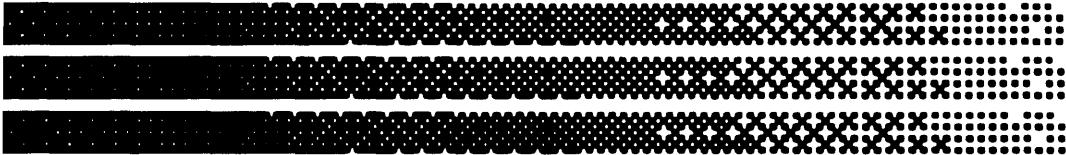


EK-RQDX3-UG-001

RQDX3 Controller Module

User's Guide

digital™



RQDX3 Controller Module

User's Guide

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MASSBUS	RSTS	Work Processor

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Preface

The RQDX3 (M7555) controller module is a dual-height module designed for both MicroPDP-11 and MicroVAX II systems. The module interfaces up to four logical drive units to the system's Q22-Bus.

This manual defines the RQDX3 controller module and tells how to install it in both BA23 and BA123 enclosures. This manual is designed for the following types of users.

1. Ones who may require an additional RQDXn disk controller
2. People who need advance knowledge about the RQDX3 controller module
3. Field Service personnel responsible for installing and maintaining RQDX3 controllers

Chapter 1 gives physical and functional descriptions of the RQDX3 controller. It explains what the controller is and what it does.

Chapter 2 provides installation instructions for the BA23 and BA123 enclosures. It also discusses how to configure RQDX3 jumpers for the following purposes.

1. Standard base address
2. Starting Logical Unit Numbers (LUNs)
3. Drive cable compatibility with RQDX1/RQDX2 controllers

Chapter 3 explains how to verify the operation of installed RQDX3 controller modules in the following manner.

Chapter 4 contains a glossary of MSCP and DUP commands supported by the RQDX3 controller module.

1. What the RQDX3 controller self-test indications mean
2. What diagnostics are made available to the user and field engineer
3. How RD drive(s) are formatted and tested in a system that is using the RQDX3 controller.

NOTE

This document shows console displays for XXDP+ Diagnostics and MicroVAX Maintenance System – Diagnostic Release Version 1.06.

Backup data is given in Appendices A and B. Appendix C provides the geometry information of the drives supported at time of printing.

The following documents provide additional information and may be of interest to RQDX3 controller module users.

Title	Document Number
Microcomputer Interface Handbook	EB-20175-20
Microcomputer Memory Handbook	EB-18451-20
MicroPDP-11 Illustrated Parts Breakdown*	EK-OLCP5-IP
MicroPDP-11 Illustrated Parts Breakdown†	EK-BA123-IP
MicroPDP-11 Systems Maintenance Guide	EK-MIC11-SG
MicroPDP-11 Systems Technical Manual*	EK-MIC11-TM
MicroPDP-11 Systems Technical Manual†	AZ-GLHAA-MC
MicroVAX II Systems Owner's Manual*	AZ-FE05A-TN
MicroVAX II Systems Owner's Manual†	AZ-FE08A-TN
MicroVAX II 630QY, 630QZ Technical Manual*	AZ-GLOAA-MN
MicroVAX II 630QB Technical Manual†	AZ-GLBAA-MN
RD51 Disk Drive Technical Description	EK-RD51A-TD
RD52 Disk Drive Technical Description	EK-RD52A-TD
RD53 Disk Drive Technical Description	EK-RD53A-TD
RQDXE Expander Module User's Guide	EK-RQDXE-UG
RX50 Diskette Drive Technical Description	EK-RK50-TD

* BA23 Enclosure

† BA123 Enclosure

INTRODUCTION

This chapter provides both physical and functional descriptions of the RQDX3 controller module. The physical description describes the attributes of the RQDX3 module by discussing the following.

1. Features
2. Comparison with the RQDX1 and RQDX2 controller modules
3. Performance enhancements
4. Supported drives
5. Physical and environmental specifications

The functional description explains the RQDX3 module's functions in terms of four subsystems.

1. Multi-port memory subsystem
2. Microprocessor subsystem
3. Q-Bus interface subsystem
4. Disk interface subsystem

PHYSICAL DESCRIPTION

The RQDX3 controller is a dual-height module that interfaces up to four logical drive units to the Q22-Bus. It uses a multi-port memory architecture that permits the following operations in parallel.

- Host data transfers
- Disk data transfers
- Microprocessor access to local data structures

Most of the data path functions are contained in two CMOS gate array devices, which contain the hardware functions required to:

- Implement the 3-port memory system
- Provide the host processor interface
- Provide support logic for the on-board microprocessor
- Provide digital logic for the disk data separator

RQDX3 Features

The RQDX3 controller module offers these features.

1. A dual-size module
2. Self-test capability
3. Q-Bus blockmode DMA data transfers in 16-, 18-, or 22-bit addressing modes
4. No sector interleave on hard disk drives for maximum data transfer rate
5. Various disk access performance optimizations
6. Hard disk geometry information stored on the disk surface, not in the controller (this allows the support of future hard disk drives without microcode changes).

Table 1-1 compares features common to the RQDX1, RQDX2, and RQDX3 controller modules.

Table 1-1 Product Difference Matrix

Feature	Controllers		
	RQDX1	RQDX2	RQDX3
Elevator seek algorithm	Yes	Yes	Yes
Buffered seeks	Yes	Yes	Yes
Overlapped seeks	No	No	Yes
Error Correction Code (ECC)	No	No	Yes
RX50 floppy support	Yes	Yes	Yes
Supports greater than 33 Mbyte fixed disks	No	Yes	Yes
Number of logical units supported	4	4	4
Number of hard disks supported	2	4	4
Sector interleave	3:1	3:1	1:1
Q-Bus slot independent	No	No	Yes
Module size	Quad	Quad	Dual
LBNs/Track for hard disks	18	18	17
Location of disk geometry information	Controller's microcode	Controller's microcode	Disk surface

Performance Enhancements

The 3-port architecture optimizes RQDX3 controller operation, allowing these performance enhancements.

1. Elimination of hard disk sector interleave
2. Overlapped seeks
3. Error correction

For RD52 and RD53 hard disks, the RQDX3 controller allows a 1:1 sector interleave on disk surfaces, reducing the average transfer time from 3.5 to 1.5 revolutions per track. For RD51 hard disks, the RQDX3 controller allows a 2:1 sector interleave.

When multiple hard disks are attached to the controller, the seek pulses for each drive are sent without waiting for a seek complete indication from the drive. The drives are then polled for the first seek completion, at which time that data transfer operation is performed. This allows a percentage of the seek time to be overlapped with data transfers on another drive.

The controller performs retries to eliminate soft data errors. If a reasonable number of command specific retries cannot correct the data, then it is considered a hard data error. For hard disk drives, an attempt will be made to correct this error with an ECC algorithm. The algorithm is capable of detecting up to an 11-bit burst within a sector, but limits corrections to single bit errors.

On hard disk drives, sectors with hard errors indicating that the sector is defective are automatically replaced with available replacement blocks. The total number of replacement blocks on a drive is specified at format time and depends upon the drive capacity.

Drives and Capacities Supported

The RQDX3 controller is capable of supporting four logical disk units with up to 16 surfaces per unit and 2048 tracks per surface. The module contains enough logic to support a system front panel for four hard disk drives. For floppy disks there is no front panel support.

Software Interface

The RQDX3 controller identification number returned to the host processor upon interrogation is decimal 19.

M7555 Controller Specifications

This listing presents physical and operational specifications regarding the RQDX3 module while Table 1-2 describes the environmental specifications.

Overall dimensions

Height:	26.56 cm (10.46 in)
Width:	1.27 cm (0.5 in)
Length:	22.70 cm (8.94 in)

Power requirements

+5 Vdc ±5% at 2.48 A (typ.) 2.9 A (max.)
+12 Vdc ±5% at 0.06 A (typ.) 0.1 A (max.)

Bus Loads

AC	1.9
DC	0.5

Drives per controller Up to four logical units

LSI-11 bus-addressable registers 2

Base drive address
(standard) 17772150 (octal) for 22-bit addressing

Vector Set by operating system software

Table 1-2 Environmental Specifications

Specifications	Operating	Non-Operating
Temperature	5°C–60°C (41°F–140°F)	–40°C–66°C (–40°F–151°F)
Relative humidity (noncondensing)	10% to 95%	10% to 95%
Maximum altitude	2.4 km (8,000 feet)	9.1 km (30,000 feet)

FUNCTIONAL DESCRIPTION

The RQDX3 module is a microprocessor-based peripheral controller operating subordinate to a host processor. It responds to commands originated by its host and executes a number of functions including the following.

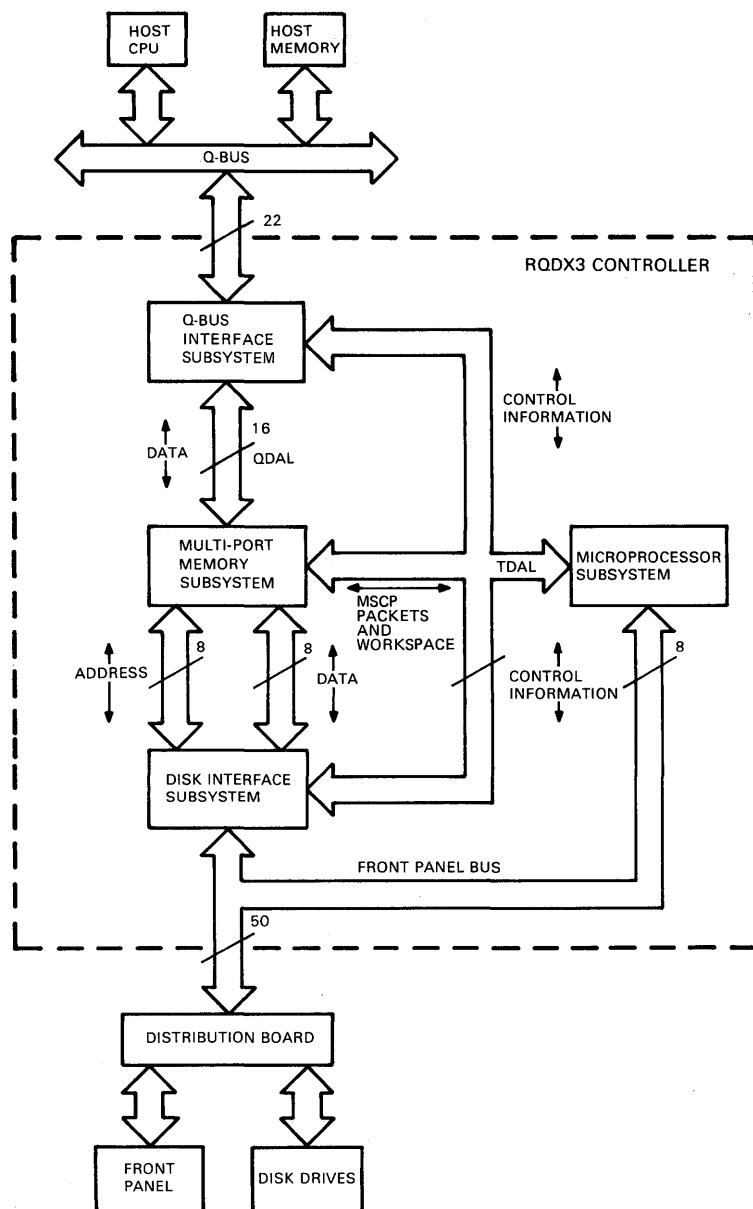
- Self-initializing
- Performing internal diagnostics
- Decoding of host command packets
- Encoding of controller response packets
- Controlling all disk operations
- Transferring data on the Q-Bus via DMA cycles

Digital's proprietary Mass Storage Control Protocol (MSCP) defines communications between the host processor and the RQDX3 controller. The host originates the communications handshake by sending command packets to the RQDX3 module. It completes the communications handshake by returning response packets to the host.

