PRODUCT SPECIFICATION
AND USER'S MANUAL

TDL-12 HOST ADAPTER

A Q-BUS INTERFACE
FOR
SCSI DISK CONTROLLERS

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SECTION 1: FEATURES AND SPECIFICATIONS

1.1 INTRODUCTION

The TDL-12 is a Host Adapter that interfaces DEC Q-Bus systems to low-cost disk controllers using the SCSI (Small Computer Systems Interface) bus. The TDL-12 emulates a DEC RLV12 controller with 22-bit addressing and RL01/02 disk drives. It is fully compatible with all DEC Q-Bus processors and operating systems.

The TDL-12 can operate with any of the popular SCSI disk controllers, which are available for virtually any type of disk drive. Each of the four logical 'DL' units may be configured as either an RL01 or RL02, and may be mapped to any controller and disk drive. RL01's and RL02's may be mixed on one TDL-12.

Controller and disk drive parameters are stored in non-volatile memory on the TDL-12, and are sent to the controller(s) on power-up. These parameters, and the configuration information described above, may be displayed and changed using the TDL-12's on-board diagnostic monitor. This diagnostic monitor also contains a complete set of self-tests and drive exercisers, as well as comprehensive formatting utilities.

But performance is the key issue, and the TDL-12 has it. With a suitable controller, the TDL-12 can run an ST506-style Winchester with NO sector interleaving. This translates into a maximum data rate of 5 MBits/sec. In the real world this means that disk-bound operations are noticeably faster with the TDL-12 than with the RL drives it emulates.

1.2 FEATURES

* Emulates DEC RLV controllers with 22 bit addressing. Emulates up to four DEC RL01 or RL02 drives (41.6MB max).

* Fully compatible with ALL DEC operating systems and processors.

* 5 MBit/s maximum throughput.

* Comprehensive, menu-driven self-diagnostics and drive diagnostics are built-in. Formatting and configuration utilities are built-in. Runs standard DEC diagnostics.

* Runs with ALL popular SCSI controllers. Controllers and disk drives of different types may be mixed on one TDL-12.

* Dual-wide board with low power consumption. On-board bootstrap. Automatic power-on boot option. Alternate address and vector strap option. Configuration and drive characteristics stored in non-volatile EEPROM.

* Format alternate track and format with defect list supported. Fully compatible with all DEC Bad Sector File utilities.

* Direct SCSI command mode for use with ANY SCSI peripheral.

1.3 SPECIFICATIONS

Identification:	Assy. No. 210-00028
Board size:	Dual (5.2 wide X 9.0 high including handles)
Power:	+5 VDC +/-5% at 1.7 A max.
Bus Loads, AC:	1
DC:	1
Bus address:	Standard: 774400-774416 (18-bit systems) 17774400-17774416 (22-bit systems) Alternate: (jumper plug option) 774420-774436 (18-bit systems) 17774420-17774436 (22-bit systems)
Interrupt vector:	Standard: 160 Alternate: 164 (jumper plug option)
Interrupt priority:	Level 4 (single level)
Bootstrap:	DL, DX, DY bootstraps at address 773000. May be disabled with jumper plug option. Automatic power-on boot option.
Maximum controllers:	4
Maximum drives:	4
Maximum storage:	41.6 MB formatted (four RL02's)

1.4 CONTROLLERS SUPPORTED

Adaptec:	ACB-4000, ACB-4010, ACB-4000A, ACB-5500
Adaptive Data:	Sabre, David
DTC:	510A/510B, 515CU, 520A/520B, 600/610, 615 700/701, 703, 900/910, 101/101D 900/910, 1403ES, 1401/1403D
Iomega:	Alpha 10.5, 10.5H, 20H drives and subsystems
Konan:	DJ210, DJ1100
OMTI:	Model 10, Model 20, 5000 Series
Western Digital:	WD1002-SHD
Xebec:	Model 1410/1410A, 9710/9730 subsystems

SECTION 2: INSTALLATION AND USE

2.1 INSTALLING THE TDL-12

2.1.1 TDL-12 Hardware Options

There are two basic TDL-12 hardware options: base address and vector, and bootstrap enable/disable. These two options are selected by means of two jumper plugs labelled 'A' and 'B' in the center of the board:

Jumper plug 'A' = Address and vector select

Installed:	Base address =	774400 for 18-bit systems. 17774400 for 22-bit systems.
	Vector = 160.	
Removed:	Base address =	774420 for 18-bit systems. 17774420 for 22-bit systems.
	Vector = 164.	

Jumper plug 'B' = Enable bootstrap

Installed:	Enable onboard bootstrap at 773000.
Removed:	Disable onboard bootstrap.

The TDL-12 is shipped with both plugs installed. Note that only one bootstrap should be enabled in a system. If your system already has a bootstrap on some other board, the TDL-12 bootstrap should be disabled (jumper plug 'B' removed).

2.1.2 Location in the Q-Bus Backplane

The TDL-12 requires a single dual-wide slot in the Q-Bus backplane. Because the TDL-12 system is fully buffered, DMA priority is not critical. The TDL-12 supports only single-level interrupt priorities, so it should be placed AFTER any multi-level interrupting devices on the Q-Bus.

NOTE: The DEC RQDX1 (RX50/RD50/RD51) controller DOES NOT pass DMA grants. The TDL-12 must be installed AHEAD of the RQDX1 in the backplane.

2.1.3 Cabling: TDL-12 to Controller

A 50 conductor ribbon cable is supplied to connect the TDL-12 to one SCSI disk controller. The mating connector on the TDL-12 main board is keyed so that the cable may be installed only in the correct orientation. Care should be taken to avoid incorrect installation at the controller connector.

If more than one controller is to be used, a custom cable will be necessary. Follow the controller manufacturers' recommendations as to lengths and location of terminators. Note that the TDL-12 MUST be at one end of a multiple-controller cable because it has non-removable terminators.

2.1.4 Cabling: Controller to Disk Drive(s)

Refer to the specific controller and Winchester drive manuals for directions on cabling and powering the controller and drives.

2.2 CONTROLLER OPTIONS

The following three controller options may have to be set before beginning operation:

2.2.1 SCSI Bus Parity

The TDL-12 generates parity on SCSI bus transfers, but does not check parity. Therefore it can operate with any parity option.

2.2.2 SCSI Controller Address

The TDL-12 can work with any controller SCSI address from 0-3 (four controllers maximum). In multiple controller systems, the controllers must be strapped to different SCSI addresses in the range 0-3.

2.2.3 Sector Size

The TDL-12 can work with either 256 or 512 byte sectors. 512 byte sectors are recommended to maximize storage capacity and performance. Make sure that the controller's sector size strap (if it has one) agrees with the value entered in the drive parameters for drives attached to that controller. See Paragraphs 2.5 and 3.7.

2.3 FIRST-TIME OPERATION

2.3.1 Power-On

Power the system on for the first time. Examine the contents of the TDL-12's registers using Micro-ODT. They should contain the octal values listed below. If the register values are not as shown, a serious hardware problem exists within the TDL-12 board.

The standard base address is 774400 (17774400 for 11/73 systems). The alternate base address (refer to Paragraph 2.1.1) is 774420 (17774420 for 11/73 systems).

```
CSR (base address) = 201 or 601
BAR (CSR+2)        = 0
DAR (CSR+4)        = 0
MPR (CSR+6)        = 0
BAX (CSR+10)       = 0
```

2.3.2 Running the TDL-12 Diagnostic Monitor

The TDL-12's internal self-tests should be run after successful power-up to further verify the operational state of the board. The self-tests are started from the TDL-12's Diagnostic Monitor (DMON). A complete description of DMON and its functions can be found in Section 3. To run DMON, do the following:

1) Halt the Processor: move the RUN/HALT switch to the 'HALT' position. This will start Micro-ODT in the processor.

2) Using the system console and Micro-ODT, deposit a '1000' to the TDL-12 CSR at location 774400 (774420 if the alternate bus address option is selected, 17774400 or 17774420 for 11/73 systems). This will cause the TDL-12 to load the Diagnostic Monitor into Host memory at location 1000(8).

a) Type: '774400/' ('17774400/' for 11/73).
b) Micro-ODT will respond with '201' or '601'.
c) Now type '1000'<CR>.

