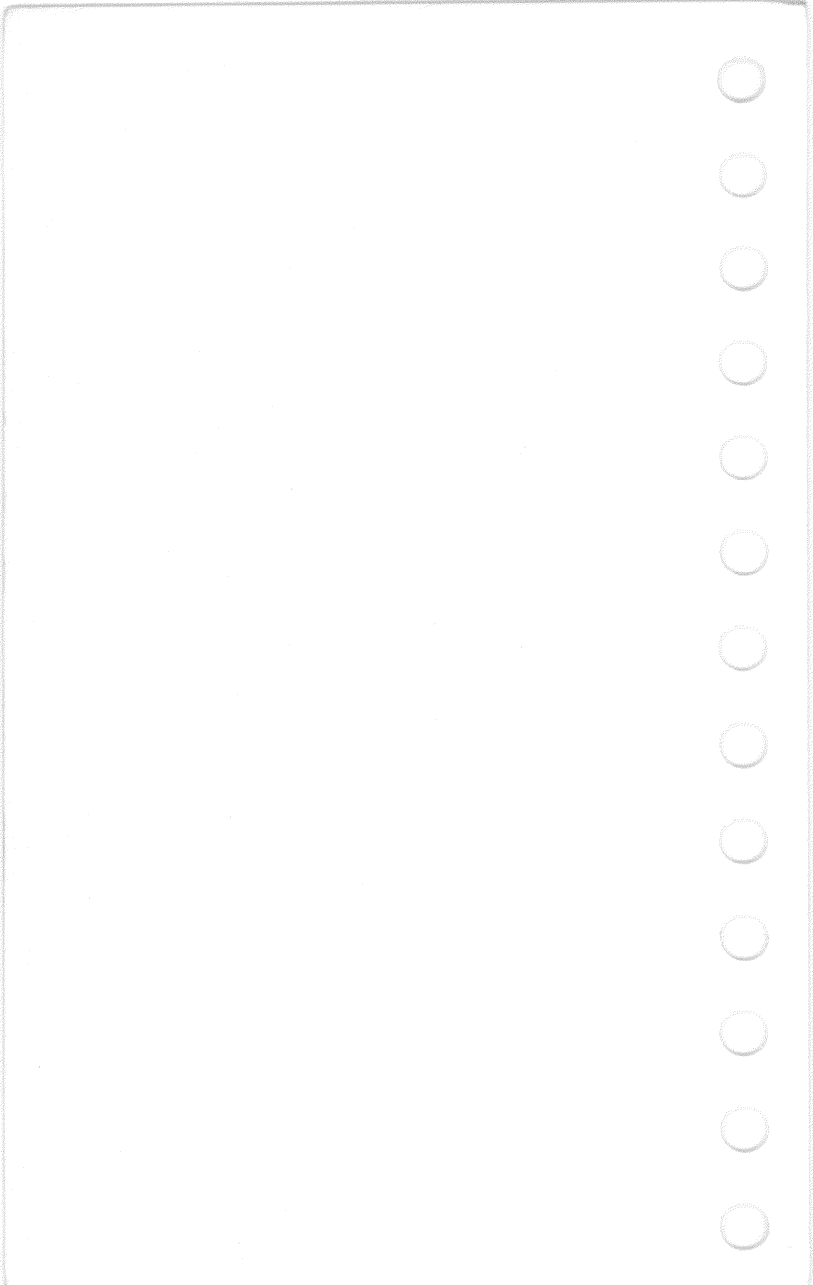


AA-M880B-TC

RA60  
Maintenance  
Guide

digital



AA-M88OB-TC

# RA60 Maintenance Guide

Digital Equipment Corporation  
Colorado Springs, Colorado

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## CONTENTS

Page

### 1 INTRODUCTION

1.1	INTRODUCTION.....	1
1.2	GENERAL INFORMATION.....	1
1.3	RA60 BLOCK DIAGRAM.....	2
1.4	RA60 RELATED DOCUMENTATION....	4

### 2 REMOVAL AND REPLACEMENT PROCEDURES

2.1	INTRODUCTION.....	7
2.2	POWER PRECAUTIONS .....	7
2.3	REMOVING POWER FROM THE DISK DRIVE.....	7
2.4	RA60 FRU LIST AND PART NUMBERS.	8
2.5	SPECIAL TOOLS.....	9
2.6	RA60 FRU LOCATION.....	10
2.7	REPLACEMENT SEQUENCE.....	12

### 3 DRIVE-RESIDENT DIAGNOSTICS

3.1	INTRODUCTION.....	15
3.2	FUNCTIONAL AND DIAGNOSTIC FIRMWARE.....	15
3.3	THE DIAGNOSTIC TERMINAL.....	15
3.4	SHIFT KEYS.....	17
3.5	CONTROL CHARACTERS.....	17
3.6	CONTINUE (CONT) AND CLEAR (CLR) KEYS.....	17
3.7	X-ON, X-OFF KEYS.....	18
3.8	DELETE KEY.....	18
3.9	DISPLAY SCROLL SWITCH.....	18

## CONTENTS

<b>3</b>	<b>DRIVE-RESIDENT DIAGNOSTICS (CONT)</b>	<b>Page</b>
3.10	BREAK KEY.....	19
3.11	CR KEY (CARRIAGE RETURN) .....	19
3.12	ESCAPE KEY.....	19
3.13	POWERING UP THE DRIVE.....	19
3.14	INSTALLING THE TERMINAL.....	19
3.15	DIAGNOSTIC COMMAND SELECTION.....	21
3.16	TERMINATING THE TEST.....	26
<b>4</b>	<b>FAULT ISOLATION</b>	
4.1	INTRODUCTION.....	27
4.2	RA60 TROUBLESHOOTING AIDS.....	27
4.3	POWER REGULATOR MODULE LEDS.....	36
4.4	RA60 FAULT ISOLATION FLOW- CHART.....	40
<b>FIGURES</b>		
1.1	RA60 Block Diagram.....	3
2-1	RA60 FRU Location.....	11
2-2	Sequential Part Removal and Replacement.....	12
3-1	Field Service Diagnostic Terminal.....	16
3-2	Diagnostic Terminal Connections.....	20
4-1	Front Panel Fault Codes.....	28
4-2	Regulator Module LEDs.....	37
4-3	RA60 Fault Isolation Flowchart .....	41

## CONTENTS

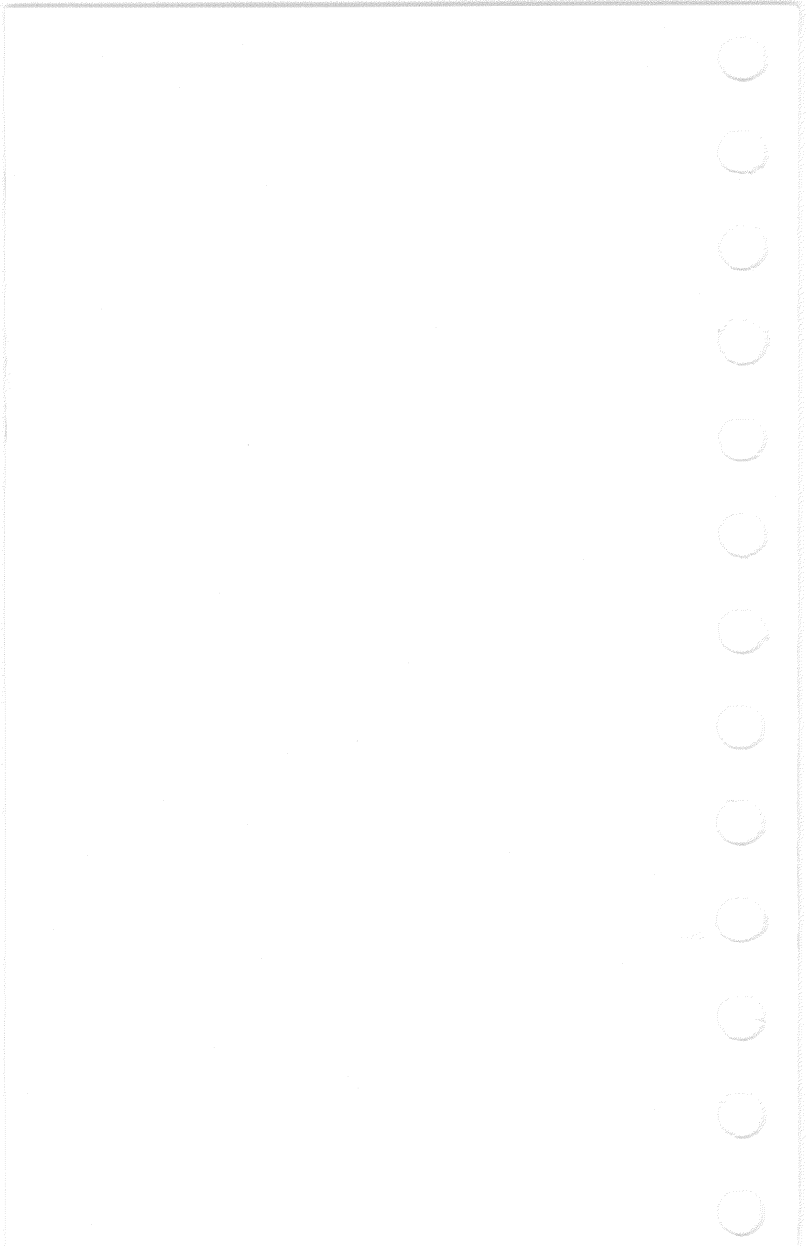
### FIGURES (CONT)