The RQDX3 controller uses two sequential locations to form a communications port with the host.

1. Initialization and Poll (IP) register – the RQDX3 controller's standard base address (17772150)
2. Status and Address (SA) register – the next sequential address (17772152)

RQDX3 controller functions are described in terms of multi-port memory, microprocessor, Q-Bus interface, and disk interface subsystems. Refer to Figure 1-1 for a functional partition of the RQDX3 controller module.



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Figure 1-1 RQDX3 Controller – Functional Partition

Multi-Port Memory Subsystem

The multi-port memory subsystem is a 3-port RAM structure providing buffers for data communicated between the various RQDX3 controller subsystems. It consists of an $8\text{ K} \times 16$ static RAM, a memory controller, three ports, and various other logic as shown in Figure 1-2. The RAM provides the following.

- Data buffers
- Command and response buffers
- Microprocessor workspace

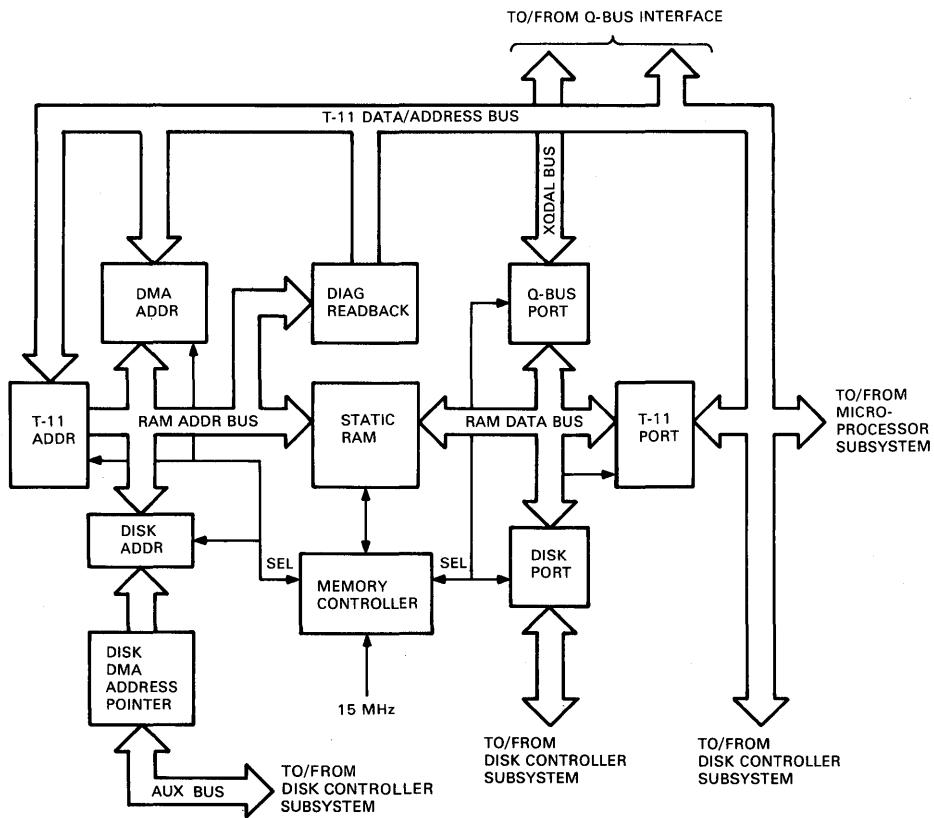


Figure 1-2 Multi-Port Memory Subsystem Block Diagram

The memory controller receives requests from the three ports and performs the memory cycle for the highest priority requesting port. During a memory cycle, the highest priority port is allowed to write or read the 8 K static RAM. The memory controller sends port select signals (SEL) that grant priority to ports in accordance with the following protocol.

- Disk port – first priority
- Q-Bus port – second priority
- T-11 port – third priority

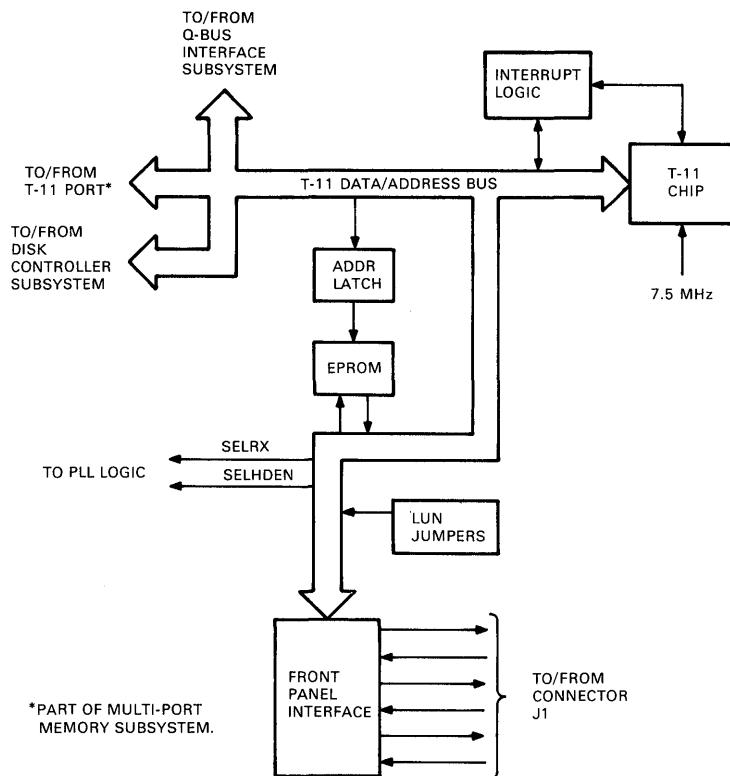
Each port receives addresses and data from its corresponding RQDX3 subsystem. These addresses and data are held temporarily in port registers until the memory controller grants that port access to the static RAM. The three ports interconnect with the other RQDX3 subsystems as shown in Figure 1-2.

Microprocessor Subsystem

The microprocessor subsystem (Figure 1-3) is the central point of control. It supervises control of the following functions.

- Self-Test diagnostics
- MSCP command decode and response encode
- Supervision of Q-Bus and disk subsystems
- Performance optimization
- Interface to the host's front panel which provides switches and status indicators

As shown in Figure 1-3, the microprocessor subsystem is made up of a T-11 microprocessor chip, address latches, an EPROM memory, a front panel interface, and priority granting interrupt logic.



MR-16582

Figure 1-3 Microprocessor Subsystem Block Diagram

T-11 Address Space – T-11 address space consists of 32 K words that are mapped as follows and as shown in Figure 1-4.

1. 16 K words dedicated to EPROM memory for the microcode
2. 8 K words set aside for RAM space
3. 8 K words set aside for the I/O page

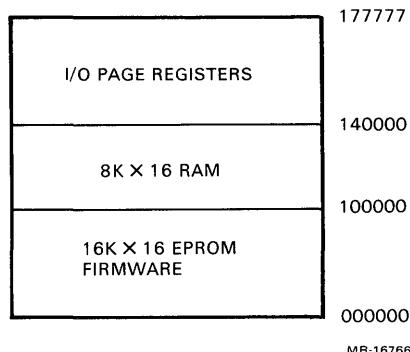


Figure 1-4 T-11 Memory Map

The T-11 front panel interface connects the RQDX3 controller module to switches and status indicators in the host's manual control panel. (See connector J1 and the 50-wire flat cable shown in Figure 1-3.) Manual control panels of push-button switches, status LEDs, and associated circuitry are provided with host systems. Signals output from the T-11 front panel interface are buffered with open collector inverters. Signals returned from the host's manual control panel are routed to the T-11 microprocessor via front panel status logic which are also part of the T-11 front-panel interface.

T-11 Interrupt Functions – The T-11's interrupt logic handles one non-maskable power fail interrupt and seven maskable interrupts. Power fail interrupts have highest priority. Maskable interrupts have lower priorities (descending from 7 to 1).

Q-Bus Interface Subsystem

The Q-Bus interface subsystem is made up of three sections.

1. The programmed I/O section, made up of the IP and SA logic
2. The Q-Bus DMA controller section
3. The Q-Bus interrupt section

Programmed I/O Section – The programmed I/O section of the RQDX3 controller includes IP and SA logic. The IP logic allows the host processor to create two independent control strobes on the RQDX3 controller module: the IP WRITE and the IP READ strobes. An IP WRITE to the base address (17772150) initializes the RQDX3 controller module and interrupts the T-11 microprocessor. An IP READ signals the module, allowing the DMA controller to begin a polling sequence of host memory for command packets.