3) Move the RUN/HALT switch to the 'RUN' position.

4) Type '1000G'. The DMON menu will be printed out on the on the console as shown below. DMON is now ready to accept commands. You can return to Micro-ODT at any time by entering a Control C (^C) or by hitting the BOOT switch.

```
TDL12 1.XX (C) 1985,1986 TD Systems
 C  Configuration
 D  Display
 E  Exercise
 F  Format
 I  Initialize
 L  Error Log
 S  SCSI Cmd
 T  Test TDL
 W  Write BSF
DMON>
```

2.3.3 TDL-12 Self-Tests

Run the TDL-12 self-tests by typing 'T'<CR> in response to the 'DMON>' prompt. Each dot represents a successful pass through the set of self-tests. Hit any key to halt the self-tests and return to the DMON prompt.

2.4 SELECTING THE TDL-12 CONFIGURATION

The TDL-12 can be set up to run with virtually any combination of drives and controllers. But before it can work in your particular system, you have to tell it what kind of system you have. That information is stored in non-volatile memory on-board the TDL-12 and retrieved whenever the system is powered-up.

The first part of the set-up procedure is to enter the configuration you want. 'Configuration' in this case means the mapping of logical 'DL' units onto physical controller/drive combinations, and how large each 'DL' is (RL01 or RL02).

As shipped, the TDL-12 is configured to emulate four RL02's on four physical drives attached to controller '0'. Thus, 'DL0' maps to physical drive 0, 'DL1' to drive 1, and so on. This default configuration can be displayed by typing 'C'<CR> in response to the DMON prompt:

```
Configuration
DLn = Type  Cntrl  Drive  Off
 0    RL02    0      0     0
 1    RL02    0      1     0
 2    RL02    0      2     0
 3    RL02    0      3     0
Autoboot off
```

To change the configuration, use the DMON Initialize (I) command. Type 'I'<CR>. DMON will respond:

```
Initialize configuration? (Y/N)
```

If you answer 'Y', DMON will repeat the following set of questions for each logical unit DL0-3 in turn:

```
DL0 exist? (Y/N) Y
        Enter RL type (1,2)= 2
        Enter controller (0-3)= 0
        Enter drive (0-3)= 0
```

When all DL's have been configured, DMON will ask if the Autoboot option should be enabled.

```
Enable Autoboot? (Y/N)
```

Enabling Autoboot causes the TDL-12 to boot automatically from one of the four DL units whenever the computer powers up or the boot switch is hit. If Autoboot is not enabled, the TDL-12 boot routine displays a boot prompt and requires that the operator enter the boot device.

Note that the Autoboot option requires that the on-board bootstrap be enabled and that the Host processor be strapped to jump to the standard boot address (773000) on power-up. If you answer 'Y' to the enable question, DMON will ask for the DL unit (0-3).

After the Autoboot option is configured, DMON will display the new configuration and ask if you want to save it. If you answer anything but 'Y' the new information will be discarded and the old configuration restored. In the configuration display, any DL's that don't exist will have '??' for the type entry. Refer to Section 3 for more about 'C' and 'I' commands.

Note that it is perfectly valid to mix RL types, and to put more than one DL on one physical drive. The example below is a three drive, two controller system in which DL0, DL1, and DL2 are all RL02's while DL3 is an RL01. Further, both DL0 and DL1 are mapped to controller 0, drive 0. The 'Off =2' entry in the configuration display means that DL1 is offset two 'RL01' units above DL0 on that drive.

CONFIGURATION EXAMPLE:

```
Initialize configuration? (Y/N) Y

DL0 exist? (Y/N) Y
        Enter RL type (1,2)= 2
        Enter controller (0-3)= 0
        Enter drive (0-3)= 0

DL1 exist? (Y/N) Y
        Enter RL type (1,2)= 2
        Enter controller (0-3)= 0
        Enter drive (0-3)= 0
```

```
DL2 exist? (Y/N) Y
        Enter RL type (1,2)= 2
        Enter controller (0-3)= 0
        Enter drive (0-3)= 1

DL3 exist? (Y/N) Y
        Enter RL type (1,2)= 1
        Enter controller (0-3)= 1
        Enter drive (0-3)= 0

Enable Autoboot? (Y/N) Y
 Enter DL (0-3) = 0

Configuration
DLn = Type  Cntrl  Drive  Off
 0    RL02    0      0     0
 1    RL02    0      0     2
 2    RL02    0      1     0
 3    RL01    1      0     0
Autoboot from DL0

Save this configuration? (Y/N) Y
 Saved
```

2.5 ENTERING DRIVE PARAMETERS

After your configuration is entered, you will want to enter information about the controllers and drives that you have referred to. The TDL-12 is shipped with default controller/drive information stored in its non-volatile memory, but this will usually not match your system's characteristics.

The 'I' (Initialize) command is used to enter controller and drive information, too. After entering a new configuration or answering 'NO' to the configuration question, DMON will ask:

```
Initialize drive parameters? (Y/N)
```

Any response other than 'Y' will return you to the DMON prompt. If you answer 'Y' DMON will search its configuration tables to find all the references to distinct controller/drive combinations, and ask you to enter the specifics about each one, starting with the controller type code:

```
Enter parameters:
Controller 0, Drive 0
 Controller type (D)=
```

The table of controller type codes is in Appendix B at the back of the manual. After you enter the type, DMON will request drive parameters. The exact information required will vary depending on the controller type. A listing of parameters requested for each controller type may be found in Appendix C. The example below is typical.

DRIVE PARAMETER EXAMPLE:

```
Enter parameters:
Controller 0, Drive 0
 Controller type (D)= 1
 Sector size (1,2)= 2
 Sectors/track (D)= 17
 Cylinders (D)= 306
 Heads (D)= 4
 RWC (D)= 128
 WPC (D)= 128
 Step rate (D)= 1
 Interleave (D)= 1
Save new parameters? (Y/N) Y
 Saved, Cleared error log
```

The example above is for an Adaptec ACB-4000 controller with a Seagate ST412 drive. The entries mean the following:

Controller type:	The controller type code found in Appendix B for the ACB-4000.
Sector size:	The desired sector size: 1=256, 2=512.
Sectors/track:	The number of sectors on each track. (decimal).

Cylinders:	The number of cylinders on the drive. (decimal).
Heads:	The number of heads on the drive. (decimal).
RWC:	The starting cylinder number at which Reduced Write Current is applied. (decimal).
WPC:	The starting cylinder number at which Write Precompensation is applied. (decimal).
Step rate:	The step rate option selected for the drive. This may be decimal or hex depending on the controller type.
Interleave:	The sector interleave factor desired.

Other controllers may require more or less information. In general, this information is passed directly to the controller to tell it what drive type and size is attached to it.

***** WHEN IN DOUBT, REFER TO THE CONTROLLER AND DRIVE MANUALS *****

Using the case of step rates for example, a '1' passed to the Adaptec ACB-4000 will mean something entirely different than a '1' passed to a Xebec 1410 controller, but both controllers need step rate information. Refer to Appendix C for a summary of drive parameters for the various controller types.

2.6 FORMATTING THE DRIVES

With the exception of some cartridge drives with pre-formatted cartridges (such as the Iomega Alpha 10.5), most drives will have to be formatted before they can be used. DMON provides the 'F' (Format) command for this purpose. See Paragraph 3.6.

2.7 ON-BOARD BOOTSTRAP

The TDL-12's on-board bootstrap program starts at the standard DEC bootstrap address (773000). It may be started automatically on power-up if the processor is strapped for it, or it may be started from Micro-ODT. When started, the bootstrap routine will either respond with its prompt (Autoboot disabled) or boot from the previously selected DL unit (Autoboot enabled). If Autoboot is disabled, the user may enter the device from which to boot (DL0-3, DX0,1 or DY0,1):

```
BOOT> DL0<CR>
```

If no device is entered before the <CR>, the boot device defaults to DL0. If no unit number is entered, unit 0 is used.

