QD24 DISK CONTROLLER
INSTALLATION AND USER GUIDE

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QD2450901-00, Rev D
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WARNING

This equipment generates, uses and can radiate radio frequency energy, and if not installed and used in accordance with the technical manual, may cause interference to radio communications. It has been tested and found to comply with the limits for a Class A computing device pursuant to Subpart J of Part 15 of Federal Communications Commission (FCC) Rules, which are designed to provide reasonable protection against such interference when operating in a commercial environment. Operation of this equipment in a residential area is likely to cause interference in which case the user at his own expense will be required to take whatever measures may be required to correct the interference.

The information in this manual is for information purposes and is subject to change without notice.

Emulex Corporation assumes no responsibility for any errors which may appear in the manual.

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STATEMENT OF WARRANTY

DECEMBER 1, 1987

BASIC WARRANTY - In the absence of any optional warranty or continuing provisions extended by formal agreement, Emulex warranties its Products in accordance with the schedules listed below.

In all cases where equipment is to be returned to Emulex, a "Return Authorization" must be issued by the "Repair Center," (714) 662-5600.

CONTROLLERS - PERIPHERALS - DATA COMMUNICATION PRODUCTS - Emulex warrants for a period of twelve (12) months, sixty (60) months in case of FAX modems and Data Pump modems, from the date of shipment, that each product shall be free of defects in material and workmanship. These products include all Disk and Tape Controllers, Magnetic Disk and Tape Drives, Optical Disk Drives, Communication Multiplexers, and modem products.

During this period, if the customer experiences difficulties with an Emulex product and is unable to resolve the problem via the phone with Emulex Technical Support, a Return Authorization will be issued. Following receipt of a Return Authorization, the customer is responsible for returning the product to Emulex, freight prepaid. Emulex, upon verification of warranty will, at its option, repair or replace the product in question, and return to the customer freight prepaid.

PACKAGED SUBSYSTEMS - Emulex warrants all packaged subsystems for a period of six (6) months from the date of shipment. These products include all versions of Sabre, Vault, Medley, Decathlon, and Javelin. In the event of difficulty, the procedure for problem resolution is the same as defined above. Please note that major assemblies of these packages including controllers and peripherals are covered under the 12 month warranty above if returned to Emulex as separate assemblies.

SOFTWARE WARRANTY - Emulex warrants for a period of ninety (90) days, from the date of shipment, that each software package supplied shall be free from defects and shall operate according to Emulex specifications under those Digital Equipment Corporation ("DEC"), IBM, Intel, and Unix, operating system versions supported by Emulex. Emulex does not warrant its software products under any operating system which has not been specifically identified. Any software revisions required hereunder will cover supply of distribution media only and will not cover on-site installation or integration.

CABLE WARRANTY - (Return to Factory) - All Emulex provided cables are warranted for ninety (90) days from the time of shipment. Questionable cables should be returned to Emulex, freight prepaid, where they will be repaired or replaced by Emulex at its option and returned to the customer freight prepaid.

MEDIA WARRANTY - Emulex warrants all media to be free of defects and material for a period of thirty (30) days from date of shipment. The customer is responsible for return of media to Emulex and Emulex for freight associated with replacement media being returned to the customer.

RETURN TO FACTORY - All of the warranties referenced above provide for corrective action on products returned to the Emulex factory accompanied by a "Return Authorization".

On-site services are not included as a part of these warranties.

GENERAL TERMS - The above warranties shall not apply to expendable components such as fuses, bulbs, and the like, nor to connectors and other items not a part of the basic product. Emulex shall have no obligation to make repairs or to cause replacement required through normal wear and tear or necessitated in whole or in part by catastrophe, fault or negligence of the user, improper or unauthorized use of the Product, or use of the Product in such manner for which it was not designed, or by causes external to the Product, such as, but not limited to, power failure or air conditioning. Emulex's sole obligation hereunder shall be to repair or replace items covered in the above warranties, unless covered by an Emulex On-Site Warranty Contract. Purchaser shall provide for removal of the defective Product, shipping charges for return to Emulex, and installation of its replacement. Above warranties are subject to change without notice.

RETURNED MATERIAL -Warranty claims must be received by Emulex within the applicable warranty period. A replaced product, or part thereof, shall become the property of Emulex and shall be returned to Emulex at Purchaser's expense. All returned material must be accompanied by a Return Authorization Number assigned by Emulex.

In the event product(s) returned under the provisions of this Warranty are subsequently determined by Emulex to be functionally operational and in accordance to its published specifications, i.e., "No Defect Found" (NDF), Purchaser will be charged a NDF fee and the product shall be returned to Purchaser freight collect.

THE EXPRESSED WARRANTIES SET FORTH IN THIS AGREEMENT ARE IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING WITHOUT LIMITATION, ANY WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, AND ALL SUCH OTHER WARRANTIES ARE HEREBY DISCLAIMED AND EXCLUDED BY EMULEX. THE STANDARD EXPRESSED WARRANTIES ARE IN LIEU OF ALL OBLIGATIONS OR LIABILITIES ON THE PART OF EMULEX FOR DAMAGES, INCLUDING BUT NOT LIMITED TO SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES ARISING OUT OF OR IN CONNECTION WITH THE USE OR PERFORMANCE OF THE PRODUCTS.

Section 1
GENERAL DESCRIPTION

1.1 Introduction

The QD24 Disk Controller, designed and manufactured by Emulex Corporation, is an MSCP-compatible controller that interfaces ESDI disk drives with DEC's Q-Bus. This manual is designed to help you install and use your QD24 Disk Controller. It assumes that you have some knowledge of hardware configuration, Q-Bus architecture and terminology, and interpretations of error messages and device register contents. This manual documents both the QD24-E and the QD24-I models of the QD24 Disk Controller. Unless otherwise noted, the references to the QD24 Disk Controller apply to both the QD24-E model and the QD24-I model. The contents of the seven sections and two appendices are described as follows:

- **Section 1 (General Description):** This section contains an overview of the QD24 Disk Controller.
- **Section 2 (Controller Specification):** This section contains the specification for the QD24 Disk Controller.
- **Section 3 (Installation):** This section contains the information needed to set up and physically install the controller, including switch settings and cabling. It also describes the firmware-resident diagnostics and contains instructions for loading drive configuration parameters into the NOVRAM.
- **Section 4 (Troubleshooting):** This section describes fault isolation procedures that can be used to pinpoint trouble spots.
- **Section 5 (Registers and Programming):** This section describes the QD24's Q-Bus registers and presents an overview of the Mass Storage Control Protocol (MSCP).
- **Section 6 (Functional Description):** This section describes the controller architecture.
- **Section 7 (Interfaces):** This section describes the controller, Q-Bus and ESDI interfaces.
- **Appendix A (PROM Removal and Replacement):** This appendix contains instructions to remove and replace the firmware so that the user can upgrade the QD24 Disk Controller in the field.
- **Appendix B (Disk Drive Configuration Parameters):** This appendix contains configuration parameters for supported ESDI disk drives.

1.2 Subsystem Overview

The QD24 Disk Controller connects high-capacity mass storage peripherals to the Q-Bus MicroVAX 3500/3600 computers manufactured by Digital Equipment Corporation (DEC). The QD24 implements DEC's Mass Storage Control Protocol (MSCP) to provide a software-transparent interface for the host DEC computer. To provide traditional Emulex flexibility in peripheral selection, the QD24 uses the industry standard Enhanced Small Device Interface (ESDI) interface as its peripheral interface. The QD24 supports the magnetic disk drive and serial options of ESDI. For more information on the QD24's ESDI interface, see subsection 7.3.

1.2.1 Mass Storage Control Protocol (MSCP)

MSCP is a software interface designed to lower the host computer's mass storage overhead by offloading much of the work associated with file management into an intelligent mass storage subsystem. In concert with ESDI compatible peripherals, the QD24 provides just such a subsystem. The QD24 relieves the host CPU of many file maintenance tasks. The QD24 Disk Controller performs these MSCP functions: error checking and correction, bad block replacement, seek optimization, command prioritizing and ordering, and data mapping.

This last feature is, perhaps, the most important. This feature allows the host computer's operating system software to store data in logical blocks that are identified by simple logical block numbers (LBNs). Thus, the host does not need to have detailed knowledge of the peripheral's geometry (cylinders, tracks, sectors, etc.). This feature also makes autoconfiguration a simple matter. During system start-up, the host operating system queries the subsystem to find its capacity (the number of logical blocks that the subsystem can store).

Because the host operating system does not need to have detailed knowledge of its mass storage subsystem, the complexity of the operating system itself has been reduced. This reduction comes about because only one or two software modules are required to allow many different subsystems to be connected to a host.

1.3 Physical Organization Overview

The QD24 Disk Controller is a modular, microprocessor-based disk controller that connects directly to the MicroVAX 3500/3600's Q-Bus backplane. The microprocessor architecture ensures excellent reliability and compactness.

The QD24 supports up to four physical or eight logical disk drives. Aggregate data storage capacities are limited only by the capacities of the peripherals.

The QD24 controller is available in two models:

- QD24-E
- QD24-I

1.3.1 QD24-E Model

The QD24-E is designed to be used in those installations where the attached drives are mounted external to the DEC BA 213 chassis. These drives may be either mounted in their own cabinet next to the UVAX 3500/3600 cabinet, or in a user supplied drive chassis mounted in the rear of the UVAX 3600 cabinet. In either case since the drive cables will be routed outside of the FCC hardened BA 213 CPU chassis it will be necessary to use the QD24-E, with shielded cables and a cable distribution panel available from EMULEX, to maintain FCC compliance. In either case the maximum drive cable length is 3 meters.

Figure 1-1 shows one possible ESDI configuration using the QD24-E Disk Controller.

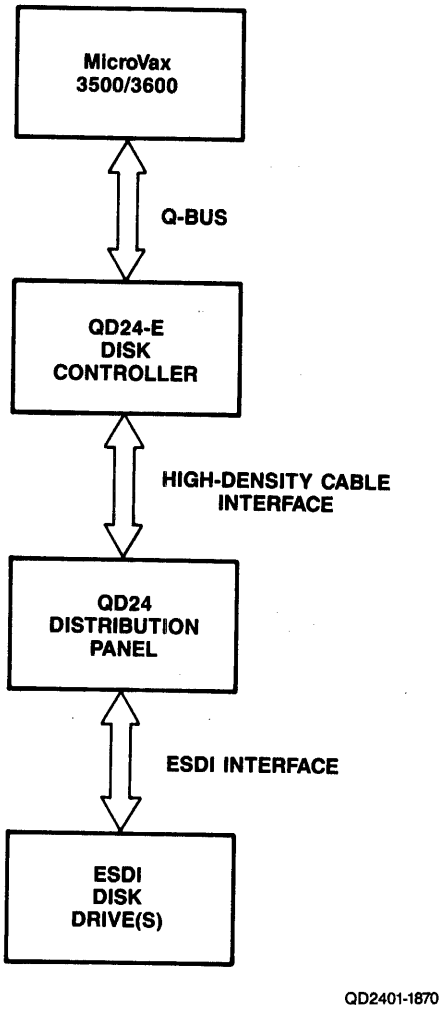


Figure 1-1. QD24-E Subsystem Configuration

1.3.2 QD24-I Model

The QD24-I is designed for those users who intend to mount the attached drives inside the FCC hardened BA 213 chassis. In this case the user is totally responsible for maintaining FCC compliance of the finished subsystem. EMULEX supplies only the QD24-I controller. The user is responsible for supplying drive cables and drive mounting hardware and for adhering to correct installation procedures. Like the QD24-E, the maximum drive cable length is 3 meters.

Figure 1-2 shows a possible ESDI configuration using the QD24-I Disk Controller.

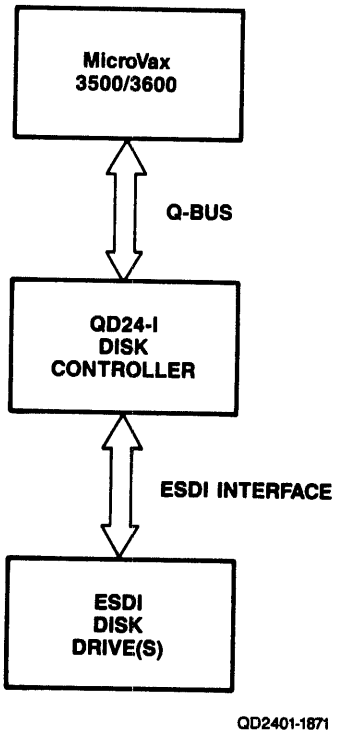


Figure 1-2. QD24-I Subsystem Configuration

1.4 Subsystem Components

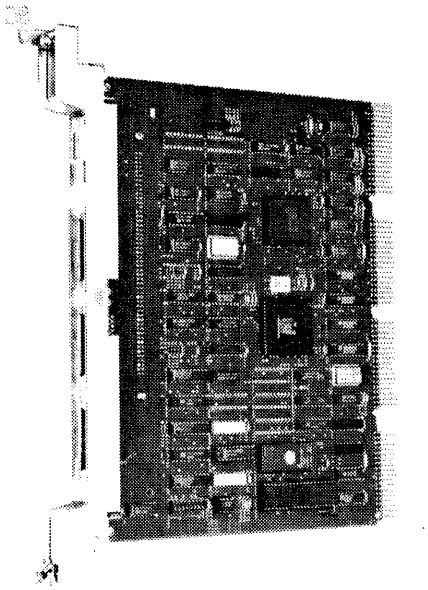
The following subsections describe the standard components shipped with each model of the QD24 Disk Controller.

1.4.1 QD24-E Standard Components

The QD24-E disk controller, shown in Figure 1-2, is shipped with the items listed in Table 1-1. Options are listed in Table 1-2. The QD24 requires round-shielded interface cables, a QD24 distribution panel, and flat-ribbon cables to connect to an ESDI disk drive. You may also need a rack-mount panel for the QD24 distribution panel. The number of cables required depends on the number of drives in your subsystem configuration. The available cable types and lengths are listed in Table 1-2.

Table 1-1. QD24-E Standard Components

Itm	Qty	Description	Part Number
1	1	QD24-E Disk Controller	QD2410201-02
2	2	Gap-Filler Panels	QT1420102-00
3	1	QD24 User Guide	QD2450901-00
4	1	QD24 Transition Panel	QD2410204-01



QD2401-1684

Figure 1-3. QD24-E Disk Controller

QD24-E
Table 1-2. Cables and Panels

Item	Model/ Part Number	Cable	Length (Feet)	Qty Rqd	Application
1	QU0111203-01	34-cond, flat-ribbon	3	1	ESDI control
2	QU0111201-01	34-cond, flat-ribbon	1	0-3	ESDI daisy-chain
3	QU0111202-01	20-cond, flat-ribbon	3	1-4	ESDI data
4	QD2410203-00	QD24 Distribution Panel	NA	1	
5	CU222031	Rack-Mount Panel	NA	1	
6	CKQD242-5	5 ft, high density cables[1]	NA	1	Interface
7	CKQD244-5	5 ft, high density cables[2]	NA	1	Interface
8	CKQD242-8	8 ft, high density cables[1]	NA	1	Interface
9	CKQD244-8	8 ft, high density cables[2]	NA	1	Interface
10	CU2213002-00	Mounting frame w/ blank	NA	1	

[1] 2 drive support
[2] 4 drive support

1.4.2 QD24-I Standard Compenents

The QD24-I disk controller, shown in Figure 1-3, is shipped with the items listed in Table 1-3.

Table 1-3. QD24-I Standard Components

Itm	Qty	Description	Part Number
1	1	QD24-I Disk Controller	QD2410201-04
2	1	QD24 User Guide	QD2450901-00

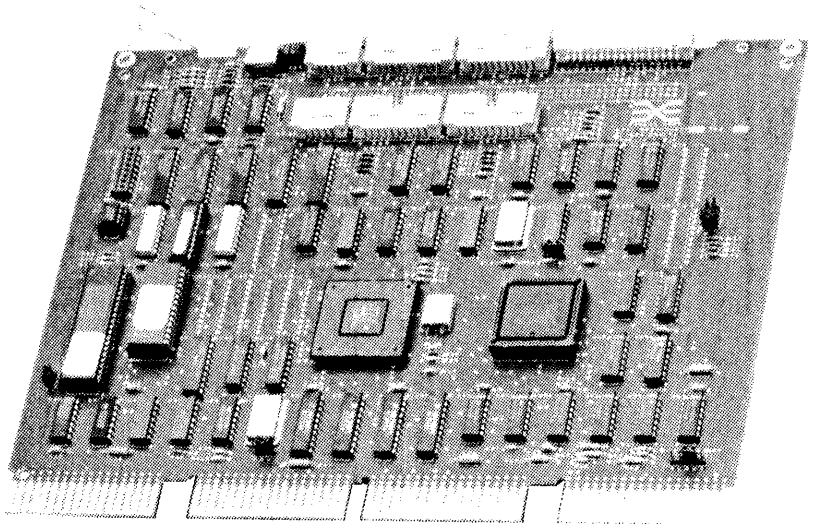


Figure 1-4. QD24-I Disk Controller

QD24-I
Table 1-4. Cables and Panels

Item	Model/ Part Number	Cable	Length (Feet)	Qty Rqd	Application
1	QU0111203-01	34-cond, flat-ribbon	3	1	ESDI control
2	QU0111201-01	34-cond, flat-ribbon	1	0-3	ESDI daisy-chain
3	QU0111202-01	20-cond, flat-ribbon	3	1-4	ESDI data

1.5 Features

The following features enhance the usefulness of the QD24 Disk Controller.

1.5.1 Microprocessor Design

The QD24 design incorporates an eight-bit, high-performance MOS microprocessor to perform all controller functions. The microprocessor approach provides a reduced component count, high reliability, easy maintainability, and the microprogramming flexibility that allows MSCP to be implemented without expensive, dedicated hardware.