Page

4-4	Location of Circuit Breakers (Old Style Transformer).....	44
4-5	Location of Circuit Breakers (New Style Transformer).....	45

### TABLES

2-1	RA60 FRU List.....	8
2-2	Special Tools.....	10
3-1	RA60 Diagnostic Codes.....	21
4-1	RA60 Front Panel Fault Codes.....	29
4-3	Regulator LED Fault Codes.....	38





# 1 INTRODUCTION

## 1.1 INTRODUCTION

This chapter includes general information about the RA60 Disk Drive, a simplified block diagram of system functions and their relationship to one another as well as a list of related RA60 documentation.

## 1.2 GENERAL INFORMATION

The RA60 is a random access, imbedded servo, moving head disk drive capable of storing and recovering information to and from a removable disk pack. The RA60 is static dual ported and is connected to the host controller via a single standard disk interface (SDI) cable. A dual drive attached to a mid-range system via the UDA50 SDI controller is the primary systems application.

### NOTE

**The RA60 disk pack formatting information is protected under the copyright laws.**

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The RA60 operates with a RA60-P pack. This pack has five platters (three data platters) with six read/write surfaces for data recording. Track servo information is pre-recorded on each surface. The servo information is interleaved with the data area at the sector boundaries. The servo information may not be re-recorded in the field.

The servo information is pre-recorded on the disk at the time of production. It is read with the same head that reads and writes data.

## 2 INTRODUCTION

### 1.3 RA60 BLOCK DIAGRAM

Figure 1-1 shows a block diagram of the RA60 disk drive and its following functions.

- **Front panel** – controls and displays the state of the drive.
- **Port A and Port B connectors** – connects the SDI cables to the backplane module.
- **Drive logic module** – allows the drive to execute all the drive commands.
- **SDI module** – controls communication between the host controller and the drive electronics.
- **Post/amp data separator module** – controls the reading and writing of data.
- **Backplane module** – interconnects the three logic modules referred to above. It also provides the cable connections to the other units within the RA60 Disk Drive. It has no active components.
- **Preamp module** – provides the means to receive the read signal from the read/write heads, amplify the signal, and send it to the post/amp data separator module. It also includes write current drivers and head select logic.
- **Positioner assembly** – loads the heads and moves them to the correct location on the disk pack.

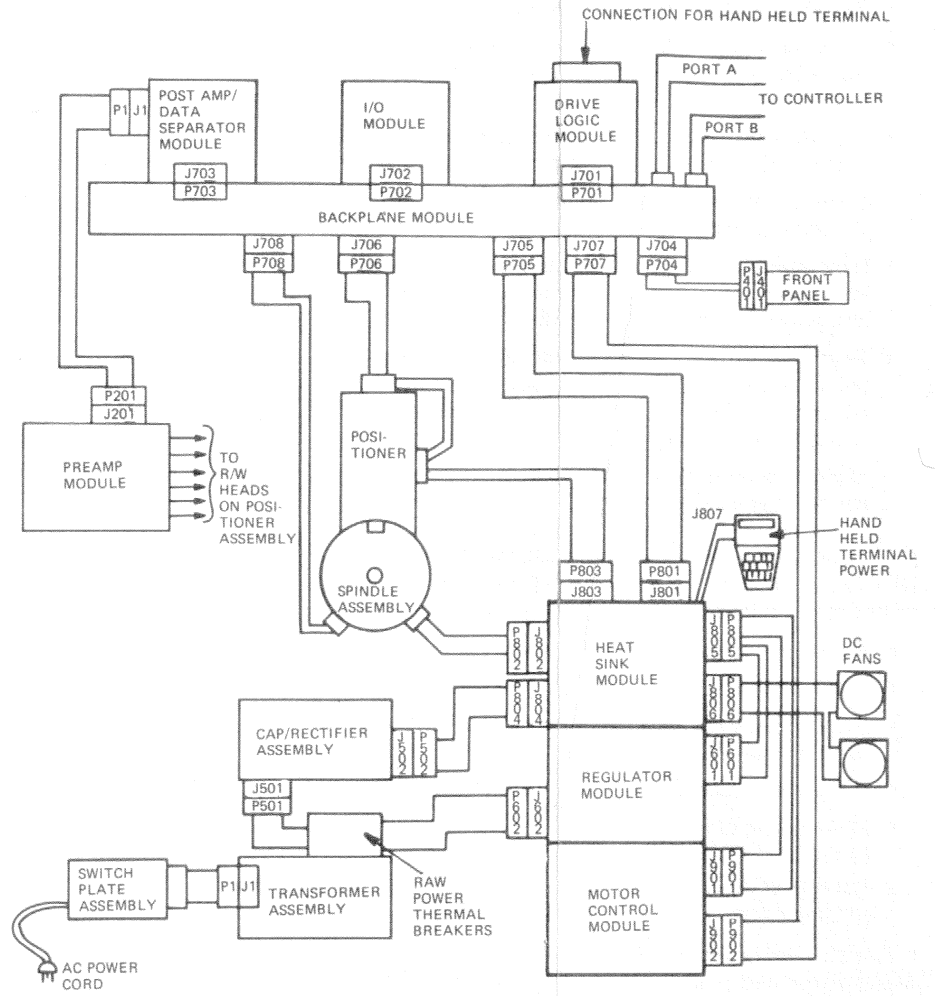


Figure 1-1 RA60 Block Diagram

- **Spindle assembly** – spins the disk pack.
- **Capacitor assembly** – supplies unregulated power to the heatsink module in conjunction with the transformer assembly.
- **Transformer assembly** – supplies unregulated raw power to the capacitor and regulator modules.
- **Power switch assembly** – supplies input ac power to the transformer assembly.
- **Heat sink module** – provides the power and control for both the regulator and motor control modules. It also provides power to the backplane module.
- **Regulator module** – takes the unregulated power output from the capacitor/rectifier assembly and regulates it at the heatsink module to the correct voltages required for the RA60 logic.
- **Motor control module** – controls both the spindle and the linear positioner motors.

#### 1.4 RA60 RELATED DOCUMENTATION

DIGITAL customers may order the following list of RA60 related manuals from the Accessories and Supplies Group.

- *RA60 User Guide* (EK-ORA60-UG)
- *RA60 Service Manual* (EK-ORA60-SV)
- *RA60 Illustrated Parts Breakdown* (EK-ORA60-IP)
- *RA60 Maintenance Guide* (AA-M880A-TC)
- Maintenance Guide Looseleaf Binder (AV-L980A-TK)
- *UDA50 Maintenance Documentation Kit* (QP904-GZ)\*

\* This kit consists of a small looseleaf binder, the *UDA50 Maintenance Guide*, and the current maintenance guides for disks that operate on the UDA50 Controller.

Within the United States, DIGITAL Customers may order the above manuals from the Accessories and Supplies Group over a toll free number (800-258-1710). Orders by mail should be addressed to one of the following primary distribution centers.

**Northeast/Mid-Atlantic Region**

Accessories & Supplies Group  
Cotton Road  
Nashua, NH. 03060  
Tel: 603-884-5111

**Central Region**

Accessories & Supplies Group  
1050 E. Remington Road  
Schaumburg, Illinois 60195  
Tel: 312-640-5612

**Western Region**

Accessories & Supplies Group  
Moffett Park Warehouse  
632 East Caribbean Drive  
Sunnyvale, CA 94086  
Tel: 408-734-9125

Outside the United States regional areas, consult local DIGITAL offices.

## 6 INTRODUCTION

Internal Digital Equipment Corporation customers should order the *RA60 User Guide*, the *RA60 Service Manual*, and the *RA60 Illustrated Parts Breakdown* directly from Printing and Circulation Services. Order the *RA60 Maintenance Guide*, the Maintenance Guide looseleaf binder, and the *UDA50 Maintenance Documentation Kit* from the Software Distribution Center.

