

RA60 Disk Drive Service Manual

RA60 Disk Drive Service Manual

Prepared by Educational Services
of
Digital Equipment Corporation

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PREFACE

This service manual provides the information needed to implement the RA60 Disk Drive corrective maintenance procedures.

Chapter 1 describes the RA60 maintenance features, the RA60 maintenance philosophy, and a list of related documentation used for the RA60 Disk Drive.

Chapter 2 describes the detailed removal and replacement procedure for each RA60 FRU. Chapter 2 also contains a list of all FRU's and their part numbers.

Chapter 3 describes how to use the drive resident diagnostics. Following this, a description of each utility routine and diagnostic test is presented.

Chapter 4 describes the theory of operation of the RA60 Disk Drive.

Chapter 5 describes the fault isolation procedures that Field Service engineers use to troubleshoot the disk drive.

Chapter 6 describes the installation procedures necessary to install and check-out the RA60 Disk Subsystem.

CHAPTER 1 INTRODUCTION

1.1 INTRODUCTION

This chapter has general information about the RA60 Disk Drive. It also describes the RA60 maintenance features, philosophy, and lists the RA60 related 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 per port. A dual drive configuration attached to a mid-range system via the UDA50 SDI controller is the primary systems application.

The RA60 drive operates with a RA60-P pack. This pack is a five-platter pack (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.

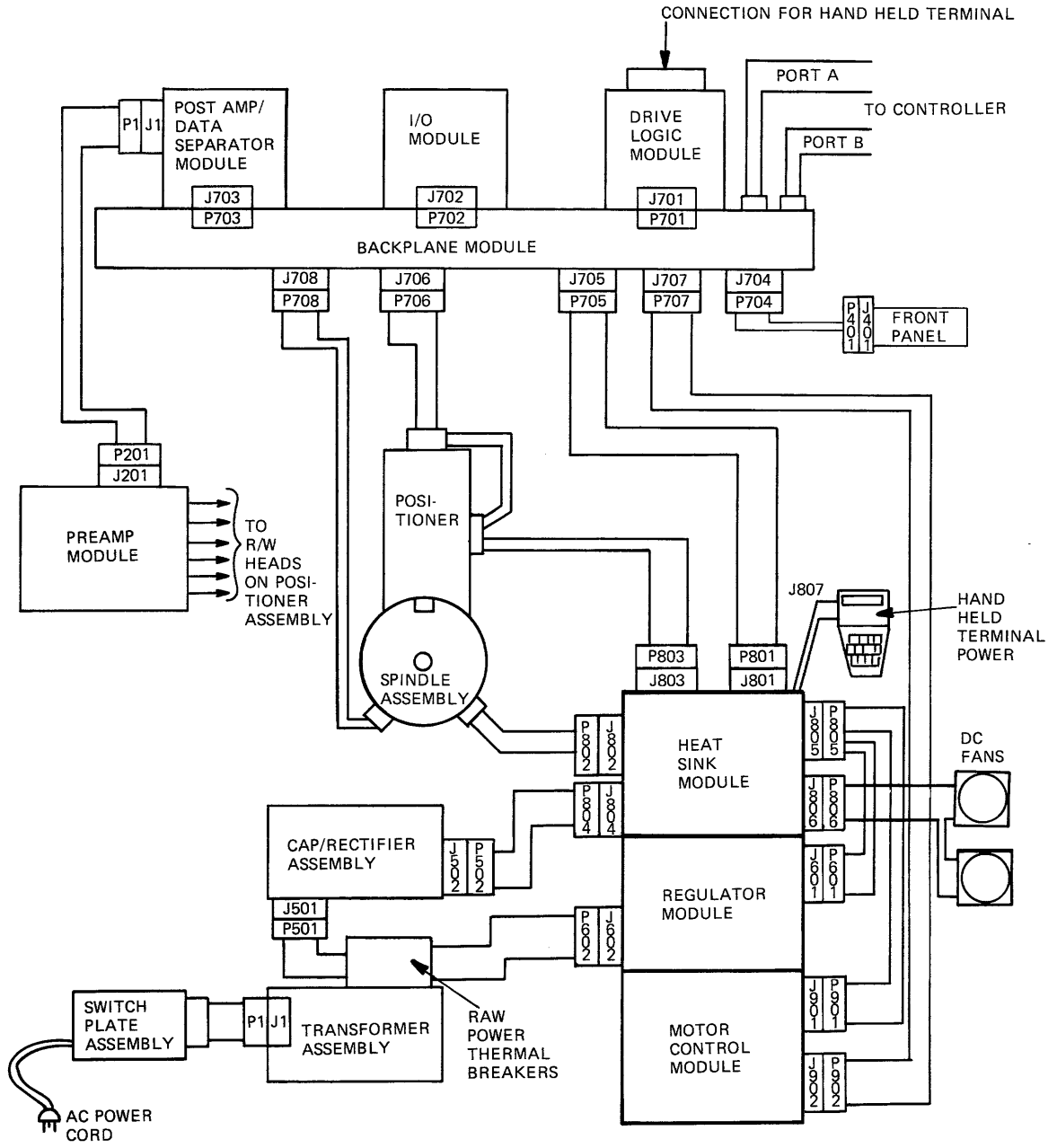
The servo information is pre-recorded on the disk at the time of production. It is read with the same head that reads and writes data.

1.3 RA60 BLOCK DIAGRAM

Figure 1-1 shows a block diagram of the RA60 Disk Drive. The function of each block is described below.

- 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—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.

- 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 electronics.
- Motor control module–controls both the spindle and the linear positioner motors.



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Figure 1-1 Simplified RA60 Block Diagram

1.4 RA60 MAINTENANCE FEATURES

The RA60 Disk Drive has been designed with great emphasis on serviceability. The drive incorporates the maintenance features listed below.

- Quick access to all field replaceable parts.
- Fault reporting by the operator control panel.
- Hand held terminal capability.
- Drive-resident diagnostic and utility routines.
- No head alignment or adjustments.

1.5 RA60 MAINTENANCE PHILOSOPHY

The repair philosophy for the RA60 is “Intelligent Module Replacement”. This is accomplished by use of the drive-resident diagnostics. The field service engineer uses these diagnostics to isolate fault conditions to the field replaceable unit (FRU) level. In addition to the drive-resident diagnostics, host-level diagnostics are available to support and verify corrective maintenance decisions.

The RA60-trained field service engineers will find the *RA60 Maintenance Guide* to be a helpful quick reference tool. The maintenance guide provides an abbreviated form of the troubleshooting information found in the service manual, though it is not designed to replace the service manual’s use as a complete source of maintenance procedures.