Whether Autoboot is enabled or not, if the bootstrap encounters an error, it will halt at one of the following locations:

2402	An I/O error was detected.
2630	The first location of the boot block does not contain an octal 240.

NOTE: Other bootstraps may be used with the TDL-12 if the onboard bootstrap is first disabled. See Paragraph 2.1.

SECTION 3: DMON COMMANDS

3.1 RUNNING THE TDL-12 DIAGNOSTIC MONITOR

A Diagnostic MONitor program (DMON) for PDP-11 processors is stored internally in ROM on the TDL-12 board. This program provides access to the TDL-12's utility and diagnostic routines and allows the user to perform complete functional checks of the TDL-12 and the disk system; to enter configuration and drive parameter information; and to format disk drives. To run the diagnostic monitor, do the following:

1) Halt the processor: move the RUN/HALT switch to the 'HALT' position. This will start Micro-ODT in the LSI-11.

2) Using Micro-ODT, deposit a '1000' to the TDL-12 CSR at location 774400 (17774400 for 11/73 systems). This will cause the TDL-12 to load the Diagnostic Monitor into LSI-11 memory at location 1000(8).

a) Type: '774400/'.
b) Micro-ODT will respond with '201' or '601'.
c) Now type '1000'<CR>.

3) Move the RUN/HALT switch to the 'RUN' position.

4) Type '1000G'. The processor will print the DMON function menu on the console and wait for the operator to enter a selection.

3.2 DMON MENU

When started or re-started, DMON will display the TDL-12 firmware revision level, a menu of available functions, and its prompt:

```
TDL12 1.XX  (C) 1985,1986 TD Systems
 C  Configuration
 D  Display
 E  Exercise
 F  Format
 I  Initialize
 L  Error Log
 S  SCSI Cmd
 T  Test TDL
 W  Write BSF
DMON>
```

To select a function, the operator enters the one letter function designator followed by a carriage return. The functions are described in the paragraphs below. If an error is made in entry, DMON will print '? Bad entry' and display the menu again.

Numeric values printed out by DMON can be either decimal or hexadecimal. Decimal values will be preceded by a '(D)'. Other values are hexadecimal.

While entering a selection or running any DMON function, the following special keystrokes can be used to edit input lines and/or control execution:

DEL	Delete last character typed. The deleted character will be echoed, prefaced by a '\'. The next non-delete character will be prefaced by a second '\'.
^S	Stop terminal output.
^Q	Resume terminal output.
^C	Return to Micro-ODT

When one of the functions 'D, E, F or S' is selected, the operator will be asked to enter the controller and drive number. If there is a drive or controller problem DMON will display the error message: **? Error = XX.** The value 'XX' will correspond to one of the error codes listed in Appendix A.

3.3 C - DISPLAY CONFIGURATION

The 'C' function displays the size (RL01 or RL02) and mapping of each 'DL' unit to a specific controller and drive, as well as the selected Autoboot option. The mapping is entered using the 'Initialize' command. In the example below, DL0 and DL1 are both mapped to controller, 0 drive 0. DL2 is mapped to controller 1 drive 0, and DL3 is mapped to controller 1 drive 1. The 'Off' entry indicates the location of the DL unit on the physical drive. In the example, DL0 starts at the first sector of the drive, while DL1 is offset 2 'RL01 units' above the first sector. Also in the example, Autoboot is enabled and will boot from DL0.

Configuration

DLn =	Type	Cntrl	Drive	Off
0	RL02	0	0	0
1	RL02	0	0	2
2	RL02	1	0	0
3	RL02	1	1	0

Autoboot from DL0

3.4 D - DISPLAY DRIVE PARAMETERS

The 'D' command displays the drive parameter information that was entered with the 'I' command. This information will vary depending on the controller type. In general it will include controller type, sector size, sectors/track, number of cylinders and heads, etc. Refer to Appendix C for more details.

3.5 E - EXERCISE DRIVE

The 'E' functions allow the operator to exercise any of the drives with read, write and seek tests. The operator selects which test to run from a sub-menu:

```
Exercise drive
  1=seek, 2=read, 3=write
Enter #
```

E1: Drive Seek Test

Repetitive seeks are performed over all disk surfaces and correct position is verified. The seek sequence used is a modified butterfly pattern: seeks to ascending cylinder numbers alternate with seeks to track 0. This test will halt immediately if an error is encountered or when the operator strikes any key.

E2: Read Data Test

In this test the entire drive is read sequentially, one track at a time, with the data from each track being written to Host memory starting at location 2000(8). The test records all data errors that it encounters. It will terminate when:

a) The operator strikes any key.
b) The error list overflows (20 errors).
c) A drive or controller error is encountered.

On termination, the test will display the error count and the errors (if any) in the format shown below. Note that error code is given in hex, while the location of the error is given as a decimal SCSI logical address. Only hex error codes 10-13 and 18 are recorded. Other errors cause the test to abort. See Appendix A for error code explanations.

```
3 errors
Code - SCSI address (D)
 11      20808
 18      1007
 18      1007
```

E3: Write Test

This test writes, reads, and verifies the data on a specific sector of the drive. When the test is started, the operator will be asked to enter the SCSI address of a sector to test. The contents of the specified sector will be saved in Host memory at location 2000(8). The test will run until an error is encountered or the operator strikes any key. At termination, the contents of the specified sector will be restored.

3.6 F - FORMAT COMMAND

The 'F' command formats one of the drives attached to the TDL-12. On entry to the format routine, DMON prints an identifying message and tests the selected drive to see if it is ready. If the drive is not ready, or has some other problem that makes formatting impossible, the error will be displayed and DMON will return the to menu state. Note that if the drive parameters have not been initialized, formatting will not be allowed. Several different formatting operations are available depending on controller type. These are listed below.

NOTE: The format command ONLY formats drives.
It does NOT initialize Bad Sector Files.
Use the 'W' command (Paragraph 3.11).

3.6.1 Format unit

This command formats the entire drive. First the SCSI bus is reset and the drive parameters that were entered via the Initialize command are sent to the controller. The interleave is set to the value specified in the drive parameters and a format command is issued to the controller. On successful completion of the command DMON prints 'Done' and returns to the menu state.

If an error occurs during the sending of drive parameters the command is aborted and the error code is diplayed. If an error occurs during the format command, the error code and SCSI address are displayed, and the operator is asked if the operation should continue. If the answer is yes, formatting is continued one track at a time (provided the controller supports the 'Format Track' command), starting with the track AFTER the one with the error. The defective track should be re-assigned to an alternate track after initial fomatting is completed.

3.6.2 Format alternate track

Controllers from Xebec, DTC, OMTI, and others allow the formatting of alternate tracks as a method of defect handling. The specified bad track is re-formatted with special 'bad track' headers that contain the address of a specified replacement track. The replacement track is then re-formatted as an alternate track. Any subsequent access to the bad track is automatically mapped to the designated alternate track.

When formatting an alternate track, DMON proceeds through the steps shown below. Note that the data on the bad track is NOT preserved.

1) Finds the first available replacement track starting with the last track on the drive and working backwards. 'Available' means a track that isn't already an alternate.

2) Displays the location (a decimal SCSI address) of the first sector of the selected replacement track.

3) Requests the location of the bad track as a decimal SCSI address. This would be the same value displayed by the Read Test or found in the Error Log. Any sector on the track may be entered, and the whole track will be re-formatted.

4) Requests confirmation from the operator.

5) Issues the 'Format Alternate Track' command to the controller. Note: the controller may spend as long as 30 seconds executing the command.

3.6.3 Format with defect list

Controllers that implement the 'full SCSI' format command allow formatting with a list of drive defects as an option. DMON supports this version of the format command by giving the operator a chance to enter a defect list before the format command is issued. Note that the 'Format with Defect List' command still formats the ENTIRE drive.