# 2

## REMOVAL AND REPLACEMENT PROCEDURES

### 2.1 INTRODUCTION

This chapter describes the RA60 part removal and replacement procedures. It includes the power precautions that should be observed before replacing field replaceable units (FRUs). It also supplies a RA60 FRU list, their part numbers, a diagram showing the major FRU locations and a replacement sequence flow chart showing which order the FRUs should be removed.

### 2.2 POWER PRECAUTIONS

Since hazardous voltages are present inside this equipment, servicing should be performed only by qualified service representatives. Bodily injury or equipment damage may result from improper servicing.

#### WARNING

**Always remove power from the unit before replacing internal parts or cables.**

### 2.3 REMOVING POWER FROM THE DISK DRIVE

Before replacing assemblies in the RA60 Disk Drive, the disk should be spun down and the ac line power removed. Use the instructions in the following two paragraphs.

#### 2.3.1 Removing Power From Drive Internal Assemblies

To remove power to everything but the power supply, switch off CBI at the rear of the RA60 Disk Drive.

#### 2.3.2 Removing Power From The RA60 Power Supply

To remove power to the RA60 power supply, unplug the ac cord from the receptacle on the power control unit at the bottom of the RA60 cabinet.

8      REMOVAL AND  
REPLACEMENT PROCEDURES

**2.4 RA60 FRU LIST AND PART NUMBERS**

Table 2-1 lists the RA60 Disk Drive FRUs. Since these FRU part numbers change occasionally, use the *RA60 Illustrated Parts Breakdown* as your primary source of information.

**Table 2-1 RA60 FRU List**

<b>Part Number</b>	<b>Description</b>
12-09403-02	Fan ac
12-12714-00	RUN/STOP switch cap
12-12714-01	WRITE PROT switch cap
12-12714-02	FAULT switch cap
12-12714-03	A switch cap
12-12714-04	B switch cap
12-12716-00	Lamp, 6.3V, .2A
12-18199-00	UNIT READY switch cap
17-00083-03	Power cable (125V)
17-00083-06	Power cable (250V)
54-15264-00	Postamp module
54-15266-01	Logic/servo module
54-15268-01	Preamp module
54-15270-01	SDI module
54-15272-01	Front panel module
54-15278-01	Backplane module
70-17740-01	Spindle assembly
70-17742-01	Air filter assembly
70-18332-01	Home switch assembly
70-18452-01	Positioner assembly



**Table 2-1 RA60 FRU List (Cont)**

<b>Part Number</b>	<b>Description</b>
70-18461-01	R/W Head A-up
70-18461-02	R/W Head A-down
70-18461-03	R/W Head B-up
70-18461-04	R/W Head B-down
70-18473-01	Switch plate assembly
70-18474-01	Power module assembly
70-18476-01	Cap/rectifier assembly
70-18477-01	Transformer assembly
70-19049-01	Logic cable
70-19052-01	Operator control panel cable
70-19053-01	Pre/postamp interconnect cable
70-19054-01	Positioner power harness
70-19055-01	DC spindle motor power harness
70-19056-01	DC spindle motor positioner cable
70-19057-01	DC power harness
70-19058-01	DC unregulator harness
70-19065-01	Spindle ground harness
70-19066-01	Positioner ground harness
70-19086-01	DC fan harness

## 2.5 SPECIAL TOOLS

Table 2-2 lists the special tools required to maintain the RA60 disk drive.

10      REMOVAL AND  
REPLACEMENT PROCEDURES

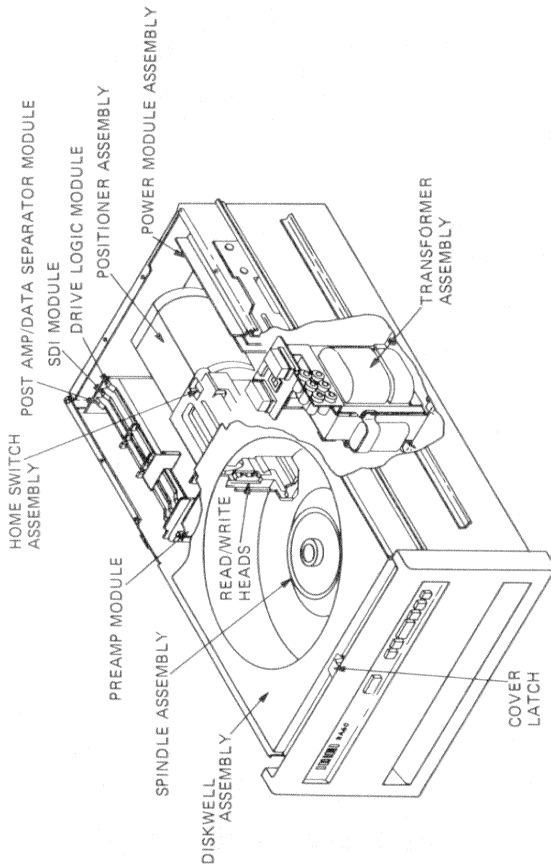
**Table 2-2 Special Tools**

<b>Part Number</b>	<b>Description</b>
29-24192-00	Wrench 97, hex adapter, torque
29-24193-00	Wrench, cam-over torque
29-24194-00	Screwdriver, flat 10 inch blade
29-24195-00	Handheld terminal service kit
29-24672-00	Head insertion tool
29-24671-00	Head separator tool

**2.6 RA60 FRU LOCATION**

Figure 2-1 shows the location of the major FRUs contained within the RA60 Disk Drive.

# REMOVAL AND REPLACEMENT PROCEDURES



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Figure 2-1 RA60 FRU Location

**2.7 REPLACEMENT SEQUENCE**

Figure 2-2 provides an RA60 part removal sequence. To remove a part, locate it on the sequential flow diagram and follow the path to the top of the diagram. Begin by removing the topmost item on the path that the flowline passes through. Continue down the flow line until the correct part is reached. Parts that can be removed directly are not shown on the diagram.

**NOTE**

Unless otherwise indicated, reverse the removal procedure to replace each FRU.

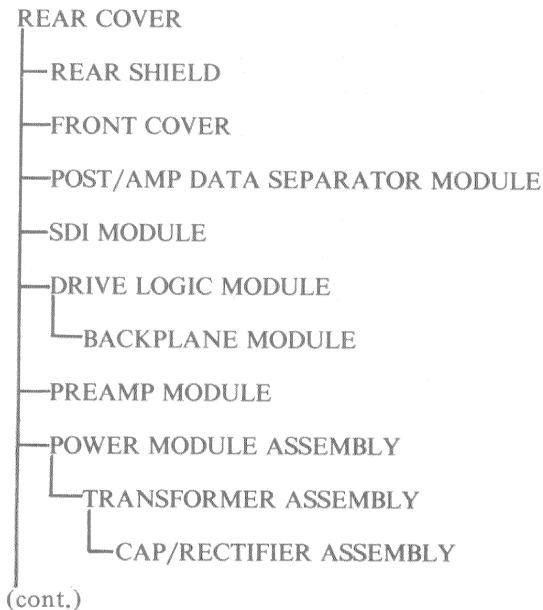
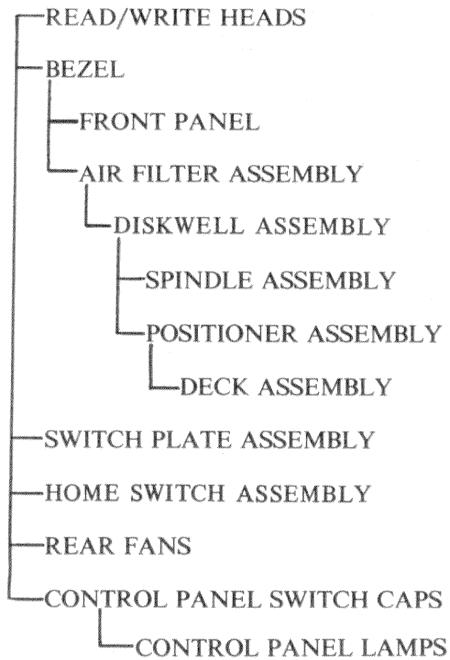


Figure 2-2 Sequential Part Removal  
and Replacement

REMOVAL AND  
REPLACEMENT PROCEDURES 13



CZ-0876

Figure 2-2 Sequential Part Removal  
and Replacement (cont.)

**NOTE**  
Refer to the *RA60 Service Manual* for a  
detailed description of the removal and  
replacement of the major FRUs contained  
within the RA60 Disk Drive.



## **3 DRIVE-RESIDENT DIAGNOSTICS**

### **3.1 INTRODUCTION**

This chapter describes the RA60 firmware diagnostic capabilities, how to run the drive-resident diagnostics, and explains each test.