1.6 RA60 RELATED DOCUMENTATION

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

- *RA60 Service Manual* (EK-ORA60-SV)
- *RA60 Field Maintenance Print Set* (MP-01421)
- *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, New Hampshire 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
32 East Caribbean Drive
Sunnyvale, California 94086
Tel: 408-734-9125

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

Internal Digital Equipment Corporation customers can order the *RA60 User Guide*, the *RA60 Service Manual*, the *RA60 Field Maintenance Print Set*, and the *RA60 Illustrated Parts Breakdown* manuals directly from Printing and Circulation Services, 444 Whitney Street, Northboro, Massachusetts 01532.

The *RA60 Maintenance Guide*, the *Maintenance Guide Looseleaf Binder*, and the *UDA50 Maintenance Documentation Kit* can be ordered from the Software Distribution Center, Order Administration/Processing, 20 Forbes Road, Northboro, Massachusetts 01532.

CHAPTER 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) and supplies the RA60 FRU list, their part numbers, and the detailed procedures that are used for FRU replacement.

2.2 POWER PRECAUTIONS

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

Caution

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

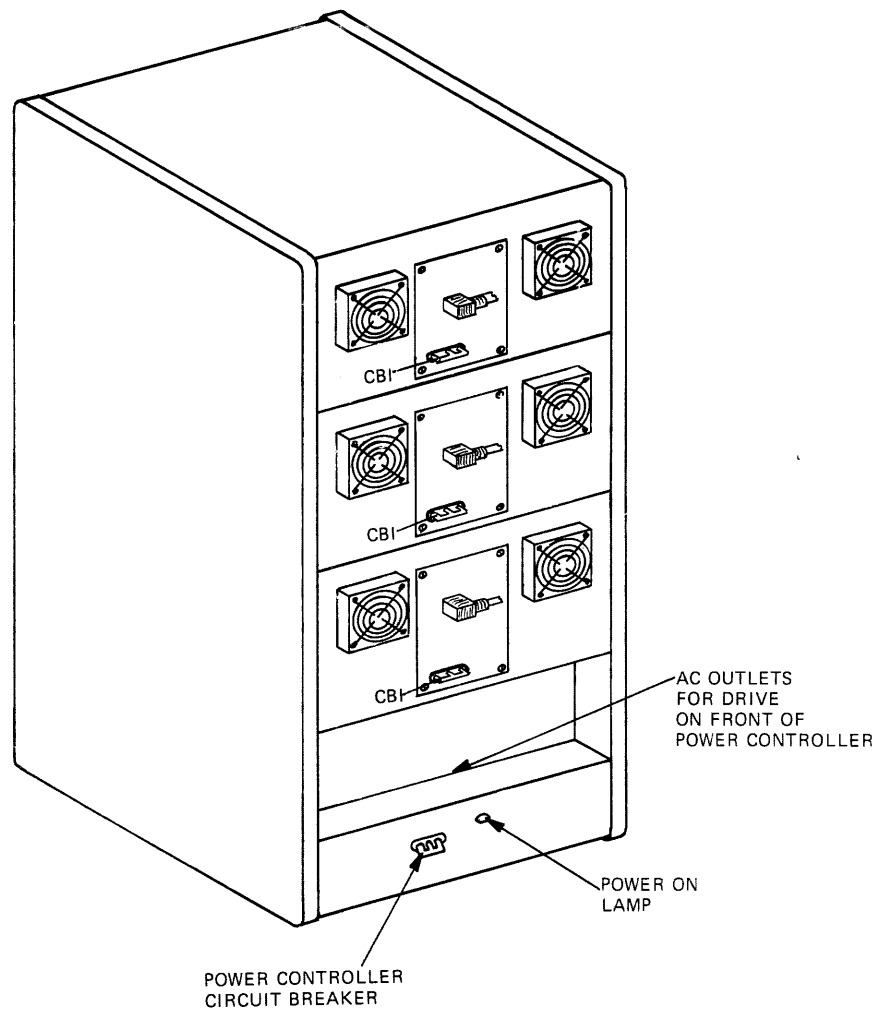
2.3 POWER SUPPLY LOCATION AND CONTROLS

The power controls for the RA60 Disk Drive and power controller (874) are shown in Figure 2-1.

2.4 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, using the instructions below.

1. To remove power to the drive internal assemblies, switch off CB1 at the back of the RA60 Disk Drive.
2. To remove power to the RA60 power supply, unplug the ac cord from the back of the drive.



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Figure 2-1 RA60 Power Controls

2.5 RA60 FRU LIST AND PART NUMBERS

Table 2-1 is a list of RA60 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

Part Number	Description
12-17556-01	Fan DC
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	Preamplifier 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
70-18461-01	R/W head A-up
70-18461-02	R/W head A-dn
70-18461-03	R/W head B-up
70-18461-04	R/W head B-dn
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 unregulated harness
70-19065-01	Spindle ground harness
70-19066-01	Positioner ground harness
70-19086-01	DC fan harness

2.6 SPECIAL TOOLS

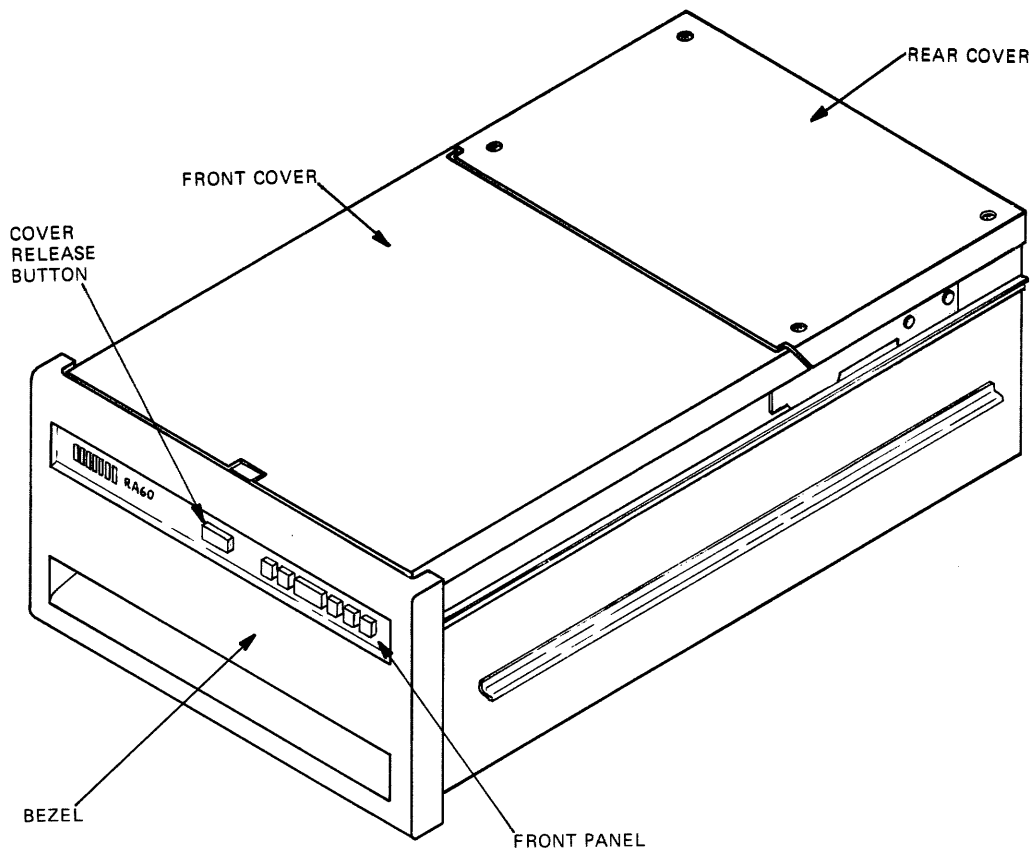
Table 2-2 lists the special tools required to maintain the RA60 Disk Drive.