The defects entered into the list MUST be in order of ascending SCSI address; i.e. from cylinder 0, head 0, sector 0 up. A maximum of 128 defects is allowed. A defect may be entered into the list either as a decimal SCSI address or in a 'bytes-from-index' format. For each new entry the operator is asked:

Use SCSI address for defect location? (Y/N)

If the answer is 'N' the operator will be asked for the defect location in a 'bytes-from-index' format. All entries are in decimal.

Enter cylinder=
Enter head=
Enter bytes from index=

If the defect location is entered as a SCSI address, the operator will be asked for a decimal number:

Enter SCSI defect address=

DMON will calculate use this address to calculate the location of the defect in terms of cylinder/head/sector and display the result. It will then ask for the total bytes/sector as a decimal number:

Enter total bytes/sector=

This number is NOT data bytes per sector, but rather the TOTAL bytes/sector including header, gaps, data, and ECC/CRC bytes. This number can be determined either from the controller manual (look for a section on sector formats) or by taking the total bytes/track figure from the disk drive manual and dividing it by the desired sectors/track. DMON takes this entry, calculates the 'bytes-from-index' figure, and displays it.

Note that each succeeding new entry may be in either defect format. After each new entry, DMON will ask if there are more entries. If not, DMON will ask if it should proceed with formatting.

3.6.4 Iomega format commands

When the format command is for an Iomega disk subsystem, the user will be asked to select a specific formatting operation from a submenu:

Iomega format
1=Standard
2=Format Z-tracks
3=Remake Z-tracks
Enter #

1) Standard Format:

The 'standard format' command causes the controller to completely rewrite all sectors on the cartridge. It then tests all sectors and reassigns any bad ones that it finds. Before starting, the user is asked to enter a decimal interleave number. This number must be either 1, 2, 4, 17, or 34. After the inter-

leave has been entered, DMON will ask if it should proceed. Any response other than a 'Y' will cause the command to be aborted.

```
Standard format
 Interleave = 2
Proceed? (Y/N)
```

NOTE: The recommended interleave is '2'.

2) Format Z-tracks:

The 'format Z-tracks' command causes the controller to change the information on the Z-tracks of the cartridge. Refer to the Alpha-10.5 manual, page 40 for an explanation of the entries:

```
Format or remake Z-tracks
 Interleave = 2
 Disable ECC? (Y/N) Y
 Disable CRC check? (Y/N) Y
 Dwell count = 10
Ready to format: proceed? (Y/N)
```

3) Remake Z-tracks:

The 'remake Z-tracks' command is used to recreate the Z-tracks on a cartridge where they are not readable. Otherwise it is identical to the 'format Z-tracks' command above.

3.7 I - INITIALIZE COMMAND

The Initialize command is used to enter configuration and drive parameter data. The data entered is stored in non-volatile memory. The Initialize command is covered in some detail in Paragraphs 2.4 and 2.5.

3.8 L - DISPLAY ERROR LOG

The TDL-12 maintains an error log in its non-volatile memory. This log stores the error code and location of the last 10 data errors encountered during on-line operation. It may be examined with the 'L' command. The display format is:

```
Code  Cntrl  Drive  SCSI address (D)
  18      1      0      10342
  10      0      1      20808

Clear error log? (Y/N)
```

Only data errors are logged: i.e. SCSI error codes 10-13 and 18 hex (see Appendix A). Drive errors such as 'Not Ready' are not logged. The error log may be cleared after it is displayed. The log is always cleared when a new configuration or new drive parameters are entered.

3.9 S - SCSI COMMAND

The 'S' command allows the operator to execute a single controller command, either once or repetitively. The operator first specifies the controller and drive, and then a hex command byte, SCSI address (in decimal) and hex count and control bytes. DMON will then ask:

Execute? CR=once E=error halt L=loop Q=quit

Loop mode terminates when the operator strikes any key. Error mode halts only when an error is encountered or the operator strikes a key. On completion DMON prints the last status returned by the controller. A zero value indicates no error.

Status = XX

3.10 T - TDL-12 SELF-TESTS

The 'T' command executes a test sequence that verifies the basic components of the TDL-12, the bus interface, and the controller and cable connection. The test sequence repeats until an error is encountered or the operator strikes any key.

1) ROM CRC test. The 16 bit CRC-16 for the entire ROM is calculated and verified.

2) RAM tests. Address and data tests are performed on the Read/Write memory.

3) I/O test. The various internal I/O registers and the controller interface are tested.

4) DMA test. The TDL-12 DMA interface is tested to ensure that data can be written and read correctly.

3.11 W - WRITE BAD SECTOR FILE

The 'W' command is used to write an RL-compatible Bad Sector File to a DL unit. Both the factory and field BSF's for the specified DL are initialized to a 'no entry' state.

When this command is executed, the operator will be asked for the 'DL' number as shown below. Note that this is the DL unit number (0-3), NOT the physical drive number.

Write BSF: enter DL #

SECTION 4: PERFORMANCE CONSIDERATIONS

4.1 GENERAL

There are four basic factors that affect the overall performance of a TDL-12 disk system: the disk drive itself, the controller, the TDL-12, and the host system.

The disk drive has two figures of merit: data rate and average access time. Data rate is the bit rate of serial data read from or written to the disk surface. Most 5.25" Winchester disks have a data rate of 5 megabits/second. This bit rate translates to 522 kilobytes per second formatted (17 512 byte sectors in one revolution), a figure which represents the maximum performance available from the drive. Average access time is the average time it takes to access a random sector from a random current position on the disk surface. Low cost Winchesters typically have an average an average access time of about 75 milliseconds. If all disk accesses were random single-sector accesses, the equivalent performance figure would be 6.8 KB/second (assuming 512 byte sectors).

The host system (hardware and operating system) affects performance in two ways. The most important factor is how data on the disk is organized and accessed. Inefficient data organization will result in performance that approaches the random single-sector figure. Frequent directory references will have the same affect. The second factor is software driver overhead, although this is relatively unimportant compared to the affect of disk organization.

The TDL-12 and the controller together determine what fraction of the disk drive's data rate is actually sustained in multi-sector transfers between disk drive and host once the drive heads are over the first sector. This fraction is directly related to the interleave factor of the sectors on a track, and the resulting net data rate is called the 'burst' rate. Normally the burst rate cannot be sustained over many transfers because of seek times and system overhead.

4.2 INTERLEAVE FACTOR

Interleave factor is the mapping of logical sector numbers onto the physical sectors of a track. If the logical numbers are identical to the physical, the interleave factor is 1:1 (i.e. no interleaving). If consecutive logical sectors are separated by one physical sector, then the interleave is 2:1. Two physical sectors between consecutive logical sectors is 3:1, and so on.

Put another way, the interleave factor equates to the number of disk revolutions required to read all the sectors on a track. Thus an interleave of 3:1 would require three disk revolutions to read an entire track. Interleaving therefore reduces the effective data rate. With an interleave of 2:1, the drive's net data rate (burst rate) would be reduced to 261 KB/second.

Interleaving is critical to performance once the other factors are fixed (as they usually are). If the controller can only 'make' 4:1 interleave, then the 'burst' data rate on multi-sector reads is only four sectors per disk revolution, or 123 KB/second (512 byte sectors, ST506-type drive). The penalty for not 'making' interleave is worse: one sector transferred per revolution, or 30.7 KB/second.

4.3 THE REAL WORLD

As stated implicitly in the first part of this section, the burst data rate is only part of the performance story, albeit an important one. What happens BETWEEN consecutive multi-sector transfers has a significant effect, too. Controller overhead, TDL-12 overhead, system overhead, and seek time all add up to guarantee that the system will have missed the next sequential sector by the time the next command to transfer data is issued, and will have to wait one additional disk revolution.

If each multi-sector transfer extended over many revolutions, this wouldn't be a large penalty. But with RL emulation this is not the case. The longest multi-sector transfer possible for the RLV12 controller is 10,240 bytes, or 20 512 byte sectors. This is only a little more than one track for an ST506-type Winchester. For systems with 1:1 interleave, this means that there will be at least one extra revolution between consecutive transfer commands, i.e. it will take at least two revolutions on the average to execute each maximum-length transfer command, without considering seek and head switching times.