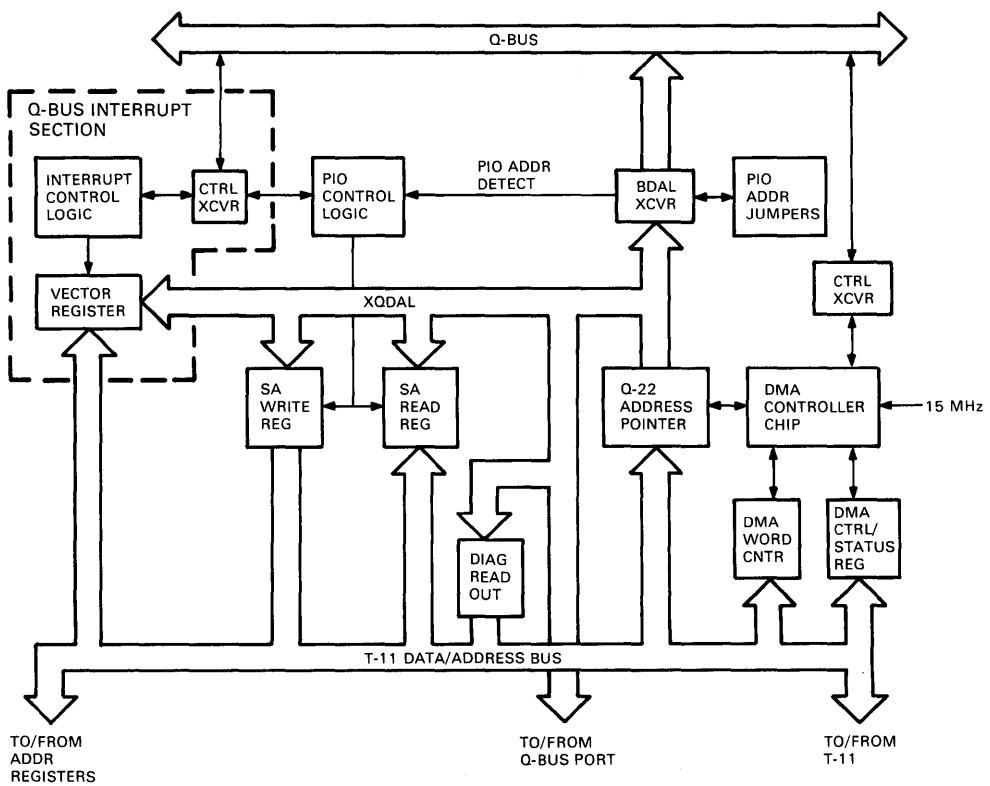
NOTE

**Instructions for selecting the standard base address (17772150)
are included in Chapter 2.**

The SA logic passes status and address information between the T-11 microprocessor and the host processor during the port initialization sequence. As shown in Figure 1-5, the SA logic consists of SA READ and SA WRITE registers.

The SA READ register is written into by the T-11 microprocessor and read from by the host processor. The SA WRITE register is written into by the host processor and read from by the T-11 microprocessor. This register passes MSCP command buffer addresses and the interrupt vector to the T-11 during initialization.

The programmed I/O section also provides PIO control logic, Q-Bus transceivers (XCVRs), and internal buses that allow two-way communication with the host processor via the Q-Bus.



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Figure 1-5 Q-Bus Interface Subsystem Block Diagram

Q-Bus DMA Controller Section – The Q-Bus DMA controller section incorporates a DMA controller state machine and data path logic to perform the following functions.

- 22-bit Q-Bus DMA addressing
- 16-bit DMA word counting
- Q-Bus memory parity detection
- Implementation of blockmode transfers
- Timing to regulate Q-Bus activities

Q-Bus DMA transfers are started under program control by the T-11 microprocessor. The data path logic which supports Q-Bus DMA controller operations consists of the following.

- A DMA CTRL/Status register
- A DMA word counter
- A Q-22 address pointer

The following conditions cause the DMA controller to stop performing DMA data transfers.

- Word counter reaches zero
- Non-existent memory errors reported
- Q-Bus memory parity errors occur
- IP WRITE
- Q-Bus initialization sequence
- Transfer halted by microprocessor

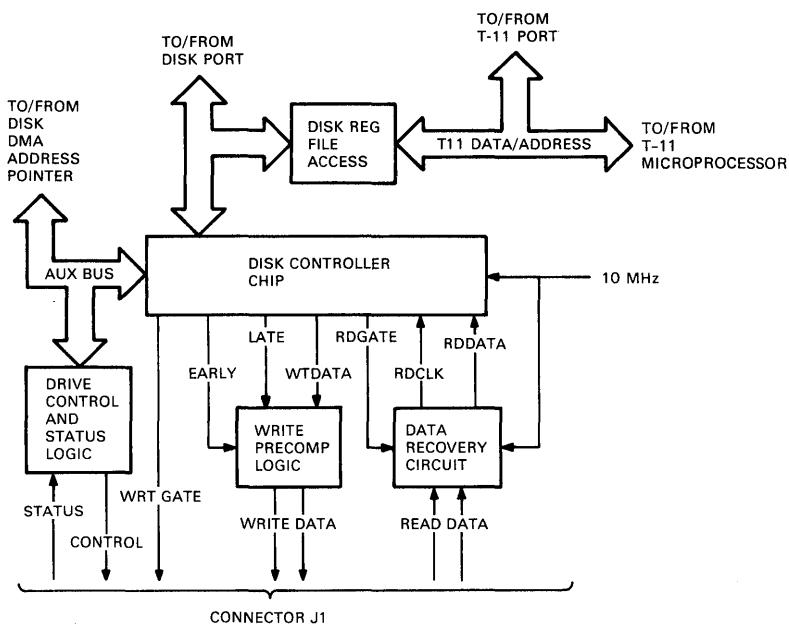
Q-Bus Interrupt Section – The Q-Bus interrupt logic consists of the vector register and interrupt control logic shown in Figure 1-5.

During the interrupt sequence, the contents of the interrupt vector register are gated to the Q-Bus as a vector. The MSCP initialization function supplies the T-11 microprocessor with the vector number and the microprocessor loads this number into the vector register.

Disk Interface Subsystem

The disk controller subsystem provides control and data path functions for both floppy and hard disk drives. It is made up of the following functional elements which are also shown in Figure 1-6.

1. Disk controller chip
2. Drive control and status logic
3. Data recovery circuit
4. Write precompensation logic



MR-16584

Figure 1-6 Disk Interface Subsystem Block Diagram

Control of Communications – The disk controller chip permits the T-11 microprocessor to supervise control of communications between attached disk drives and the RQDX3 controller module. The disk controller chip sequentially executes a number of RQDX3 functions.

To implement the following operations and functions, the disk controller chip executes sequences that are queued by the T-11 microprocessor.

- DMA data transfers between the on-board sector buffers and attached disk drives
- Error detection
- Interruption of the T-11 microprocessor upon completion of current operation, or when errors are detected

Disk Drive Control and Status – As shown in Figure 1-6, the disk controller chip interconnects with the drive control and status logic via the AUX bus. The drive control logic passes control signals which are routed to the disk drives. The drive status logic returns drive status signals to the disk controller chip via the AUX bus.

Data Recovery and Separation – The RQDX3 data separator has been designed to receive and convert the MFM encoded data stream into an NRZ data stream and a READ CLK. Received data comes from the disk and converted data and the READ CLK go to the disk controller chip. The RQDX3 data separator is designed to operate at the following data frequencies.

1. 5 MHz MFM ENCODED DATA from ST412 Winchester disks, type RDxx
2. 500 kHz MFM ENCODED DATA from high-speed, high-density floppy disks
3. 250 kHz MFM ENCODED DATA from standard, double-density floppy disks

Write Precompensation – The precomp block (see Figure 1-6) represents a delay line and a multiplexer used by the disk controller chip to provide write precompensation for hard disks.

Write precompensation for floppy disk drives is provided internally by the disk controller chip.

Controller Configuration and Installation

INTRODUCTION

This chapter discusses how to configure RQDX3 jumpers and provides installation instructions for the BA23 and BA123 enclosures. It also includes information regarding interrupt vectors, priority levels, and disk drive configurations.

CONFIGURATION OF JUMPERS

RQDX3 controller jumpers are installed as required to assign the following.

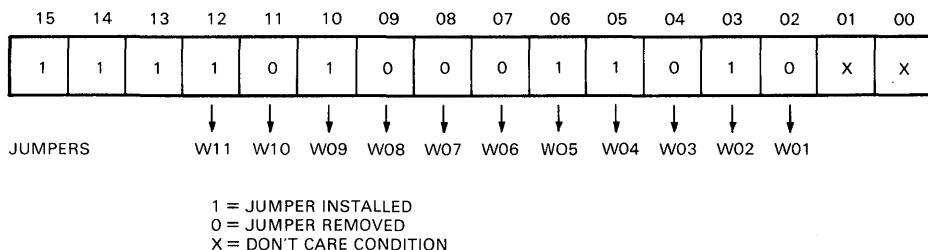
- The module base address
- Starting LUN
- Drive cable compatibility with RQDX1/RQDX2 (Jumper W23)

NOTE

All MSCP devices (including the RQDX3 controller) have the same standard base address (17772150). If a conflict exists between the RQDX3 and a second MSCP device, the base address of either one of them, the RQDX3 or the other MSCP device, must be changed to a system-specific value in the floating address space.

Module Base Address

The module base address is configured by installing jumpers W02, W04, W05, W09, and W11 and removing jumpers W01, W03, W06, W07, W08, and W10 as shown in Figure 2-1. Address bits 13–15 are always asserted high because they are jumpered permanently by hard wire connections.



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Figure 2-1 Base Address Jumper Assignments

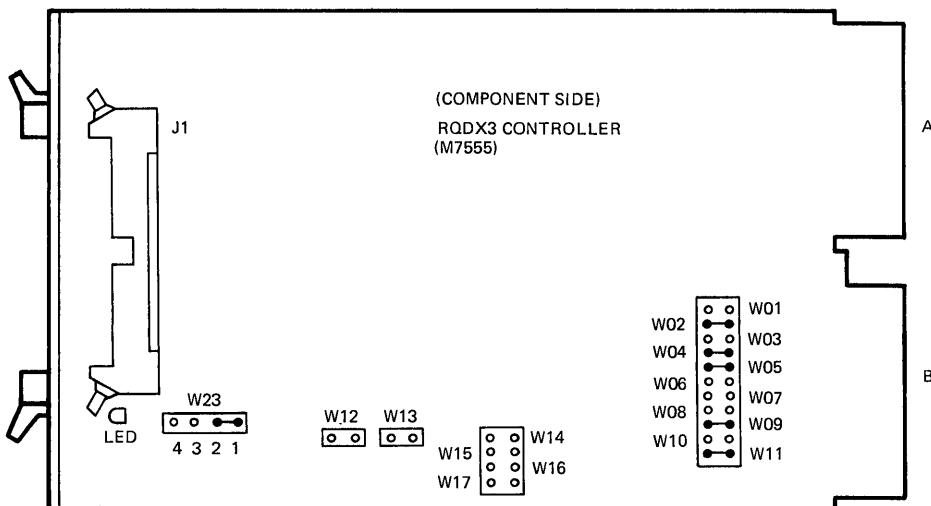
Starting LUN

The starting LUN equals the binary number represented by jumpers W12 (LSB) through W17 (MSB) multiplied by 4. When jumpers W12 through W17 are removed as shown in Figure 2-2, a starting LUN of 0 is selected. Refer to Table 2-1 for typical examples.