Table 2-2 Special Tools

Part Number	Description
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

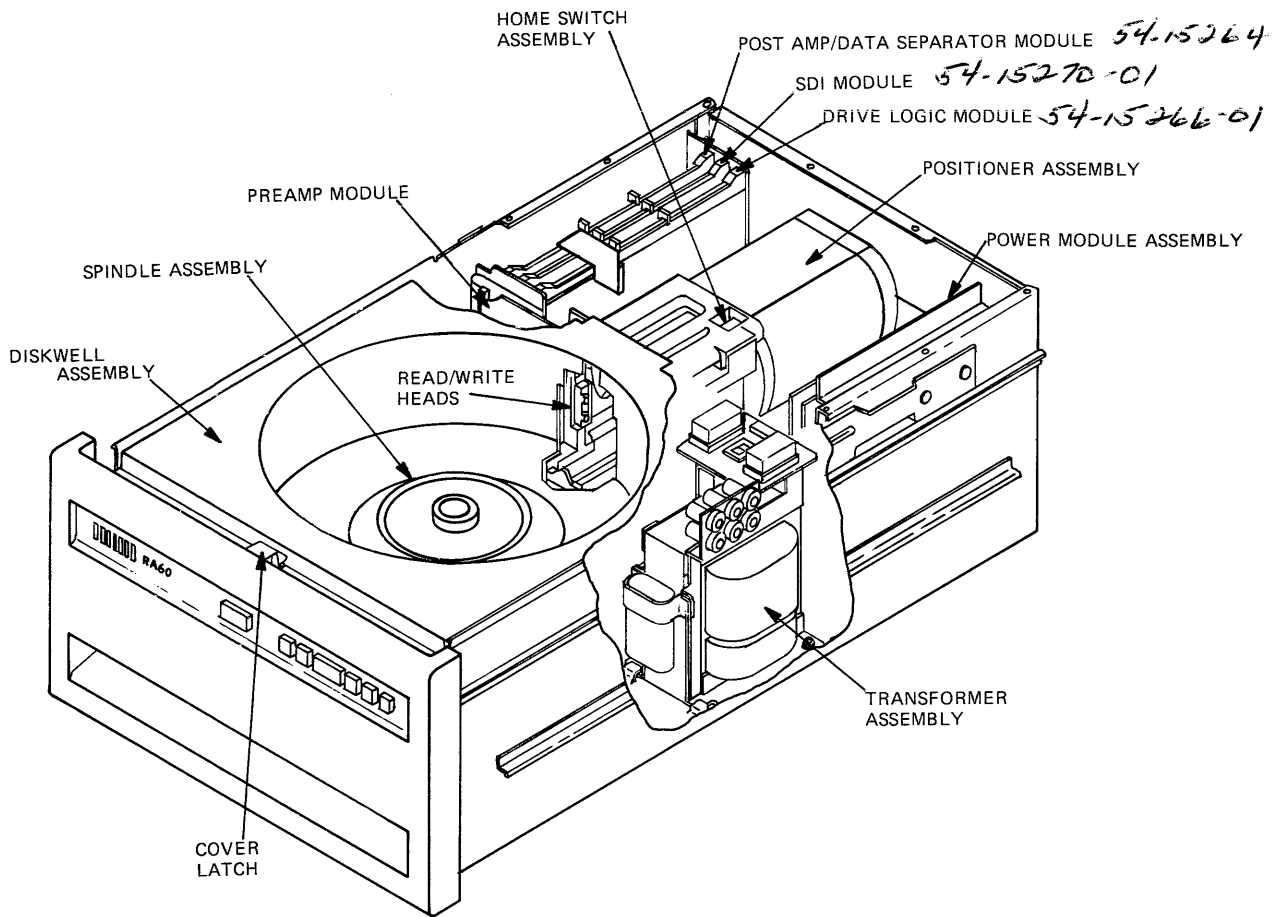
2.7 RA60 FRU LOCATION

Figures 2-2 and 2-3 show the location of the main FRUs contained within the RA60 Disk Drive.



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Figure 2-2 RA60 External FRU Location