4.4 MEASURED PERFORMANCE

The following times were measured on an 11/23 system with 256 KBytes of memory running RT11 Version 5 with the SJ monitor. The controller was an Adaptec 4000. The drive was a Tandon TM802 10MB unit formatted with 1:1 interleave and configured as an RL02. There were bout 12,000 free blocks on the disk. Note that the copy time would be improved significantly if it were run with a faster disk drive.

```
DIR/BAD DL0:
Time = 50.4 seconds / 208 kilobytes/second

COPY TEST.TXT TEST1.TXT
(TEST.TXT = 2032 blocks)
Time = 16.2 seconds / 128 kilobytes/second
```

SECTION 5: DEC DIAGNOSTICS ON THE TDL-12

5.1 GENERAL

DEC RL diagnostics provide a useful set of tools for verifying the system operation of the TDL-12, for testing the data integrity of the disk drive(s) attached to it, and for examining and updating DEC RL Bad Sector Files. This section deals with what the applicable DEC diagnostics are, how to run them with the TDL-12, and what to expect when you do.

5.2 DEC DIAGNOSTICS

The currently available DEC diagnostics for RL controllers consist of the set of eight test programs listed below. These test programs are included as part of the DEC XXDP(+) diagnostic package and are designed to run as standalone programs under the Diagnostic Supervisor included with XXDP. They are available on a variety of media including RX01/02, RK05/06/07, RL01/02, magnetic tape, DECtape, and DEC cassette.

DIAGNOSTIC	DESCRIPTION
CZRLGxx	Controller Test #1 Tests controller functions, interface logic, and register operation.
CZRLHxx	Controller Test #2 Tests write data, read data, and write check operations.
CZRLIxx	Drive Test #1 Tests drive interface and basic drive logic. Requires programmable clock.
CZRLJxx	Drive Test #2 Tests inner/outer guard band detection and seek operations.
CZRLNxx	Drive Test #3 Tests seek and rotational timing and write/read data. Tests 1 and 4 require a programmable clock.
CZRLKxx	Performance Exerciser Performs random operations of seek, get status, read header, read, and write. Requires a programmable clock for performance statistics.
CZRLLxx	Drive Compatibility Test Verifies interchangeability of cartridges between drives.

CZRLMxx	Bad Sector File Utility A utility program for accessing bad sector files and verifying disk media.

The diagnostic name conforms to the following convention:

```
CZ = Standard prefix
  RL = Device
    G = Test
      xx = Revision level
```

5.3 RUNNING THE DEC XXDP DIAGNOSTICS WITH THE TDL-12

5.3.1 Setting up the TDL-12

In order to run the XXDP diagnostics, the TDL-12 has to be connected to a formatted drive. Also, the drive should have its Bad Sector File(s) initialized. This may be done in DMON with the 'W' command, or by running the CZRLMxx diagnostic.

5.3.2 Booting XXDP

XXDP is a standalone diagnostic monitor. The XXDP distribution medium has a bootstrap built-in. Boot XXDP just as you would any other standalone program.

When running, the XXDP monitor will display the size of the available memory and ask if the system is a Unibus system or not. <CR> implies yes, so enter 'N'.

The monitor prompt is a period. Once the prompt is displayed, you can enter commands to XXDP.

Command	Action
R	Run a program
L	Load a program
S	Start a program
C	Run a batch job (chain)
D	Display a directory of the load medium
F	Set terminal fill count
E	Enable alternate system device
H	Type HELP file
H/L	Print HELP file

5.3.3 Running a Test Program

The actual XXDP RL test programs are named as shown above, but without the 'C' prefix. To run a test program, type:

```
R ZRLHA0<CR>
```

This may be simplified by indicating in the command that you don't care what the revision level of the program is. Type:

```
R ZRLH??<CR>
```

When the test program starts execution, it will print the program name, a brief test description and the diagnostic supervisor prompt 'DR>'.

```
CZRLH-A-0
CZRLH TESTS WRITE DATA, READ DATA, WRITE CHECK OPERATIONS
UNIT IS RL01,RL02
RESTART ADR XXXXXX
DR>
```

The test may be started by typing 'START<CR>' in response to the prompt. Once it is started, the test will ask for any changes in hardware/software parameters that may be required. A typical dialog is shown, with the test's questions underlined.

```
CHANGE HW (L) ? Y<CR>

# UNITS (D) ? 1<CR>

UNIT 0<CR>
RL11 (L) Y ? N<CR>
BUS ADDRESS (O) 174400 ? <CR>
VECTOR (O) 160 ? <CR>
BR LEVEL (O) 5 ? 4<CR>
DRIVE (O) 0 ? <CR>
DRIVE TYPE = RL01 (L) Y ? N<CR>


CHANGE SW (L) ? N<CR>
```

In this example we want to change the hardware configuration because the defaults are not correct, so we answer 'Y' to the first question. This causes a set of hardware configuration questions to be displayed. Each question is followed by a letter in parentheses and a default value. A carriage return <CR> will select the default value. The letter in parentheses indicates whether the new value is to be entered in Decimal (D), Octal (O), or Logical 'Y', 'N' (L).

In the 'CHANGE SW ?' question, 'SW' refers to software test parameters such as error filters, maximum error counts, test limits, retry limits, etc.

When running any of these tests with the TDL-12, the hardware parameters having to do with the BR level and whether the unit under test is an RL11 or RLV11/12 will have to be changed as shown in the example above. Most other parameters are self-explanatory. Refer to the XXDP User's Guide and the specific test documentation for more information.

As each test runs, it will print an error message for each error encountered. It will also print the pass count and total errors at the end of each pass. Control C (^C) may be used to return to the diagnostic supervisor. Type 'EXIT<CR>' in response to the 'DR>' prompt to return to the XXDP monitor.

5.3 XXDP DIAGNOSTIC RESULTS WITH THE TDL-12

The following is a summary of what results to expect when you run the XXDP diagnostics with the TDL-12.

TEST	RESULT	COMMENT
CZRLG	No errors	
CZRLH	No errors	
CZRLI	Timing errors	Depends on particular drive used.
CZRLJ	Error on test 1 Error on test 5	TDL-12 does not hold DRIVE READY off for 3 Msec after a seek past the inner/outer guard bands.
CZRLN	No errors	
CZRLK	No errors	
CZRLM	All Bad Sector File utilities are useable.	

SECTION 6: IOMEGA ON-LINE FORMATTING

6.1 GENERAL

A special on-line formatting function is available that allows the user to format Iomega cartridges without running DMON. This means that system integrators can provide their customers with a simple format program that runs under the Host operating system.

The on-line format function is initiated by issuing a Maintenance command to the TDL-12 with bit 15 of the CSR set. The format parameters required by controller are passed to the TDL-12 through its registers. On receipt of the format command, the TDL-12 executes the following steps:

1) Verifies that the selected drive is ready.
2) Issues the format command.
3) Issues a 'Request Sense' command to get the results of the formatting operation.
4) If the format command was successful, writes an RL-compatible Bad Sector File for each 'DL' unit on the cartridge.

6.2 IOMEGA FORMAT OPTIONS

The Iomega controller implements a variety of format commands. Three of these are supported by the TDL-12. The selection is determined by the contents of the low byte of the BAR at the time the format command is issued.

1) Standard Format. The controller re-formats the entire cartridge, verifies all sectors, and reassigns bad sectors. A new interleave factor is specified. CRC, ECC, and timeout values are unchanged. The standard format command is selected when bits 0-7 of the BAR are all set to 0.

2) Format Z-tracks. Setting bit 7 in the BAR selects the Format Z-track option. This command is used to change cartridge-specific information on the cartridge such as enabling/disabling ECC and post-write CRC checks, and setting the spindown timeout.

3) Remake Z-tracks. Setting bit 3 in the BAR selects the Format Z-track option. This command is used to remake the Z-tracks if they have become unreadable.