Table 2-1 Typical Examples of Starting LUNs

Starting LUN	Jumpers Installed	Jumper Representations	
		Binary	Decimal
0	None*	000000	0
4	W12 (LSB)	000001	1
8	W13	000010	2
12	W13 and W12	000011	3
16	W14	000100	4

* Factory configuration



MR-16713

Figure 2-2 RQDX3 Jumper Installation Diagram

Jumper W23

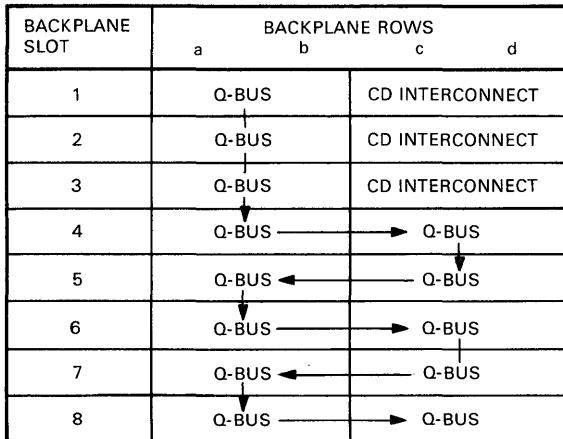
Jumper W23 is installed as specified in Table 2-2.

Table 2-2 W23 Installation

Points					Remarks
1	2	3	4		
W23					The factory configuration; it allows the HEADSEL 3 (L) and REDUCWRTI (L) signals to be tied to the same connector pin (pin 22 of J1).
o	-	o	o	o	W23 connected between points 2 and 3 ties the HEADSEL 3(L) signal to pin 9 of J1, and the REDUCWRTI (L) signal to pin 22 of J1.

BA23 INSTALLATION

The RQDX3 controller module plugs into any available slot on the BA23 backplane except the CD positions of slots 1-3 as shown in Figure 2-3. Slots 1-3 are reserved for CPU and memory modules. For backplane pin assignments (mating pins AA1-AV1 and BA1-BV1), refer to Appendix A.



NOTES:

1. PRIORITY INTERRUPTS AND DMA BUS GRANT DAISY CHAIN SHOWN BY ARROWS.
2. THE RQDX3 CAN PLUG INTO ANY UNUSED Q-BUS SLOT AS LONG AS THE DAISY CHAIN REMAINS INTACT.

MR-1676B

Figure 2-3 BA23 Backplane Slots

Installing Three Drives

Figure 2-4 shows typical cabling for one disk and two diskette drives. As shown, connector J1 on the RQDX3 controller interconnects with connector J3 on the BA23-A distribution panel via a ribbon cable. The BA23-A distribution panel is part of the interface allowing the RQDX3 module to run one disk and two diskette drives, which are installed in ports 0 and 1 of the BA23 enclosure. For BA23 installation details, refer to the appropriate MicroPDP-11 manual.

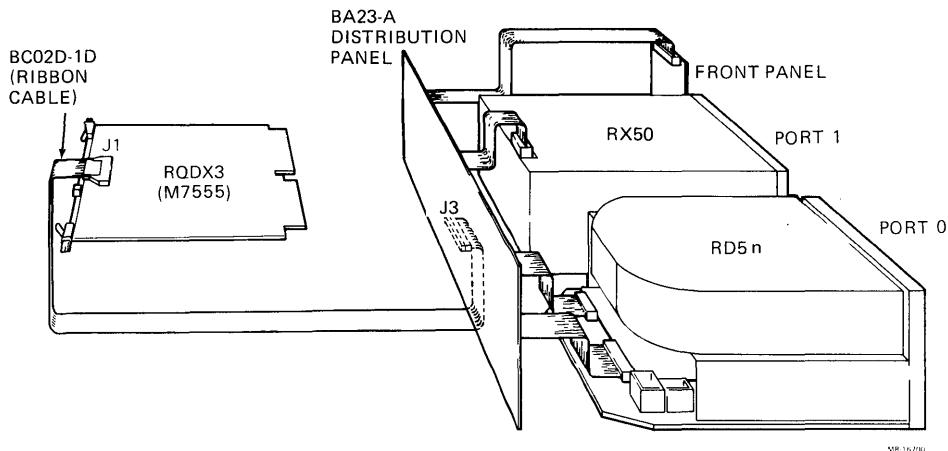


Figure 2-4 RQDX3 – BA23 Cabling Diagram

Installing Four Drives

Figure 2-5 shows typical cabling for two disk and two diskette drives. The RQDX3 module is interconnected with the RQDXE expander module, and the RQDXE module is interconnected with both the BA23 and the BA23-C distribution panels via separate cables. Point-to-point interconnections are as follows.

- RQDX3 J1 to RQDXE J2 via cable BC02D-01
 - RQDXE J1 to BA23-A distribution panel connector J3 via cable BC02D-1D
- The BA23-A distribution panel is part of the interface allowing the RQDX3 module to run one disk and two diskette drives, which are installed in ports 0 and 1 of the BA23-A.
- RQDXE J3 to BA23-C distribution panel connector J3 via cable BC02D-04

Connector J3 on the RQDXE interconnects with the BA23-C distribution panel via cable BC02D-04. This allows the RQDX3 to drive a second disk which is installed in port 0 of the BA23-C expansion box.

For a pinout of connector J1 on the RQDX3 controller, refer to Appendix B.

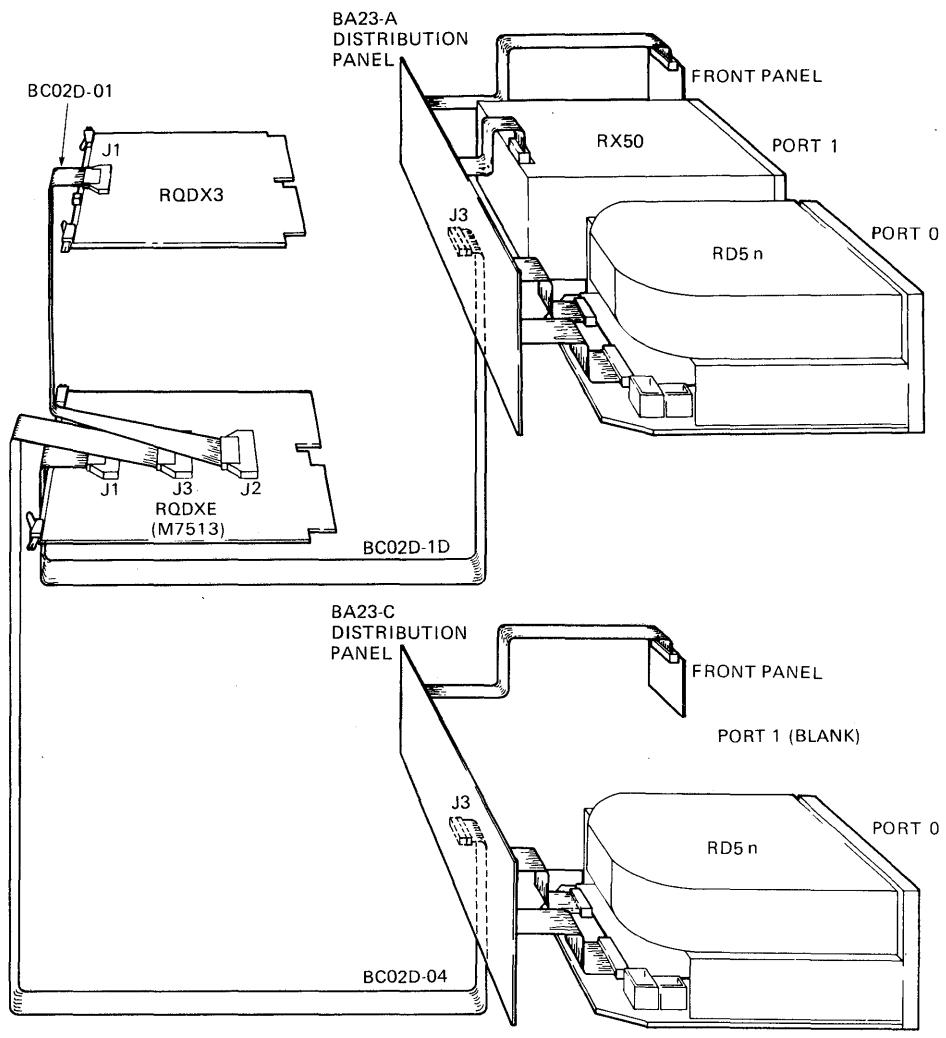


Figure 2-5 RQDX3/RQDXE – BA23-A/BA23-C Cabling Diagram

BA123 INSTALLATION

The RQDX3 controller module plugs into any available Q-Bus slots on the BA123 backplane except the CD positions of slots 1–4 and slot 13 as shown in Figure 2-6.

BACKPLANE SLOTS	BACKPLANE ROWS			
	a	b	c	d
1	Q-BUS		CD INTERCONNECT	
2	Q-BUS		CD INTERCONNECT	
3	Q-BUS		CD INTERCONNECT	
4	Q-BUS		CD INTERCONNECT	
5–12	Q-BUS		Q-BUS	
13	RESERVED FOR FUTURE USE		SIGNAL DISTRIBUTION BOARD	

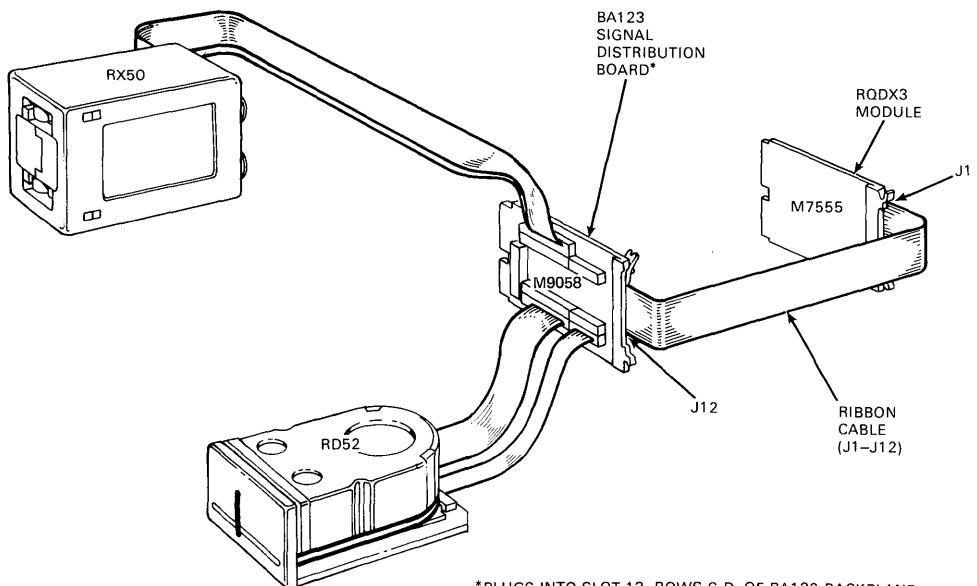
MR-16769

Figure 2-6 BA123 Backplane Slots

Refer to the appropriate MicroVAX II Technical Manual for BA123 backplane configuration rules. These rules specify plug-in priorities for BA123 backplane modules. Connector J1 on the RQDX3 controller interconnects with a connector on the BA123 signal distribution board via a ribbon cable as shown in Figure 2-7. Refer to Appendix B for the J1 pinout.