CZ-0832

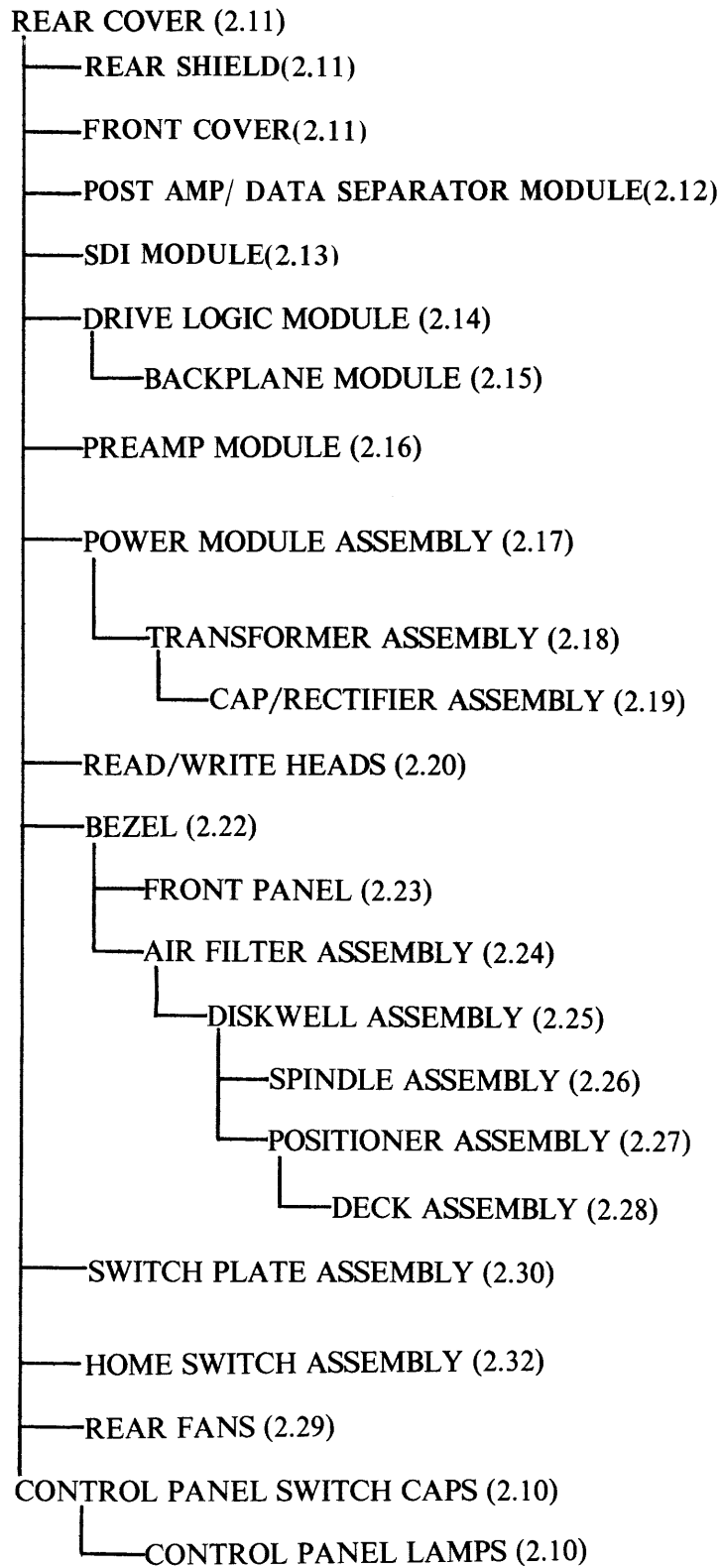
Figure 2-3 RA60 Internal FRU Location

2.8 REPLACEMENT SEQUENCE

Figure 2-4 provides a RA60 part removal sequence. To remove a part, find it on the sequential flow diagram and follow the path to the top of the diagram. Start by removing the topmost item on the path that the flow line passes through. Continue down the flow line until the correct part is reached. Paragraph numbers are provided to assist in locating the removal procedures. Parts that can be removed directly are not shown on the diagram.

Note

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



CZ-0876

Figure 2-4 Sequential Part Removal and Replacement

2.9 REMOVING THE REAR CABINET DOOR AND SIDE PANELS

Refer to Figures 2-5 and 2-6 while performing this procedure.

1. Unlock the rear door with a 5/32 inch hex key.
2. Disconnect the green/yellow striped ground wire using a Phillips screwdriver.
3. Unlatch the rear door and lift it off the frame assembly.
4. Remove the side panels by loosening the screws on the two side panel locks and then lift the locks off.
5. Lift the side panels up and away from the cabinet.
6. Unscrew the green/yellow ground wire from the cabinet and set the side panel aside.