6.3 REGISTER DESCRIPTIONS

Four TDL-12 registers are used with the on-line format command. They are shown below with specific bit descriptions. Refer to the Iomega controller manual for details on specific parameters

CONTROL AND STATUS REGISTER (CSR) 774400

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CMD ERR	0	0	0	0	0	DS1	DS0	CTL RDY	IE	X	X	F2	F1	F0	DRV RDY

Bit: 15 **Name:** CMD/ERR
Description: Command / Error
This bit must be set to '1' at command initiation to indicate a format command. If set at command completion, this bit indicates that an error was detected during execution of the command. The error code may be read from the MPR (774406).

Bit: 14-10 **Name:**
Description:
These bits must be set to '0' to indicate a format command.

Bit: 9,8 **Name:** DS (1:0)
Description: Drive Select
These bits are set by the Host to select which drive will be formatted. Note that these bits refer to the logical unit, not necessarily the physical drive. If more than one logical unit are mapped to one drive, formatting any of them will cause the entire drive to be formatted.

Bit: 7 **Name:** CTL RDY
Description: Controller Ready
When cleared by the Host, this bit starts execution of the command in bits 3-1. CRDY will become set again at the completion of the command.

Bit: 6 **Name:** IE
Description: Interrupt Enable
When this bit is set by the Host, the TDL-12 will interrupt the Host at the completion of the format command. The interrupt will occur on either normal or error completion.

Bit: 5,4 **Name:** BA (17:16)
Description: Bus Address Extension
Not used for the format command. Ignored by the TDL-12.

Bit: 3-1 **Name:** F (2:0)
Description: Function
These bits must be set to '0' to indicate a maintenance (format) command.

Bit: 0 **Name:** DRV RDY
Description: Drive Ready
Indicates that the selected drive is ready.

BUS ADDRESS REGISTER (BAR) 774402

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DIS CRC	DIS ECC	INTERLEAVE (1,2,4,17,32)						FMT Z	0	0	0	REM Z	0	0	0

Bit: 15 **Name:** DIS CRC
Description: Disable post-write CRC
This bit, when set, causes the Iomega controller to disable the post-write CRC check. Not used for the standard format command.

Bit: 14 **Name:** DIS ECC
Description: Disable ECC
This bit, when set, causes the Iomega controller to disable the ECC function. Not used for the standard format command.

Bit: 13-8 **Name:** INTERLEAVE
Description: Interleave.
This field is the desired interleave factor.

Bit: 7 **Name:** FMT Z
Description: Remake Z-tracks.
This bit, when set, causes the Iomega controller to execute the Format Z-track format command. If this bit and bit 3 are both 0, the standard format command is executed.

Bit: 6-4 **Name:**
Description: Not used. Must be 0.

Bit: 3 **Name:** REM Z
Description: Remake Z-tracks.
This bit, when set, causes the Iomega controller to execute the Remake Z-track format command. If this bit and bit 7 are both 0, the standard format command is executed.

Bit: 2-0 **Name:**
Description: Not used. Must be 0.

DISK ADDRESS REGISTER (DAR) 774404

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
												DWELL COUNT (2-12 or 15)			

Bit: 15-4 **Name:**
Description: Not used. Set to 0.

Bit: 3-0 **Name:** DWELL COUNT
Description: Dwell timer count.
These bits set the head unload timeout period. Not used for the standard format command.

MULTI-PURPOSE REGISTER (MPR) 774406

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
									ERROR CODE						

Bit: 15-7 **Name:**
Description: Not used. Read =0

Bit: 6-0 **Name:** ERROR CODE
Description: Error Code (Read only)
When bit 15 of the CSR is set on command completion, this register contains the descriptive error code. Refer to Appendix A.

6.4 FORMATTING EXAMPLE - STANDARD FORMAT

1) Determine the desired interleave and load the value into bits 8-13 of the BAR (774402). An interleave of 2 is recommended. The balance of the BAR should be cleared to indicate the standard format command.

2) Clear the DAR (774404) and the WCR (774406). These are not used for the standard format.

3) Load the CSR (774400) with bit 15 =1, the unit number in bits 8 and 9, and the function bits =0. The IE bit (bit 6) may be set to generate an interrupt at the completion of the command if desired. The other CSR bits must be =0. For unit 0 and no interrupts, load 100000(8) into the CSR.

4) Wait for the Controller Ready bit (bit 7) in the CSR to become set. This will indicate completion of the format command. If the IE bit was set, an interrupt will be generated.

5) Test bit 15 of the CSR to determine if the command was completed successfully. If bit 15 is clear, no error ocurred. If bit 15 is set, the error code may be read from the MPR (774406).

SECTION 7: DIRECT SCSI COMMAND EXECUTION

7.1 GENERAL

Direct SCSI command execution is now available on the TDL-12. This function allows customers to provide features beyond those offered by 'normal' RL emulation, such as increased disk capacity, tape and floppy support, etc.

Direct SCSI commands are accomplished by means of a modified Maintenance command (RLV Function 0). The TDL-12's registers are used only for command initiation, command status, and to contain a pointer to a Command Block in Host memory. Interrupt-on-command-completion is supported at the normal RL vectors.

The Command Block in Host memory contains the actual SCSI command, target controller address, and data pointer. This Command Block may be anywhere in the Host's (22 bit) memory space.

7.2 COMMAND SEQUENCE:

1) A Command Block (CB) is first set up in Host memory. The CB contains a six, ten, or twelve byte SCSI command, the SCSI address of the target device (0-7), and a pointer to the data buffer. The CB formats are shown in Paragraph 1.4 below.

2) The Bus Address Register and the Bus Address Extension register of the TDL-12 are loaded with the address of the Command Block. Note that these values will not be changed during command execution.

3) The command is started by writing an octal value of 14X0 or 15X0 to the TDL-12's CSR. The 100 bit (bit 6), when set, enables an interrupt at the completion of the command. The vector address is normally 160. If the TDL-12 is jumpered for its alternate address, the vector is 164. The 'X' value represents the two high-order bits of the Command Block address as discussed below in Paragraph 1.5.

4) The TDL-12 reads the CB into its internal memory, sets its DMA address to the value specified by the data pointer in the CB, and selects the controller specified in the CB.

5) The TDL-12 passes the SCSI command bytes directly through to the controller when it requests the command.

6) If the command involves a data transfer, data is passed directly between the SCSI interface and Host memory. The direction of data flow is determined by the controller.

7) If the SCSI command completes normally, the TDL-12 loads the end status byte from the controller into the MPR register. If the TDL-12 has detected an error while attempting to execute the SCSI command it sets the Host Adapter Error bit (bit 15) in the CSR, and loads the error code into CSR bits 14-12.

8) The TDL-12 sets the Ready bit in the CSR to indicate command completion.

THINGS TO WATCH OUT FOR:

1) When executing a direct SCSI command, the TDL-12 does NOT use any of the configuration information that is stored on-board. Nor does the TDL-12 do any parameter checking or sanity testing.

2) It is NOT a good idea to mix RL emulation with direct SCSI commands in an on-line system.

4) The contents of the SCSI command bytes shown in the CB formats are very general. Read the manual for the specific controller carefully to identify those areas where it deviates from what is shown. This is particularly true of the control byte, which usually has 'vendor unique' bits in it.

5) Note that the order of the SCSI Block Address bits in the Command Block is decidedly non-orderly.

7.3 HOST COMMAND BLOCK FORMAT

The six and ten byte formats of the Host Command Block are shown. Twelve byte SCSI commands are also supported, but the format is not shown. The first entry in all cases is the lower 16 bits of the pointer to the data buffer. The twelve bytes of the Command Block from the SCSI command byte on are passed unmodified to the selected controller. None of the data in the CB are changed by the execution of the command.