The BA123 system box is designed such that separate drive slots are permanently connected to a specific DRVSEL_n signal. This is done to eliminate the need to configure the disk drives to respond to different DRVSEL_n signals. Please refer to the MicroPDP-11 or the MicroVAX II 630QB technical manuals for full descriptions of the BA23 and the BA123 system boxes.

Therefore, drives installed in the BA123 enclosure and connected via the signal distribution board are configured automatically, and it is not necessary to configure the drive select jumpers on these drives.



*PLUGS INTO SLOT 13, ROWS C-D, OF BA123 BACKPLANE.

MR-16711

Figure 2-7 RQDX3 – BA123 Cabling Diagram

INTERRUPT VECTORS AND PRIORITY LEVELS

Interrupt vectors for MSCP controllers are set under program control. When the RQDX3 controller is the first MSCP device installed in the system, it is assigned a fixed interrupt vector of 154. If more MSCP devices are installed, they will be assigned floating interrupt vectors.

The RQDX3 controller's interrupt priority level is 4.

DISK DRIVE CONFIGURATION

The disk drives connected to the RQDX3 controller must be configured so each drive responds to a different DRVSEL_n output signal from the controller.

The RQDX3 assigns LUNs to the physical drives based upon the drive select jumper in the disk drive and the number of drives in the system. The controller looks for disk drives in the following order of drive select settings.

1. DRVSEL3
2. DRVSEL4
3. DRVSEL1
4. DRVSEL2

Starting with the LUN base address set with the jumpers, responding drives are assigned the next available LUN. Because of this action, there will be no gaps in the LUN numbering of drives connected to the controller.

As an example, consider a system with an RD52 disk drive set to respond to drive select 3 and a dual floppy RX50 diskette drive set to respond to drive selects 1 and 2. The drives on this system would be assigned as specified in Table 2-3.

Table 2-3 Drive Assignment

Disk	Assignment
RD52	(Binary LUN jumper setting) * 4 + 0
RX50	(Binary LUN jumper setting) * 4 + 1
RX50	(Binary LUN jumper setting) * 4 + 2

For hard disk drives, configuration is usually performed via a set of four push-on jumpers or breakable metallic strips. One jumper is installed, or a metallic strip is not broken, to connect the drive to a specific DRVSEL_n signal. Refer to the appropriate drive manual for a description of how to configure the specific drive in question.

The RX50 floppy disk drive is factory configured to respond to the DRVSEL1 and DRVSEL2 signals. This leaves the DRVSEL3 and DRVSEL4 signals available for hard disk drive selection.

CAUTION

Systems incorrectly configured to allow multiple drives to respond to the same DRVSEL_n signal will cause unpredictable results and possible loss of data and format information from the disk surface.

Testing and Formatting

INTRODUCTION

The RQDX3 controller module tests itself when it is powered up and when initialized by the host system. This testing capability verifies operation of the RQDX3 module's internal functional elements. A successful test takes 7–10 s. During host initialization, test time is shorter (less than 1 s).

At the beginning of testing, the RQDX3 module's LED is lit. If the test is successful, the LED goes OFF.

DIAGNOSTICS SOFTWARE

User diagnostics and Field Service diskettes are used to verify system operation. These diskettes usually isolate faults to Field Replaceable Units (FRUs). FRUs include the RQDX3 (M7555) controller and any connected disk or diskette drives.

MicroPDP-11 User Diagnostics

User diagnostics detect system errors and isolate errors to FRUs. They do not isolate errors below the FRU level. The user diagnostics are visible to the user as two diskettes. Use of these diskettes does not require familiarity with XXDP+ diagnostic supervisor software.

1. User Test 1 – Detect System Errors
2. User Test 2 – Isolate Error to FRUs

MicroPDP-11 Field Service Diagnostics – A set of five Field Service diskettes provide the XXDP+ diagnostic programs (Table 4-1) required to test the RQDX3 controller module as well as format disks using the RQDX3 module.

Table 3-1 XXDP+ Diagnostic Programs

Program	Title
ZRQC??	RQDX3 formatter
ZRQA??	RD/RX exerciser

XXDP+ Formatting with an RQDX3 Controller – The following formatting procedure is an example of formatting a MicroPDP-11 system with an RQDX3 controller module. Procedures for other systems may differ.

NOTE

New drives or drives originally formatted with an RQDX1 or RQDX2 controller must be re-formatted using the RQDX3 controller.

CAUTION

Formatting an RD5n fixed disk destroys any files that are present on the disk. If you think that files exist, make a backup copy before you proceed. Write-protect any other fixed disk drives that are present. Refer to your software documentation for instructions.

To format a RD disk drive with the RQDX3 formatter program and the RQDX3 controller, perform the following procedural steps. This procedure assumes that the RQDX3 module is the first installed MSCP device.

NOTE

Please be advised that your console displays may differ from those shown herein because you may be using updated diagnostics.

1. Install the Field Service diskette 4 (CZXD4D0) into the appropriate RX50 slot.
2. When the console displays or prints the XXDP+ prompt (.)
type **R ZRQC??** and press the **Return** key.
3. When the console displays or prints
DR>
type **START** and press the **Return** key.
4. When the console displays or prints
CHANGE HW (L) ?
type **Y** and press the **Return** key.
5. When the console displays or prints
UNITS (D) ?
type the digit **1** (for one unit) and press the **Return** key.

6. When the console displays or prints
IP ADDRESS (0) 172150 ?
press the **Return** key if the RQDX3 module is the first MSCP device.
7. When the console displays or prints
VECTOR ADDRESS (0) 154
press the **Return** key if the RQDX3 controller is the first MSCP device.
8. When the console displays or prints
AUTO FORMAT MODE (L) Y ?
type **Y** (yes) and press the **Return** key.
9. When the console displays or prints
LOGICAL DRIVE (0-255) (D) 0 ?
press the **Return** key if the RQDX3 controller is the first MSCP device.
10. When the console displays or prints
DRIVE SERIAL NUMBER (1-32000) (D) ?
type your serial number (**XXXXX**) and press the **Return** key.
11. When the the console displays or prints
WARNING ALL DATA ON THIS DRIVE WILL BE DESTROYED
followed by
PROCEED TO FORMAT THE DRIVE (L) N ?
type **Y** and then press the **Return** key to begin the drive format if all user data is backed up.
12. When the console displays or prints
MSCP CONTROLLER MODEL# :19
MICROCODE VERSION #
FORMAT BEGUN
wait about 35 min to allow the formatting to be completed.
13. When the console displays or prints
FORMAT COMPLETED
remove the diskette.

Formatting Help – For formatting help and information, refer to the following list of the most commonly reported error messages generated by the formatter program.

(1) DUP PROTOCOL ERROR, UNEXPECTED MESSAGE

This is a hardware error indicating a problem with the disk drive or its configuration. Insure the proper configuration.

(2) CONTROLLER DOES NOT EXECUTE LOCAL PROGRAMS OR NON STD DUP DIALOG PROGRAM

This can be either a hardware or software error. Check for proper controller configuration or for a defective controller.

(3) CONTROLLER IN AN UNEXPECTED ACTIVE STATE

This can be a wrong microcode version or a defective disk drive being used. Re-run the formatting procedure and if the same error message is displayed, check the new controller for ECOs or microcode.

(4) CONTROLLER NEVER ADVANCED TO NEXT STEP

This is a controller initialization error. Check the controller IP address and insure that no other device has the same address.

(5) CONTROLLER INITIALIZED TIMEOUT

The controller is defective or the Q-Bus is not operating. Re-run the formatter.

(6) WRONG MODEL NUMBER ON CONTROLLER

The wrong formatter is being used. Check the title of the diskette inserted in the RX50 diskette drive.

(7) NXM TRAP AT THE CONTROLLER IP ADDRESS

Wrong configuration controller IP address. Check the jumpers on the controller.

(8) UNEXPECTED OR DELAYED CONTROLLER INTERRUPT

Controller being interrupted by a system device. Re-run the formatter program.

(9) FATAL SA ERROR CTLR OFFLINE

Controller error. Check controller configuration and re-run the formatter. If this error occurs during re-run, then the controller is defective.

(10) BAD RESPONSE PACKET RETURN

A software controller error. Re-run the formatter.

(11) NO PROGRESS SHOWN AFTER A CMD HAD TIMED OUT

This can be either a hardware disk drive error or a drive with many revector blocks. Let the formatter program run a few more minutes to see if the error condition occurs again. If error condition does not reoccur, the disk drive is probably defective. If error condition reoccurs, the drive contains many revector blocks.

(12) GET DUST CMD TIME-OUT AFTER ANOTHER CMD TIME-OUT

Controller and host are out of sync. Check the controller for electrical interconnections (cables and backplane) and reboot the system.

RD/RX Exerciser Procedure – This sample of the RD/RX procedure assumes a configuration that comprises four logical units, one RX50 disk drive and two RD disk drives.

NOTE

This procedure assumes all user data has been backed up. If only one drive needs to be tested, make sure all other drives are write-protected and off-line.

After successfully formatting the RD disk(s), select the exerciser program by typing **R ZRQA??** after the XXDP+ prompt (.) and press the **Return** key. The console displays or prints the following.

```
DRSXM-A0
ZRQA-G-0
RD/RX EXERCISER
UNIT IS RQDX or RUX50
RESTART ADDRESS 141656
```

DR>

Remove the diagnostic diskette from the RX50 unit and replace it with the scratch diskettes. Run the exerciser program as follows.

1. When the console displays or prints the DRS prompt, type **START** and press the **Return** key.

2. When the console displays or prints

Change HW (L) ?

type **Y** and press the **Return** key.

3. When the console displays or prints

UNITS (D) ?

type **4** and press the **Return** key.