1.5.2 Firmware-resident Diagnostics

The QD24 disk controller firmware incorporates a self-contained set of disk preparation and diagnostic utilities. These utilities allow the user to communicate directly with the QD24 via a firmware-resident terminal driver that is compatible with either CRT or hardcopy devices connected to a MicroVAX 3500/3600 console port. These firmware-resident diagnostics (F.R.D.) provide several important disk preparation functions, including the ability to:

- Configure the controller NOVRAM
- Format the drive
- Test the disk surface and replace defective blocks, and
- Perform reliability testing of the attached disk subsystem.

1.5.3 Custom Configuration Capability

An onboard NOVRAM can be programmed for four independent physical drive configurations. Using the firmware-resident utilities, you can control drive parameters, such as number of cylinders per drive and number of sectors per track.

1.5.4 Automatic Drive Configuration

This feature allows you to take advantage of the drive configuration information available from the attached ESDI drive to set the drive parameters. You can configure the QD24 to use this information instead of entering the parameters manually. This feature supports both hard and soft sector formats. (Note: Emulex recommends hard sectoring whenever possible.)

1.5.5 Self-test

The QD24 incorporates an internal self-test routine which exercises all parts of the microprocessor, the on-board memory, the buffer controller, and the Host Adapter Controller (HAC). Although this test does not completely test all circuitry, successful execution indicates a very high probability that the disk controller is operational. If the QD24 fails the self-test, it leaves three light-emitting diodes (LEDs) ON and sets an error bit in the Status and Address (SA) register (base address plus two).

1.5.6 Error Control

The QD24, in conjunction with the operating system software, presents error-free media to the host. The disk controller corrects soft errors and performs retry operations, and allows the operating system to dynamically replace blocks with correctable errors before they become uncorrectable.

1.5.7 Media Defect List Management

During format operations, the QD24 replaces all blocks on the disk that are labeled bad in the Manufacturer's Defect List. After formatting, the firmware-resident utilities can be used to test the entire disk surface with four worst-case data patterns and replace any pattern-sensitive blocks not found by the manufacturer. QD24 supports both 256- and 512-byte defect list formats.

1.5.8 Host-initiated Bad Block Replacement

The QD24 uses DEC-compatible host-initiated bad block replacement to dynamically replace any defective blocks that occur during the life of the system. For maximum reliability, the QD24 reports even corrected single bit errors as candidates for replacement.

1.5.9 Seek Optimization

The QD24 is able to pool the various seeks that need to be performed and determine the most efficient order in which to do them. This is an especially important feature in heavily loaded systems. The disk controller's ability to arrange seeks in the optimal order saves a great deal of time and makes the entire system more efficient.

1.5.10 Command Buffer

The QD24 contains a buffer that is able to store 13 MSCP commands. This large buffer allows the subsystem to achieve a higher throughput and to operate at a very efficient level.

1.5.11 Adaptive DMA

During each DMA data transfer burst, the QD24 monitors the Q-Bus for other pending DMA requests and suspends its own DMA activity to permit other DMA transfers to occur. The host processor programs the DMA burst length during the MSCP initialization sequence and you may program the QD34 NOVRAM to monitor DMA requests from as often as every word to as long as every eight words.

In addition, the QD24 firmware design includes a switch selectable DMA burst delay to avoid data late conditions on other slower devices that may be on a given system. Because of these adaptive DMA techniques, the QD24 ensures that CPU functions, including interrupt servicing, are not locked out for excessive periods of time by high-speed disk transfers.

1.5.12 Block-Mode DMA

The QD24 supports block-mode DMA for accessing memory. In this mode, the initial address of the data is transmitted, followed by a burst of up to 16 words of data. The memory address is automatically incremented to accommodate this burst. Block mode transfers considerably reduce the overhead associated with DMA operations.

1.5.13 Twenty-Two-Bit Addressing

The QD24 supports the 22-bit addressing capability of the extended Q-Bus, which is required for the MicroVAX 3500/3600.

1.6 Compatibility

This section describes the operating systems and hardware components that are compatible with the QD24.

1.6.1 Operating Systems

The QD24 implements MSCP. Emulex supports its implementation of MSCP beginning with the indicated version of the following DEC operating systems:

Operating System	Version
Micro/VMS	4.0
Ultrix-32m	1.1

1.6.2 Hardware

The QD24 Disk Controller complies with DEC Q-Bus protocol, and it directly supports 22-bit addressing and block-mode DMA.

The QD24 supports the serial mode implementation of the ESDI interface on magnetic disk drives that have clocks up to 20 Megahertz.
The disk drives supported by the QD24 are not media compatible with comparable DEC MSCP products.

Section 2
CONTROLLER SPECIFICATION

2.1 Overview

This section contains the general, environmental, physical, electrical, and port specifications for the QD24 Disk Controller.

Subsection	Title
2.1	Overview
2.2	General Specification
2.3	Environmental Specification
2.4	Physical Specification
2.5	Electrical Specification

2.2 General Specification

Table 2-1 contains a general specification for the QD24 Disk Controller.

Table 2-1. QD24 General Specifications

Parameter	Description
FUNCTION	Provides mass data storage interface to Digital Equipment Corporation (DEC) MicroVAX 3500/3600 computers
Logical CPU Interface	Emulates DEC's Mass Storage Control Protocol (MSCP)
Diagnostics	Embedded diagnostics
Operating System Compatibility	Micro/VMS V4.0 and above Ultrix-32m V2.2 and above
CPU I/O Technique	Direct Memory Access (DMA), including adaptive techniques and block mode

(continued on next page)

Table 2-1. QD24 General Specifications (continued)

Parameter	Description
INTERFACE	
CPU Interface	Extended Q-Bus interface
Device Base Address	
Standard Alternates	17772150_8 17760364_8 17772154_8 17760370_8 17760334_8 17760374_8 17760340_8 17760400_8 17760344_8 17760404_8 17760350_8 17760410_8 17760354_8 17760414_8 17760360_8 17760420_8
Vector Address	Programmable
Priority Level	BR4 or BR5 (jumper-selectable)
Bus Loading	1 DC Load, 2.5 AC Loads
Peripheral Interface	Enhanced Small Disk Interface (ESDI) for disks up to 15 MHz
Number of Physical Drives Supported	4
Drive Sectoring	Hard or Soft Sectored
Interface Cables	34-line control cable (daisy-chain), maximum 10 ft. (3 m); 20-line data cables (radial), maximum 10 ft. (3 m).
Firmware Diagnostic Access Path	
MicroVAX 3500/3600	Processor-resident console port

2.3 Environmental Specification

Table 2-2 contains the environmental specifications for the QD24 Disk Controller.

Table 2-2. QD24 Environmental Specifications

Parameter	Description
OPERATING TEMPERATURE	10°C (50°F) to 40°C (104°F), where maximum temperature is reduced 1.8°C per 1000 meters (1°F per 1000 feet) altitude
RELATIVE HUMIDITY	10% to 90% with a maximum wet bulb of 28°C (82°F) and a minimum dewpoint of 2°C (3.6°F)
COOLING	6 cubic feet per minute
HEAT DISSIPATION	82 BTU per hour

2.4 Physical Specification

Table 2-3 contains the physical specifications for the QD24 Disk Controller.

Table 2-3. QD24 Physical Specifications

Parameter	Description
PACKAGING	Quad-wide PCBA
Shipping Weight	3 pounds

2.5 Electrical Specification

Table 2-4 lists and describes the electrical specification for the QD24 Disk Controller.

Table 2-4. QD24 Electrical Specification

Parameter	Description
POWER	+5 VDC ± 5%, 2.6 amperes (A) MAX

Section 3
INSTALLATION

3.1 Overview

This section describes the installation of the QD24 Disk Controller. This section is divided into seven main subsections:

Subsection	Title
3.1	Overview
3.2	Inspection
3.3	QD24 Disk Controller Setup (both models)
3.4	Installing the QD24-E
3.5	Installing the QD24-I
3.6	F.R.D. (both models)
3.7	Operation (both models)

The installation subsections **do not** contain every step necessary for bringing up the system. An Installation Checklist for each model outlines the process at the beginning of each installation subsection.

If you are unfamiliar with the subsystem installation procedure, Emulex recommends reading this Installation Section before beginning.

The QD24 is software transparent to DEC MSCP drivers under MicroVMS and Ultrix-32m. Refer to DEC software documentation for sysgen, addressing, and other information.

3.1.1 Subsystem Configurations

This section is limited to switch setting data and physical installation instructions. No attempt is made to describe the many subsystem configurations that are possible.

When you are installing the subsystem, you should make a record of the subsystem configuration and environment. Figure 3-1 is a Configuration Record Sheet that lists the information required and shows where the data can be found. This information will be of help to an Emulex service representative should your subsystem require service.

QD24 CONFIGURATION REFERENCE SHEET

GENERAL INFORMATION

- Host computer type _____
- Host computer operating system _____
  Version _____
- Other MSCP Controllers; Type _____ , Q-bus address _____

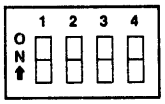
NOVRAM/DRIVE CONFIGURATION PARAMETERS

- Drive Manufacturer (0) _____ Model _____
- Drive Manufacturer (1) _____ Model _____
- Drive Manufacturer (2) _____ Model _____
- Drive Manufacturer (3) _____ Model _____
- NOVRAM Parameters:
  Adaptive DMA Threshold _____

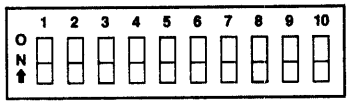
	DRIVE 0	DRIVE 1	DRIVE 2	DRIVE 3
Number Units				
Type Code				
Head Offset				
Sectors/Track				
Heads				
Cylinders				
Spare Sectors				
Alternate Cylinders				
Configuration Bits				
Split Code				
Removable Media				
Gap 0				
Gap 1				
Gap 2				
Cylinder Offset				
Spiral Offset				

QD24 CONFIGURATION

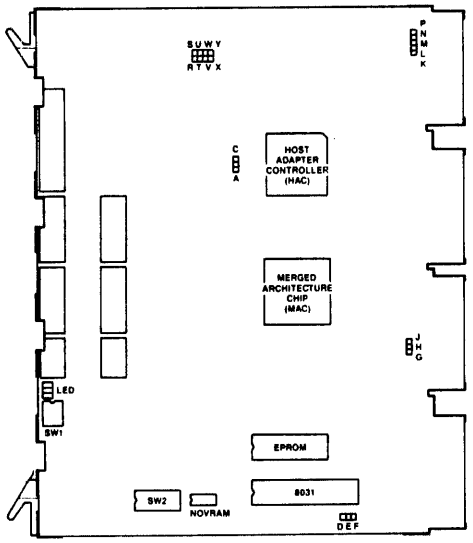
- Firmware revision number _____
- Top assembly number _____
- Q-Bus address _____
- Switch settings (□ = OFF ■ = ON)
- Warranty expiration date _____
- Serial number _____
- Interrupt vector address _____



SW1



SW2



QD2401-1860

Figure 3-1. QD24 Configuration Reference Sheet

3.2 Inspection

Emulex products are shipped in special containers designed to provide full protection under normal transit conditions. Immediately upon receipt, the shipping container should be inspected for evidence of possible damage incurred in transit. Any obvious damage to the container, or indications of actual or probable equipment damage, should be reported to the carrier company in accordance with instructions on the form included in the container.

Unpack the QD24 subsystem and, using the shipping invoice, verify that all equipment is present. Verify also that model or part numbers (P/N), revision levels, and serial numbers agree with those on the shipping invoice. These verifications are important to confirm warranty. If evidence of physical damage or identity mismatch is found, notify an Emulex representative immediately. If the equipment must be returned to Emulex, it should be shipped in the original container.

Visually inspect the QD24 Disk Controller after unpacking. Check for such items as bent or broken connector pins, damaged components, or any other evidence of physical damage.

Examine all socketed components carefully to ensure that they are properly seated.

3.3 Disk Controller Setup

Several configuration setups must be made on the QD24 Disk Controller before inserting it into the chassis. These setups are made by option switches SW1 and SW2.

Figure 3-2 shows the locations of the configuration switches on the QD24-E; Figure 3-3 shows switch locations on QD24-I.

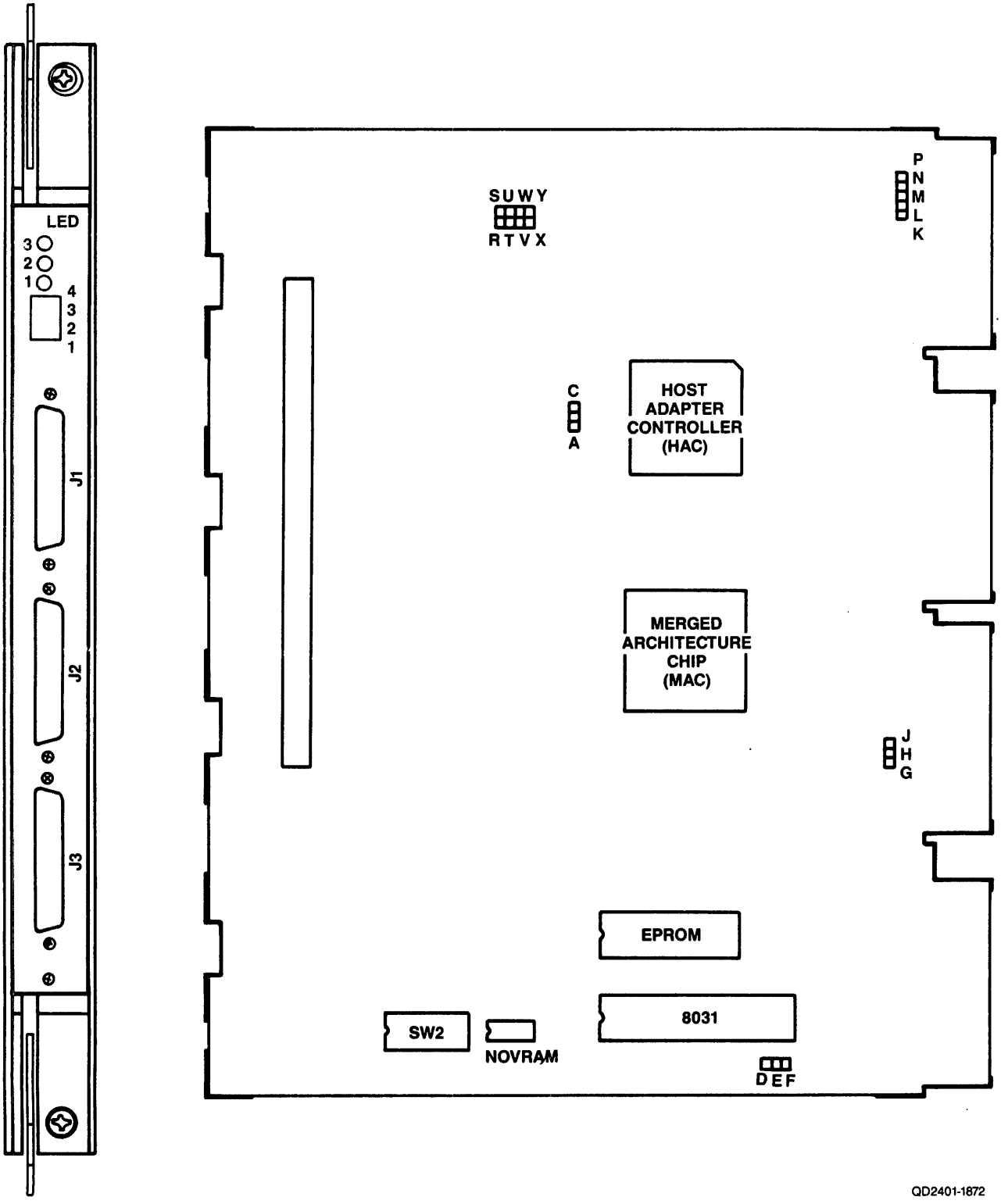


Figure 3-2. QD24-E Disk Controller Assembly

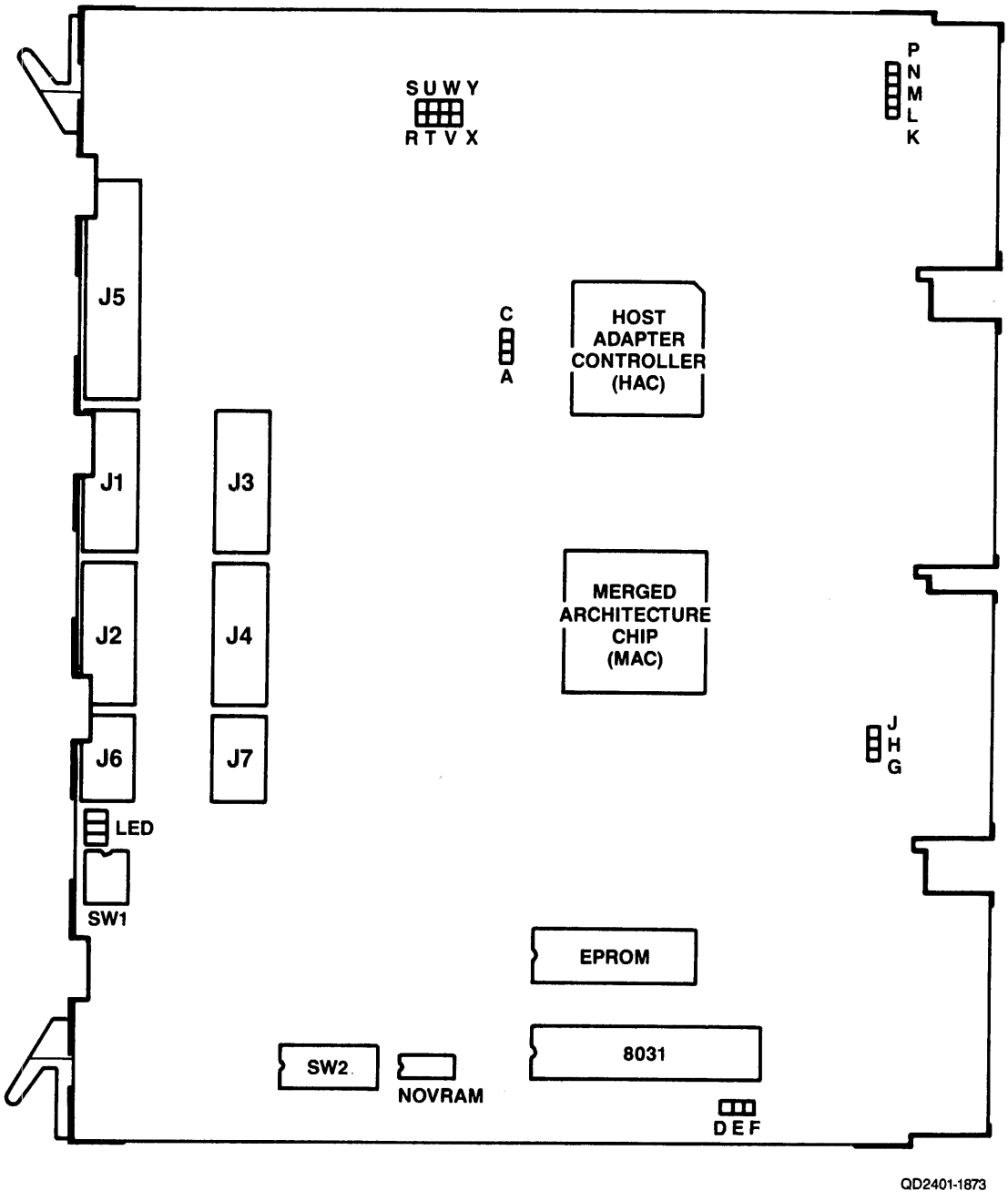


Figure 3-3. QD24-I Disk Controller Assembly

NOTE

If you change a switch position on the QD24 or change configuration values in NOVRAM, you must also reset the QD24 so that the host operating system's initialization sequence reads the codes established by the switch settings and/or NOVRAM. To reset the QD24, either toggle switch SW1-1 (ON then OFF), or power-down and power-up the system.