### **3.2 FUNCTIONAL AND DIAGNOSTIC FIRMWARE**

Functional and diagnostic firmware are two separate software modules in the RA60 Disk Drive. The functional firmware controls fault monitoring and interface handshaking operations. The drive is operating in an on-line mode when the functional firmware is controlling the drive operations. The drive is operating in an off-line mode when it is under control of the diagnostic firmware. This firmware controls all drive-resident tests and utility programs.

### **3.3 THE DIAGNOSTIC TERMINAL**

A field service diagnostic terminal used to communicate with the RA60 drive is stocked with every spares kit. Refer to Figure 3-1. The terminal contains a two-level LED display and a keyboard. The display holds a maximum of 32 characters at one time while an internal buffer stores 2K characters for the display. The keyboard contains a standard ASCII set of alphanumeric characters. The larger character on each keybutton is the default character displayed when the button is pushed.





### 3.4 SHIFT KEYS

The three characters shown on any keybutton correspond to one of the three shift keys on the right side of the terminal. When the upper shift key on the terminal is pushed simultaneously with a keyboard button, the left-most character is displayed.

For example, when the middle shift key and the number five keybutton are pushed simultaneously, the letter K is displayed. Pushing the lower shift key and the zero keybutton results in the letter Q being displayed.

### 3.5 CONTROL CHARACTERS

A control character (e.g.  $\wedge C$ ) is obtained by using the CTRL key, the side shift keys, and the appropriate letter key. Push the CTRL key and one of the shift keys simultaneously with the appropriate letter key.

Example: A  $\wedge C$  is desired. The following steps should be used:

1. Push the CTRL key.
2. Push the upper shift key on the right-hand side of the terminal.
3. Simultaneously push the number two key with the upper shift key.

### 3.6 CONTINUE (CONT) AND CLEAR (CLR) KEYS

The X-On, X-Off feature is enabled when power is applied to the terminal. The CONT key disables the automatic X-On, X-Off feature while the CLR key re-enables it. Keeping this feature in automatic allows the display buffer to fill and then to automatically transmit a signal (X-Off) to the microprocessor. This signal stops all transmission of data to the display buffer until the buffer is unloaded. At this time, the terminal automatically sends an X-Off signal to re-enable transmission.

## 18 DRIVE-RESIDENT DIAGNOSTICS

### 3.7 X-ON, X-OFF KEYS

These keys manually control the display buffer of the terminal. If the display buffer is full, an automatic X-Off signal stops all transmission to the buffer. The X-On key is used to reload the buffer with new information even though the buffer has not been read.

The X-Off key may be used to stop the loading of the buffer even though the buffer is not full. For example, the automatic X-On, X-Off feature is disabled by the CONT key and the diagnostics are inputting test messages to the terminal. These messages are being sent at a faster rate than can be read by the human eye. Pushing the X-Off key stops the diagnostic testing and the messages. This enables the user to read the display and manually scroll through the buffer.

### 3.8 DELETE KEY

The delete key is used to correct mistakes in keyboard entries. Once a mistake is discovered, the delete key may be pushed causing a backslash (\) to be displayed with the last character input. The new character may now be keyed in. For example, if RUN DIAF was erroneously keyed in, the delete key could be used as follows.

```
RUN DIAF\FAG
```

The command RUN DIAG is now input correctly.

### 3.9 DISPLAY SCROLL SWITCH

The display scroll switch is located on the left side of the terminal. Its function is to back up or advance the display within the 2K display buffer. Long messages cannot be read all at once on a 32 character display. The scroll switch is moved upward for a forward display of the buffer and downward for a backward display of the buffer.

**3.10 BREAK KEY**

The break key transmits a break character when pushed. Its purpose is the same as a VT100 break key. It is not used in RA60 diagnostic operation.

**3.11 CR KEY (CARRIAGE RETURN)**

This key is pushed after typing a command string. It is the same as the carriage return key on a computer terminal.

**3.12 ESCAPE KEY**

This key transmits an escape character when pushed. Its purpose is the same as a VT100 escape key. It is not used in RA60 diagnostic operation.

**3.13 POWERING UP THE DRIVE**

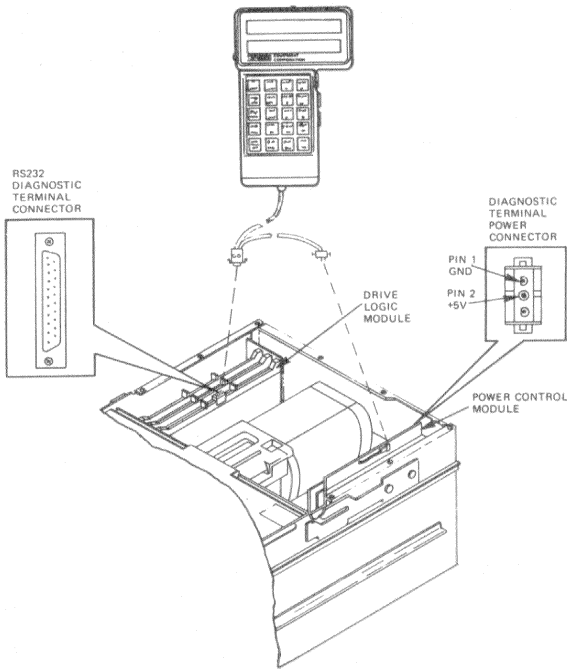
Apply power to the drive so that it can run a power-up test sequence. The sequence consists of various hardcore tests with static master logic. The front panel lights turn on when the hardcore tests are being executed. Successful completion of the power-up sequence is indicated by the front panel lights going off. The run light will remain on until the drive has verified that the spindle has stopped. The cover will remain locked until the run light goes off. If the fault light is on, all or part of the power-up sequence has failed. Chapter 4 of this manual contains the trouble-shooting procedures enabling you to repair the RA60 Disk Drive.

**3.14 INSTALLING THE TERMINAL**

To use the diagnostic terminal, the diagnostic monitor mode must be entered. The drive does not respond to the keyboard until both port select switches on the drive are in the out position. If either switch is pushed in, the drive is in the available state awaiting a command from the controller.

## 20 DRIVE - RESIDENT DIAGNOSTICS

The RS232 interface cable connects to the drive logic module via a connector found at the top of the module. The +5 voltage cable required to power the hand held terminal is supplied by connector 807 on the power module assembly. Connect the power cable from the hand held terminal to connector 807. Refer to Figure 3-2.



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Figure 3-2 Diagnostic Terminal Connections

Once the cables are connected properly, key in a CTRL C (^C) on the terminal keyboard. The terminal responds to the ^C with the following diagnostic prompt.

```
%RA60 COMPLETED  
RA60 TEST >
```

Upon reception of the diagnostic prompt, testing may now be run by keying in any of the diagnostic commands. These commands are described in the following paragraphs.

### 3.15 DIAGNOSTIC COMMAND SELECTION

The RA60 Disk Drive has six internal diagnostics that will check out the status, recalibration, and seeking capability of the drive. Table 3-1 lists the codes and names of the diagnostic tests.

**Table 3-1 RA60 Diagnostic Codes**

Test Code	Name
01	Get Status
02	Recal
03	Incremental Seek
04	Random Seek
05	Seek
06	Toggle Seek

## 22 DRIVE-RESIDENT DIAGNOSTICS

### 3.15.1 Get Status Command

The get status command gives the status of the RA60 Disk Drive. This command will check to see if the drive is operation or if an error exists. To enter this test, key in the code 01 after you have received the diagnostic prompt.

```
%RA60 Completed  
RA60 Test > 01<CR>
```

Upon successful completion, you will receive the following response:

```
%RA60 Completed  
RA60 Test >
```

If an error occurs, you will receive the following response:

```
RA60 Test > 01 ERR XX*
```

\* XX will indicate the hex error code which is listed in Chapter 4, Table 4-2 of this manual.

### 3.15.2 Recalibrate (Recal) Command

The Recalibrate (Recal) command will return the read/write heads to cylinder 0, head 0. This command allows the drive to perform a seek operation starting from a known cylinder and read/write head. To enter this test, key in the code 02 after you have received the diagnostic prompt.

```
%RA60 Completed  
RA60 Test > 02<CR>
```

Upon successful completion, you will receive the following response:

```
  %RA60 Completed  
RA60 Test >
```

If an error occurs, you will receive the following response:

```
RA60 Test > 02 Err XX*
```

\* XX will indicate the hex error code which is listed in Chapter 4, Table 4-2 of this manual.