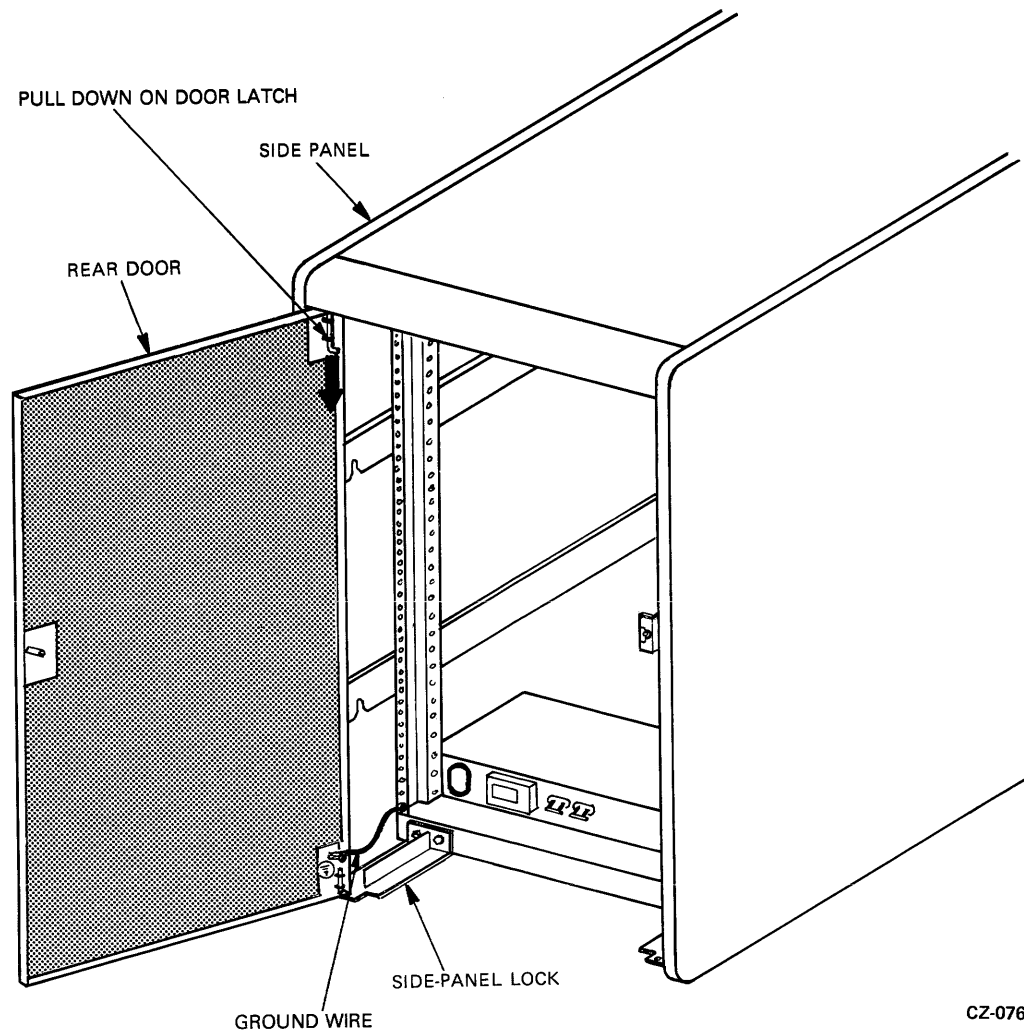


Figure 2-5 Rear Door Removal

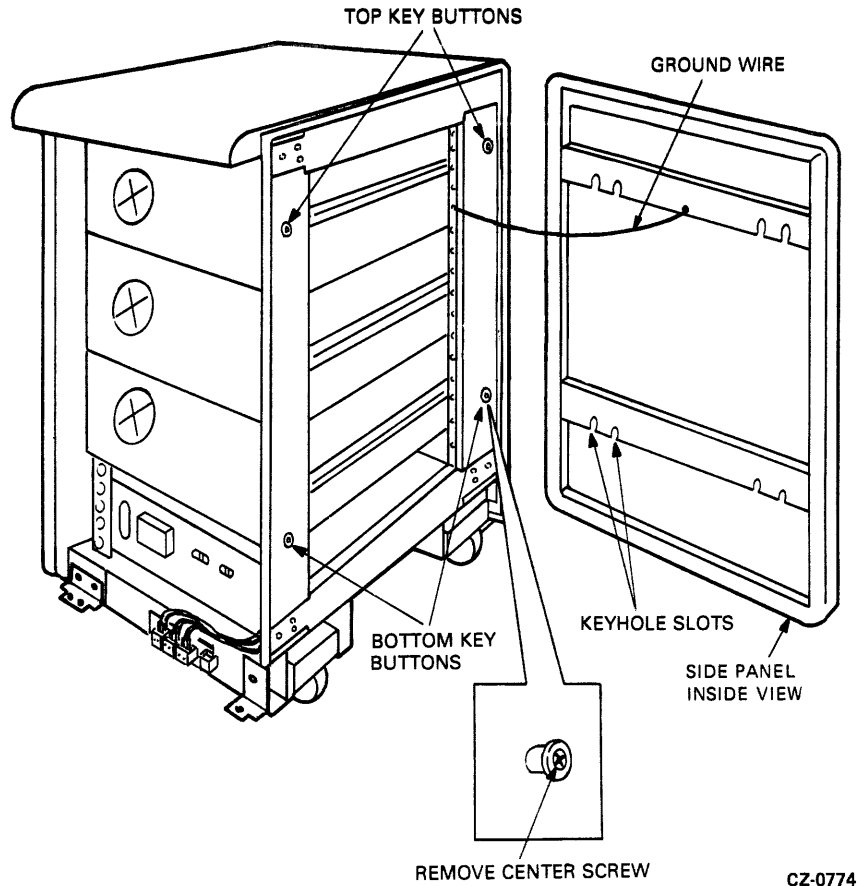


Figure 2-6 Side Panel Removal

2.10 REMOVING THE SWITCH CAPS AND LIGHTS

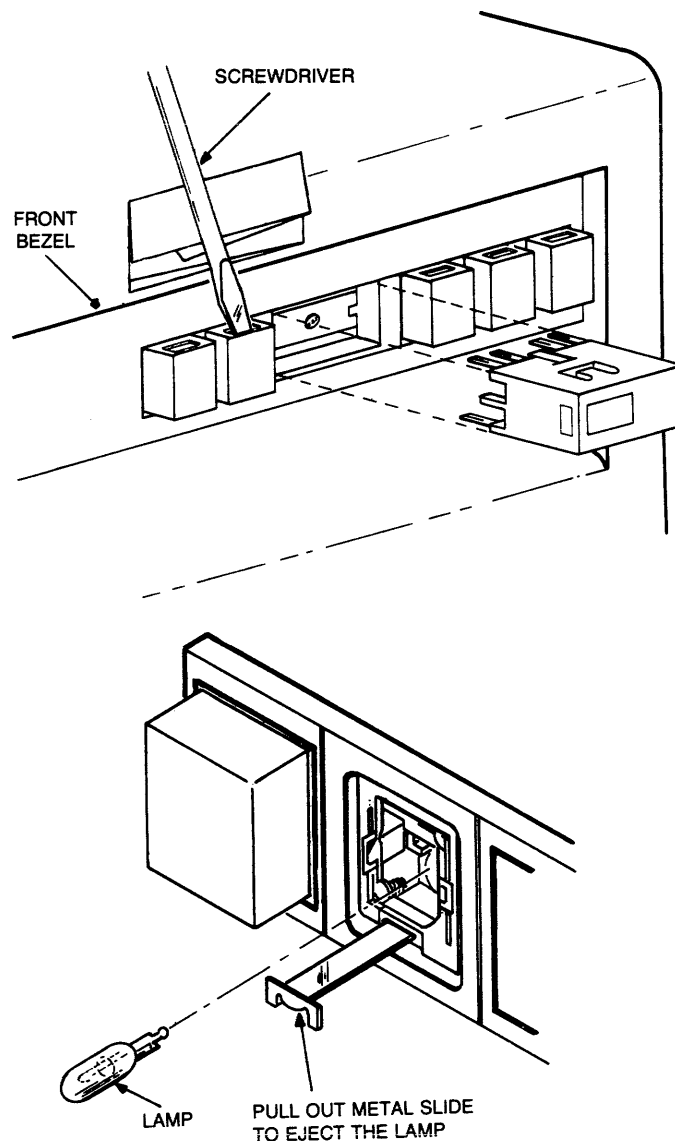
Refer to Figure 2-7 while performing this procedure

1. Turn off power from the drive by turning off CB1 at the back of the drive.
2. Remove front panel switch caps by prying the recessed side of the cap with a screwdriver.

Note

A piece of paper or some other material should be used as a protection to prevent scratching the bezel.

3. Remove the light by reaching into the switch opening and pull on the metal slide. The light will pull forward with the slide.
4. Insert the new light using the flat portion of the screwdriver. Push the light into the holder as far as it will go.
5. Replace the switch cap by pushing it into the switch opening as far as it will go, using only a small amount of pressure to snap it into place.



CZ-0636

Figure 2-7 Switch Cap and Light Removal

2.11 ACCESS TO THE INSIDE OF THE DRIVE

Refer to Figure 2-8 while performing this procedure.

1. Apply power to the drive by turning on CB1 at the back of the drive. Then release the catch by pressing the cover release button on the bezel.
2. Turn off power to the drive by turning off CB1 at the back of the drive.
3. Remove the four screws holding the rear cover in place and then lift it off the drive. The front cover needs to be raised about three inches before the rear cover can be removed.
4. Remove the four screws holding the rear shield in place.