Table 3-1 defines the function and factory configuration of all switches on the QD24 controller. The factory configuration switch settings are representative of most QD24 Disk Controller applications.

Table 3-1. QD24 Switch Definitions and Factory Configuration

Switch	OFF(0)	ON(1)	Fact	Function	Section
SW1-1	Run	Reset/Halt	OFF(0)	Run vs. Reset/Halt	
SW1-2	-	-	OFF(0)	MSCP Device Number	3.3.3.1
SW1-3	-	-	OFF(0)	MSCP Device Number (LSB)	3.3.3.1
SW1-4	-	-	OFF(0)	MSCP Device Number (MSB)	3.3.3.1
SW2-1	-	-	OFF(0)	Reserved	
SW2-2	4 usec	8 usec	OFF(0)	DMA Burst Delay	3.3.3.2
SW2-3	-	-	OFF(0)	Q-Bus Address	3.3.1
SW2-4	-	-	OFF(0)	Q-Bus Address	3.3.1
SW2-5	-	-	OFF(0)	Q-Bus Address	3.3.1
SW2-6	-	-	OFF(0)	Q-Bus Address	3.3.1
SW2-7	-	-	OFF(0)	Reserved	
SW2-8	Disable	Enable	OFF(0)	Loop on Self-Test Error	

ON (1) = Closed
OFF (0) = Open
Fact = Factory switch setting

Table 3-2 lists the function and factory configuration of all jumpers on the controller.

Table 3-2. QD24 Jumper Definitions and Factory Configuration

JUMPER	OUT	IN	FACT	COMMENT
A-B	Enable Clock	Disable Clock	OUT	Must be OUT
B-C	Disable Clock	Enable Clock	IN	Must be IN
D-E	Disable Fact Test Clock	Enable Fact Test Clock	OUT	Must be OUT
E-F	Disable Clock	Enable Clock	IN	Must be IN
G-H	Enable Clock	Disable Clock	OUT	Must be OUT
H-J	Disable Clock	Enable Clock	IN	Must be IN
K-L	Normal Operation	Factory Test	OUT	Must be OUT
R-S	Factory Test	Factory Test	OUT	Must be OUT
U-T	Factory Test	Factory Test	OUT	Must be OUT
W-V	Factory Test	Factory Test	OUT	Must be OUT
X-Y	Factory Test	Read Gate Delay	IN	Must be IN
BR4	M-N	P-N	FACT	Normal Operation
BR5	P-N	M-N	---	Special Application
FACT	= Factory Setting			

3.3.1 Disk Controller Bus Address

Every Q-Bus I/O device has a block of several registers through which the system can command and monitor that device. The registers are addressed sequentially from a starting address assigned to that controller, in this case an MSCP-class Disk Controller.

The address for the first of the QD24's two Q-Bus registers is selected by DIP switches SW2-3 through SW2-6. See Table 3-3 for register address switch settings. For more information on determining the Q-Bus address, refer to DEC operating system and MicroVAX 3500/3600 system documentation.

Table 3-3. Controller Address Switch Settings

Bus Address (in octal)	--- SW2 --- 6	5	4	3	Factory Config	Bus Address (in octal)	--- SW2 --- 6	5	4	3	Factory Config
772150	0	0	0	0		760364	0	0	0	1	
772154	1	0	0	0		760370	1	0	0	1	
760334	0	1	0	0		760374	0	1	0	1	
760340	1	1	0	0		760400	1	1	0	1	
760344	0	0	1	0		760404	0	0	1	1	
760350	1	0	1	0		760410	1	0	1	1	
760354	0	1	1	0		760414	0	1	1	1	
760360	1	1	1	0		760420	1	1	1	1	

3.3.2 Interrupt Vector Address

The interrupt vector address for the QD24 is programmed into the device by the operating system during the MSCP initialization sequence.

3.3.3 Options

The QD24 switch-selectable options are described in the following subsections.

3.3.3.1 MSCP Device Number

QD24 switches SW1-2 through SW1-4 are used only if the QD24 is installed at an alternate Q-Bus address. These switches specify the MSCP device number of the first drive supported by the alternate QD24. That first drive may be drive 0 through 7. See appropriate DEC operating system documentation for MSCP devices for more information.

If your QD24 is installed at an alternate address, switches SW1-2 through SW1-4 select the MSCP device number of the first drive supported by the QD24. Table 3-5 defines the MSCP device numbers selected by switches SW1-2 through SW1-4 if the QD24 is at an alternate address.

Table 3-4. MSCP Device Number

Starting MSCP Device Number	--- SW1 --- 3 (LSB)	2	4 (MSB)
0	0	0	0
1	1	0	0
2	0	1	0
3	1	1	0
4	0	0	1
5	1	0	1
6	0	1	1
7	1	1	1

3.3.3.2 DMA Burst Delay

The QD24 firmware design includes a switch-selectable DMA burst delay to avoid data late conditions. Switch SW2-2 selects either a 4-microsecond or 8-microsecond delay between DMA bursts. Even with the QD24 adaptive DMA, some applications may require a longer burst delay to allow other devices adequate time on the bus.

Switch	OFF	ON	Factory
SW2-2	4 usec	8 usec	OFF

3.3.3.3 Interrupt Priority Level

The QD24 is factory configured for interrupt request (IRQ) level 4 (BR4). This is the preferred configuration for most DEC Q-Bus systems. In the case of special applications, the user may change to IRQ5 (BR5) via jumpers. The table below describes the different jumper settings. If you use IRQ5, Emulex strongly recommends that the QD24 be located ahead of all DEC devices on the bus.

Jumper	BR4 Factory	BR5
M-N	OUT	IN
N-P	IN	OUT

3.4 Installing the QD24-E

This subsection describes the physical installation of the QD24-E Disk Controller. You should have already completed steps 1 and 2 on the following Installation Checklist:

QD24-E INSTALLATION CHECKLIST

- ☐ 1. Inspect the QD24 Disk Controller. (Subsection 3.2)
- ☐ 2. Set up the switches on the QD24 module. (Subsection 3.3)
- ☐ 3. Install the controller in the MicroVAX 3500/3600 backplane.
- ☐ 4. Install the QD24 Distribution Panel in the rack-mount cabinet and connect to the QD24 PCBA.
- ☐ 5. Install and connect the disk drive(s) to the QD24 Distribution Panel.
- ☐ 6. Run the onboard embedded diagnostics. (This step includes formatting the disk drives.)
- ☐ 7. Bring the system up.

3.4.1 Maintaining FCC Class A Compliance

Emulex has tested the QD24-E Intelligent Disk Controller with DEC computers that comply with FCC Class A limits for radiated and conducted interference. When properly installed, the QD24-E does not cause compliant computers to exceed Class A limits.

The QD24-E Disk Controller subsystem has only one physical configuration. The QD24-E PCBA is installed in the MicroVAX 3500/3600 cabinet and the QD24 Distribution Panel and disk drives are mounted in a separate rack-mount cabinet.

To limit radiated interference, DEC completely encloses the components of its computers that generate or could conduct radio-frequency interference (RFI) with a grounded metal shield (earth ground). During installation of the QD24-E, nothing must be done that would reduce this shield's effectiveness. That is, when the QD24-E installation is complete, no gap in the shield that would allow RFI to escape can be allowed.

Conducted interference is generally prevented by installing a filter in the AC line between the computer and the AC outlet. Most power distribution panels that are of current manufacture contain suitable filters.

3.4.2 Physically Installing the QD24-E PCBA

The following subsections describe the physical installation of the QD24-E Disk Controller PCBA.

3.4.2.1 System Preparation

To prepare the MicroVAX 3500/3600 to accept the QD24-E, use the following procedure:

1. Power down the system by switching OFF the main power switch.
2. Open the front chassis door.
3. Remove a blank cover from the front of the chassis so that an empty slot is exposed.

3.4.2.2 Slot Selection

The QD24-E may be assigned to any desired slot because it uses the LSI four-level interrupt scheme to perform distributed interrupt arbitration.

There must be no unused slots, however, between the CPU and the QD24-E.

3.4.2.3 Mounting

Plug the QD24-E into the MicroVAX 3500/3600 backplane with components oriented in the same direction as the CPU and other modules. Always insert and remove the boards with the computer power OFF to avoid possible damage to the circuitry.

The QD24-E PCBA includes a front panel with extractor handles. To install the board, slide the board in the slot with the extractor handles in the open position (aligned with the front panel of the PCBA). See Figure 3-4. When the board is properly positioned in the throat of the board guides, secure the board by pushing the extractor handles towards the center of the front panel.

The front panel of the QD34 PCBA will be set back further than the panels of the DEC boards in the backplane. Install a gap-filler panel on either side of the QD24-E, between a flat-board cover and the front panel of the QD24-E. (Each QD24-E is shipped with two gap-filler panels; refer to Table 1-1 for part number.)

Use a Philips head screwdriver and push and turn the handle-locking screws a quarter-turn to lock the QD24-E PCBA into the chassis.

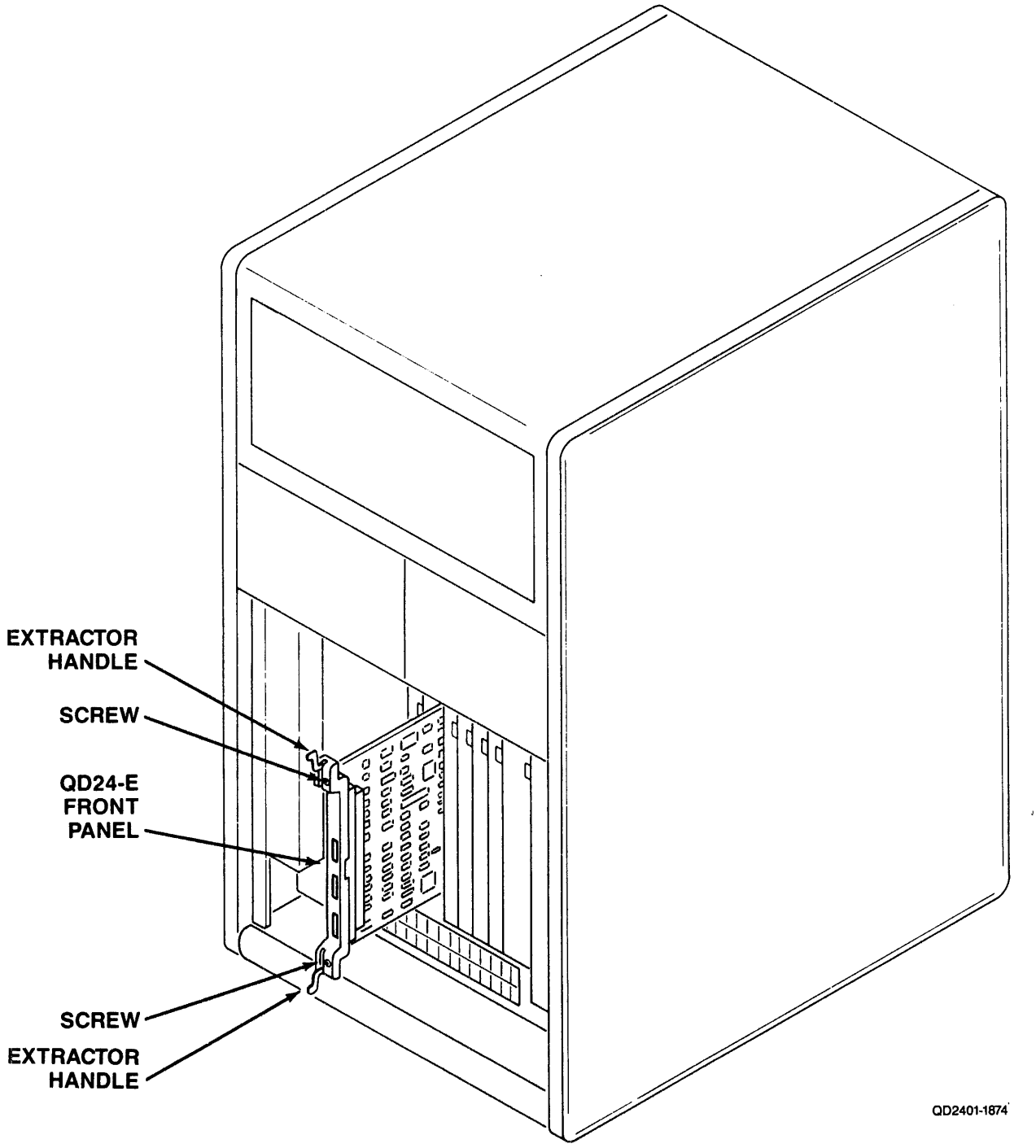


Figure 3-4. Mounting the QD24-E PCBA in a MicroVAX 3500/3600

3.4.2.4 ESDI Disk Drive Preparation

The disk drive(s) must have an ID plug or address selection switches properly configured and, if hard-sectored, be configured for the proper number of sectors.

3.4.2.5 Drive Placement

Uncrate and install the disk drives according to the manufacturer's instructions. Position the disk drives in their final places before beginning the installation of the QD24. This positioning allows the I/O cable routing and length to be accurately judged.

3.4.2.6 Sectoring

The QD24 supports both hard- and soft-sectored drives. In general, if a drive is capable of both hard- and soft-sector format, hard-sectoring is preferred as long as the number of hard sectors does not reduce the possible drive capacity. For information on setting the drive's switches, refer to the drive manufacturer's manual.

3.4.2.7 Drive Numbering

An address from 0 to 3 must be selected for each drive. Be careful that no two drives are assigned the same number. The logical unit number is determined by the address given to the drive.

Drive manufacturers use jumpers, switches, or ID plugs to select addresses. Consult the appropriate drive manual for the exact procedure.

3.4.2.8 Spindle Motor Spin-Up

Most ESDI drives have a spindle motor control option which allows the drive controller to control the timing of the drive spindle motor spin-up. Emulex recommends that you allow the QD24 controller to start the spindle motor spin-up of the drive(s). If there is more than one drive, the QD24 issues the spin-up commands to each drive sequentially. This will minimize any power surge on multiple drive systems.

3.4.2.9 Termination

Terminator power is supplied by the drive. The terminated drive must, therefore, have power applied in order for termination to be effective. Otherwise, indeterminate results will occur.

Only the last drive in the string is terminated.

3.4.3 Cabling

In a QD24-E subsystem, the QD24-E PCBA is installed in the MicroVAX 3500/3600 cabinet and the disk drives are mounted in a separate rack-mount cabinet. In the maximum physical drive configuration, the QD24-E interfaces with four ESDI disk drives using:

- three, 50-conductor round shielded control cable
- a QD24 Distribution Panel
- one, 34-conductor flat-ribbon cable
- four, 20-conductor flat-ribbon cables
- two, 10-conductor flat-ribbon cables

A 50-conductor round-shielded control cable connects from the high-density connector J1 on the QD24-E PCBA front panel to the 50-pin connector J5 on the front side of the QD24 Distribution Panel. From the 34-pin cable connector on the back side of the QD24 Distribution Panel, one cable daisy-chains to all of the supported drives, terminating on the last drive. Maximum control cable length from the QD24-E to the last ESDI drive is 10 feet (3 meters).

A 50-conductor round-shielded data cable connects from high-density connector J2 on the QD24-E front panel to the cable connector for Ports 0 and 1, labeled J1, located on the front side of the QD24 Distribution Panel. The back side of the QD24 Distribution Panel has separate connectors for Port 0 and Port 1. A 20-conductor flat-ribbon connects from each port to an ESDI drive in a radial scheme. (Figure 3-6 shows the connectors on the front and back sides of the QD24 Distribution Panel.)

A second round-shielded data cable connects from J3 on the QD24-E front panel to the cable connector for Ports 2 and 3, labeled J3, on the QD24 Distribution Panel. Data cables connect from Port 2 and Port 3 on the back side of the panel to ESDI drives in a radial scheme. The maximum data cable length (cumulative) for each drive is 10 feet (3 meters).