### 3.15.3 Incremental Seek Command

The incremental seek command will incrementally seek one cylinder at a time until the maximum cylinder number is reached. This command allows you to check the drive capability to perform one cylinder seek. To enter this test, key in the code 03 after you have received the diagnostic prompt. This test will run until an error is detected. To terminate the test, type in a control C (^C).

```
  %RA60 Completed  
RA60 Test > 03<CR>
```

Upon successful completion, you will receive the following response:

```
  %RA60 Completed  
RA60 Test >
```

If an error occurs, you will receive the following response:

```
RA60 Test > 03 Err XX*
```

\*XX will indicate the hex error code which is listed in Chapter 4, Table 4-2 of this manual.

## 24 DRIVE-RESIDENT DIAGNOSTICS

### 3.15.4 Random Seek Command

The random seek command will randomly seek from the cylinder it is presently at to a random cylinder specified by the microcode. This command allows you to check the drive capability to randomly seek to any cylinder. To enter this test, key in the code 04 after you have received the diagnostic prompt.

```
%RA60 Completed  
RA60 Test > 04<CR>
```

Upon successful completion, you will receive the following response:

```
%RA60 Completed  
RA60 Test >
```

If an error occurs, you will receive the following response:

```
RA60 Test > 04 Err XX*
```

\*XX will indicate the hex error code which is listed in Chapter 4, Table 4-2 of this manual.

### 3.15.5 Seek Command (with parameters)

The seek command will seek from the cylinder it is presently at to the cylinder specified. You can also specify which read/write head to use with this command. This test allows you to check the drive capability of seeking to a specific cylinder using a specific read/write head. To enter this test, key in the code 05 after you have received the diagnostic prompt: After you have keyed in the code 05, key in the hex number of the cylinder desired and the number of the read/write head desired.

```
%RA60 Completed  
RA60 Test > 05 space XXX space X<CR>
```



XXX is the hex number of the desired cylinder. The valid cylinder address is from 0 to 63F hexadecimal.

X is the number of the desired read/write head to use for the seek test.

Upon successful completion, you will receive the following response:

```
%RA60 Completed
RA60 Test >
```

If an error occurs, you will receive the following response:

```
RA60 Test > 05 Err XX*
```

\*XX will indicate the hex error code which is listed in Chapter 4, Table 4-2 of this manual.

### 3.15.6 Toggle Seek (with parameters)

The toggle seek test will seek from the cylinder it is presently at to the cylinder specified. This test allows you to check the drive capability to seek to a specific cylinder but does not allow you to select a specific read/write head. To enter this test, key in the code 06 after you have received the diagnostic prompt. After you have keyed in the code 06, key in the hex number of the desired cylinder. This test will loop until an error is detected and is terminated by typing in a control C (^C).

```
%RA60 Completed
RA60 Test > 06 space XXX<CR>
```

XXX is the hex number of the desired cylinder. The valid cylinder address is from 0 to 63F hexadecimal.

## 26 DRIVE-RESIDENT DIAGNOSTICS

Upon successful completion, you will receive the following response:

```
%RA60 Completed  
RA60 Test >
```

If an error occurs, you will receive the following response:

```
RA60 Test > 06 Err XX*
```

\*XX will indicate the hex error code which is listed in Chapter 4, Table 4-2 of this manual.

### 3.16 TERMINATING THE TEST

To terminate any of the internal diagnostic tests mentioned above, key in a Control C (^C) on the terminal. The Control C (^C) will return you to the diagnostic prompt.

```
%RA60 Completed  
RA60 Test >
```

# 4 FAULT ISOLATION

## 4.1 INTRODUCTION

This chapter discusses the RA60 fault isolation procedures. It also describes the troubleshooting aids used by the RA60 Disk Drive which include the front panel fault codes, error code tables, the power supply tables, and a fault isolation flowchart.

## 4.2 RA60 TROUBLESHOOTING AIDS

The RA60 has several troubleshooting aids. Two of them are as follows:

- Front panel fault codes
- Hand held terminal error messages/host diagnostic error messages

### 4.2.1 Front Panel Codes

Figure 4-1 describes the fault codes, shows the front panel light configuration and the hex code of the lights.

## 28 FAULT ISOLATION

DESCRIPTION OF ERROR	RUN STOP	FAULT	READY	WRT PROT	A	B	HEX CODE
MICROCODE ERROR (NOT SENT TO FRONT PANEL)	*	OFF	OFF	OFF	OFF	OFF	00
HEADS HOME SWITCH FAULT	*	ON	OFF	OFF	OFF	ON	01
FRONT PANEL FAULT	*	ON	OFF	OFF	ON	OFF	02
LONG SPIN UP TIME FAULT	*	ON	OFF	OFF	ON	ON	03
BAD SERVO SAMPLES FAULT	*	ON	OFF	ON	OFF	ON	05
BAD VELOCITY FAULT	*	ON	OFF	ON	ON	OFF	06
LINEAR MODE FAULT	*	ON	OFF	ON	ON	ON	07
RETRY ON SEEK FAULT	*	ON	ON	OFF	OFF	OFF	08
LOST SERVO SAMPLES FAULT	*	ON	ON	OFF	OFF	ON	09
HEADS HOME SWITCH WOULD NOT OPEN	*	ON	ON	OFF	ON	OFF	0A
MASTER PROCESSOR FAULT	*	ON	ON	OFF	OFF	OFF	10
SDI FAULT	*	ON	ON	OFF	OFF	ON	11
INVALID SDI LEVEL 1 COMMAND	*	ON	ON	OFF	ON	ON	13
MASTER PROCESSOR FAULT	ON	ON	ON	ON	ON	ON	3F

\* THE RUN/STOP SWITCH MAY BE ON OR OFF DEPENDING ON THE STATE OF THE DRIVE.

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Figure 4-1 Front Panel Fault Codes

**4.2.2 RA60 Error Messages**

Refer to Table 4-1 for the RA60 error messages. Table 4-1 shows the error code, front panel fault code, a description of the error, and the most likely failing FRU. The error codes are displayed on the hand-held terminal when internal diagnostics are run or are printed out on the system console when running host diagnostics. The front panel fault codes are displayed on the front panel lights.

Replace Tables 4-1 and 4-2 in the existing *RA60 Maintenance Guide* (AA-M880A-TC), with the following table:

**Table 4-1 RA60 Error Messages**

<b>ERROR CODE</b>	<b>FRONT PANEL CODE</b>	<b>DESCRIPTION</b>	<b>MOST LIKELY FRU FAILURE</b>
08	01	Heads were not home when run command was issued	1. Push heads home 2. Check P803
09	01	Heads home switch opened during spinup	3. Drive logic switch assembly 4. Heads home switch assembly
0A	01	Heads home switch would not close during unload	
10	02	Lid lock open during spinup	1. Front panel module 2. Drive logic module
11	02	Cover open during spinup	3. Front panel ribbon cable
12	02	Cover or lid lock opened during head load	
13	02	Lid not locked when run command was issued	
8A	02	Tests front panel and serial number ROM	
97	02	Solenoid release timeout	
9A	02	Run switch or cover invalid at spinup	
18	03	Spinup required too long a time	1. Drive logic module 2. Power module assembly
19	03	Motor sample would not change during spinup	3. Check spindle motor connections 4. Spindle motor

Table 4-1 RA60 Error Messages (Cont.)

ERROR CODE	FRONT PANEL CODE	DESCRIPTION	MOST LIKELY FRU FAILURE
24	04	Too long to acquire spindle speed control on head load	1. R/W preamp module
25	04	Heads misaligned	2. Drive logic module
27	04	More than 32 sectors to settle on track retry failed	3. Post amp/data separator module
			4. Check head
			5. Power module assembly
			6. Positioner assembly
28	05	Too many bad servo samples during RTZ	1. Pack
29	05	Too long to acquire good samples on head load	2. Post amp/data separator module
2C	05	Bad servo samples during RTZ on head load	3. R/W preamp module
2D	05	Bad samples during linear mode	4. Drive logic module
2F	05	Off track in linear state	5. Heads
	06	No pack in drive	6. Cable from preamp module to data separator module
			1. Check to see if pack is in drive
			2. Drive logic module
41	08	Retry on seek due to bad servo samples, retry failed	1. Pack
			2. Post amp/data separator module
43	08	Retry on seek due to bad guard band flags, retry failed	3. R/W preamp module
			4. Drive logic module
45	08	Retry on seek due to bad position polarity, retry failed	5. Heads
47	08	Retry on seek failed due to wrong gray code	

Table 4-1 RA60 Error Messages (Cont).