SIX BYTE COMMANDS

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DATA POINTER															
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
-	-	-	-	-	CONTROLLER ADRS 0-7			-	-	DATA POINTER 21	20	19	18	17	16
UNIT			BLOCK ADDRESS 20	19	18	17	16	SCSI COMMAND							
BLOCK ADDRESS								BLOCK ADDRESS							
07	06	05	04	03	02	01	00	15	14	13	12	11	10	09	08
CONTROL								NUMBER OF BLOCKS							

TEN BYTE COMMANDS

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DATA POINTER															
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
-	-	-	-	-	CONTROLLER ADRS 0-7			-	-	DATA POINTER 21		20	19	18	17	16
UNIT			-	-	-	-	-	SCSI COMMAND							
BLOCK ADDRESS								BLOCK ADDRESS							
23	22	21	20	19	18	17	16	31	30	29	28	27	26	25	24
BLOCK ADDRESS								BLOCK ADDRESS							
07	06	05	04	03	02	01	00	15	14	13	12	11	10	09	08
NUMBER OF BLOCKS								-	-	-	-	-	-	-	-
15	14	13	12	11	10	09	08								
CONTROL								NUMBER OF BLOCKS							
								07	06	05	04	03	02	01	00

7.4 TDL-12 REGISTER CONTENTS

CONTROL AND STATUS REGISTER (CSR) 774400

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
H/A ERR	ERROR CODE			0	0	1	1	RDY	IE	CBA 17	CBA 16	0	0	0	1

15: Host Adapter Error.
This bit must be cleared for command initiation. When set at command completion, this bit indicates that the TDL-12 detected an error during execution of the last SCSI command. The error code is contained in bits 14-12 of the CSR.

14-12: Host Adapter Error Code.
These bits must be cleared for command initiation. When bit 15 is set at command completion, these bits contain a code indicating the nature of the error:

0	SCSI bus busy or hung.
1	Can't select controller.
2	SCSI bus sequence error.
5	DMA bus timeout.

11,10: Not used. Set to zeroes.

9,8: Operation Select.
These bits must both be set by the Host to initiate a direct SCSI command.

7: Ready.
This bit is set by the TDL-12 to indicate that it has finished a command and is ready to accept another. The Host clears this bit to initiate a command. If the Interrupt Enable bit is set when this bit becomes set, an interrupt will occur.

6: Interrupt Enable.
This bit when set enables an interrupt to occur when the Ready bit transitions to 1. The vector will be 160 for the standard address jumper setting and 164 for the alternate address.

5,4: **Command Block Address bits 17,16.**
Two of the high-order Command Block address bits. These bits, along with the values in the BAR and BAX, must point to a valid Command Block in Host memory. Note that these two bits are duplicated in the BAX regsiter, and that a value loaded here will force the corresponding bits in the BAX to the same value.

3-1: **Function Select.**
These bits must be cleared to initiate a direct SCSI command.

0: **Not used.** Will always read as one.

BUS ADDRESS REGISTER (BAR) 774402

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
COMMAND BLOCK ADDRESS															
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00

The Bus Address Register is loaded with bits 0-15 of the Command Block address. Bit 0 is forced to 0. The balance of the CB address is contained in the CSR and BAX registers.

DISK ADDRESS REGISTER (DAR) 774404
The Disk Address Register is NOT USED in the SCSI command mode. The previous contents will not be affected.

MULTI-PURPOSE REGISTER (MPR) 774406

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
								SCSI STATUS BYTE							

The Multi-Purpose Register is a read-only register which contains the Status byte returned by the controller during the command just executed. The contents of this register are only valid if 1) The READY bit in the CSR is set, and 2) bit 15 of the CSR is cleared.

BUS ADDRESS EXTENSION REGISTER (BAX) 774410

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
										COMMAND BLOCK ADDRESS					
										21	20	19	18	17	16

The Bus Address Extension register is loaded with bits 21-16 of the Command Block address. The balance of the CB address is contained in the BAR register. Note that address bits 16 and 17 also appear in the CSR. Writing these bits in either register will change the value in the other register correspondingly.

CAUTION: Since the CSR will be the last register written when a command is initiated, the value of address bits 16 and 17 written to it will be the actual ones used.

APPENDIX A: ERROR CODES

The table below summarizes the hex error codes that may be displayed by DMON. These same error codes are also available in the MPR (in octal) during normal operation at the completion of any Host command. The error byte that is displayed has the following format:

7	6	5	4	3	2	1	0
0	ERROR CLASS			ERROR CODE			

Class 0-5 errors are generated by the CONTROLLER in response to error conditions in either the drive or the controller itself. The error codes given below for these classes may not apply to all controllers, and some controllers may implement additional codes. Refer to the controller manual.

Class 6 errors come directly from the TDL-12. They indicate either a hardware error, an error in communicating with the controller, or a Q-Bus error.

Class 7 errors are controller errors that are accompanied by an extended status return.

ERROR CODE SUMMARY

CLASS	SOURCE	CODE	DESCRIPTION
0	Both	0	No error detected
0	Drive	1	No index from drive
		2	No seek complete from drive
		3	Write fault
		4	Drive not ready
		5	Drive not selected
		6	Track 0 not found
		7	Multiple drives selected
		9	Media not loaded
1	Controller	0	Read ID error
		1	Uncorrectable data error
		2	ID address mark not found
		3	Data address mark not found
		4	Sector not found
		5	Seek error
		7	Write protected
		8	Correctable data error
		9	Bad track/block found
		A	Format error
2	Controller	0	Invalid command
		1	Illegal sector address
3-5	Controller	?	Controller dependent

6	TDL-12	0	SCSI bus busy
		1	SCSI select timeout
		2	SCSI command phase error
		3	SCSI bad status return
		4	SCSI sense command error
		5	DMA bus error
		6	No configuration
		7	No drive parameters
		8	Invalid controller type
		9	ROM test error
		A	DAM test error
		B	I/O test error
7	Controller	0	No error
		1	Recoverable error
		2	Unit not ready
		3	Media error
		4	Hardware error
		5	Illegal request
		6	Unit attention
		7	Write protect
		B	Aborted command
		D	Volume overflow

APPENDIX B: CONTROLLER TYPES

The following list summarizes the controllers that are supported by TDL-12 firmware version 1.60 and up. If your controller is not listed, contact the factory for clarification.

The 'FORMAT' designation indicates whether the controller offers a 'Format with Defect List' command ('DL') or a 'Format Alternate Track' command ('AT').

TYPE	FORMAT	MANUFACTURER	MODEL(S)
0	none		Default type
1	'DL'	Adaptec	4000 4000A soft-sectored, fixed drives 5500 soft-sectored, fixed drives
2	'DL'	Adaptec	4010 4000A hard sectored or removable 5500 hard sectored or removable
3	'DL'	Adaptive Data	Sabre
4	'AT'	DTC	1401, 1403D, 700/701, 101/101D
5	'AT'	DTC	1403ES, 600/610, 703, 900/910
6	'AT'	DTC	510A/B, 520A/B, 615
7	'AT'	DTC	515CU
8	'AT'	OMTI	Model 20
9	'AT'	OMTI	5000 Series
10	'AT'	Xebec Western Digital Konan	1410 WD1002SHD DJ210/DJ1100
11	'AT'	Xebec	1410A
12	'AT'	Xebec	97xx Subsystems
13	none	Iomega	Alpha 10.5, 10.5H
14	none	Iomega	Alpha 20H

APPENDIX C: SUMMARY OF DRIVE PARAMETERS

This appendix shows the drive parameters required by each of the various controller types when those parameters are initialized using the 'I' command. The actual text of the parameter requests is shown, along with comments about the less obvious parameters. In all cases, the following entries have the same meaning:

```
Sector size (1,2)=      1 = 256 byte,  2 = 512 byte
RWC (D)=                Starting Reduced Write Current cylinder
WPC (D)=                Starting Write Precomp Cylinder
```

The following notes also apply where shown:

(1) Must be the same as controller option. i.e. the controller has this parameter as a hardware strap option, and the TDL-12 must know how the controller is optioned.

(2) Not required by controller, but included for consistency and for diagnostic purposes. 'Sectors/track', for example, is not required by many controllers, but is necessary in order to calculate SCSI addresses for alternate track formatting and defect lists.

(3) Sent directly to controller. Refer to the controller manual for a parameter with this name.