In addition, the back side of the QD24-E distribution panel contains two, 10-pin connectors; one for Port 0 and 1 and one for Port 2 and 3. These connectors provide the signals for the drive activity panels (described in subsection 7.4)

Figure 3-5 is a basic cabling diagram.

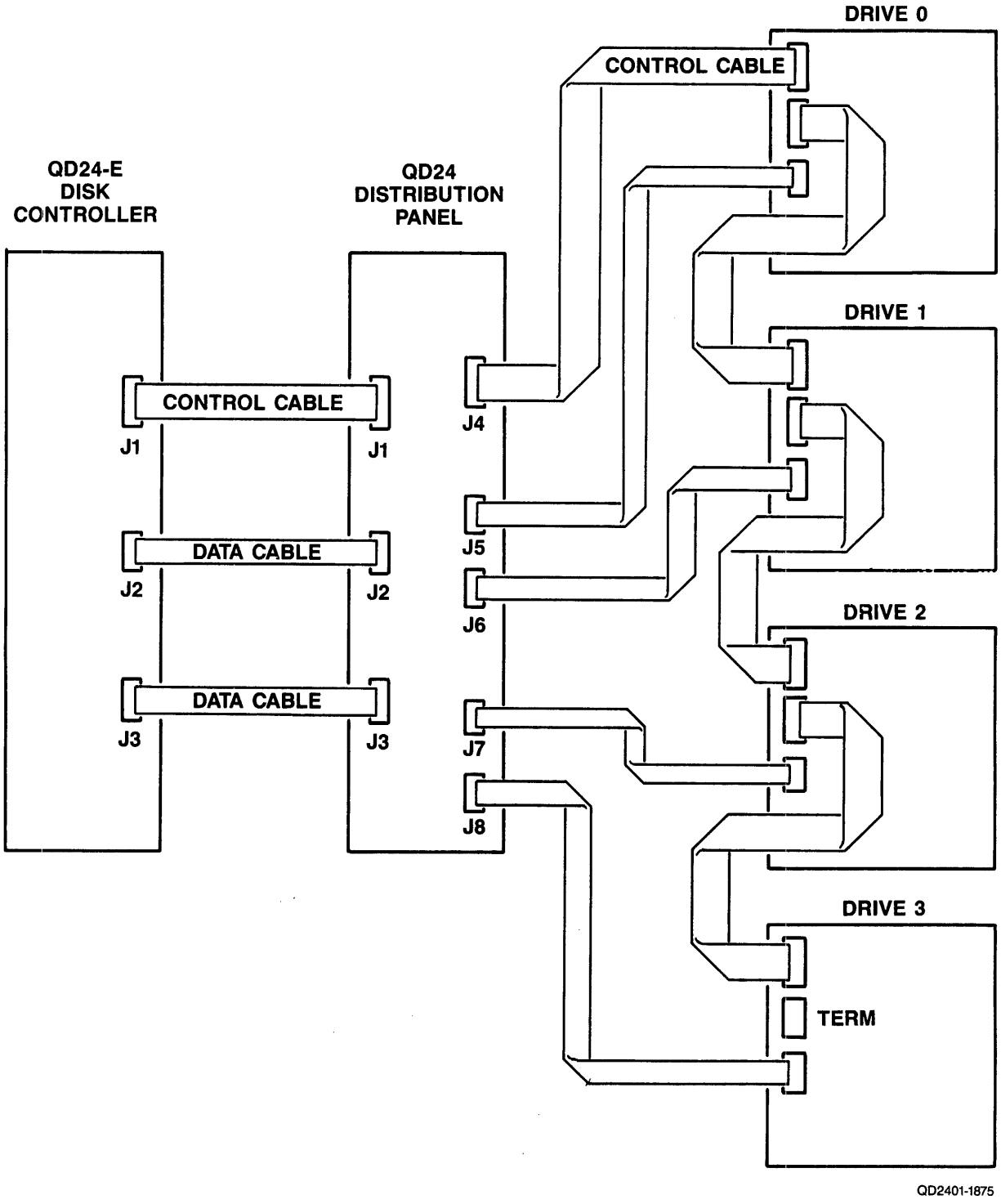


Figure 3-5. Drive Cabling for the QD24-E

Because the QD24-E PCBA and the ESDI drives are located in separate enclosures, the cables that run between the enclosures must be shielded. The points of enclosure exit and entry must not cause the computer installation to exceed FCC limits for RFI. The QD24 Distribution Panel, rack-mount panel, and round-shielded cables designed for this purpose are available from Emulex (Table 1-2). The QD24 Distribution Panel (Figure 3-5) is designed to fit directly into a rack-mount panel which installs in any standard 19-inch RETMA rack. The rack-mount panel is shown in Figure 3-7.

Procedure:

1. Ensure the QD24-E PCBA is installed in the backplane of the MicroVAX 3500/3600 and that the system power is OFF.

2. Remove all four of the small panels from one side of the rack-mount panel (Figure 3-7). Install a QD24 Distribution Panel (Figure 3-6) in the resulting aperture and secure it with the eight captive screws. Tighten the screws finger-tight. Make sure that no gaps are present around the QD24 Distribution Panel.

3. Install the rack-mount panel containing the QD24 Distribution Panel on the RETMA rails in the disk drive cabinet (Figure 3-8).

4. Connect the round-shielded control cable from the QD24-E PCBA to the Distribution Panel. Align the top of the cable header on the 50-conductor round-shielded cable (the cable runs out the bottom) with the top of the high-density connector J1 on the front panel of the QD24-E PCBA. Hold in the latch on the top of the cable header and press the header into J1; connect the header at the other end to connector J1 on the front side of the QD24 Distribution Panel.

5. Connect the drive control cable from the QD24 Distribution Panel to the first ESDI drive in the configuration. Align the molded arrow on the cable header of the flat-ribbon cable with pin 1 of connector J4 on the back side of the QD24 Distribution Panel. Press the header into J4; attach the header at the other end of the cable to the control cable connector on the first ESDI drive. Daisy-chain the control cable, connecting to each control cable connector on each ESDI drive, terminating on the last drive. Make sure that the latches on the connector fully engage the cable header.

6. Connect a round-shielded data cable from the QD24-E PCBA to the Distribution Panel. Align the top of the cable header on the 50-conductor round-shielded cable (the cable runs out the bottom) with the top of the high-density connector J2 on the front panel of the QD24-E PCBA. Hold in the latch on the top of the cable header and press the header into J2; connect the header at the other end to connector J2 for Ports 0 and 1 on the front side of the QD24 Distribution Panel.

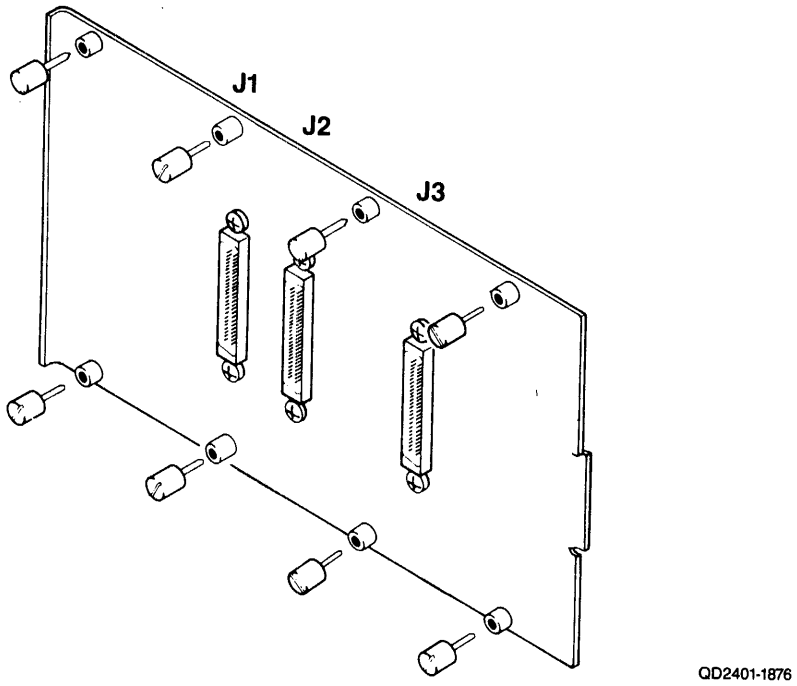


Figure 3-6. QD24 Distribution Panel (Front)

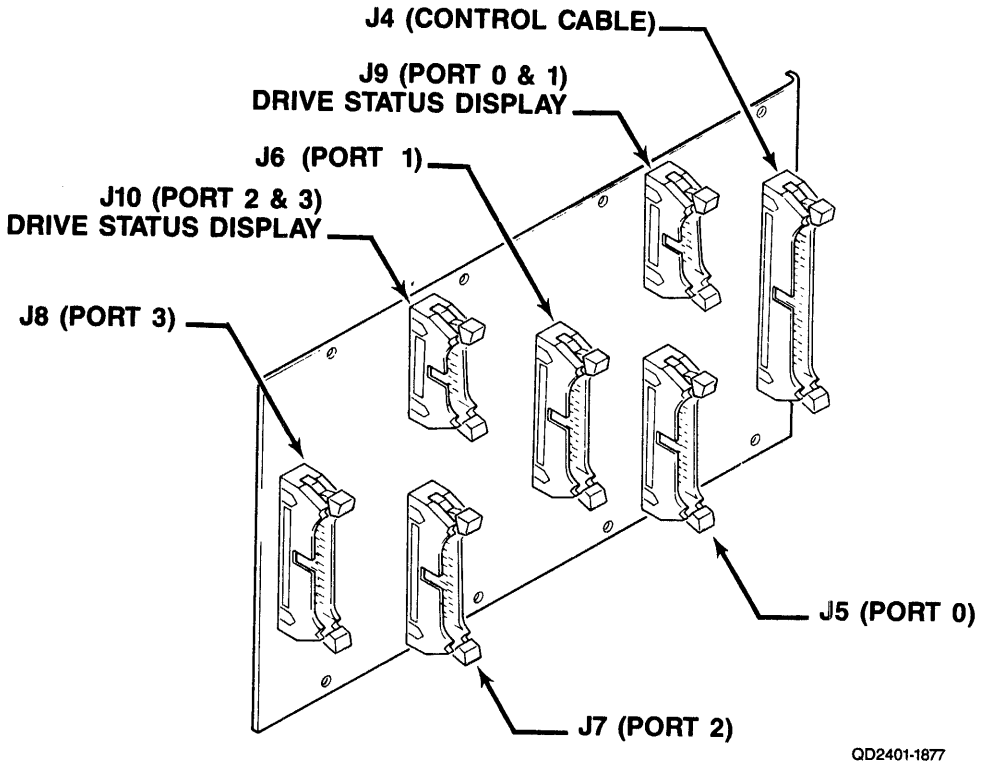


Figure 3-7. QD24 Distribution Panel (Rear)

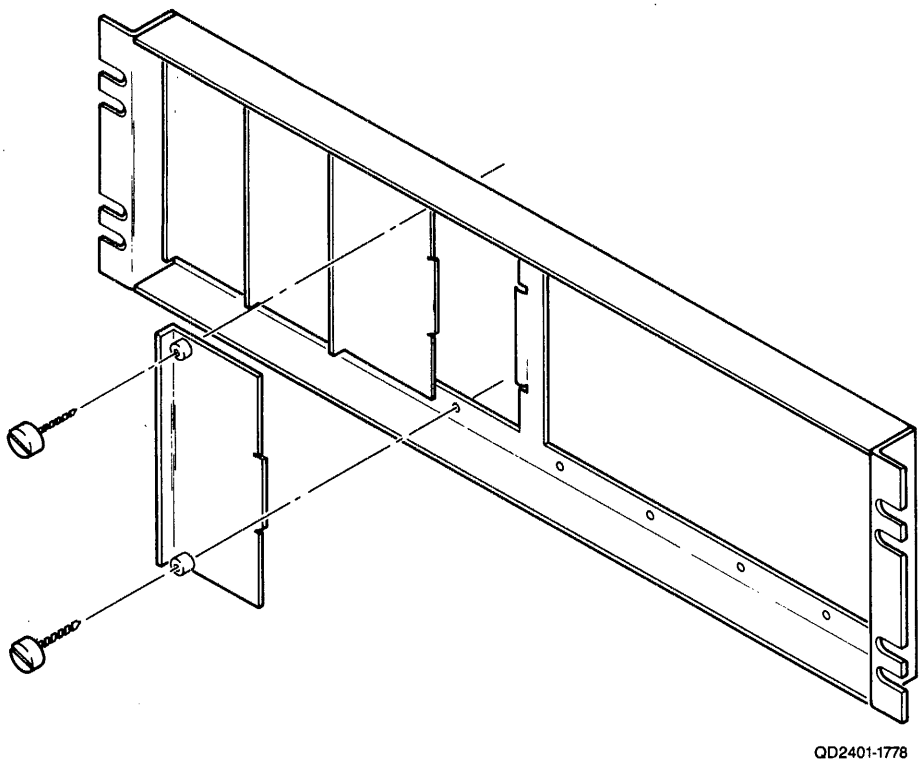


Figure 3-8. Rack-Mount Panel

7. Connect the drive data cables from the QD24 Distribution Panel to the ESDI drives in a radial scheme. Align the molded arrow on the cable header of the 20-conductor cable with pin 1 of connector J5 (Port 0) on the back side of the QD24 Distribution Panel. Press the header into J5; attach the header at the other end of the cable to the data cable connector on the first ESDI drive. Make sure that the latches on the connector fully engage the cable header.

   Connect another 20-conductor cable from the Port 1 data cable connector J6 on the back side of the distribution panel to the data cable connector on the second ESDI drive.

8. Connect a second round-shielded data cable from connector J3 on the QD24-E front panel to connector J3 on the distribution panel (Port 2 and 3). Follow the instructions in step 6.

9. Connect the drive data cables from the QD24 Distribution Panel connectors J7 (Port 2) and J8 (Port 3) to the ESDI drives in a radial scheme. Follow the instructions in step 7.

10. Distribution panel connectors J9 and J10 contain signals that may be used to drive an external control and status panel. Refer to section 7.4 for pin assignments.

End of Procedure

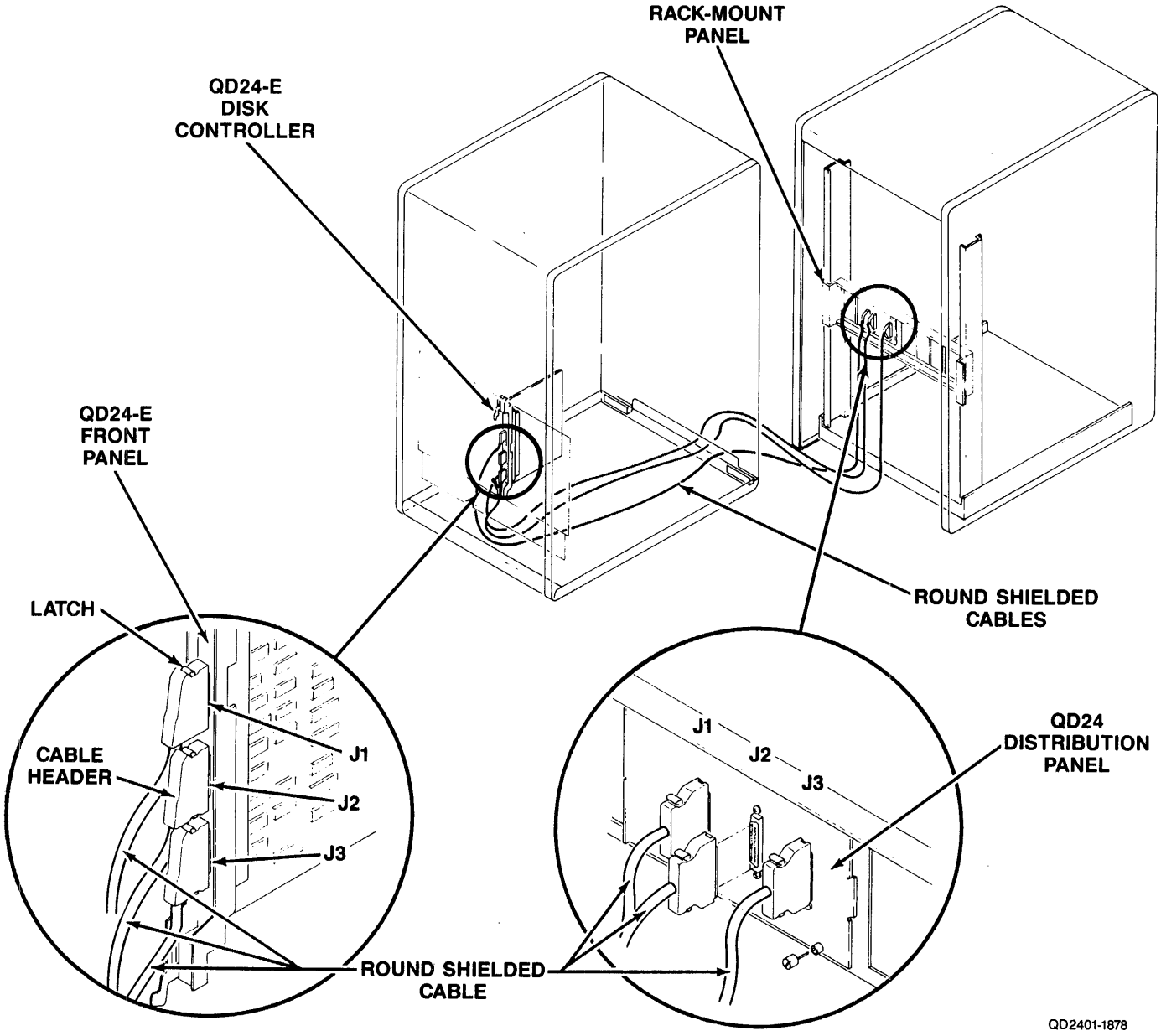


Figure 3-9. QD24-E Subsystem Cabling

3.5 Installing the QD24-I

This subsection describes the physical installation of the QD24-I Disk Controller. You should have already completed steps 1 and 2 on the following Installation Checklist:

QD24-I INSTALLATION CHECKLIST

- ☐ 1. Inspect the QD24 Disk Controller. (Subsection 3.2)
- ☐ 2. Set up the switches on the QD24 module. (Subsection 3.3)
- ☐ 3. Install the controller in the MicroVAX 3500/3600 backplane.
- ☐ 4. Install and connect the disk drive(s).
- ☐ 5. Run the onboard embedded diagnostics. (This step includes formatting the disk drives.)
- ☐ 6. Bring the system up.