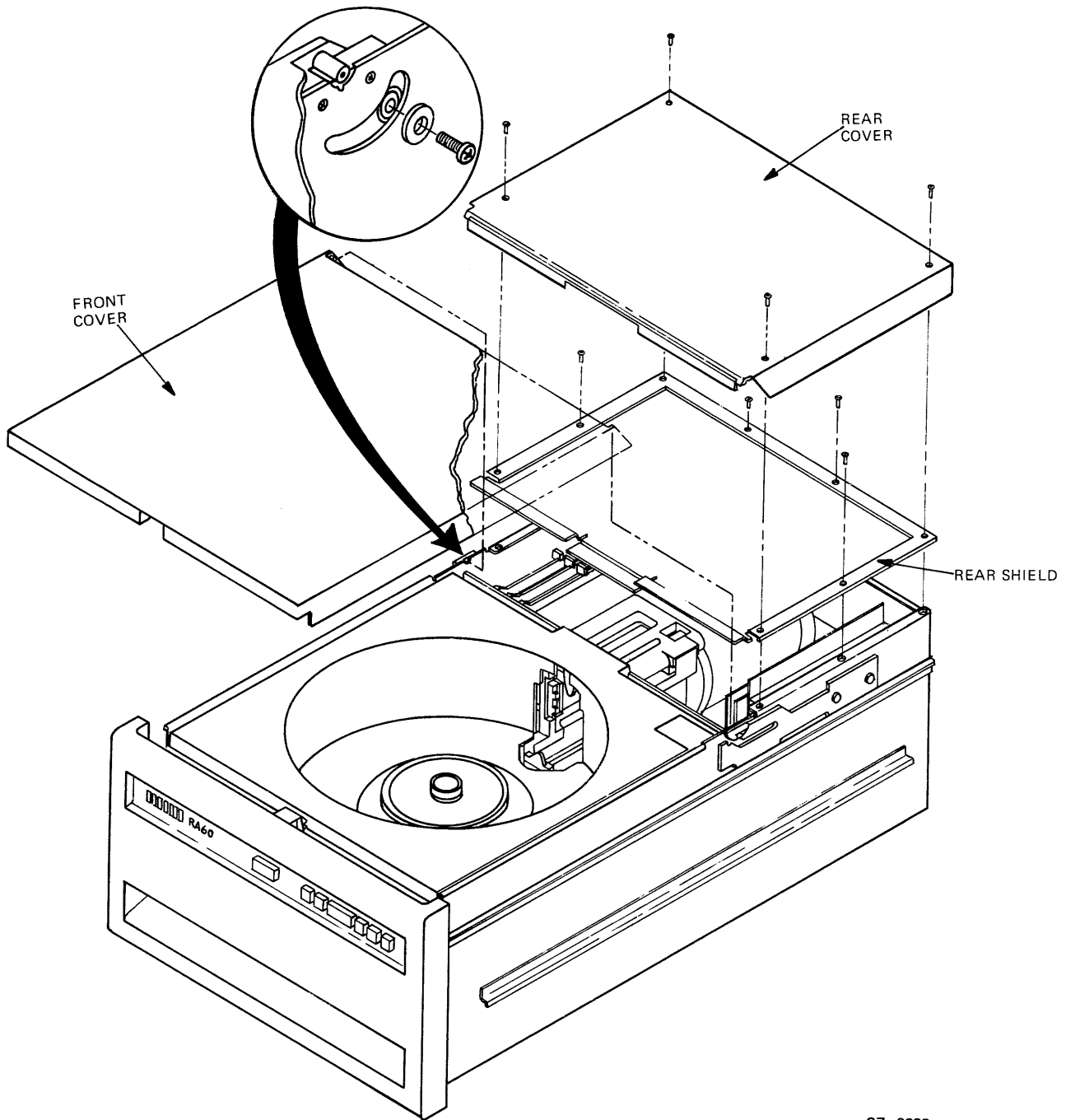


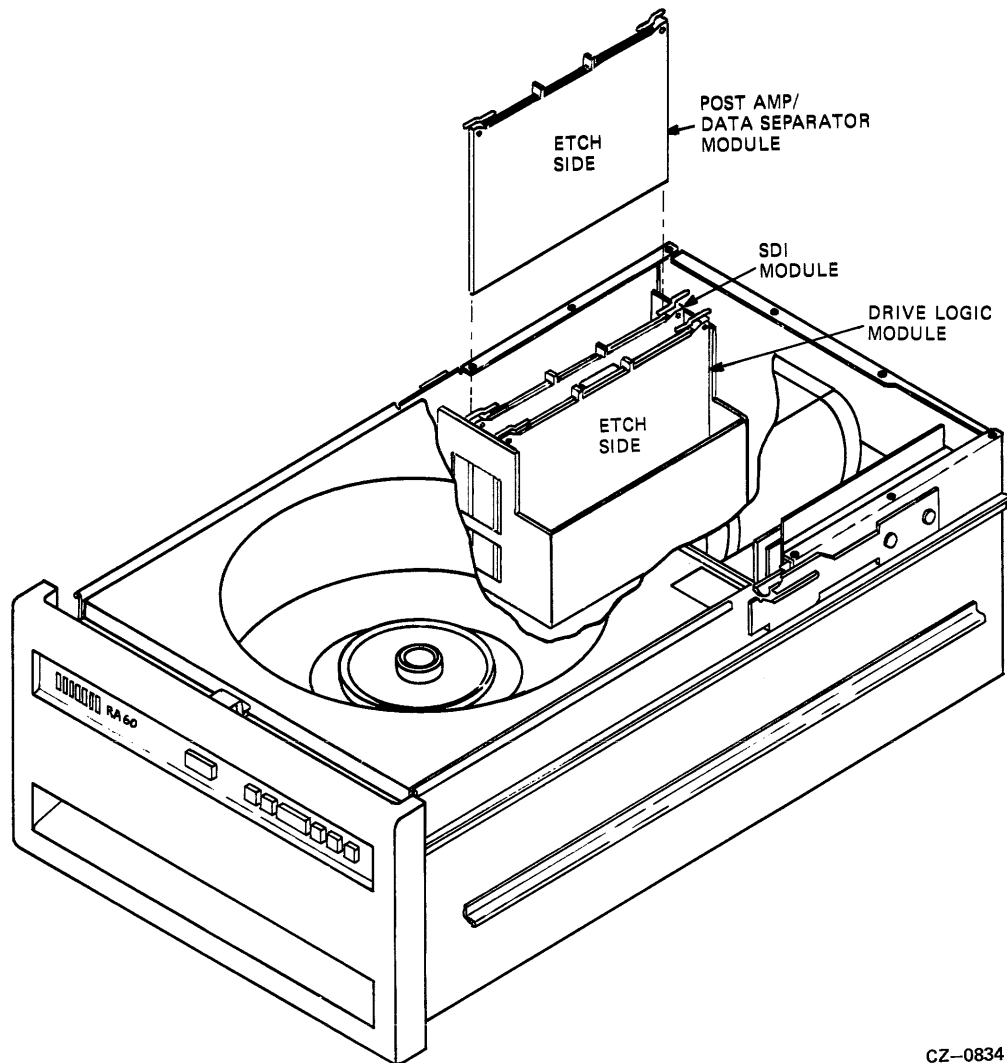
Figure 2-8 Access to the Inside of the Drive

5. Remove the rear shield by lifting the back end of the shield and sliding it toward the rear of the drive.
6. Remove the screws located on the back of each side of the front cover.
7. Raise the front cover completely to the rear and then lift it off the drive.