4. When the console displays or prints

unit 0

IP address (O) 172150 ?

press the **Return** key if the RQDX3 module is the first MSCP device.

5. When the console displays or prints

Vector (O) 154 ?

press the **Return** key if the RQDX3 module is the first MSCP device.

6. When the console displays or prints

BR level [usually 4-RQDX 5-RUX50] (O) 4 ?

press the **Return** key.

7. When the console displays or prints

Drive number (D) 0 ?

type **0** and press the **Return** key.

8. When the console displays or prints

Also run DUP exerciser (L) N ?

press the **Return** key.

9. When the console displays or prints

Test entire customer area of the disk (L) Y ?

press the **Return** key.

10. When the console displays or prints

Write on customer data area of this disk unit (L) ?

type **Y** and press the **Return** key.

11. When the console displays or prints

WARNING - CUSTOMER DATA AREA MAY BE
OVERWRITTEN ! ... CONFIRM (L) ?

type **Y** and press the **Return** key.

The diagnostic will repeat the above procedure for units 1 to 3. Type in the same responses except for the drive number prompts which will be 1-3 respectively.

12. When the console displays or prints

Change SW (L) ?

type **N** and press the **Return** key to select defaults. (Refer to diagnostic listings to change parameters if desired.)

13. When the console displays or prints

FUNCTIONAL TEST STARTED
EXERCISER STARTED

the RQDX exerciser procedure is completed.

MicroVAX II System Diagnostics

MicroVAX Maintenance System (MMS) diagnostics provide the programs necessary to verify operation of all MicroVAX system components, including the RQDX3 module. Two MMS versions are available.

1. Customer Version (MMS Menu 1)
2. Service Version (MMS Menu 2)

The main difference between the two versions is that the customer version supports system test, LIST, and EXIT commands only, while the service version supports all system commands.

Customer Version – The customer version is loaded from diskettes which are supplied with the system. This version implements the MAIN MENU which checks out installation configurations. Incorrect installations are evident to system users when devices known to be physically installed are not found by the MAIN MENU.

Service Version – The service version implements all menus and is loaded from diskettes purchased separately by the user. RQDX3 formatting programs and exerciser tests are run using the SERVICE MENU.

The SERVICE MENU permits the user to select both the RD/RX utility exerciser and the RQDX3 formatting programs. The following formatting procedure is an example of formatting a MicroVAX II system with an RQDX3 controller module. Procedures for other systems may differ.

NOTE

New drives or drives originally formatted with an RQDX1 or RQDX2 controller must be re-formatted using the RQDX3 controller.

CAUTION

Formatting an RD disk drive destroys any files that are present on the disk. If you think that files exist, make a backup copy before you proceed. Write-protect any other fixed disk drives that are present. Refer to your software documentation for instructions.

To run the MDM formatting and utility testing programs for diagnostic release version 1.06 follow these steps.

NOTE

**The console displays shown herein are typical examples only.
They may differ from your displays because you may be using
updated MicroVAX maintenance diagnostics.**

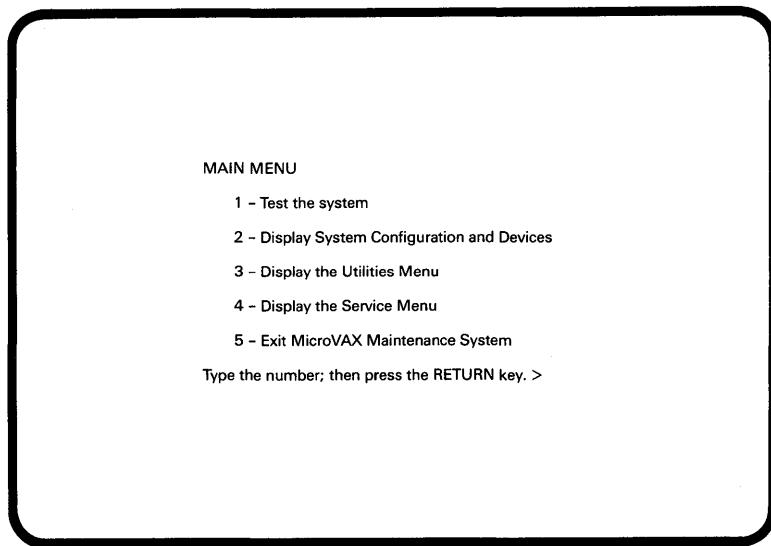
1. Install service version diskette number 1 into the appropriate RX50 slot and boot the system.
2. The console displays or prints the following line.

MICROVAX MAINTENANCE SYSTEM - DIAGNOSTIC RELEASE 1.06

NOTE

After diskette 1 has been loaded, MDM will prompt you to load the remaining diskettes. Follow the instructions displayed or printed on the console until MDM says your system is ready for testing.

3. The MAIN MENU is displayed or printed.

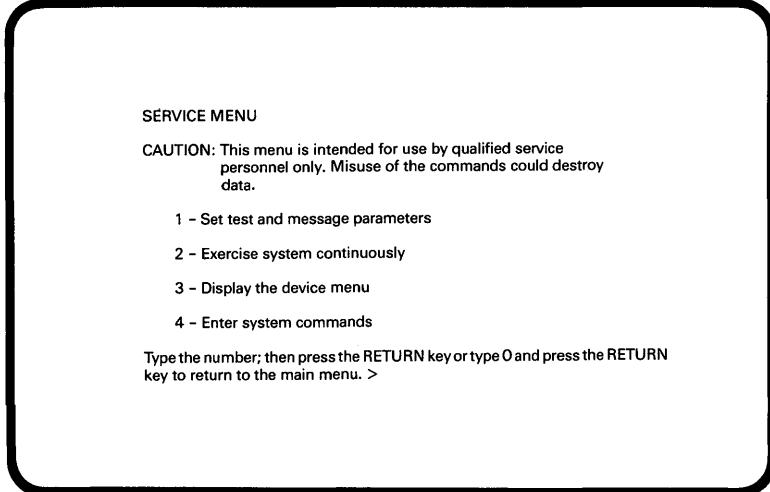


NOTE

System configuration won't show RD disk drives configured with an RQDX3 controller if the formatter has not been run successfully.

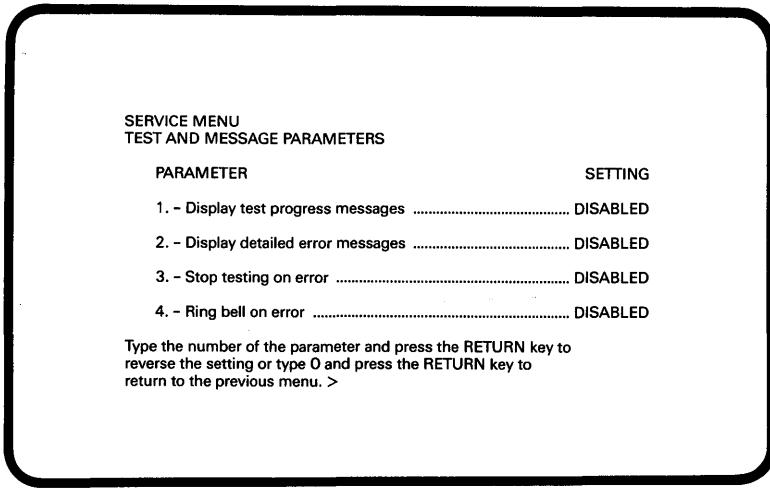
Testing and Formatting

- When the MAIN MENU is displayed or printed, type 4 and press the Return key, enabling the user to enter the SERVICE MENU.



MR - 17041

- Set the test and message parameters by typing 1 and press the Return key, allowing the following console display or printout.

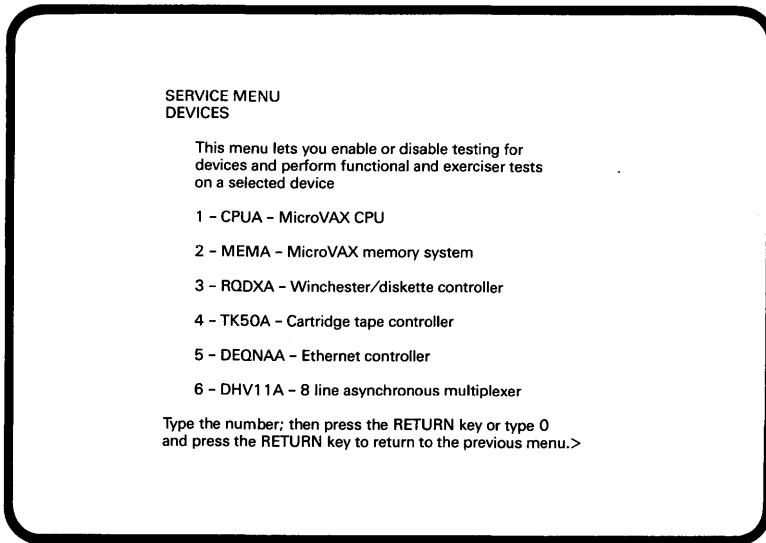


MR - 17042

NOTES

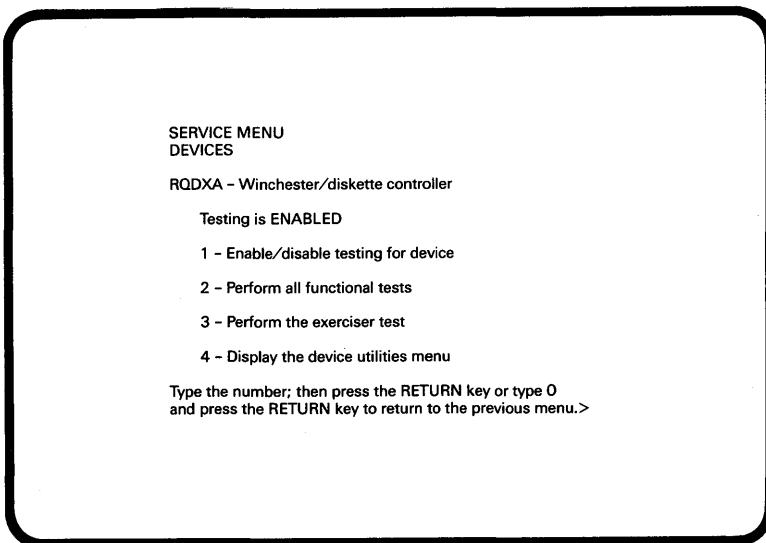
- To enable parameter 1, type "1" and return.
- To enable parameter 2, type "2" and return. The settings will now be displayed as enabled for parameters 1 and 2.
- Return to service menu by typing "0" and return.

6. To select the DEVICE MENU, type **3** and press the **Return** key, allowing the following console display or printout.