3.5.1 Physically Installing the QD24-I PCBA

The following subsections describe the physical installation of the QD24-I Disk Controller PCBA.

3.5.1.1 System Preparation

To prepare the MicroVAX 3500/3600 to accept the QD24-I, use the following procedure:

1. Power down the system by switching OFF the main power switch.
2. Open the front chassis door.
3. Remove a blank cover from the front of the chassis so that an empty slot is exposed.

3.5.1.2 Slot Selection

The QD24-I may be assigned to any desired slot because it uses the LSI four-level interrupt scheme to perform distributed interrupt arbitration.

There must be no unused slots, however, between the CPU and the QD24-I.

3.5.1.3 Mounting

Plug the QD24-I into the MicroVAX 3500/3600 backplane with components oriented in the same direction as the CPU and other modules. Always insert and remove the boards with the computer power OFF to avoid possible damage to the circuitry. Be sure that the board is properly positioned in the throat of the board guides before attempting to seat the board by means of the extractor handle.

3.5.1.4 ESDI Disk Drive Preparation

The disk drive(s) must have an ID plug or address selection switches properly configured and, if hard-sectored, be configured for the proper number of sectors.

3.5.1.5 Drive Placement

In order to maintain FCC compliance, the drives must be mounted in the cabinet's FCC hardened BA 213 CPU/Drive Chassis. The user is responsible for installation methods.

3.5.1.6 Sectoring

The QD24 supports both hard- and soft-sectored drives. In general, if a drive is capable of both hard- and soft-sector format, hard-sectoring is preferred as long as the number of hard sectors does not reduce the possible drive capacity. For information on setting the drive's switches, refer to the drive manufacturer's manual.

3.5.1.7 Drive Numbering

An address from 0 to 3 must be selected for each drive. Be careful that no two drives are assigned the same number. The logical unit number is determined by the address given to the drive.

Drive manufacturers use jumpers, switches, or ID plugs to select addresses. Consult the appropriate drive manual for the exact procedure.

3.5.1.8 Spindle Motor Spin-Up

Most ESDI drives have a spindle motor control option which allows the drive controller to control the timing of the drive spindle motor spin-up. Emulex recommends that you allow the QD24 controller to start the spindle motor spin-up of the drive(s). If there is more than one drive, the QD24 issues the spin-up commands to each drive sequentially. This will minimize any power surge on multiple drive systems.

3.5.1.9 Termination

Terminator power is supplied by the drive. The terminated drive must, therefore, have power applied in order for termination to be effective. Otherwise, indeterminate results will occur.

Only the last drive in the string is terminated.

3.5.2 Cabling

In a QD24-I subsystem, both the QD24-I PCBA and the ESDI disk drives are installed in the BA 213 chassis in the MicroVAX 3500/3600 cabinet. You are totally responsible for maintaining FCC compliance of a QD24-I Disk Controller. In the maximum physical drive configuration, the QD24-I interfaces with four ESDI disk drives using standard ESDI control and data interface cables. (Refer to subsection 7.3 for a description of the ESDI interface.)

Standard ESDI cables are connected to the QD24-I controller. The ESDI cable connectors on the QD24-I PCBA are identified as follows:

- J5 ESDI Control Interface
- J8 ESDI Data Interface
- J2 ESDI Data Interface
- J3 ESDI Data Interface
- J4 ESDI Data Interface

The QD24-I uses connectors J6 and J7 (10-pin connectors) for the drive activity panel interface (described in subsection 7.4).

3.6 NOVRAM Loading, Disk Formatting, and Testing

After physically installing the QD24, several steps are required to prepare the subsystem for operation. They are:

- Loading the configuration data into the NOVRAM
- Formatting and verifying the media
- Testing the subsystem

The QD24 disk controller firmware incorporates a self-contained set of disk preparation and diagnostic utilities, called firmware-resident diagnostics (F.R.D.). F.R.D. provides several important disk preparation functions, including the ability to configure the controller NOVRAM, format the drive, test the disk surface and replace defective blocks, and perform reliability testing of the attached disk subsystem. These utilities allow you to communicate directly with either CRT or hardcopy devices connected to a MicroVAX 3500/3600 console port.

The basic application of F.R.D. is in preparing MSCP disk drives for use in your subsystem. Before data can be stored on a drive, the disk must be formatted and any bad blocks identified. F.R.D. provides options that allow you to perform these functions. You use NOVRAM configuration options to set and review your drive parameter values.

The steps involved in disk preparation are formatting the drive and then verifying that each logical block is good. F.R.D. supports both automatic and manual block replacement operations to allow for replacing defective and pattern-sensitive blocks.

Automatic replacement, or blanket bad block replacement, is a feature of several F.R.D. options. With this feature, you can format a drive, verify, and replace any bad blocks in one step. During this format/verify operation, bad blocks are displayed in logical block number (LBN) format. If replacement is enabled, the blocks are replaced automatically.

Manual bad block replacement is a separate option. This option allows you to identify specific bad blocks to be replaced. In addition, you can identify the blocks in Bytes From Index (BFI) format or in LBN format. Using BFI format eliminates the calculation required for LBN. This is most often useful in replacing blocks identified as bad in the manufacturer's defect list.

BFI replacement must be done before any LBN replacement. Once LBN replacement occurs, the BFI values are no longer valid.

There are several ways you can use F.R.D. options to format and verify your disk. The method you choose depends on whether you:

- have formatted this disk
- want to replace blocks using BFI or LBN information
- want to preserve data on this disk

Each method is described below. The options listed are on the F.R.D. main menu. Use them in the order they are listed. (F.R.D. options are described in section 3.8.)

F.R.D. will find and replace defects with the four worst-case data patterns plus those listed in the Manufacturer's Defect List. If this is the initial format of a disk and you want to replace those defects, use:

- Option 4, Format and Verify with replacement enabled

If this is the initial format of a disk and you want to replace manufacturer's detected defects from the hardcopy list, use:

- Option 2, Format
- Option 9, Replace Block using BFI format
- Option 3, Verify with replacement enabled

If this disk is formatted and you want to preserve data and obtain a list of bad blocks, use:

- Option 7 with replacement disabled

3.6.1 F.R.D. Conventions

F.R.D. uses the following keyboard conventions:

<CR>	required to terminate operator inputs
<Ctrl C>	aborts the current operation and returns to the main menu

A minimum delay of 10 seconds may occur between the <Ctrl C> and the next display. During some verify operations, the delay may be considerably longer because the abort is delayed until the successful completion of the current command. In this case, a screen message informs you of the delay.

In this section, operator responses to F.R.D. prompts appear in **bold** print. The symbols used in this section are listed below with their meanings:

<CR>	carriage return key
<LF>	line feed key
<Ctrl C>	Ctrl key and the letter C pressed at the same time

3.6.2 Starting F.R.D. on a MicroVAX 3500/3600

To start F.R.D. on a MicroVAX 3500/3600, first apply power to the system. Put the system in console mode, then enter the following commands via the host console in response to the >>> prompt:

```
>>>I                                    !BUS INIT
>>>D/P/W 20001F40 20<CR>               !ENABLE MEMORY
>>>D/P/L 20088000 80000000<CR>         !SETUP MAP 0
>>>D/P/L 20088004 80000001<CR>         !SETUP MAP 1
>>>D/P/W 2000XXXX 1<CR>                !INIT CONTROLLER
>>>E/P/W 2000YYYY<CR> 900 OR B00       !STEP ONE FROM QD24
>>>D/P/W 2000YYYY 3003<CR>             !ENABLE SPECIAL MODE
>>>E/P/W 2000YYYY<CR> 0100             !ACK SPECIAL MODE
>>>D/P/W 2000YYYY 4401<CR>             !UPLOAD DRIVER
>>>E/P/W 2000YYYY<CR> 0400             !UPLOAD DONE
>>>S 80<CR>                            !START DRIVER
```

NOTE: XXXX and YYYY are offsets dependent on the address of the QD24 controller. See Table 3-8 for the available values.

Table 3-8. MicroVAX Offsets

CONTROLLER BUS ADDRESS	XXXX	YYYY
772150	1468	146A
772154	146C	146E
760334	00DC	00DE
760340	00E0	00E2
760344	00E4	00E6
760350	00E8	00EA
760354	00EC	00EE
760360	00F0	00F2
760364	00F4	00F6
760370	00F8	00FA
760374	00FC	00FE
760400	0100	0102
760404	0104	0106
760410	0108	010A
760414	010C	010E
760420	0110	0112

When the appropriate start procedure is completed, F.R.D. identifies itself by displaying the controller type and firmware revision. Then, it displays the menu options.

3.6.3 Terminating F.R.D.

To terminate F.R.D., choose one of the following:

- Press the BREAK key
- Reinitialize the system, or
- Halt the CPU.

You can restart the diagnostics from a halted condition if you have not changed the memory contents. On a MicroVAX 3500/3600, enter **S 80**.

3.7 F.R.D. Options

F.R.D. is an interactive, menu-driven utility. This section describes the function of each option on the F.R.D. main menu. The menu appears as follows:

```
Program Option Menu

1  - Self-test loop
2  - Format
3  - Verify
4  - Format and verify
5  - Data reliability test
6  - Format, verify, and data reliability test
7  - Read only test
8  - List known units
9  - Replace block
10 - Print RCT
11 - Display Novram
12 - Edit / Load Novram

Enter option number:
```

The main menu and each submenu prompt for required input. When you enter a valid selection, the next menu displays or F.R.D. performs the selected option. If you make an invalid entry, F.R.D. rejects it, displays an error message, and reprompts.

Based on the nature of the MSCP emulation being performed, some operations may produce an observable delay when performed on previously unformatted drives. This delay is approximately 30 seconds.

When an option is finished, F.R.D. displays the prompt "Hit any key to continue" and waits for you to do so before returning to the main menu.

3.7.1 Option 1 - Self-test Loop

The Self-test Loop option detects intermittent hardware failures that have already passed through the first self-test. The LED indicators on the QD24 front panel will blink when a pass has compeleted. If an error occurs, the self-test loop option stops and reports an error; the LEDs on the front panel display the error code. A description of the error codes is displayed on the host console device. This option may be aborted by <Ctrl C>

3.7.2 Option 2 - Format

The Format option is used to initially format a drive. The operation writes sector headers; initializes the drive's replacement caching tables (RCT), and replaces any defects listed in the MDL. It is used to format a virgin drive, a drive that has been determined to contain unusable data, or a drive with a format that is improper to use with a particular controller.

If a type 2 drive is being formatted (configuration parameters are read from the drive), F.R.D. prompts for spiral offset.

After formatting, the drive contains a valid RCT with a serial number you specified. During format, F.R.D. attempts to read and use the MDL. F.R.D. displays a message if the MDL cannot be read. If portions of the MDL are bad, F.R.D. uses whatever good information can be extracted.

It is possible that either type 1 or type 2 drives might have so many multiple sector/track defects that the default number of spare cylinders allocated for replacement usage is not large enough. If the number of defects in the MDL exceeds the replacement area allocated, you will be alerted by a message stating that the present value doesn't allow formatting with MDL and how many spare cylinders are required to accomodate the MDL. This number of spare cylinders includes two additional cylinders for future bad spots. If this occurs, you have two choices:

Drive Type Code 2. Continue to format without MDL, running two passes of verify and 10 passes of reliability to remove pattern sensitive bad blocks.

Drive Type Code 1. Change to type code 1 and change the number of spare cylinders as required by the message from F.R.D; restart the format.

You will be notified if a drive has been formatted without the MDL; this will occur if a drive's MDL cannot be read and/or if there is an insufficient number of spare cylinders. You have the option to let the formatting continue or to abort using <Ctrl C).

3.7.3 Option 3 - Verify

The Verify option Write/Read exercises all user-available blocks. F.R.D. uses four worst-case data patterns to find and replace pattern-sensitive blocks not found in the drive defect list. It asks for the logical unit number (LUN) of the drive to be verified. After you enter the LUN, F.R.D. prompts for the number of write/read passes.

Verify operations are performed on 120 logical blocks at a time. Logical blocks are referenced by logical block number (LBN).

During Verify operations, F.R.D. disables all controller error recovery capabilities so that a sector is replaced for any repeatable single bit error. Each data pattern is run until error-free for a single pass, ensuring that replacement blocks are also verified.

When a block is encountered that cannot be accessed because of header or data field errors, the Logical Block Number in error displays. Because the failing pattern may not be the first pattern, it is possible that replacement blocks may not be tested with all patterns. For this reason, Emulex recommends running at least two Verify passes over all 4 data patterns.

The Verify option has many features which allow you to enable full error description. When Error Description is enabled, it reports the type of error that occurs on the bad blocks. If a drive is producing an excessive number of bad blocks, this feature helps determine the kinds of errors responsible.

The Verify option also offers a bad block replacement feature which, when enabled, replaces any bad blocks using the appropriate technique.

At the end of all testing or when you enter a <Ctrl C>, F.R.D. reports the number of bad blocks detected by the Verify operation. There will be no message if the Verify option does not detect any errors.

3.7.4 Option 4 - Format and Verify

This option formats a drive, then tests the surface to replace pattern-sensitive and defective sectors. It performs both of the operations that are available separately with options 2 (Format) and 3 (Verify). This option also offers a bad block replacement feature which, when enabled, replaces any bad blocks found during the verify operation.

3.7.5 Option 5 - Data Reliability Test

This option allows you to thoroughly test your subsystem. The reliability test uses Write, Write/Check, and Read functions to test the controller-to-drive portion of the subsystem. In addition, an independent DMA operation between the host memory and the controller tests the host/controller interface.

The test defaults to two reserved diagnostic cylinders so that user data will be protected; a test of the full pack is your option. To run the reliability test indefinitely, select 0 (zero) passes.

If the test encounters errors, F.R.D. displays text error messages. These messages are primarily for use by Emulex technical support personnel.

3.7.6 Option 6 - Format, Verify, and Data Reliability Test

This option combines options 2 (Format), 3 (Verify), and 5 (Data Reliability Test). This option automates the initialization and testing of drives, since you can select multiple drives and activate the data reliability test without having to wait for the format and verify options to complete. The format and verify portions of this option run in the order of the drives selected. Drives with hard faults are dropped and the sequence moves to the next drive in the list. The reliability portion of this option runs simultaneously on all selected drives.

3.7.7 Option 7 - Read Only Test

This option causes all the user-available blocks on the selected drive to be Read-only, not Write/Read, during the Verify pass. When a block is encountered that cannot be accessed because of header or data field errors, the utility displays the Logical Block Number.

The Read Only Test option also offers a bad block replacement feature, which, when enabled, replaces any bad blocks. Because F.R.D. runs with ECC disabled and does not cache any read data, no corrected data is available to put in the replacement block. This means that even though the defective block is replaced and no forced error flag is set in the replacement sector, the data is nonvalid.

CAUTION

This may cause problems if the replaced blocks contain executable program files. For this reason, you should back up sensitive data before running this option with the replacement feature enabled.

This option is usually used after the drive is formatted. However, if you plan to manually replace the bad blocks identified in the manufacturer's defect list, be certain to do so before using Option 7 with replace enabled.

3.7.8 Option 8 - List Known Units

This option causes the program to list all the drives that are configured in the NOVRAM. Only those units that can be selected by the controller are listed as available.

A user size (in 512-byte blocks) and a media type I.D. are listed with all drives found by this option. The user size does not include RCT area, diagnostic cylinders, designated or hidden spare tracks or blocks, etc.

In addition, this option displays the attached drive's physical geometry. This display includes all areas of the disk. If the device size in logical blocks is calculated from this data, the number will be larger than the displayed user size. The difference is the number of LBNs used for RCT, diagnostic cylinders, spares, etc.

3.7.9 Option 9 - Replace Block

This option allows you to replace a specific bad block or group of blocks without using the blanket replacement feature found in the Verify and Read Only options. You choose to identify either logical blocks (entered in decimal MSCP Logical Block Number format) or Bytes From Index (as listed in the manufacturer's defect list), then enter the block to be replaced. If you specify LBN, then you will be prompted to enter the block to be replaced. If you specify BFI, you will be prompted for the number of bytes from index, then to enter the length in bits.

BFI replacement eliminates the calculation required to translate BFI to LBN format. F.R.D. requires the cylinder, track, and bytes from index of the defect for each BFI entry. When you initiate replacement, F.R.D. prompts for the number of bytes from index. As soon as you enter this value, you are prompted to enter the length in bits, then F.R.D. begins replacing blocks.

LBN replacement allows you to replace blocks identified as bad during the format operation, when they are identified in LBN format by older versions of DEC operating systems which do not support host-initiated replacement.

If you are using both types of replacement, BFI replacement must be complete before LBN replacement is begun. Further, BFI replacement must be complete before the blanket bad block replacement feature of other options is enabled.

Emulex recommends that you run the Verify option after the replacement option is complete. The Verify option runs test patterns that may detect any pattern-sensitive blocks.

3.7.10 Option 10 - Print RCT

This option allows you to display the selected drive's Replacement Caching Table. The entries listed will show the pack serial number, the displayed RCT copy (multiple copies are saved), and if the sector was primary, secondary or nonusable with the associated logical block number. The number of remaining spare tracks (used for track replacements) is also shown. Zero remaining replacement tracks will force the system to software writelock the drive upon the next replace command.