ERROR CODE	FRONT PANEL CODE	DESCRIPTION	MOST LIKELY FRU FAILURE
48	09	Lost servo samples	<ol style="list-style-type: none"> <li>1. Pack</li> <li>2. Post amp/data separator module</li> <li>3. R/W preamp</li> <li>4. Drive logic module</li> <li>5. Heads</li> </ol>
50	0A	Too long for heads home switch to open on head load	<ol style="list-style-type: none"> <li>1. Shipping pin or head locking screw not removed</li> <li>2. Check P803</li> <li>3. Heads home switch assembly</li> <li>4. Power module assembly</li> </ol>
	0B	Bad serial ROM	<ol style="list-style-type: none"> <li>1. Replace front panel</li> <li>2. Drive logic module</li> <li>3. Front panel ribbon cable</li> </ol>
81	10	Inits and tests front panel	<ol style="list-style-type: none"> <li>1. Drive logic module</li> <li>2. SDI module</li> <li>3. Post amp/data separator module</li> <li>4. Front panel</li> <li>5. Backplane module</li> </ol>
82	10	Checks processor registers	
83	10	Tests RAM 0	
84	10	Tests ROM 0	
85	10	Tests ROM 1	
86	10	Tests ROM 2	
87	10	Verify ROM version numbers	
88	10	Tests the SDI clear interface bit	

Table 4-1 RA60 Error Messages (Cont.)

ERROR CODE	FRONT PANEL CODE	DESCRIPTION	MOST LIKELY FRU FAILURE
8B	10	Initiates the UART	1. Drive logic module
8D	10	Tests the 8155 timer	2. SDI module
8E	10	Tests the slave control port	3. Post amp/data separator module
8F	10	Slave diagnostics	4. Backplane module
90	10	Command available or slave done already set when issuing a new slave command	
91	10	Slave command received timeout on opcode	
92	10	Slave attention timeout	1. Drive logic module
93	10	Slave done timeout to slave stop (TOSTP)	2. SDI module
94	10	Slave done timeout to status (1 ms)	3. Post amp/data separator module
95	10	Slave done timeout	4. Backplane module
96	10	Slave attention timeout	
B9	10	Slave done timeout (1 ms) to get status	
98	10	Watchdog timer detected master insane	1. Drive logic module
99	10	Watchdog timer detected slave insane	2. Post amp/data separator module
			3. SDI module
			4. Backplane module
A8	10	Slave done timeout to seek command	1. Drive logic module
A9	10	Slave done timeout to RTZ command	2. SDI module
			3. Post amp/data separator module
			4. Backplane module



Table 4-1 RA60 Error Messages (Cont.)

ERROR CODE	FRONT PANEL CODE	DESCRIPTION	MOST LIKELY FRU FAILURE
AA	10	Slave response error to RTZ command	
AB	10	Slave done timeout during first pass	
AC	10	Command received timeout during diagnostic stop or ASCII port command time = TODGN2	
AD	10	Slave done timeout during diagnostic stop or ASCII port command time = 1 ms	
C0	10	Slave done timeout from get status command	1. Drive logic module
C1	10	Error response to get status command	2. SDI module
C3	10	Micro code fault errors	3. Post amp/data separator module
C4	10	No watchdog interrupt (processor halted)	4. Backplane module
C5	10	Slave done timeout (ASCII PORT)	
C6	10	Slave command received error (ASCII PORT)	
C7	10	Invalid 'TT' bit	
89	11	Tests the SDI control/status register	1. R/W preamp module
8C	11	Tests the error registers	2. Drive logic module
C8	11	Multi-head select	3. Post amp/data separator module
			4. SDI module
			5. Backplane module
9B	12	Spindle not ready during recal command	1. SDI module
A2	12	SDI command checksum error	2. Drive logic module
A3	12	SDI frame error	3. Post amp/data separator module
A4	12	SDI command parity error	4. Backplane module
A5	12	SDI command out of range	

Table 4-1 RA60 Error Messages (Cont.)

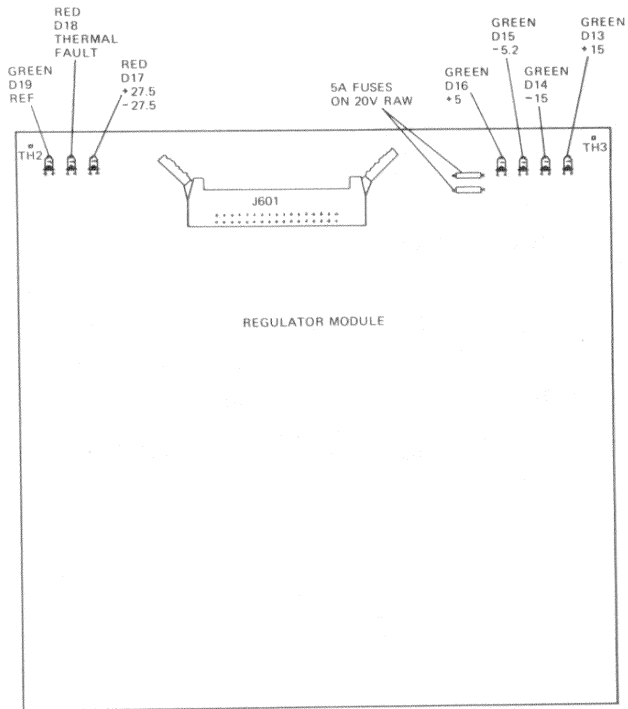
ERROR CODE	FRONT PANEL CODE	DESCRIPTION	MOST LIKELY FRU FAILURE
A6	12	SDI command length error	1. SDI module
A7	12	SDI error status byte was non zero	2. Drive logic module 3. Backplane module
AE	12	Drive not on-line	1. Drive logic module
AF	12	Command bytes 4 & 5 are not zero	2. SDI module 3. Post amp/data separator module
B0	12	Invalid group number	4. Backplane module
B1	12	Invalid head select number	
B2	12	Invalid cylinder range	
B3	12	Spindle not ready	
B4	12	Controller timeout equals 0	
B5	12	Spindle not ready	
B6	12	Illegal memory region	
B7	12	DD bit set	
B8	12	Tried to clear a hard fault	
BA	12	Non-zero level	1. Drive logic module
BB	12	Wrong subunit error	2. SDI module
BC	12	Diagnostic command, memory region HI not zero	3. Post amp/data separator module 4. Backplane module
BD	12	Diagnostic command, invalid parameters	
BE	12	Write enable a write protected drive	
BF	12	Setting S7 equals 1	
C2	12	Invalid group number	

Table 4-1 RA60 Error Messages (Cont.)

ERROR CODE	FRONT PANEL CODE	DESCRIPTION	MOST LIKELY FRU FAILURE
9C	13	SDI transfer error from DC703	
9D	13	Write or format when write protected	
9E	13	Format when format disabled	
9F	13	Transfer command when drive error	
A0	13	Sector R/W overrun error	
A1	13	Transfer command when R/W error	
61	0C	Command cannot be executed with the drive in its current state	1. Drive logic module 2. Front cover open
62	0C	Non-existent head or cylinder requested with seek	
63	0C	Op-code was not one of the six valid op-code	
64	0C	Cover was not closed when run was issued	
65	0C	Program error during head load	
	3F	Master micro-processor insane	1. Drive logic module 2. SDI module 3. Post amp/data separator module 4. Backplane module

**4.3 POWER REGULATOR MODULE LEDS**

The regulator module has seven LEDs on the top to help in fault isolation. Five of the LEDs are green and the remaining two LEDs are red. The green LEDs indicate normal operation and the red LEDs indicate an abnormal condition. The location of these LEDs is shown in Figure 4-2. Use the chart in Table 4-3 to help isolate power supply problems.