2.12 REMOVING THE POST/AMP DATA SEPARATOR MODULE

Refer to Figure 2-9 while performing this procedure.

1. Turn off power to the drive.
2. Remove the rear cover and rear shield (Paragraph 2.11).
3. Disconnect the cable (P1) from the post/amp data separator module.
4. Lift the module straight up from the logic cage.



CZ-0834

Figure 2-9 Removing the Logic Modules

2.13 REMOVING THE SDI MODULE

Refer to Figure 2-9 while performing this procedure.

1. Turn off power to the drive.
2. Remove the rear cover and rear shield (Paragraph 2.11).
3. Lift the SDI module straight up from the logic cage.

2.14 REMOVING THE DRIVE LOGIC MODULE

Refer to Figure 2-9 while performing this procedure.

1. Turn off power to the drive.
2. Remove the rear cover and rear shield (Paragraph 2.11).
3. Lift the drive logic module straight up from the logic cage.

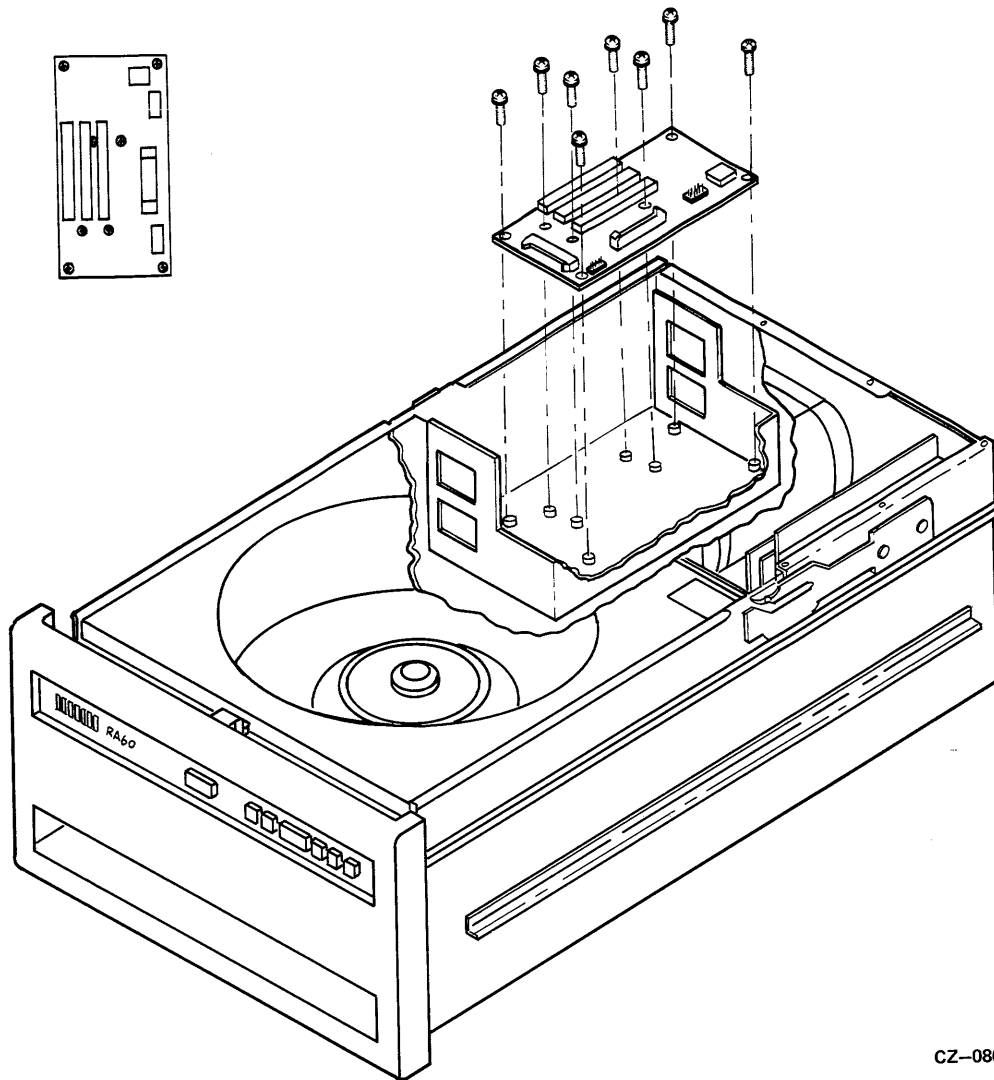
Caution

Ensure that the above modules are installed in their proper locations. Failure to do so could damage the modules.

2.15 REMOVING THE BACKPLANE MODULE

Refer to Figures 2-9 and 2-10 while performing this procedure.

1. Turn off power to the drive.
2. Remove the rear cover and rear shield (Paragraph 2.11)
3. Remove the post/amp data separator, SDI, and drive logic modules (Paragraphs 2.12, 2.13, and 2.14).
4. Disconnect all cables to the backplane module.
5. Remove the eight screws holding the backplane module in place.
6. Remove the backplane module by lifting it so it will clear the card cage and the cap/rectifier assembly mounting tabs.