3.7.11 Option 11 - Display NOVRAM

This option displays the current contents of the NOVRAM for your drives. The information displayed depends on the type code entered in the NOVRAM. For type 1 drives, this option displays the current NOVRAM parameter values. For type 2 drives, this option lists the drive as type 2 with parameters read from the drive.

3.7.12 Option 12 - Edit/Load NOVRAM

This option allows you to enter the drive configuration parameters into the controller. If a drive type code of 1 is specified, F.R.D. prompts you for the required drive parameters. If a drive type code of 2 is specified, the controller obtains configuration parameters from the drive.

3.8 Drive Configuration Parameters

When you edit or load NOVRAM configuration parameters, you are asked to enter the values required for your configuration. This section describes each parameter and states the range of valid entries for each.

You begin loading NOVRAM parameter values by selecting Option 11 from the F.R.D. main menu. F.R.D. then displays each parameter, one at a time. The parameter displays with a range of valid entries and a default value. Enter the appropriate value (in decimal) or simply press the return key to accept the default value (the last value entered). The next parameter then displays.

3.8.1 Adaptive DMA Threshold

This parameter specifies the number of words the QD24 will transfer before it looks for another device that wants to use the Q-Bus. The valid range is from 1 through 8; the recommended value for the MicroVAX 3500/3600 is 8.

You are prompted for this parameter when you select the edit/load NOVRAM option; this prompt does not appear for each drive that you are configuring.

3.8.2 Type Code

This parameter indicates the type of disk drive. Valid values are 1 and 2. If you enter 1, the controller expects to find drive configuration information contained in the NOVRAM. F.R.D. then displays each parameter for you to enter the values.

If you enter 2, the controller obtains the drive configuration information from the drive. In this case, the only other parameter value you enter for this drive is the spiral offset, which is entered when you initiate a format option during formatting. The spiral offset parameter is saved on the disk drive. Default values are used for the number of spare sectors per track (1) and the number of alternate cylinders (2).

NOTE

A compatibility issue may exist if you define a drive as Type 1, then later redefine it as Type 2, even if the NOVRAM values you entered match those read from the drive.

If a drive is in hard sector mode, the controller is configured for Type 2 drives, and you want to switch the drive to Type 1, then the drive must first be powered down. This allows it to switch from Type 2 commanded Bytes per Sector to the number of bytes per sector determined by the drive sector switches or jumpers. This problem may be eliminated by setting the drive jumpers or switches to match the number of sectors determined by the Type 2 calculations.

3.8.3 Number of Units of this Type

This parameter specifies the quantity of attached physical disk drives that use the NOVRAM parameters that follow. Valid values are 1 to 4. If you enter 1, the utility uses a separate set of parameter values for each drive. In this case, it prompts for parameter values for the other drives. If you enter 2 or more, the same parameter values are used for that number of drives.

3.8.4 Number of Sectors per Track

This parameter specifies the total number of physical sectors per track, including spares. The valid range is from 1 through 255.

3.8.5 Number of Heads

This parameter specifies the number of data heads per physical drive. The valid range is from 1 through 63.

3.8.6 Number of Cylinders

This parameter specifies the total number of physical cylinders per drive, including spares. The valid range is from 1 through 4,095.

3.8.7 Number of Spare Sectors per Track

This parameter specifies the number of spare sectors reserved per track. Emulex recommends a value of 1; larger values will unnecessarily reduce the capacity of the drive. The default value of 1 is used if you select a type code of 2.

3.8.8 Number of Alternate Cylinders

This parameter specifies the number of spare cylinders per physical drive. The valid range is from 2 through 15. At least two cylinders must be specified as alternates. (If spare sectors are specified, the sector replacement algorithm needs one track for working space.)

If Split Code 1 is used, you must specify twice the normal number of alternate cylinders because they are divided evenly between the two logical drives. A minimum of 2 alternate cylinders must be specified if block replacement is to function with a cylinder split.

3.8.9 Configuration Bits

These parameters define additional configuration characteristics of the drive. This parameter has a 4-bit field with a valid range from 0 through 15.

If you selected type code 2 for this drive, the configuration information is read from the drive and you will not need this information.

If you selected type code 1 for this drive and your subsystem includes a drive that Emulex supports, refer to Appendix B, Table B-1, for the decimal values to enter for these parameters. If your drive is not supported by Emulex, refer to the drive manufacturer's manual for drive requirements, then enter the appropriate values as discussed subsequently.

Configuration Bits:

Bit 0: This bit is 0 if the drive is hard-sectored and 1 if the drive is soft-sectored.

Bit 1: This bit specifies whether or not the drive can perform early or late data strobe operations. The valid range for this bit is 0 or 1. If the bit is 0, the drive cannot perform early or late data strobe operations. If the bit is 1, the drive is capable of performing early or late data strobe operations.

Bit 2: This bit specifies whether or not the drive is capable of head offset operations. The valid range for this bit is 0 or 1. If this bit is 0, the drive cannot perform head offset operations. If the bit is 1, the drive is capable of performing head offset operations.

Bit 3: This bit specifies whether or not the drive negates the Command Complete signal during a head select operation. The valid range is 0 or 1. If the bit is 0, the Command Complete signal remains on during a head select. If the bit is 1, the Command Complete signal is negated during a head select.

Table 3-5. Configuration Bit Values in Decimal

Command Complete	Head Offset	Data Strobe	Sector	Decimal Value
OFF	NO	NO	HARD	0
OFF	NO	NO	SOFT	1
OFF	NO	YES	HARD	2
OFF	NO	YES	SOFT	3
OFF	YES	NO	HARD	4
OFF	YES	NO	SOFT	5
OFF	YES	YES	HARD	6
OFF	YES	YES	SOFT	7
ON	NO	NO	HARD	8
ON	NO	NO	SOFT	9
ON	NO	YES	HARD	10
ON	NO	YES	SOFT	11
ON	YES	NO	HARD	12
ON	YES	NO	SOFT	13
ON	YES	YES	HARD	14
ON	YES	YES	SOFT	15

3.8.10 Split Code

This parameter allows the drive(s) defined by this parameter block to be split into two logical disk units (two each, if more than one drive is defined by this block). The split codes are:

Code 0: No split.

Code 1: The cylinders are divided between the two logical drives. A starting cylinder offset value specifies the first cylinder of the second logical drive.

Code 2: The drive's data heads are divided between the two logical drives. A starting head offset value specifies the first head of the second logical drive. If you select a head split code on a drive with both fixed and removable media, the removable media may be configured as logical unit number (LUN) 0 and the fixed media as LUN 1.

Code 3: Identical to Code 2 except the logical assignments for the physical drives are reversed. Reverse head split codes also divide the drive by data heads, but assign the lower numbered heads to drive 1 and the higher numbered heads to drive 0.

Use of the split option disables seek-ordering and overlapped seek processing in the MSCP Controller, which reduces performance, particularly when both logicals of a split physical drive are active.

If drive type 2 is selected, no splits are available.

3.8.11 Cylinder Offset

This parameter specifies the physical cylinder that is to be used as the first cylinder of the second logical drive. This field has meaning only if a Split Code 1 is specified. If a Split Code 0, 2, or 3 is selected, this parameter must be 0.

3.8.12 Starting Head Offset

This parameter specifies the physical drive head that is to be used as the first head of the second logical drive. This field has meaning only if a Split Code 2 or 3 is specified. The valid range is from 1 through 63. If a Split Code 0 or 1 is selected, this value must be 0.

3.8.13 Removable Media

This parameter indicates whether the disk media is fixed or removable. If you are defining one physical/logical drive, this parameter uses a 1-bit field with valid values of 0 and 1, where 0 indicates fixed media and 1 indicates removable media.

If you are defining a drive with a logical split, this parameter uses a 2-bit field with a valid range from 0 through 3:

Definition	Decimal Value
LUN 0 and LUN 1 are both fixed.	0
LUN 0 is removable, LUN 1 is fixed.	1
LUN 0 is fixed, LUN 1 is removable.	2
LUN 0 and LUN 1 are both removable.	3

3.8.14 Media ID Type

This parameter identifies a media type of RA81 or RA82 and is intended for systems that run the Digital Standard Mumps (DSM) operating system. When utilizing disk drives that have a capacity greater than the DEC RA81 (456 megabytes formatted capacity), it is necessary to specify the DEC RA82 (622 megabytes formatted capacity) media type. Specifying the RA82 media type allows the use of disk drives with capacities greater than 456 megabytes and less than or equal to 622 megabytes.

0 = RA81 MEDIA ID
1 = RA82 MEDIA ID

3.8.15 Gap 0, 1, and 2 Parameters

These parameters specify the recording format for each sector on the drive. The recording format allows gaps, as, for example, between header and data fields. These gaps are based on a formula intended to allow the drive time for read/write transitions while maximizing data capacity.

Enter the appropriate value for the type code 1 drive. The values Emulex recommends for drives are calculated by using type code 2.

If you specified type code 2 for this drive, F.R.D. calculates these values based on information provided by the drive.

3.8.16 Spiral Offset

This parameter specifies the number of sectors by which sector 0 of a track is offset from sector 0 of the previous track. Offsetting sector 0 from one track to the next is a technique that is used to reduce latency when performing write or read operations that cross a track boundary. When the drive is formatted, sector 0 of a track is offset a certain number of sectors from the position of sector 0 on the previous track. When this is done, spiral write and read operations are more efficient because the drive has time to switch heads before encountering sector 0.

The valid range is from 0 through 31. Use a spiral offset of 1 for all drives except Embedded Servo drive. If you use an Embedded Servo drive (check the drive manual), use a spiral offset of 11. If poor disk performance is noted, adjust the spiral offset value until maximum throughput is achieved. **Note:** The drive must be reformatted each time the spiral offset is changed.

3.9 Operation

There are no operational instructions. The QD24 is ready for MSCP initialization as soon as its drives are formatted and tested.

3.9.1 Indicators

There are three light emitting diodes (LEDs) on the QD24. These LEDs are used for both diagnostics and for normal operations.

If switch SW1-1 is OFF, the QD24 executes a preliminary test at the following times:

- On power-up
- After a reset condition
- After a bus initialization
- After a write operation to the Initialization and Polling (IP) register (base address)

The self-test routine consists of two test sequences: preliminary and self-test. The preliminary test sequence exercises the 8031 microprocessor chip and the Disk Formatter functions of the MAC chip. When the QD24 successfully completes the preliminary test, LED3 illuminates indicating that the QD24 is waiting for the MSCP initialization sequence.

During the MSCP initialization sequence, initiated by host software control, the QD24 executes a self-test that exercises the buffer controller functions of the MAC chip, the Host Adapter Controller (HAC) chip and its associated circuitry, the onboard RAM, and the control memory PROM. If the QD24 passes this sequence of its self-test successfully, all the LED indicators on the QD24 are OFF.

If a fatal error is detected either during self-test or while the system is running, all three of the LED indicators are ON (illuminated). If the QD24 fails to pass its power-up self-tests, you can select a special diagnostic mode (switch SW2-8 ON) which causes the LED indicators to display an error code. See Self-Test Error Reporting, in Section 4, TROUBLESHOOTING.

During normal operation, LED1 and LED2 flicker occasionally. These LEDs are used to indicate Q-Bus respectively.

Section 4
TROUBLESHOOTING

4.1 Overview

This section describes the several diagnostic features with which the QD24 Disk Controller is equipped, and outlines fault isolation procedures that use these diagnostic features.

Subsection	Title
4.1	Overview
4.2	Service
4.3	Fault Isolation Procedure
4.4	Power-Up Self-Diagnostics
4.5	Fatal Error Codes

4.2 Service

Your Emulex QD24 Disk Controller was designed to give years of trouble-free service, and it was thoroughly tested before leaving the factory.

Should one of the fault isolation procedures indicate that the QD24 is not working properly, the product must be returned to the factory or to one of Emulex's authorized repair centers for service. Emulex products are not designed to be repaired in the field.

Before returning the product to Emulex, whether the product is under warranty or not, you must contact the factory or the factory's representative for instructions and a Return Materials Authorization (RMA) number.

Do not return a component to EMULEX without authorization. A component returned for service without an authorization will be returned to the owner at the owner's expense.

In the continental United States, Alaska, and Hawaii contact:

Emulex Customer Service
3545 Harbor Boulevard
Costa Mesa, CA 92626
(714)662-5600 Outside California: (800) 854-7112
FAX: (714) 996-1299 TLX: 183627

After 5 p.m. Pacific Time, call (800) 638-7243. When answered, you will be prompted to key in 37115, followed by a # symbol, then a message.

Outside the United States, contact the distributor from whom the subsystem was initially purchased.

To help you efficiently, Emulex or its representative requires certain information about the product and the environment in which it is installed. During installation, a record of the switch setting should have been made on the Configuration Reference Sheet. This sheet is contained in the Installation Section, Figure 3-1.

After you have contacted Emulex and received an RMA, package the component (preferably using the original packing material) and send the component **postage paid** to the address given you by the Emulex representative. The sender must also insure the package.

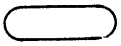
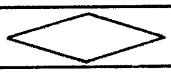
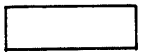
4.3 Fault Isolation Procedure

This fault isolation procedure is provided in flow chart format. The procedure is based on the self-diagnostics incorporated into the QD24. The procedure is designed to be used if the product's self-diagnostic fails or if many errors are flagged by the subsystem during normal operation. If neither of these events happens, it is not necessary to follow these procedures.

The Fault Isolation Chart is shown in Figure 4-1. The chart symbols are defined in Table 4-1.

If the fault isolation procedure indicates that a component needs to be returned to Emulex, see subsection 4.2 for instructions on how to do so.

Table 4-1. Flow Chart Symbol Definitions

Symbol	Description
	**Start point, ending point.**
	**Decision, go ahead according with YES or NO.**
	**Connector, go to same-numbered symbol on another sheet.**
	**Process.**

QD2401-0106

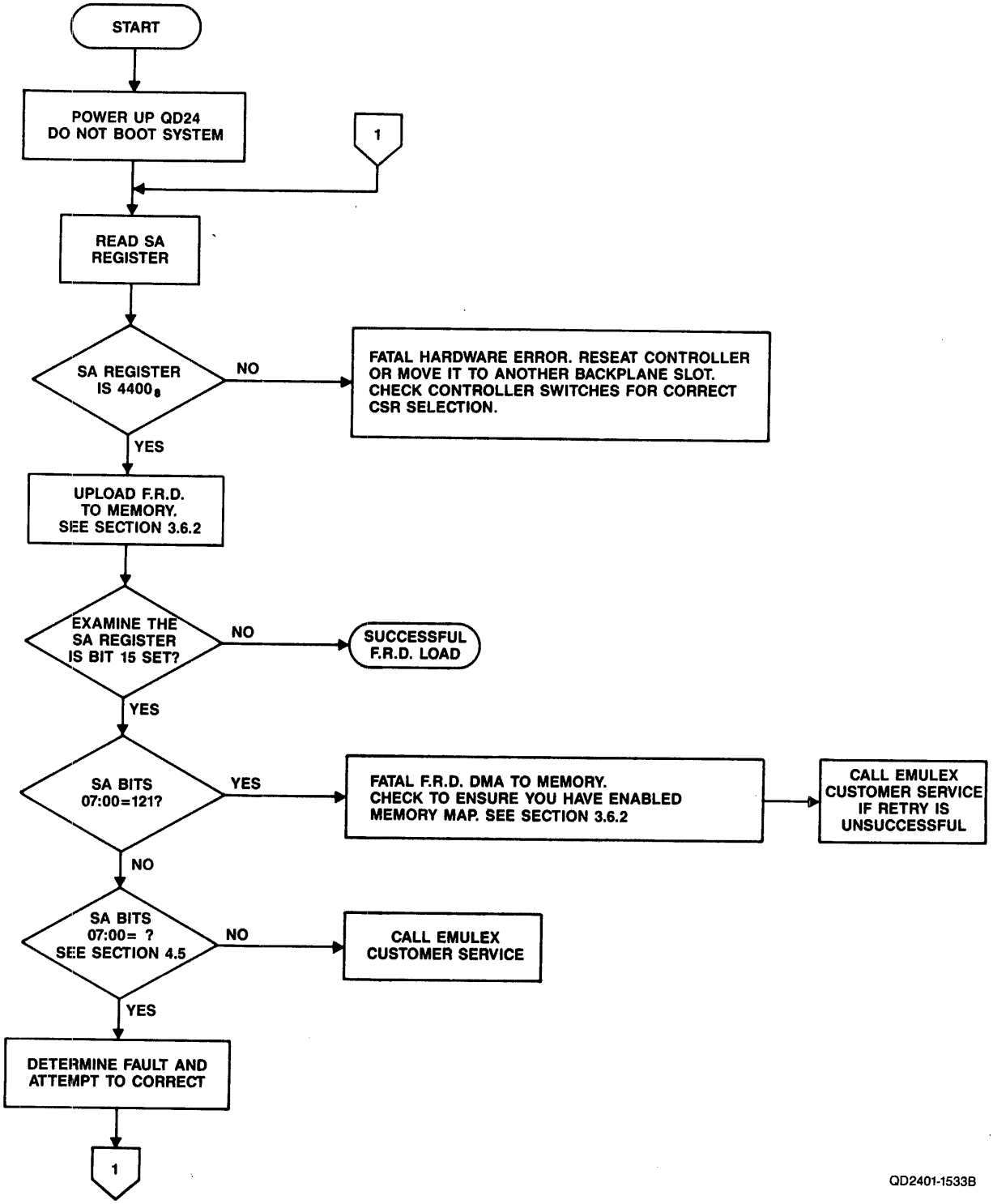


Figure 4-1. Fault Isolation Chart

4.4 Power-Up Self-Diagnostic

The QD24 executes an extensive self-diagnostic to ensure that the disk controller is in good working order. The self-diagnostic is divided into several parts. Table 4-2 indicates the order in which the tests are performed.

