERMQ
XF$CLEANUP	Deassigns the device channel and deallocates the command area

QIO Status Returns		
SS$_ABORT	SS$_BADPARAM	SS$_BADQUEHDR
SS$_BUFNOTALIGN	SS$_CANCEL	SS$_CTRLERR
SS$_DEVACTIVE	SS$_DEVREQERR	SS$_EXQUOTA
SS$_INSFMEM	SS$_IVBUFLEN	SS$_MCNOTVALID
SS$_NORMAL	SS$_PARITY	SS$_POWERFAIL

A.5 Asynchronous DDCMP DUP11 Interface Driver

Functions	Arguments
IO$_READLBLK[!IO$M_NOW] IO$_READVBLK[!IO$M_NOW] IO$_READPBLK[!IO$M_NOW] IO$_WRITELBLK IO$_WRITEVBLK IO$_WRITEPBLK	P1 - buffer address P2 - buffer size

Functions	Arguments
IO$_SETMODE IO$_SETCHAR IO$_SETMODE!IO$M_STARTUP IO$_SETCHAR!IO$M_STARTUP IO$_SETMODE!IO$M_CTRL IO$_SETCHAR!IO$M_CTRL IO$_SETMODE!IO$M_CTRL!IO$M_STARTUP IO$_SETCHAR!IO$M_CTRL!IO$M_STARTUP IO$_SETMODE!IO$M_SHUTDOWN IO$_SETCHAR!IO$M_SHUTDOWN IO$_SETMODE!IO$M_CTRL!IO$M_SHUTDOWN IO$_SETCHAR!IO$M_CTRL!IO$M_SHUTDOWN	P2 - buffer descriptor address (optional)
IO$_SETMODE!IO$M_ATTNAST IO$_SETCHAR!IO$M_ATTNAST	P1 - AST service routine address P2 - (ignored) P3 - access mode to deliver AST
IO$_SENSEMODE IO$_SENSEMODE!IO$M_CTRL IO$_SENSEMODE!IO$M_RD_COUNTS IO$_SENSEMODE!IO$M_CLR_COUNTS IO$_SENSEMODE!IO$M_RD_COUNTS !IO$M_CLR_COUNTS IO$_SENSEMODE!IO$M_CTRL !IO$M_RD_COUNTS IO$_SENSEMODE!IO$M_CTRL !IO$M_CLR_COUNTS	P1 - (ignored) P2 - buffer descriptor address

QIO Status Returns		
SS$_ABORT	SS$_BADPARAM	SS$_BUFFEROVF
SS$_CANCEL	SS$_DEVACTIVE	SS$_DEVICEFULL
SS$_DEVINACT	SS$_DEVOFFLINE	SS$_ENDOFFILE
SS$_NORMAL		

A.6 Ethernet/802 Device Drivers

Functions	Arguments	Modifiers
IO$_READLBLK IO$_READVBLK IO$_READPBLK IO$_WRITELBLK IO$_WRITEVBLK IO$_WRITEPBLK	P1 - buffer address P2 - buffer size P4 - 802 format fields (optional)[3] P5 - destination address (optional)[3]	IO$M_NOW[1] IO$M_RESPONSE[2]
IO$_SETMODE IO$_SETCHAR	P2 - extended characteristics buffer (optional)[4]	IO$M_CTRL IO$M_STARTUP IO$M_SHUTDOWN
IO$_SETMODE IO$_SETCHAR	P1 - AST service address P3 - access mode to deliver AST	IO$M_ATTNAST
IO$_SENSEMODE IO$_SENSECHAR	P1 - device characteristics buffer (optional) P2 - extended characteristics buffer (optional)	IO$M_CTRL

[1]Only for read functions

[2]Only for write functions

[3]See text for complete contents

[4]Use only with IO$M_CTRL alone or with IO$_STARTUP, that is, the set controller mode

QIO Status Returns		
SS$_ABORT	SS$_ACCVIO	SS$_BADPARAM
SS$_BUFFEROVF	SS$_COMMHARD	SS$_CTRLERR
SS$_DATACHECK	SS$_DATAOVERUN	SS$_DEVACTIVE
SS$_DEVALLOC	SS$_DEVINACT	SS$_DEVOFFLINE
SS$_DEVREQERR	SS$_DISCONNECT	SS$_DUPUNIT
SS$_ENDOFFILE	SS$_EXQUOTA	SS$_INSFMEM
SS$_INSFMAPREG	SS$_IVBUFLEN	SS$_MEDOFL
SS$_NOPRIV	SS$_NORMAL	SS$_OPINCOMPL
SS$_TIMEOUT	SS$_TOOMUCHDATA	

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