CZ-0889

Figure 4-2 Regulator Module LEDs

## 38 FAULT ISOLATION

**Table 4-3 Regulator LED Fault Codes**

**REGULATOR LEADS**

Green D19 REF	Red D18 Ther- mal Fault	Red D17 +27.5 -27.5	Green D16 +5	Green D15 -5.2	Green D14 -15	Green D13 +15
1	0	0	1	1	1	1

**POSSIBLE CAUSES:**

Normal state

D19	D18	D17	D16	D15	D14	D13
0	0	0	0	0	0	0

**POSSIBLE CAUSES:** Listed in order of most likely  
Suspect voltage reference on regulator

1. Check AC cabling and switch plate assembly
2. Transformer
3. Regulator
4. Cap/rec assembly

D19	D18	D17	D16	D15	D14	D13
0	0	1	1	1	1	1

**POSSIBLE CAUSES:** Listed in order of most likely  
 $\pm 27.5$  volt failure

1. Heat sink module
2. Cap/rec assembly
3. Transformer
4. Regulator

**Table 4-3 Regulator LED Fault Codes (Cont.)**

**REGULATOR LEADS**

D19	D18	D17	D16	D15	D14	D13
0	0	0	-----at	least	one	off-----

**POSSIBLE CAUSES:** Listed in order of most likely

- Suspect a short circuit
1. Logic module shorts
  2. Heat sink module

D19	D18	D17	D16	D15	D14	D13
0	0	0	0	0	1	1

**POSSIBLE CAUSES:** Listed in order of most likely

Suspect short or overvoltage to +5 and -5.2

1. Logic module shorts
2. Check circuit breaker
3. Heat sink module
4. Capacitor assembly
5. Regulator module

D19	D18	D17	D16	D15	D14	D13
0	0	0	1	1	0	0

**POSSIBLE CAUSES:** Listed in order of most likely

Suspect shorts to  $\pm 15$  v

1. Logic module shorts
2. Check circuit breaker
3. Heat sink module
4. Capacitor module
5. Regulator module

## 40 . FAULT ISOLATION

**Table 4-3 Regulator LEDs Fault Codes (Cont.)**

---

### REGULATOR LEDS

---

D19	D18	D17	D16	D15	D14	D13
0	1	0	1	1	1	1

**POSSIBLE CAUSES:** Listed in order of most likely  
Thermal shutdown

1. Check fans
  2. Regulator module
- 

D19	D18	D17	D16	D15	D14	D13
0	1	0	-----at	least	one	off-----

**POSSIBLE CAUSES:** Listed in order of most likely  
Thermal shutdown with faulted supply

1. Check fans
  2. Heat sink module
  3. Regulator module
- 

### 4.4 RA60 FAULT ISOLATION FLOWCHART

Use the RA60 fault isolation flowchart in Figure 4-3 as a guide to isolating disk subsystem problems. The description of each block is keyed by numbers.



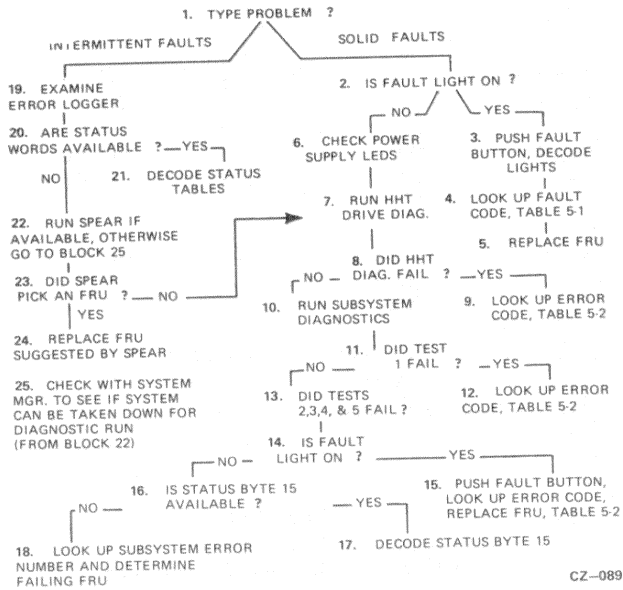


Figure 4-3 RA60 Fault Isolation Flowchart

## 42 FAULT ISOLATION

### 4.4.1 Block 1 - Type Problem

Block 1 is a decision block asking whether the fault is an intermittent or a solid one. Intermittent faults are difficult to solve because they do not occur consistently and do not always show up in fault codes or fault lights. They take the form of random software correctable errors or the slow degeneration of error rates or seek rates. Solid faults, on the other hand, are consistent enough to be pinned down to a physical or software cause. Usually, solid faults will either light the fault lamp or be caught by the drive internal diagnostics or the subsystem diagnostics and result in an error code.

Determine whether the fault is solid or intermittent and then follow that leg of the fault isolation chart shown in Figure 4-3.

### 4.4.2 Block 2 - Is The Fault Light On?

When the FAULT light is on, it indicates that there is an error condition within the RA60 Disk Drive. If the FAULT light is on, go to block 3. Otherwise, go to block 6 to check the power supply.

### 4.4.3 Block 3 - Push The Fault Button

Assuming that the FAULT light is on in block 3, push the FAULT button to obtain the blinking fault identification code in the front panel lights. This blinking light pattern will give you a hexadecimal fault code. Figure 4-1 assists in interpreting the front panel lights.

### 4.4.4 Block 4 - Look Up The Fault Code

The fault code can be found in Table 4-1. This table also gives the most likely failing FRUs for that fault code.

**4.4.5 Block 5 - Replace The Failing FRU**

Replace the most likely failing FRU indicated in Table 4-1. Since more than one FRU can be the cause of a fault code, the most likely is listed first. Always replace that FRU first.

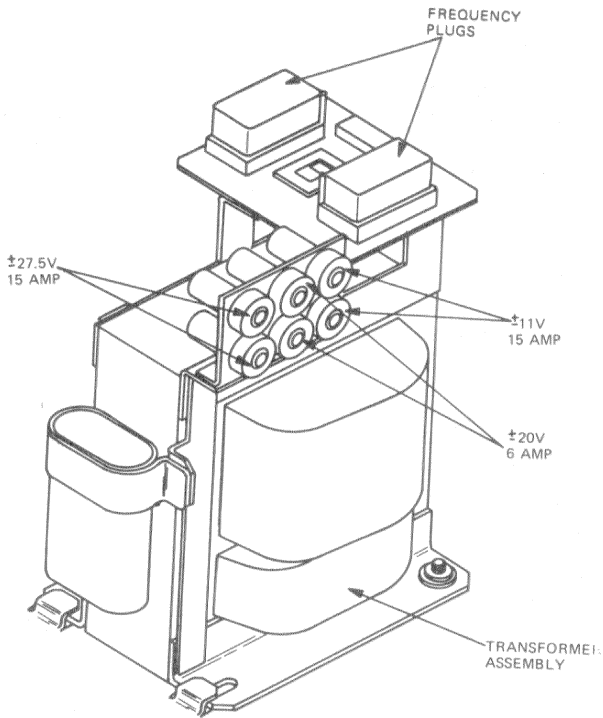
**4.4.6 Block 6 - Check Power Supply LEDs**

If you have a solid fault and the front panel FAULT light does not come on, two possible causes are a bad light bulb or a power supply problem. Perform a front panel lamp test by pushing in the FAULT button. All the front panel lights should stay on as long as the FAULT button is held in.

If no lights work, open the rear of the drive and check the power supply LEDs on the regulator module. Figure 4-2 shows the location of these LEDs. Look up the light pattern of these LEDs in Table 4-3 to determine if the power supply is at fault. If Table 4-3 does indicate a bad voltage supply, check to see if the thermal circuit breaker for that supply voltage has tripped. There are six circuit breakers located on top of the transformer assembly. Figures 4-4 and 4-5 show the location of these circuit breakers for both the old style and the new style transformer assemblies.

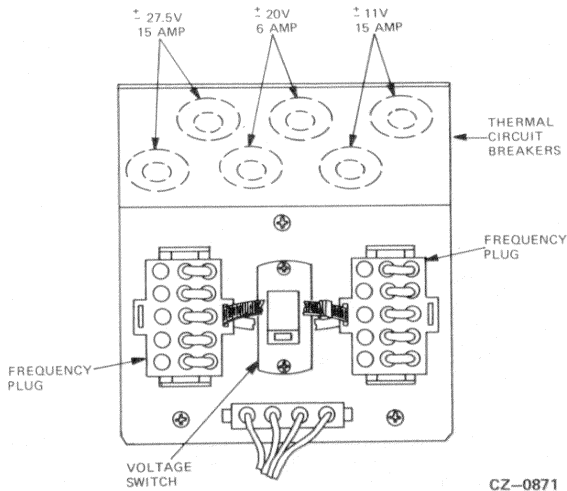
If the fault light is not on during the lamp test, go to block 7 to run the drive-resident diagnostics.

## 44 FAULT ISOLATION



CZ-0250

Figure 4-4 Location of Circuit Breakers  
(Old Style Transformer)



CZ-0871

Figure 4-5 Location of Circuit Breakers  
(New Style Transformer)

#### 4.4.7 Block 7 - Run The Drive-Resident Diagnostics

There are six drive-resident diagnostic tests that can be run with the field service hand held terminal (HHT). Refer to Chapter 3 of this manual to run these tests. These tests can only be run if the drive is placed off-line (both Port A and B buttons out).

Normally, consult with the system manager before placing a drive off-line to ensure that the disk information is not required by the operating system software. However, since this block is entered through a solid fault, it is assumed that RA60 disk information is unavailable to the operating system.

**4.4.8 Block 8 - Did The HHT Invoked Diagnostic Tests Fail?**

A test completes its sequence successfully when it returns to the %RA60 - COMPLETED prompt. If an error is detected, the HHT display will show an ERR:XX prompt with the error code in the XX spot. If an error code display is obtained, go to block 9 for decoding.