The first two tests are executed immediately after power-up, a reset, a bus INIT, or a write to the IP register (base address). The other tests are executed as the controller interacts with the MSCP initialization routine. If the QD24 fails any of the tests, it posts an MSCP fatal error code in the low-byte of the SA register (base address plus 2) and turns on three LEDs which are located on QD24 front panel. The MSCP fatal error codes used by the QD24 are listed in Table 4-3.

To help determine the location of the problem, the operator can select a special diagnostic mode that causes the LEDs to display an error code. To enable this diagnostic mode, place the CPU halt switch in the ON position and set QD24 switch SW2-8 ON (1). After setting SW2-8 ON, the host computer must be powered down or QD24 switch SW1-1 must be toggled (turned ON and then OFF) to cause the QD24 to again perform its self-test.

Upon encountering an error, the host microprocessor halts and the LEDs display an error code. The error codes are listed and described in Table 4-2.

If the QD24 completes the diagnostic mode without errors, all three LEDs are OFF. Set switch SW2-8 in the OFF position and reset the QD24 controller before using.

Table 4-2. LED Error Codes

LED 3	LED 2	LED 1	Error Description
0	0	0	Self-diagnostic complete without errors
0	0	1	CPU Chip Test failed
0	1	0	Formatter Chip Test failed
1	0	0	Controller idle, waiting for initialization
0	1	1	Buffer Controller or External Memory Test failed
1	0	1	HAC Test failed
1	1	0	Emulation PROM Checksum Test failed

4.5 Fatal Error Codes

If the QD24 encounters a fatal error anytime during operation, all three LEDs are illuminated and an error code is posted in the low byte of the SA register (base address plus 2). Table 4-3 lists the MSCP fatal error codes used by the QD24.

Table 4-3. MSCP Fatal Error Codes used by the QD24

Octal Code	Hex Code	Description
0	0	No information in message packet.
1	1	Possible parity or timeout error when the QD24 attempted to read data from a message packet.
2	2	Possible parity or timeout error when the QD24 attempted to write data to a message packet.
4	4	QD24 diagnostic self-test indicated a controller RAM error.
5	5	QD24 diagnostic self-test indicated a firmware checksum error.
6	6	Possible parity or timeout error when the QD24 attempted to read an envelope address from a command ring.
7	7	Possible parity or timeout error when the QD24 attempted to write an envelope address to a command ring.
11	9	Host did not communicate with QD24 within the time frame established while bringing the controller online.
12	A	Operating system sent more commands to the QD24 than the controller can accept.
13	B	Controller unable to perform DMA transfer operation correctly.
14	C	QD24 diagnostic self-test indicated controller fatal error.
16	E	The MSCP connection identifier is invalid.
23	13	An error occurred during the MSCP initialization sequence.

Additional fatal error messages may appear. These error codes are listed in Table 4-4.

Table 4-4. Fatal Error Codes

Octal Code	Hex Code	Description
004	04	RAM error
005	05	Firmware checksum error
014	0C	Fatal error during self-test
111	49	Autoboot timeout
121	51	F.R.D. load to memory failed

Section 5
DEVICE REGISTERS AND PROGRAMMING

5.1 Overview

This section contains an overview of the QD24 device registers that are accessible to the Q-Bus and that are used to monitor and control the QD24 Disk Controller. The registers are functionally compatible with DEC implementations of MSCP controllers.

The following table outlines the contents of this section.

5.2 Overview of MSCP Subsystem

Mass Storage Control Protocol (MSCP) is the protocol used by a family of mass storage controllers and devices designed and built by Digital Equipment Corporation. MSCP allows a host system to be connected to subsystems with a variety of capacities and geometries. This flexibility is possible because MSCP defines data locations in terms of sequential, logical blocks, not in terms of a physical description of the data's location (i.e., cylinder, track, and sector). This scheme gives the MSCP subsystem the responsibility for converting MSCP logical block numbers into physical addresses that the peripheral device can understand.

This technique has several implications. First, the MSCP subsystem must have detailed knowledge of the peripheral's capacity, geometry, and status. Second, the ability to make the translation between logical and physical addresses implies considerable intelligence on the part of the subsystem. Finally, the host is relieved of responsibility for error detection and correction because its knowledge of the media is insufficient to allow error control to be done efficiently.

There are several advantages to this type of architecture. First, it provides the host with an "error-free" media. Second, it provides for exceptional operating system software portability because, with the exception of capacity, the characteristics of all MSCP subsystems are the same from the operating system's point of view.

In terms of implementation, this protocol requires a high degree of intelligence on the part of the subsystem. Essentially, this intelligence is a process that runs on a microprocessor and is referred to as an MSCP controller. The MSCP controller has all of the responsibilities outlined above.

The host computer runs corresponding software processes which take calls from the operating system, convert them into MSCP commands, and cause the resulting command to be transferred to the MSCP controller.

In summary, an MSCP subsystem is characterized by an intelligent controller that provides the host with the view of a perfect media. It is further characterized by host independence from a specific bus, controller, or device type.

5.3 Programming

A complete description of MSCP commands and the corresponding status responses which the QD24 Disk Controller posts is beyond the scope of this manual.

5.3.1 Command Support

No currently available MSCP Controller supports the entire range of MSCP commands. The following subsections describe the extent of MSCP command support by the QD24.

5.3.1.1 Minimal Disk Subset

The QD24 Disk Controller supports the entire minimal disk subset of MSCP commands.

5.3.1.2 Diagnostic and Utility Protocol (DUP)

The QD24 Disk Controller does not support any of the DUP commands or maintenance read/write commands. Therefore, the QD24 is not compatible with DEC diagnostics that use the MSCP DUP commands.

5.4 Registers

During normal operation, the QD24 Disk Controller is controlled and monitored using the command and status packets that are exchanged by the Class Driver (host) and the MSCP Controller. The QD24 has two 16-bit registers in the Q-Bus I/O page that are used primarily to initialize the subsystem. During normal operation, the registers are used only to initiate polling or to reset the subsystem. These registers are always read as words. The register pair begins on a longword boundary. Table 5-1 lists the octal and hexadecimal values for the Initialization and Polling (IP) register (base address) and the Status and Address (SA) register (base address plus 2) supported by the QD24.

The IP register (base address) has two functions as detailed below:

- When written with any value, it causes a hard initialization of the MSCP Controller.
- When read while the port is operating, it causes the controller to initiate polling.

The SA register (base address plus 2) has four functions as listed below:

- When read by the host during initialization, it communicates data and error information relating to the initialization process.
- When written by the host during initialization, it communicates certain host-specific parameters to the port.
- When read by the host during normal operation, it communicates status information including port and controller-detected fatal errors.
- When zeroed by the host during either initialization or normal operation, it signals the port that the host has successfully completed a bus adapter purge in response to a port-initiated purge request.

Table 5-1. QD24 IP and SA Registers

Register	Octal	MicroVAX 3500/3600
IP	772150	20001468
SA	772152	2000146A
IP	772154	2000146C
SA	772156	2000146E
IP	760334	200000DC
SA	760336	200000DE
IP	760340	200000E0
SA	760342	200000E2
IP	760344	200000E4
SA	760346	200000E6
IP	760350	200000E8
SA	760352	200000EA
IP	760354	200000EC
SA	760356	200000EE
IP	760360	200000F0
SA	760362	200000F2

Section 6
FUNCTIONAL DESCRIPTION

6.1 Overview

This section contains a description of the QD24 Disk Controller's architecture.

6.2 QD24 Disk Controller Architecture

The QD24 is a microprocessor-based emulating disk controller that is contained on a single quad-wide PCBA. The QD24's major functional blocks are shown in Figure 6-1. The disk controller is organized around the eight-bit 8031 microprocessor. The board has an eight-bit internal data bus with 16-bit addressing capability. The Host Adapter Controller and the Merged Architecture Chip (which includes disk formatter and buffer controller functionalities) are addressed as memory (memory-mapped I/O).

The 8031's primary task is to decode and implement commands from the host. At command completion, the microprocessor is also responsible for generating status and transmitting it to the host. A large part of the microprocessor's job while performing those duties involves setting up the Host Adapter Controller and the Merged Architecture Chip for the large data transfers that are their specialties.

The QD24 uses a 27256 erasable programmable read-only memory (EPROM), which contains the control program, and 64K bytes of random access memory (RAM), which is used for data buffering and working storage.

The Q-Bus interface contains 22 lines. Sixteen of the lines are multiplexed for both address and data; six are used for only address. The Host Adapter Controller is used for programmed I/O, CPU interrupts, and DMA data transfers. The microprocessor responds to all programmed I/O and carries out the I/O functions required for the addressed disk controller register. The Host Adapter Controller has automatic Q-Bus address generation capability that, in conjunction with a byte counter, allows the interface to conduct Q-Bus DMA transfers without direct microprocessor intervention after the interface is set up for a transfer. This automatic DMA capability is used with the MAC's buffer controller logic to transfer large blocks of data directly between host memory and the QD24's RAM.

The Merged Architecture Chip is a single chip. This multi-channel DMA is responsible for moving large blocks of data between the 64K RAM buffer and the ESDI interface, and between the Q-Bus interface and the 64K RAM buffer. After being set up for an operation by the microprocessor, either interface requests DMA service from the Merged Architecture Chip by driving an individual request signal active. The transfer then proceeds without direct intervention by the microprocessor. This allows high-speed data transfers to occur while the microprocessor is focused on other processes.

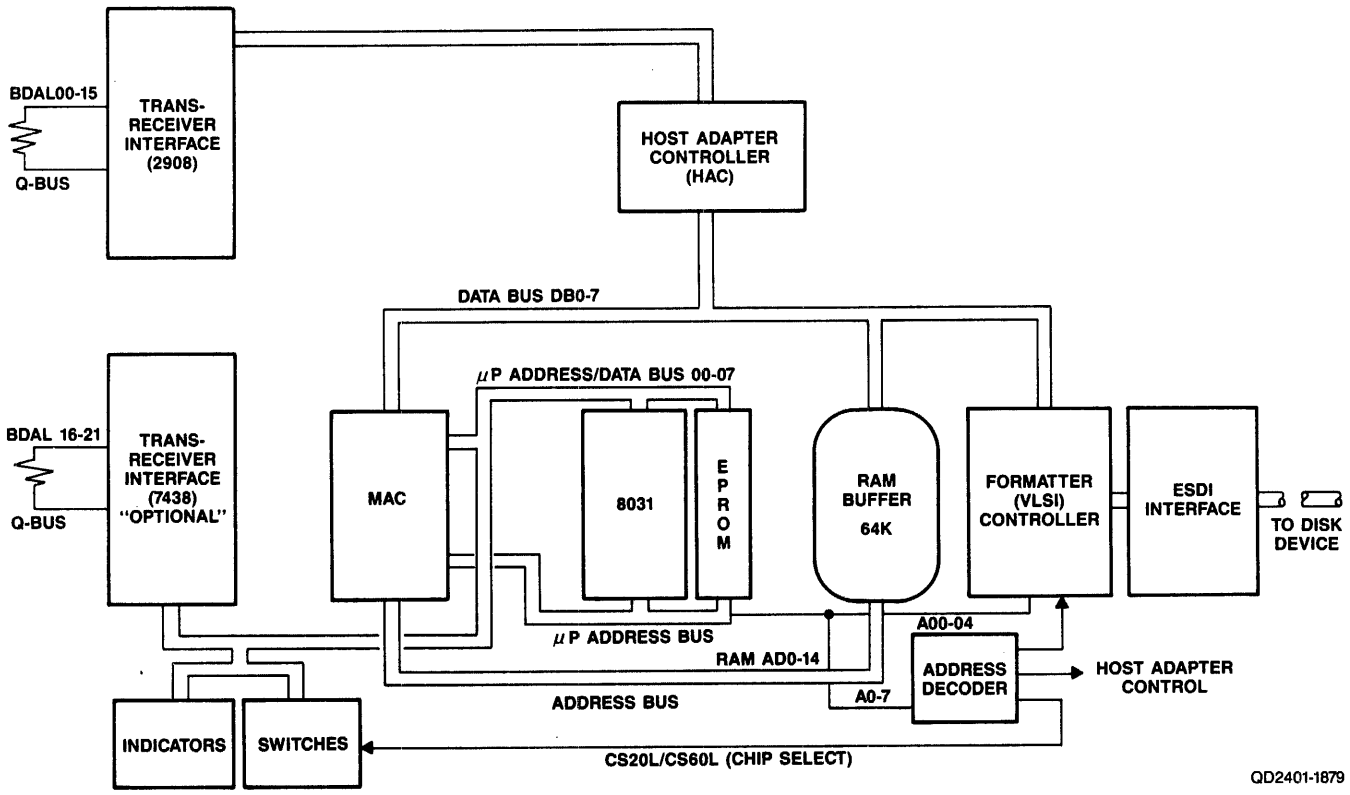


Figure 6-1. QD24 Block Diagram

Section 7
INTERFACES

7.1 Overview

This section describes the interfaces that the QD24 Disk Controller incorporates. It includes information on the QD24 implementation of ESDI interface electrical and mechanical requirements. Including this overview, the section is divided into the following subsections.

Subsection	Title
7.1	Overview
7.2	QD24 Q-BUS Interface
7.3	QD24 ESDI Drive Interface

7.2 Q-Bus Interface

The Q-Bus between the CPU and the QD24 Disk Controller contains 42 bidirectional signal lines, two unidirectional signal lines on connectors A and B, and two unidirectional signal lines on connector C. Q-Bus interface pin assignments are listed and described in Table 7-1. These signal lines provide the means by which the CPU and the QD24 Disk Controller communicate with each other.

The Q-Bus interface is used for programmed I/O, CPU interrupts, and DMA data transfer operations. Addresses, data, and control information are sent along these signal lines, some of which contain time-multiplexed information. The Q-Bus interface lines are grouped in the following categories:

- **Twenty-two Data/Address Lines** -- <BDAL00:BDAL21>. The four Data/Address lines which carry the most significant bits (MSB) are lines BDAL21:BDAL18. They are used for addressing only and do not carry data. Lines BDAL17 and BDAL16 reflect the parity status of the 16-bit data word during a Write or Read Data Transfer operation via the Q-Bus cycle.

- **Six Data Transfer Control Lines** -- BBS7, BDIN, BDOUT, BRPLY, BSYNC, and BWTBT.

- **Six Direct Memory Access (DMA) Control Lines** -- BDMR, BSACK, BDMGI, and BDMGO (the last two are on both connectors A and C).

- **Seven Interrupt Control Lines** -- BEVNT, BIAKI, BIAKO, BIRQ4, BIRQ5, BIRQ6, and BIRQ7.

- **Five System Control Lines** -- BDCOK, BHALT, BINIT, BPOK, and BREF.

Table 7-1. Q-Bus Interface Pin Assignments

Connector A Signal			Connector B Signal		
Component Side	Pin	Solder Side	Component Side	Pin	Solder Side
BIRQ5	A	+5V	BDCOK	A	+5V
BIRQ6	B		BPOK	B	
BDAL16	C	0V (GND)	BDAL18	C	0V (GND)
BDAL17	D		BDAL19	D	
	E	BDOUT	BDAL20	E	BDAL02
	F	BRPLY	BDAL21	F	BDAL03
	H	BDIN		H	BDAL04
0V (GND)	J	BSYNC	0V (GND)	J	BDAL05
	K	BWTBT		K	BDAL06
	L	BIRQ4		L	BDAL07
0V (GND)	M	BIAKI	0V (GND)	M	BDAL08
BDMR	N	BIAKO	BSACK	N	BDAL09
BHALT	P	BBS7	BIRQ7	P	BDAL10
BREF	R	BDMGI	BEVNT	R	BDAL11
	S	BDMGO		S	BDAL12
0V (GND)	T	BINIT	0V (GND)	T	BDAL13
	U	BDAL00		U	BDAL14
	V	BDAL01		V	BDAL15

Connector C Signal			Connector D Signal		
Component Side	Pin	Solder Side	Component Side	Pin	Solder Side
	A	+5V		A	+5V
	B			B	
	C	0V (GND)		C	0V (GND)
	D			D	
	E			E	
	F			F	
	H			H	
0V (GND)	J		0V (GND)	J	
	K			K	
	L			L	
0V (GND)	M	BIAKI	0V (GND)	M	
	N	BIAKO		N	
	P			P	
	R	BDMGI		R	
	S	BDMGO		S	
0V (GND)	T		0V (GND)	T	
	U			U	
	V			V	

All signals, except BDCOK and BPOK, are low active.

7.2.1 Interrupt Priority Level

The QD24 is hardwired to issue level 4 interrupt requests and monitor level 5. A jumper-selectable option allows level 5 interrupt requests and monitors level 6 (see subsection 3.3.3.3).

7.2.2 Register Address

The QD24 Disk Controller has two registers visible to the Q-Bus. Their addresses are determined by DIP switches SW2-3 through SW2-6. See subsection 3.3.1 for detailed address and switch setting information.

7.2.3 DMA Operations

All DMA data transfer operations are performed under microprocessor control. When doing a Read or Write From Memory operation, a check is made for memory parity or nonexistent memory (NXM) errors. If an error is detected, an MSCP status error is returned.

7.3 QD24 ESDI Disk Drive Interface

This subsection provides information on the QD24 implementation of the Enhanced Small Device Interface (ESDI) interface. The QD24 controller's disk interface conforms to the ESDI Specification and supports the serial mode for magnetic disk drives. The QD24 can use the drive's defect list.

The QD24 Controller can integrate up to a maximum of four physical (eight logical) ESDI disk drives. Any of the EDSI data interface connectors can plug directly into the data cable for the first disk drive. If another disk drive is configured, an unused 20-pin connector is plugged into the data cable for that disk drive.

The pin/signal assignments for control signal interface between the QD24 Controller and an ESDI disk drive are shown in Figure 7-1.