TYPES 0, 4, 12

```
Sector size (1,2)=      ;(1)
Sectors/track (D)=      ;(2)
Interleave (D)=
```

TYPES 1, 3, 10

```
Sector size (1,2)=      ;Sent to the controller
Sectors/track (D)=      ;(2)
Cylinders (D)=
Heads (D)=
RWC (D)=
WPC (D)=
Step rate (D)=          ;(3)
Interleave (D)=
```

TYPE 2

```
Sector size (1,2)=      ;Sent to controller
Cylinders (D)=
Heads (D)=
RWC (D)=
WPC (D)=
Step rate (D)=
Drive type (X)=
Sectors/track (D)=      ;Sent to controller
Interleave (D)=
```

TYPE 5

```
Sector size (1,2)=      ;(1)
Sectors/track (D)=      ;(2)
Drive type (X)=         ;(3) This entry is hexadecimal
Interleave (D)=
```

TYPE 6

```
Sector size (1,2)=
Sectors/track (D)=
Step width (D)=         ;(3) This entry is decimal
Step period (D)=        ;(3) This entry is decimal
Step mode (D)=          ;(3) This entry is decimal
Heads (D)=              ;Total heads, NOT max head address
Cylinders (D)=          ;Total cylinders, NOT max cyl address
RWC (D)=
Drive type (X)=
Interleave (D)=
```

TYPE 7

```
Sector size (1,2)=      ;Sent to controller
Step width (D)=         ;(3) This entry is decimal
Step period (D)=        ;(3) This entry is decimal
Sectors/track (D)=      ;(2)
Gap 3 size (X)=         ;(3) This entry is hexadecimal
Heads (D)=
Cylinders (D)=
RWC (D)=
WPC (D)=
Flags (X)=              ;(3) This entry is hexadecimal
Interleave (D)=
```

TYPE 8, 9

```
Sector size (1,2)=      ;Sent to controller
Step width (D)=         ;(3) This entry is decimal
Step period (D)=        ;(3) This entry is decimal
Step mode (D)=          ;(3) This entry is decimal
Heads (D)=
Cylinders (D)=
RWC (D)=
Drive type (X)=         ;(3) This entry is hexadecimal
Sectors/track (D)=
Interleave (D)=
```

TYPE 11

```
Sector size (1,2)=      ;Sent to controller
Sectors/track (D)=      ;(2)
Cylinders (D)=
Heads (D)=
RWC (D)=
WPC (D)=
Precomp value (0,1)=    ;(3)
Step rate (D)=          ;(3)
Interleave (D)=
```

TYPE 13 and 14 - Not applicable

APPENDIX D: IOMEGA OPERATION

The Iomega Alpha series of high-performance flexible cartridge drives are reliable low-cost alternatives to DEC RL02 cartridge drives. The series includes full and half-height 10MB and 20MB drives and subsystems. This Appendix summarizes the various models and describes how to configure them for use with the TDL-12. For more information on Iomega products, contact your local Iomega sales office, or Iomega headquarters at:

IOMEGA CORPORATION
1821 West 4000 South
Roy, Utah 84067
(801) 778-3000

D1: IOMEGA ALPHA 10.5

Iomega Alpha 10 and 10.5 master drives come with an embedded SCSI controller that can handle up to four drives. The master drive and an (optional) slave drive are also available in an enclosure with power supply (the Bernoulli Box).

D1.1 Alpha 10.5 Firmware

There are two versions of the Alpha 10: a 10MB version and a 10.5MB version. In order to emulate a full RL02, the Alpha 10 master drive must be ordered with '10.5' firmware. This firmware version sacrifices some of the spare sectors on the cartridge for additional capacity.

D1.2 SCSI Controller Address

The SCSI address of the controller is selected with a shunt installed in an eight position DIP socket (Shunt S1) on the controller board. The shunt may moved from position 1 (SCSI address 0) to position 8 (SCSI address 7).

D1.3 Controller Termination

Two DIP resistor packs at RN2 and RN3 provide SCSI bus termination on the controller board. These are mounted in sockets and may be removed if more than one controller is used on the TDL-12.

D1.4 Controller DIP Switch Options

SW1: ON = Normal operation.
OFF = Power on reset threshold test.

SW2: ON = Disable SCSI parity checking.
OFF = Enable SCSI parity checking.

SW3,4: ON,ON = Cyclic diagnostic mode.
OFF,ON = Retries disabled w/o comprehensive startup diagnostics.
ON,OFF = Retries enabled with comprehensive startup diagnostics.
OFF,OFF = Retries enabled w/o comprehensive startup diagnostics.

SW5: ON = Disable SCSI timeout error.
OFF = Enable SCSI timeout error.

The recommended DIP switch setting is:

SW1:	ON
SW2:	ON or OFF (parity preference)
SW3,4:	OFF,OFF
SW5:	ON

D1.5 Interleave
An interleave value of '2' is recommended for all systems.

D2: IOMEGA ALPHA 10H

The Iomega Alpha 10H is a half-high version of the Alpha 10 that uses the same cartridges. Alpha 10H master drives come with an embedded SCSI controller capable of handling up to two drives. The master drive and an (optional) slave drive are also available in an enclosure with power supply (another Bernoulli Box).

D2.1 SCSI Controller Address
The SCSI address of the controller is selected with a shunt installed in an eight position header (JP16) on the controller board next to the SCSI connector. The shunt may moved from position 1 (SCSI address 0) to position 8 (SCSI address 7). Position 1 is at the end of the header farthest away from the SCSI connector.

D2.2 Controller Termination
Three SIP resistor packs adjacent to the SCSI connector (RN2,6,8) provide SCSI bus termination on the controller board. These are NOT mounted in sockets, but may be removed if more than one SCSI controller is used on the TDL-12.

D2.3 Controller DIP Switch Options

SW1:	OFF	= Normal operation.
	ON	= Power on reset threshold test.
SW2:	ON	= Disable SCSI parity checking.
	OFF	= Enable SCSI parity checking.
SW3,4:	ON,ON	= Cyclic diagnostic mode.
	OFF,ON	= Retries disabled w/o comprehensive startup diagnostics.
	ON,OFF	= Retries enabled with comprehensive startup diagnostics.
	OFF,OFF	= Retries enabled w/o comprehensive startup diagnostics.
SW5:	ON	= Enable 10.5MB firmware.
	OFF	= Disable 10.5MB firmware.

The recommended DIP switch setting is:

SW1:	OFF
SW2:	ON or OFF (preference)
SW3,4:	OFF,OFF
SW5:	ON

D2.4 Interleave
An interleave value of '2' is recommended for all systems.

D3: IOMEGA ALPHA 20H

The Iomega Alpha 20H is a half-high 20MB drive. Alpha 20H master drives come with an embedded SCSI controller capable of handling up to two drives. The master drive and an (optional) slave drive are also available in an enclosure with power supply (yet another Bernoulli Box).

D3.1 SCSI Controller Address

The SCSI address of the controller is selected with a shunt installed in an eight position header (JP16) on the controller board next to the SCSI connector. The shunt may moved from position 1 (SCSI address 0) to position 8 (SCSI address 7). Position 1 is at the end of the header farthest away from the SCSI connector.

D3.2 Controller Termination

Three SIP resistor packs adjacent to the SCSI connector (RN2,6,8) provide SCSI bus termination on the controller board. These are NOT mounted in sockets, but may be removed if more than one SCSI controller is used on the TDL-12.

D3.3 Controller DIP Switch Options

SW1: OFF = Normal operation.
ON = Power on reset threshold test.

SW2: ON = Disable SCSI parity checking.
OFF = Enable SCSI parity checking.

SW3,4: ON,ON = Cyclic diagnostic mode.
OFF,ON = Retries disabled w/o comprehensive startup diagnostics.
ON,OFF = Retries enabled with comprehensive startup diagnostics.
OFF,OFF = Retries enabled w/o comprehensive startup diagnostics.

SW5: Not used

The recommended DIP switch setting is:

SW1: OFF
SW2: ON or OFF (preference)
SW3,4: OFF,OFF
SW5: Not used

D3.4 Interleave

An interleave value of '2' is recommended for all systems.