If all the HHT diagnostic tests are completed successfully, go to block 10 to run the subsystem diagnostics.

**4.4.9 Block 9 - Look Up HHT Error Code**

Block 9 assumes that you obtained an error code during one of the HHT drive-resident diagnostic tests. Look up this error code in Table 4-2 and replace the most likely failing FRU first.

**4.4.10 Block 10 - Run The Subsystem Diagnostic Tests**

The following description assumes that the RA60 is running on a UDA50 disk controller. The subsystem diagnostics on an RA60 disk pack are run under the control of the diagnostic supervisor program. The VAX EVRLA and the PDP-11 CZUDC are the two subsystem diagnostics described here. They consist of the following five tests.

- Test 1: The UNIBUS interrupt/address test checks out UDA50 functionality.
- Test 2: The disk-resident diagnostic test runs the drive-resident diagnostics.
- Test 3: The disk function test performs drive seek tests.
- Test 4: The disk exerciser test performs a limited read and write test only in the diagnostic cylinder area.
- Test 5: The manual intervention test allows Test 4 to be run with new input parameters that include the cus-

**4.4.11 Block 11 - Did Test 1 Fail?**

Since test 1 is a UDA50 diskless test, any failure indicates a UDA50 problem or possibly a host CPU problem. If test 1 prints out an error message, go to block 12 to see how to interpret it. If test 1 does not fail, then go to block 13.

**4.4.12 Block 12 - Look Up UDA50 Error Code**

A failure during test 1 is indicated by the CZUDC printout shown below.

```
CZUDC DVC FTL ERR 00005 ON UNIT 00 TST 001 SUB 002 PC: 023710
UDA INITIALIZE ERROR
UDA RESIDENT DIAGNOSTICS DETECTED FAILURE
UDASA REGISTER = 106040
```

The last line of the error printout shows the contents of the UDA50 UDASA register as 106040. The UDASA error code 106040 indicates that either the UDA50 module M7161 or M7485 is at fault.

The UDA50 Disk Controller has two versions. The first version, the UDA50, consists of two hex height modules, M7161 and M7162. The second version, the UDA50A, increases the memory buffer size of the controller from 4K to 16K, adds more PROM space, and introduces selectable jumpers for varying UNIBUS delays. The module numbers of the UDA50A have been changed to M7485 and M7486 respectively.

**NOTE**

**Never intermix the old UDA50 and the new UDA50A modules due to incompatibility.**

## 48 FAULT ISOLATION

### 4.4.13 Block 13 - Run Subsystem Tests 2, 3, 4, 5

Subsystem diagnostic tests 1 through 4 will run in sequence automatically without manual intervention. If test 1 passes successfully without detecting any failures, chances are likely that there is a drive related problem rather than a UDA50 related problem.

If an RA60 drive problem has not been detected previously with the drive-resident diagnostics, chances are likely that subsystem diagnostic tests 2 through 5 will detect the failure. Test 5 is to be initiated manually because it involves a deliberate attempt to read and write in the customer data area of the disk pack.

### 4.4.14 Block 14 - Is The Fault Light On?

Block 14 asks if the front panel FAULT light comes on as a result of running diagnostic tests 2 through 5. If yes, proceed to block 15. If not, go to block 16.

### 4.4.15 Block 15 - Push The Fault Button

Block 15 assumes that the front panel FAULT light comes on when subsystem diagnostic tests 2 through 5 are run. If so, push the FAULT button to display the front panel hexadecimal error code. Use Figure 4-1 to convert the front panel light into an error code. Then look up this error code in Table 4-1 and replace the suggested FRU.

### 4.4.16 Block 16 - Is Status Byte 15 Available?

Status byte 15 is important because it will give you the drive error codes. If you find that status byte 15 is available, go to block 17.

If the status message is not printed out, you will most likely obtain a subsystem error message from the EVRLA or CZUDC diagnostics. If so, proceed to block 18 to see what to do with the subsystem error message.



**4.4.17 Block 17 - Decode Status Byte 15**

When present, byte 15 will contain a two hexadecimal digit error code. This is the same drive error code that the drive-resident diagnostics report through the hand held terminal. For example, byte 15 of the status message contains a drive error code of 9C. The error can be decoded by referring to Table 4-2.

The error code 9C in Table 4-2 is described as an SDI transfer error from the DC703 chip. Table 4-2 also indicates which FRU is the most likely failing module. In this case, it lists the SDI module as the first most likely failure and the post amp/data separator module as the second most likely failure.

After finding the error code in Table 4-2, replace the most likely FRU first. Go to the second FRU only if the first does not correct the problem.

If status byte 15 is unavailable, rely on help from the subsystem diagnostic error messages described in block 18 or in the ERROR LOG or SPEAR (Standard Package for Error Analysis and Reporting) information described in blocks 19 and 22, respectively.

**4.4.18 Block 18 - Look Up Subsystem Error Messages**

This block assumes that when you run the EVRLA or CZUDC diagnostics, one of the five diagnostic tests prints out a subsystem error message.

**4.4.19 Block 19 - Examine Error Log**

No attempt is made here to teach the field engineer how to run the error log program. It is assumed this information is available or can be accessed through an operator who runs error log reports. Training courses are available for that purpose.

## 50 FAULT ISOLATION

### 4.4.20 Block 20 - Are Status Words Available?

The status words contain important disk controller and drive status and error information. These status words, however, are only available when the error log is reporting an SDI error format message. (Format code equals 03.) Therefore, you must determine if the status words are available by checking which error format applies.

In the VMS error log report, this is easily determined by reading the MLSG\$B line that gives the format code directly. In a RSTS/E error log report, first decode word 4 of the MSCP packet. If the status words are available, go to block 21 of the flowchart to see how to decode this information.

### 4.4.21 Block 21 - Decode Status Words

Block 21 of the flowchart assumes that the error log report is decoded as an SDI error format type. (Format code equals 03.) SDI error format reports contain useful information on the UDA and disk drive in the SDI status message.

For VMS error log reports, the SDI status word information is found on the MSLG\$ZSDI line. It is reported as three lines of hexadecimal data.

For RSTS/E error log reports, the SDI status word information is given in words 22 through 27 of the MSCP packet. This information is given in an octal word format.

### 4.4.22 Block 22 - Run SPEAR, If Available

Run the SPEAR (Standard Package for Error Analysis and Reporting) program if it is available on your operating system. SPEAR goes beyond the typical error log capabilities. It not only accumulates data, but has the capability of analyzing and predicting which FRU is at fault. SPEAR is a library of functions that sorts, evaluates, and reports on events recorded in the local system event file.

SPEAR is currently used on TOPS-10, TOPS-20, and VMS operating systems. Plans are underway to incorporate the RA60 and other RA drives under its diagnostic analysis though it is uncertain when this added tool will become available.

A *SPEAR Reference Card* can be ordered from Printing and Circulation Services under part number EK-SPEAR-RC-002. This reference card summarizes the SPEAR function codes, system event codes, and provides other useful information.

If SPEAR is unavailable, consult the operating system manager for permission to run the subsystem diagnostics. This will involve a temporary timeout in customer system use.

**4.4.23 Block 23 - Did SPEAR Pick Out A Bad FRU?**

If the SPEAR program did not pick out a failing FRU, consult with the operating system manager to see if the suspect disk drive can be taken off-line to run the drive-resident diagnostics with the hand held terminal. It is important to consult with the system manager before taking the drive off-line since the operating system may depend on the disk pack for a system image or back-up file.

After approval is received, place the suspect disk off-line by releasing the two port switches on the front of the drive. Then run the drive-resident diagnostics described in block 7.

If the SPEAR program suggests a faulty FRU, go to block 24.

## 52 FAULT ISOLATION

### 4.4.24 Block 24 - Replace The FRU Suggested By SPEAR

Again, consult the system manager before placing the disk drive off-line. If the drive is already off-line, then there is no danger of bringing down the customer's operating system. The disk drive is placed off-line by releasing the two front panel port switches. Use the *RA60 Service Manual* to see how to replace the FRU.

### 4.4.25 Block 25 - Obtain System Manager Approval

It is strongly recommended to consult the system manager before you remove the disk drive off-line in case the operating system depends on the disk drive in question for a system image or back-up file.

The customer must relinquish the system before you can run the host-resident subsystem diagnostics. Go to block 10 to see how to run the subsystem level diagnostics.

## READER'S COMMENTS

RA60 Maintenance Guide  
AA-M880B-TC

This Pocket Service Guide is intended for *Field Service Technicians*. Your comments and suggestions will help us in our continuous effort to improve its quality and usefulness.

What is your general reaction to this Pocket Service Guide?

	Excellent	Very Good	Good	Fair	Poor
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