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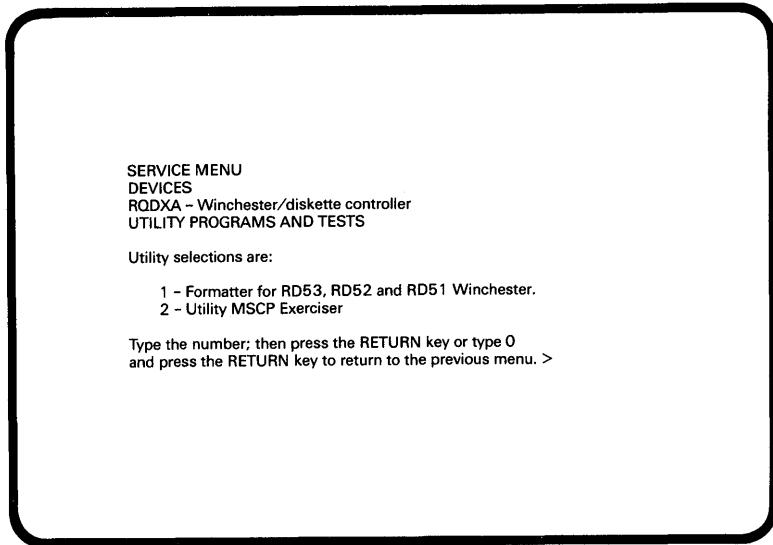
7. To select RQDXA functions, type **3** and press the **Return** key, allowing the following console display or printout.



MR - 17044

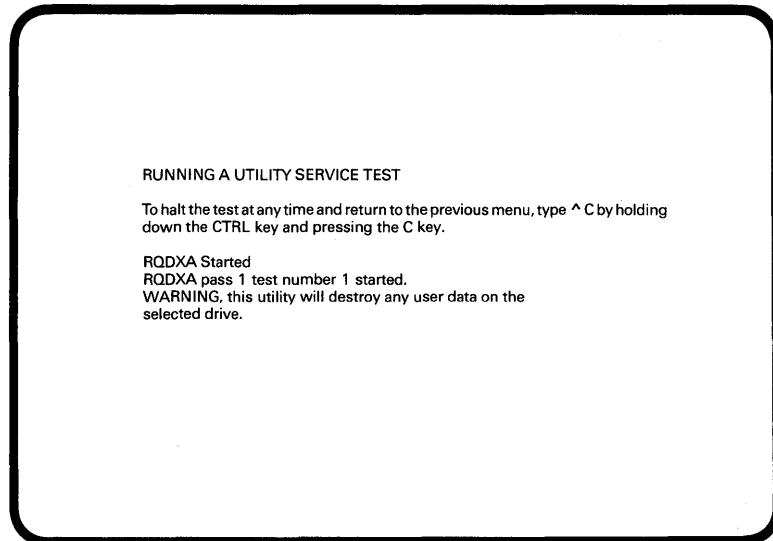
Testing and Formatting

8. To select the device utilities menu, type 4 and press the **Return** key, allowing the following console display or printout.



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9. To select the formatter for Winchester drives, type 1 and press the **Return** key, allowing the following display or printout.



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10. When the console displays or prints

Do you want to continue [YES=1, (NO=0)] ?

type **1** and press the **Return** key, assuming user data is backed up.

11. When the console displays or prints

Do you want to use the "AUTOFORMAT" mode [(Yes=1), No=0]:=

type **1** and press the **Return** key.

12. When the console displays or prints

What unit do you want to format (0-3) ?

type **0, 1, 2 or 3**, depending on whatever unit you wish to select and press the **Return** key.

13. When the console displays or prints

Is this the correct unit number? [(Yes=1), No=0] :=

type **1** and press the **Return** key.

14. When the console displays or prints

Please enter the date [MM-DD-YYYY] :=

type today's date and press the **Return** key.

15. When the console screen displays or prints

Please type in a six digit serial number :=

type in the serial number located on the disk drive and press the **Return** key.

16. When the console displays or prints

FORMAT BEGUN

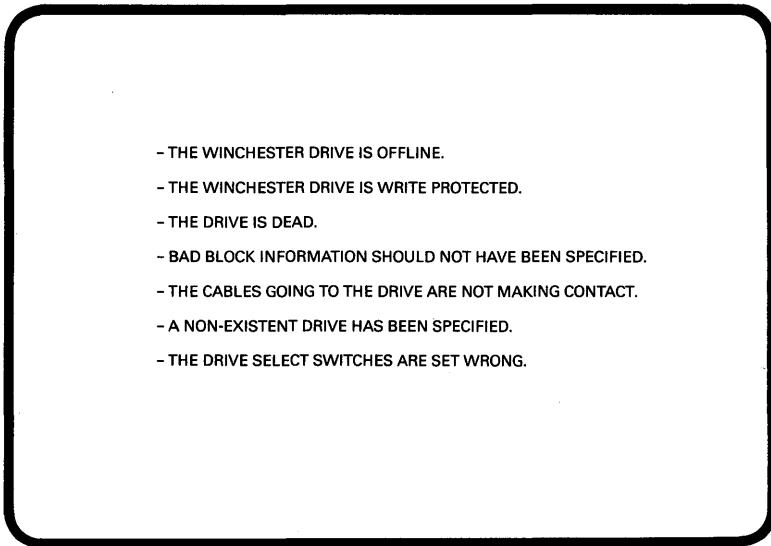
allow about 35 min for the formatting to be implemented successfully.

17. When the console displays or prints

The controller reported a successful termination of the format command

Testing and Formatting

If a failure occurs during the time allowed for formatting, the following console display or printout is obtained.



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18. After formatting has been completed successfully on the RD drive(s), go back to the menu shown in Step 7, type **2** and press the **Return** key as required to select the functional tests. Allow the functional tests to run one pass with no errors.
19. Go back to the menu shown in Step 7, type **3** and press the **Return** key as required to select the exerciser tests. Allow the exerciser tests to run three passes with no errors.
20. Go back to the menu shown in Step 4, type **2** and press the **Return** key as required to exercise the system. Allow the system to complete system tests successfully.

After successful completion of the system tests, the customer can restore data and bring up system software. However, if a drive problem is experienced while running the functional and exerciser tests, run the RQDX device utility to help isolate the fault. Perform Step 21 to do this.

21. Go back to the menu shown in Step 8, type **2** and press the **Return** key as required to select the utility MSCP exerciser. Answer the prompts as required to select the testing options you want.

Glossary of MSCP and DUP Commands

MSCP COMMANDS

The RQDX3 module supports the following MSCP commands.

ABORT COMMAND

Aborts a command which is currently in progress.

ACCESS

Reads data from a unit starting at a given logical block number and discards the data obtained.

AVAILABLE

Returns a unit to the Unit-Available state.

COMPARE

Reads data from a unit starting at a given logical block number and compares it with data read from the host.

ERASE

Fills a buffer with 0s and writes it to a unit starting at a given logical block number.

GET COMMAND STATUS

Obtains information about the progress of a command.

GET UNIT STATUS

Obtains unit geometry and status information.

ONLINE

Brings a unit from the Unit-Available state to the Unit-Online state, so that it is ready to accept further commands.

READ

Reads data from a unit, starting at a given logical block number, and copies it to the host.

SET CONTROLLER CHARACTERISTICS

Sets some controller operating characteristics.

SET UNIT CHARACTERISTICS

Sets some unit operating characteristics.

WRITE

Copies data from the host and writes it to a unit starting at a given logical block number.

DUP COMMANDS

The RQDX3 module supports the following DUP commands.

ABORT PROGRAM

Aborts a program which is currently in progress.

EXECUTE LOCAL PROGRAM

Begins running a program stored in ROM.

EXECUTE SUPPLIED PROGRAM

Loads a program into RAM and begins running it.

GET DUP STATUS

Obtains information about local DUP state.

RECEIVE DATA

Transfers data from the RQDX3 to the host.

SEND DATA

Transfers data from the host to the RQDX3.

These local programs can be invoked by the EXECUTE LOCAL PROGRAM command.

DIRECT

Transmits an ASCII directory of all available local programs to the host.

FORMAT

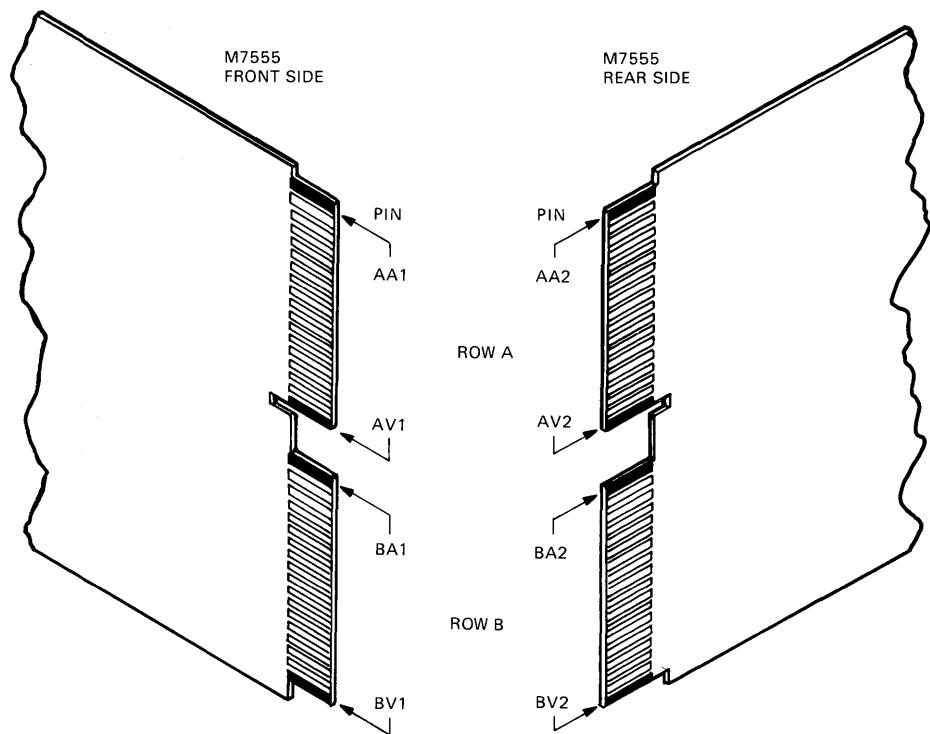
Formats a unit.

Appendix A

RQDX3 Backplane Pin Assignments

RQDX3 CONTROLLER

Digital's plug-in modules, including the RQDX3 controller all use the same contact (pin) identification system (Table A-1). See Figure A-1 for controller contact fingers.