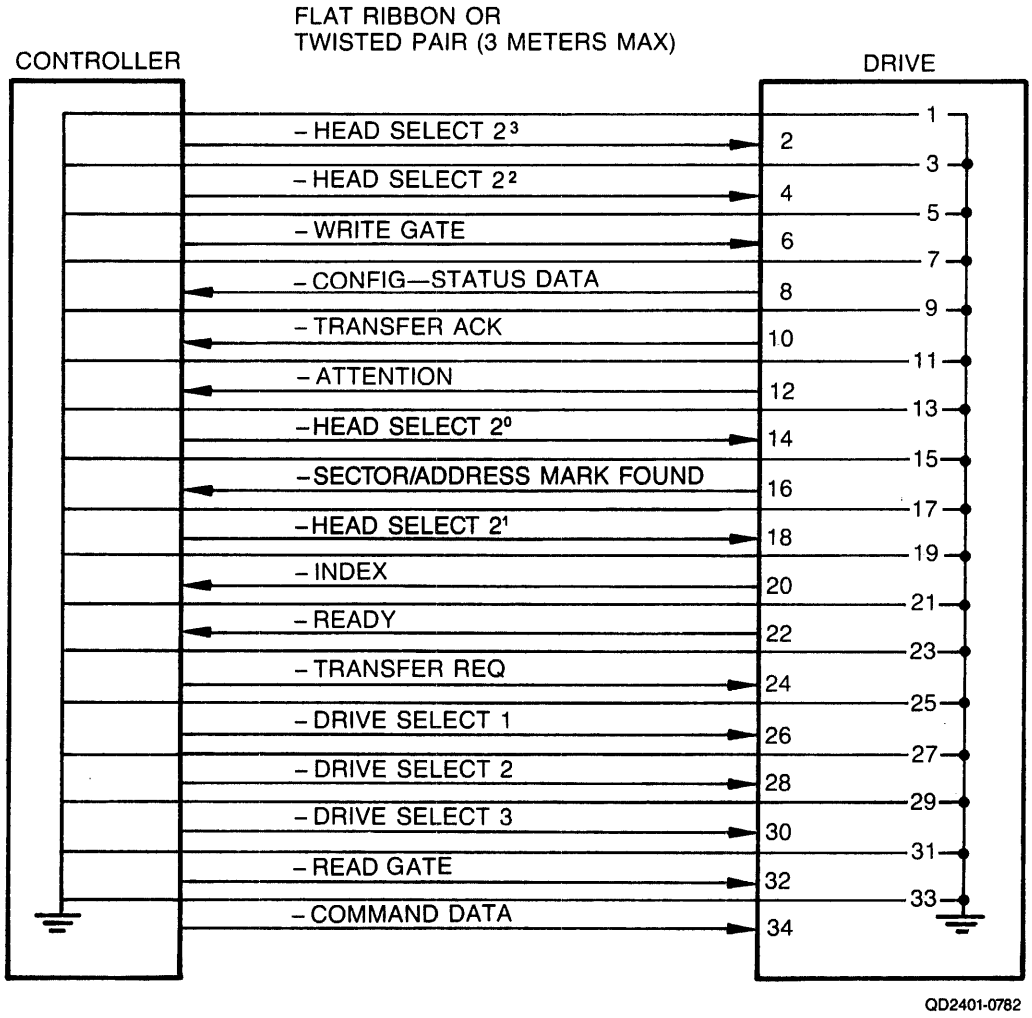


Figure 7-1. Control Pin/Signal Assignments at ESDI Disk Drive Interface

The pin/signal assignments for data signal interface between the QD24 Controller and an ESDI disk drive are shown in Figure 7-2. As indicated in Figure 7-2, lines 2, 5, 9, and 20 are not connected at the QD24 data interface. Lines 5 and 9 are reserved for step mode implementation (according to the ESDI specification) and are not used with the QD24 serial mode implementation. The QD24 does not use lines 2 and 20 to report the sector and index positions from each drive, but uses the sector and index lines on the control cable for the selected drive (see Figure 7-1).

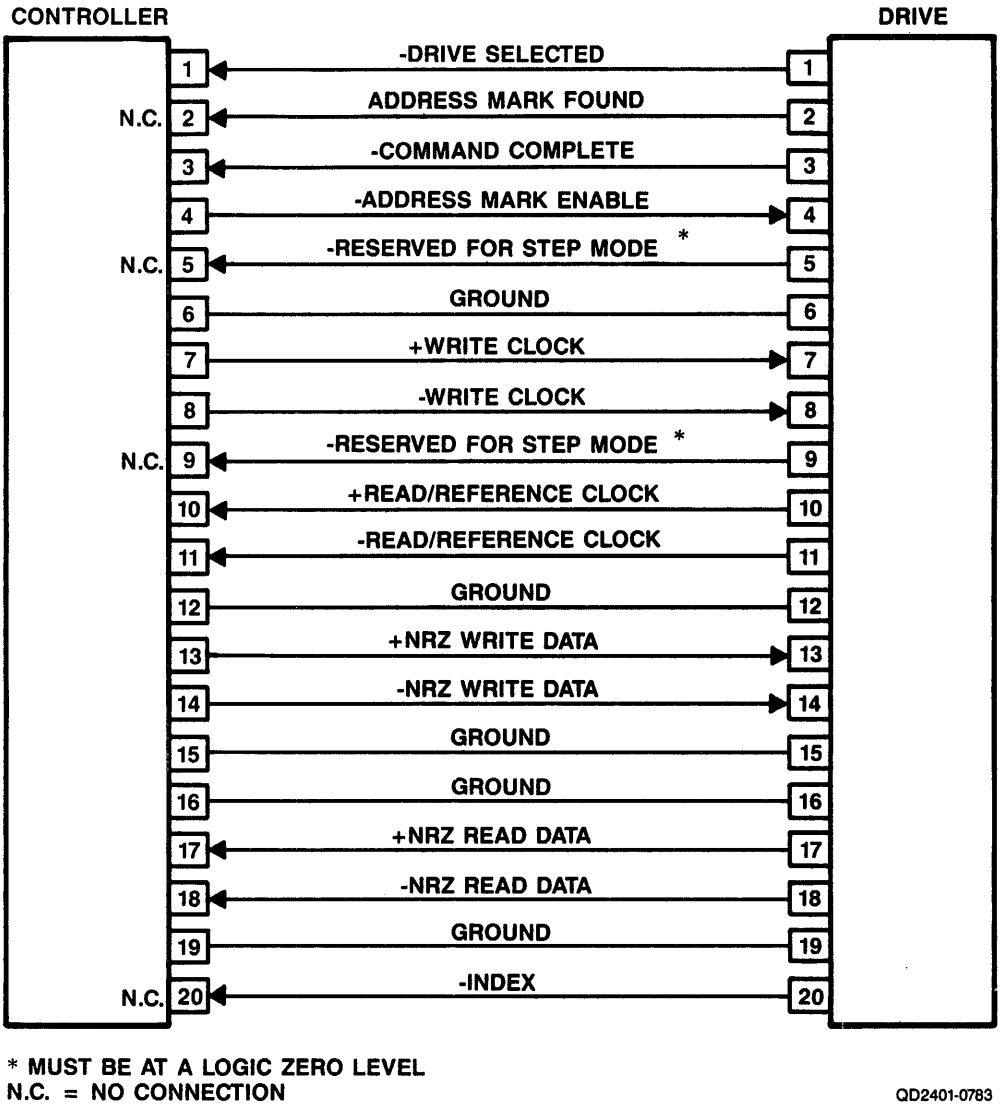


Figure 7-2. Data Pin/Signal Assignments at ESDI Disk Drive Interface

7.4 Activity Panel Interface

The QD24 provides two interfaces that allows one remote control and status panel to be connected to the controller, one per each two drives. The interface allows write protect switches for each ESDI drive to be connected, and it provides drivers for ready and write-protected status LEDs.

Each interface is implemented by using a four-wall, right-angle header (3M part number 3591-5002) designated J6 and J7. The header has 10 pins. The function of each pin is described in Tables 7-2 and 7-3. Figure 7-3 shows the pin-outs and a sample user interface.

Table 7-2. First Control and Status Interface Pin Function Description

Pin	Function	Description
1	Ground	Controller Logic Ground
2	Not Connected	
3	Disk 1 Write Protect Input	Ground this line to write protect disk 1
4	Disk 1 Active Status	This line sinks 24 mA when disk 1 is active
5	Disk 0 Write Protect Input	Ground this line to write protect disk 0
6	Disk 0 Active Status	This line sinks 24 mA when disk 0 is active
7	Disk 1 Write Protect Status	This line sinks 24 mA when disk 1 is write protected
8	Spare	
9	Disk 0 Write Protect Status	This line sinks 24 mA when disk 0 is write protected
10	+5 VDC	This line provides 5 VDC. This line is not current protected.

Table 7-3. Second Control and Status Interface Pin Function Description

Pin	Function	Description
1	Ground	Controller Logic Ground
2	Not Connected	
3	Disk 3 Write Protect Input	Ground this line to write protect disk 3
4	Disk 3 Active Status	This line sinks 24 mA when disk 3 is active
5	Disk 2 Write Protect Input	Ground this line to write protect disk 2
6	Disk 2 Active Status	This line sinks 24 mA when disk 2 is active
7	Disk 3 Write Protect Status	This line sinks 24 mA when disk 3 is write protected
8	Spare	
9	Disk 2 Write Protect Status	This line sinks 24 mA when disk 2 is write protected
10	+5 VDC	This line provides 5 VDC. This line is not current protected.

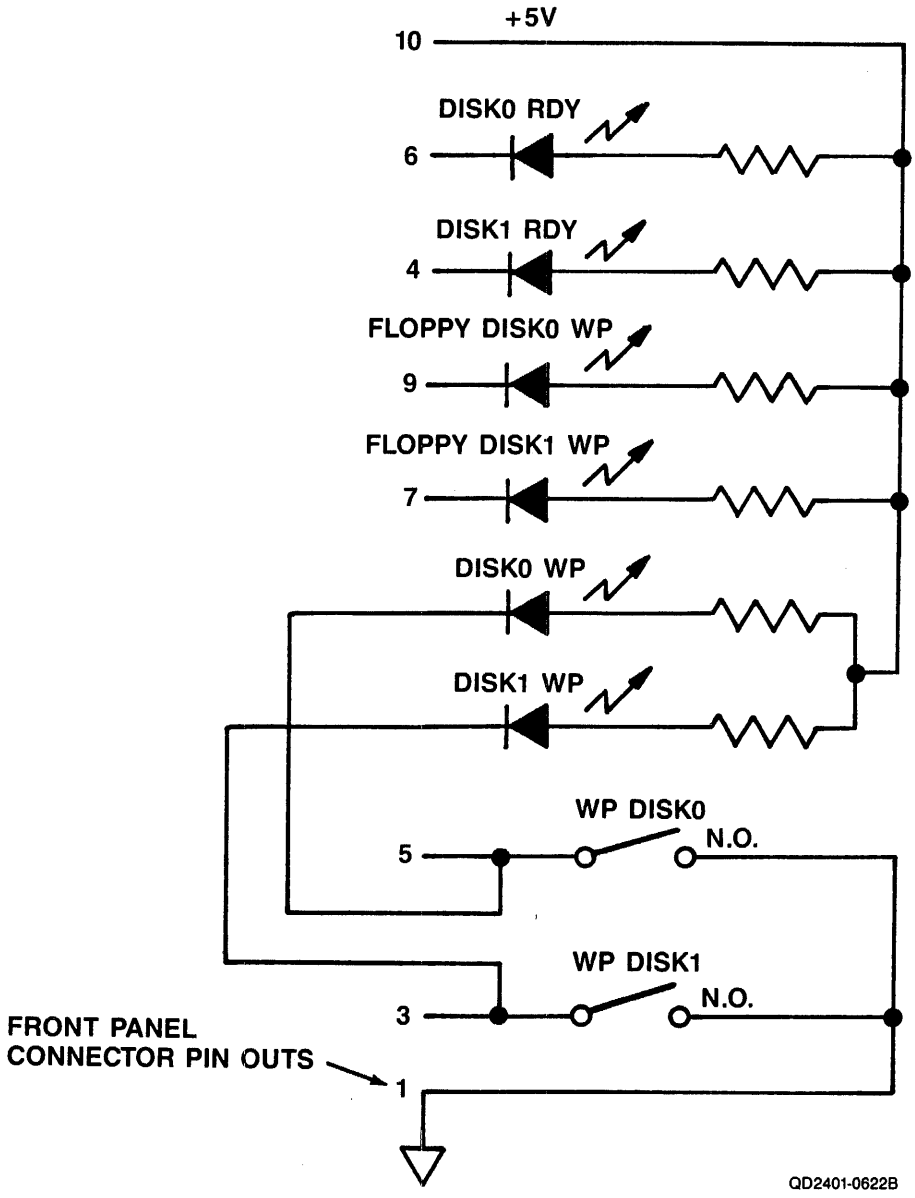


Figure 7-3. Sample Status and Control Interface

Appendix A
PROM REMOVAL AND REPLACEMENT

A.1 Overview

This appendix provides instructions for replacing the QD24's firmware PROM.

A.2 Exchanging PROMs

The QD24 firmware PROM is located in the socket at U33. Remove the existing PROM from its socket using an IC puller or an equivalent tool.

The QD24 PROM is identified by the part numbers on top of the PROMs. Place the QD24 PROM in U33. Make certain that the PROM is firmly seated and that no pins are bent or misaligned. (If the two rows of PROM pins are too far apart to fit in the socket, grasp the PROM at its ends using your thumb and forefinger and bend one of the pin rows inward by pressing it against a table top or other flat surface.)

PROM Number	PCBA Location
G114	U33

NOTE

Installation of a different revision of firmware may result in corrupt NOVRAM values. Re-enter appropriate NOVRAM values after a PROM exchange.

B.1 Autoconfigure (Type Code 2)

Each ESDI drive is autoconfigured by using type code 2 in the NOVRAM parameters. By using type code 2, the drive is automatically configured for maximum storage capacity with all relevant drive parameters obtained directly from the drive itself. The controller uses ESDI commands to obtain drive information (drive must be connected and powered up) then calculates and programs the drive for the required settings.

This procedure is performed for each MSCP on-line command from the host software. To allow the controller to program the drive for the correct number of sectors, each drive must have the PROGRAMMABLE SECTOR SIZE option enabled. If the drive does not support the PROGRAMMABLE SECTOR SIZE option, physically set the number of sectors as indicated (using the LIST KNOWN UNITS option) by using the appropriate jumpers or switches as described in the drive technical manual.

B.2 Parameter Values (Type Code 1)

If you are required to manually input the NOVRAM drive parameters, select type code 1. Type code 1 is used with drives that require split logicals (two logical drives per one physical), or to retain compatibility with a previously formatted drive used on a different Emulex controller.

If you are using type code 1 values to retain compatibility, input the parameters used for the previously formatted drives. To obtain the correct values for split logicals (or reduced capacity drive), each physical drive initially needs to use a type code 2 value. Program the NOVRAM for type code 2, connect the drive(s), and use the internal diagnostic option LIST KNOWN UNITS. This displays the drive geometry information needed in programming the NOVRAM.

For values not displayed with the LIST KNOWN UNITS command, use the default values in subsection 3.8, Drive Configuration Parameters.

Once you collect these values, change the NOVRAM to type code 1 for each drive that requires manual configuration, then input the parameters using the collected values. You can mix type codes in the NOVRAM parameter if required. This means you can use autoconfigure (type code 2) for one or more physical drives, and then use supplied values (type code 1) for the remainder of the drives.

B.3 Recommended Drive Options

When using a type code of 2, the QD24 attempts to program the sector size via ESDI command. Some drives require this option to be enabled via jumpers or switches on the drive; check the drive manufacturer's manual for more information. If the drive is not programmable, the QD24 will use the number of sectors defined by the drive switch settings.

ENGINEERING CHANGE ORDER

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ECO NO. 06058 | ISSUE DATE 22JUN90

ECR NO. 0896 | SHEET 1 OF 1

REQUESTER: I. Yokoyama | DATE: 20Jun90 | APPROVAL: Ken J. Wagner | DATE: 6-20-90 | MODEL/EQUIPMENT AFFECTED: QD21, QD24, UD23

EFFECTIVITY	AFFECTED	MATERIAL DISPOSITION	TYPE	PRIORITY
☐ ALL UNITS IN HOUSE	☒ MANUALS	1. USE AS IS	☒ CORRECTIVE	☐ 1 CRITICAL
☐ ALL UNITS IN PROCESS	☐ FIRMWARE	2. REWORK	☐ MAINTAINABILILTY	☐ 2 URGENT
☒ NEXT BUY/BUILD	☐ SOFTWARE	3. PHASE-IN	☐ RECORD CHANGE	☒ 3 ROUTINE
☐ RECORD	☐ DIAGNOSTICS	4. NOT APPLICABLE	☐ DEVIATION	
EFFECTIVE DATE __/__/__	☐ PRODUCTION TOOLING	5. SCRAP	☐ RELEASE	
	☐ CONFIGURATOR			

REASON FOR CHANGE

The new rev for these manuals adds "Media Type" NOVRAM parameter descriptions.

WHERE USED: LIST BELOW ALL DOCUMENTS, PARTS AND ASSEMBLIES THAT ARE AFFECTED BY THIS CHANGE ORDER.

DOC/PART/ASSY NUMBER	CUR REV	NEW REV	TITLE/DESCRIPTION	MATERIAL DISPOSITION CODE: NEXT ORDER	ON ORDER	RECEIVING/ INSPECTION	STOCKROOM	WORK IN PROGRESS	FINISHED GOODS	REPAIR CENTER	
QD2151002-00	H	J	QD21 Technical Manual	3	1	1	1	1	1	1	
QD2450901-00	C	D	QD24 Technical Manual	3	1	1	1	1	1	1	
Ud2351002-00	E	F	UD23 Technical Manual	3	1	1	1	1	1	1	

Change pages for the new revs are listed below:

QD2151002-00 Rev J Title page, vi, 4-33, 4-34

QD2450901-00 Rev D Title page,iv, v, 3-36, 3-37

UD2351002-00 Rev F Title page, v, 4-38, 4-39

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