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Figure A-1 Dual Module Contact Finger Identification Diagram

RQDX3 Backplane Pin Assignments

Table A-1 RQDX3 Module Finger Connections

Pin	Signal Name	Pin	Signal Name
AA1	(BIRQ5 L)*	AA2	+5 Vdc
AB1	(BIRQ6 L)	AB2	(-12 Vdc)
AC1	BDAL16 L	AC2	GND
AD1	BDAL17 L	AD2	+12 Vdc
AE1	(SSPARE1 or +5 B)	AE2	BDOUT L
AF1	(SSPARE2)	AF2	BRPLY L
AH1	(SSPARE3)	AH2	BDIN L
AJ1	GND	AJ2	BSYNC L
AK1	(MSPAREA)	AK2	BWTBT L
AL1	(MSPAREB)	AL2	BIRQ4 L
AM1	GND	AM2	BIAKI L
AN1	BDMR L	AN2	BIAK0 L
AP1	(BHALT L)	AP2	BBS7 L
AR1	BREF L	AR2	BDMGI L
AS1	(+12 B or +5 B)	AS2	BDMG0 L
AT1	GND	AT2	BINIT L
AU1	(PSPARE1)	AU2	BDAL0 L
AV1	(+5 B)	AV2	BDAL1 L
BA1	(BDC0K H)	BA2	+5 Vdc
BB1	BP0K H	BB2	(-12 Vdc)
BC1	BDAL18 L	BC2	GND
BD1	BDAL19 L	BD2	+12 Vdc
BE1	BDAL20 L	BE2	BDAL2 L
BF1	BDAL21 L	BF2	BDAL3 L
BH1	(SSPARE8)	BH2	BDAL4 L
BJ1	GND	BJ2	BDAL5 L
BK1	(MSPAREB)	BK2	BDAL6 L
BL1	(MSPAREB)	BL2	BDAL7 L
BM1	GND	BM2	BDAL8 L
BN1	BSACK L	BN2	BDAL9 L
BP1	(BIRQ7 L)	BP2	BDAL10 L
BR1	(BEVNT L)	BR2	BDAL11 L
BS1	(+12 B)	BS2	BDAL12 L
BT1	GND	BT2	BDAL13 L
BU1	(PSPARE2)	BU2	BDAL14 L
BV1	+5 Vdc	BV1	BDAL15 L

* Names in parentheses represent Q-Bus signals not used

Appendix B

RQDX3 Controller Module Cable Signals

CONNECTOR PINOUTS

Table B-1 lists the RQDX3 controller module signals on connector J1 (part number 12-13506-13).

Table B-1 J1 Connector Pinouts

J1 Pin	Signal Name	J1 Pin	Signal Name
-1	MFMWRTDT1 (H)	-26	INDEX (L)
-2	MFMWRTDT1 (L)	-27	DRV4WPT (L)
-3	GROUND	-28	DRVSEL1 (L)
-4	HEADSEL2 (L)	-29	DRVSEL2 (L)
-5	GROUND	-30	DRVSEL3 (L)
-6	SEEKCPLT (L)	-31	DRV2RDY (H)
-7	DRV1RDY (H)	-32	RXMOTORON (L)
-8	WRTFAULT (L)	-33	GROUND
-9	HEADSEL3 (L)*	-34	DIRECTION (L)
-10	HEADSEL1 (L)	-35	GROUND
-11	DRV1RDY (H)	-36	STEP (L)
-12	DRV3RDY (H)	-37	GROUND
-13	DRV1WPT (L)	-38	RXWRTDATA (L)
-14	DRVSLOACK (L)	-39	GROUND
-15	MFMRDDAT0 (H)	-40	WRTGATE (L)
-16	MFMRDDAT0 (L)	-41	GROUND
-17	MFMWRTDT0 (H)	-42	TRACK00 (L)
-18	MFMWRTDT0 (L)	-43	DRV2WPT (L)
-19	MFMRDDAT1 (H)	-44	DRVSL1ACK (L)
-20	MFMRDDAT1 (L)	-45	GROUND
-21	GROUND	-46	RXRDATA (L)
-22	REDUCWRTI (L)†	-47	GROUND
-23	DRV3WPT (L)	-48	HEADSEL0 (L)
-24	DRVSEL4 (L)	-49	GROUND
-25	GROUND	-50	READY (L)

* Connected to HEADSEL3 signal, left open or grounded via a jumper on module.

† The HEADSEL3 signal may be ORed with the REDUCWRTI signal via a jumper on the module.

CONNECTOR SIGNALS DESCRIPTION

It is recommended that the output signals from this module be terminated at the far end of a 130 ohm impedance cable with a single 220/330 resistor divider network. The maximum allowable cable length when proper termination is used is 8 ft. It is the responsibility of the system design engineer to insure the integrity of those output signals through proper cabling techniques.

The following is a description of the signals available on the drive interface connector J1. The timing and electrical characteristics of these signals are compatible with signals specified in the RD51, RD52, RD53, and RX50 drive specifications.

Table B-2 Description of Connector Signals

Signal	Input/ Output	Description
DIRECTION (L)	Output	This signal controls the direction of head movement. When asserted, the direction of movement is toward the spindle (in).
DRV<4:1>RDY (H)	Input/Output	<p>When one or more of these signals is asserted by the front panel (READY switch open), the controller will assume that the hard disk drive on the corresponding DRVSEL<4:1> line is ready for data transfers. When the controller performs a seek function on a hard disk drive, it will force this signal to an unasserted condition to turn off the READY light on the front panel for the corresponding drive.</p> <p>The controller will ignore the state of the appropriate DRV<4:1>RDY when there is a floppy disk drive attached to a DRVSEL<4:1> line.</p>

Table B-2 Description of Connector Signals (Cont.)

Signal	Input/ Output	Description
DRV<4:1>WPT (L)	Input/Output	<p>These signals, when asserted from the front panel (Write Protect switch closed), are used to indicate to the controller that hard disk drives connected to the corresponding DRVSEL<4:1> line are to be protected against write operations.</p> <p>The controller will assert a DRV<4:1>WPT signal to indicate that the system software has write protected the hard disk on the corresponding DRVSEL<4:1> line.</p>
DRVSEL<4:1> (L)	Output	<p>The controller will assert one of these signals to select one of four drives for operation.</p>
DRVSL<1:0>ACK (L)	Input	<p>These input signals are asserted by a hard disk drive to indicate that it has been selected. When either or both of these signals are asserted, the controller will assume that there is a hard disk drive connected to the currently active DRVSEL<4:1> line.</p>
GROUND		The signal return path.
HEADSEL<3:0> (L)	Output	<p>These signals are used to select one of up to sixteen surfaces on the currently selected drive.</p>
INDEX (L)	Input	<p>This input signal informs the controller that the currently selected drive is at the beginning of a track.</p>

Table B-2 Description of Connector Signals (Cont.)

Signal	Input/ Output	Description
MFMRDDAT<1:0> (H) MFMRDDAT<1:0> (L)	Input	Data from the hard disk drive surface will be transmitted to the controller on these differential pairs. The controller will assume that hard disk drives on DRVSEL1 and DRVSEL3 will transmit their data on the MFMRDDAT0 differential pair and that hard disk drives on DRVSEL2 and DRVSEL4 will transmit their data on the MFMRDDAT1 pair.
MFMWRTDT<1:0> (H) MFMWRTDT<1:0> (L)	Output	These differential signal pairs will be used to transmit data to be written to the disk surface when the Write Gate signal is asserted. There are two sets of these differential pairs to allow two hard disk drives to be connected without external logic. Both pairs will be active at the same time.
READY (L)	Input	<p>This input signal from the drive will indicate the following.</p> <ul style="list-style-type: none"> • For hard disk drives, it will indicate that when SEEKCPLT is also asserted the drive is ready to read, write or seek. • It will indicate that the drive is selected, the media door is closed and media is present for floppy disk drives.

Table B-2 Description of Connector Signals (Cont.)

Signal	Input/ Output	Description
REDUCWRTI (L)	Output	This controller output can be asserted to force a disk drive to use a low value of write current if appropriate.
RXMOTORON (L)	Output	This signal is asserted by the controller to turn on the floppy disk drive motor(s).
RXRDATA (L)	Input	This input is the read data channel from floppy disk drives.
RXWDATA (L)	Output	This output is the write data channel to floppy disk drives.
SEEKCPLT (L)	Input	This input should be asserted when the currently selected hard disk drive has completed a seek function.
STEP (L)	Output	This output signal is used to step the head(s) of the currently selected floppy disk drive or hard disk drive.
TRACK00 (L)	Input	This input signal from the currently selected hard disk drive or floppy disk drive will indicate that the drive's head(s) are positioned at track zero.

Table B-2 Description of Connector Signals (Cont.)

Signal	Input/ Output	Description
WRTFAULT (L)	Input	<p>For hard disk drives, this signal should be asserted when a condition exists in a selected drive which should cause writing to be inhibited. The signal should remain asserted until the error condition is corrected and/or the drive is de-selected. Some of these error conditions include:</p> <ul style="list-style-type: none"> • Write current and no write gate, or write gate with no write current • Multiple heads, no head, or improperly selected head • DC voltages out of tolerance • Write gate asserted and seek complete deasserted <p>For floppy disk drives, this signal is asserted when a write protected diskette is present.</p>
WRTGATE (L)	Output	When asserted, this controller output signal will turn on the write drivers of the currently selected drive.

Appendix C

Supported Drive Geometries

Table C-1 Supported Drive Matrix

Description	RD51	RD52	RD52	RD53	RX50
Sector interleave	2:1	1:1	1:1	1:1	2:1
Bytes/Sector	512	512	512	512	512
Sectors/LBN	1	1	1	1	1
LBNs/Track	18	17	17	17	10
Tracks/Group	1	8	7	8	80
Groups/Cylinder	4	1	1	1	1
Cylinders/Unit	306	512	645	1024	1
Total LBNs/Unit	22,032	69,632	76,755	139,264	800
RBNs/Unit	144	168	168	280	Track
RCT size (blocks)	36	4	4	5	-
RCT copies	4	8	8	8	-
DBNs/Unit	87	82	65	82	-
XBNs/Unit	57	54	54	54	-
User LBNs/Unit	21,600	60,480	60,480	138,672	800
User capacity (bytes)	11.06 M	30.96 M	30.96 M	71.00 M	4096 K
Step pulsedwidth (μ sec)	11.2	11.2	11.2	11.2	224
Step rate (μ sec)	17.6	17.6	17.6	17.6	8*
Write precomp (nsec)	10	10	10	-	0-55† 56-77‡
Precomp cylinders	110-305	256-511	320-644	0	-

* msec

† ±110 nsec cylinders

‡ ±210 nsec cylinders