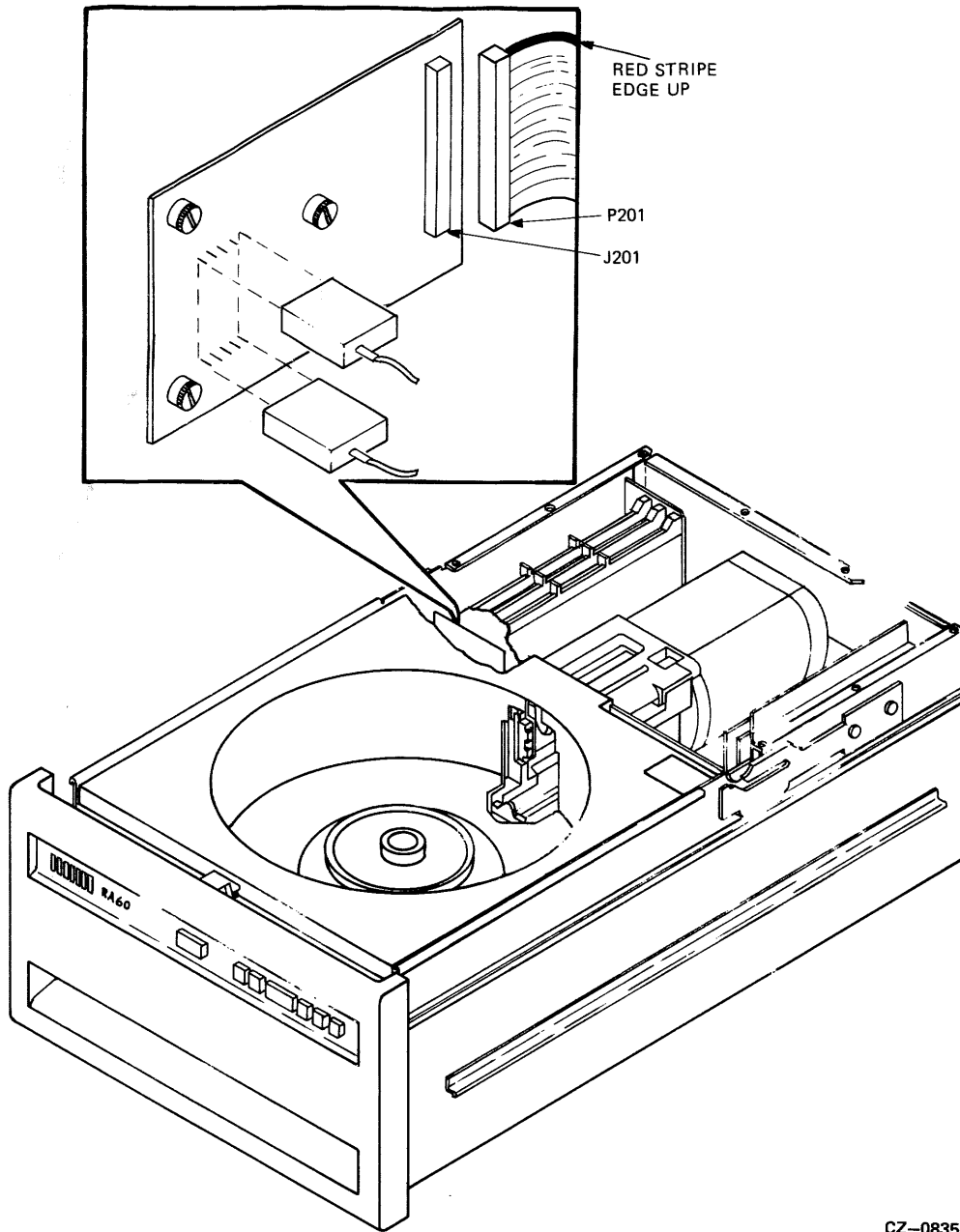
CZ-0865

Figure 2-10 Removing the Backplane Module

2.16 REMOVING THE PREAMP MODULE

Refer to Figure 2-11 while performing this procedure.

1. Turn off power to the drive.
2. Remove the rear cover and rear shield (Paragraph 2.11).
3. Disconnect P201 from the preamp module.
4. Disconnect the read/write connectors from the preamp module.
5. Loosen the three captive screws holding the preamp module in place.
6. Remove the preamp module from the drive.



CZ-0835

Figure 2-11 Removing the Preamplifier Module

2.17 REMOVING THE POWER MODULE ASSEMBLY

Refer to Figure 2-12 while performing this procedure.

1. Turn off power to the drive.
2. Remove the rear cover and rear shield (Paragraph 2.11)
3. Disconnect all connectors from the heat sink module.
4. Disconnect connector P602 from the regulator module.
5. Disconnect connector P902 from the motor control module.
6. Loosen the four captive screws holding the power module assembly in place using a 10 inch flat bladed screwdriver (29-24193-00).
7. Lift the power module assembly straight up and remove from the drive.

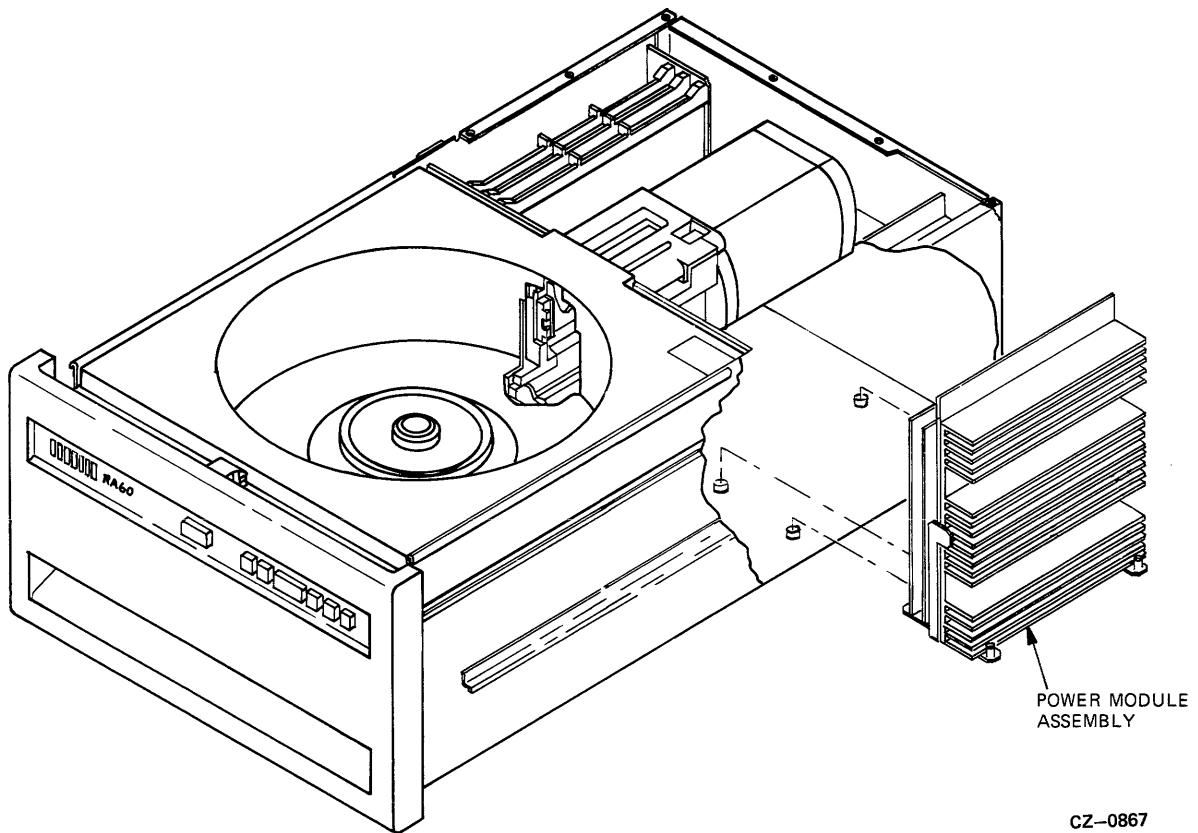
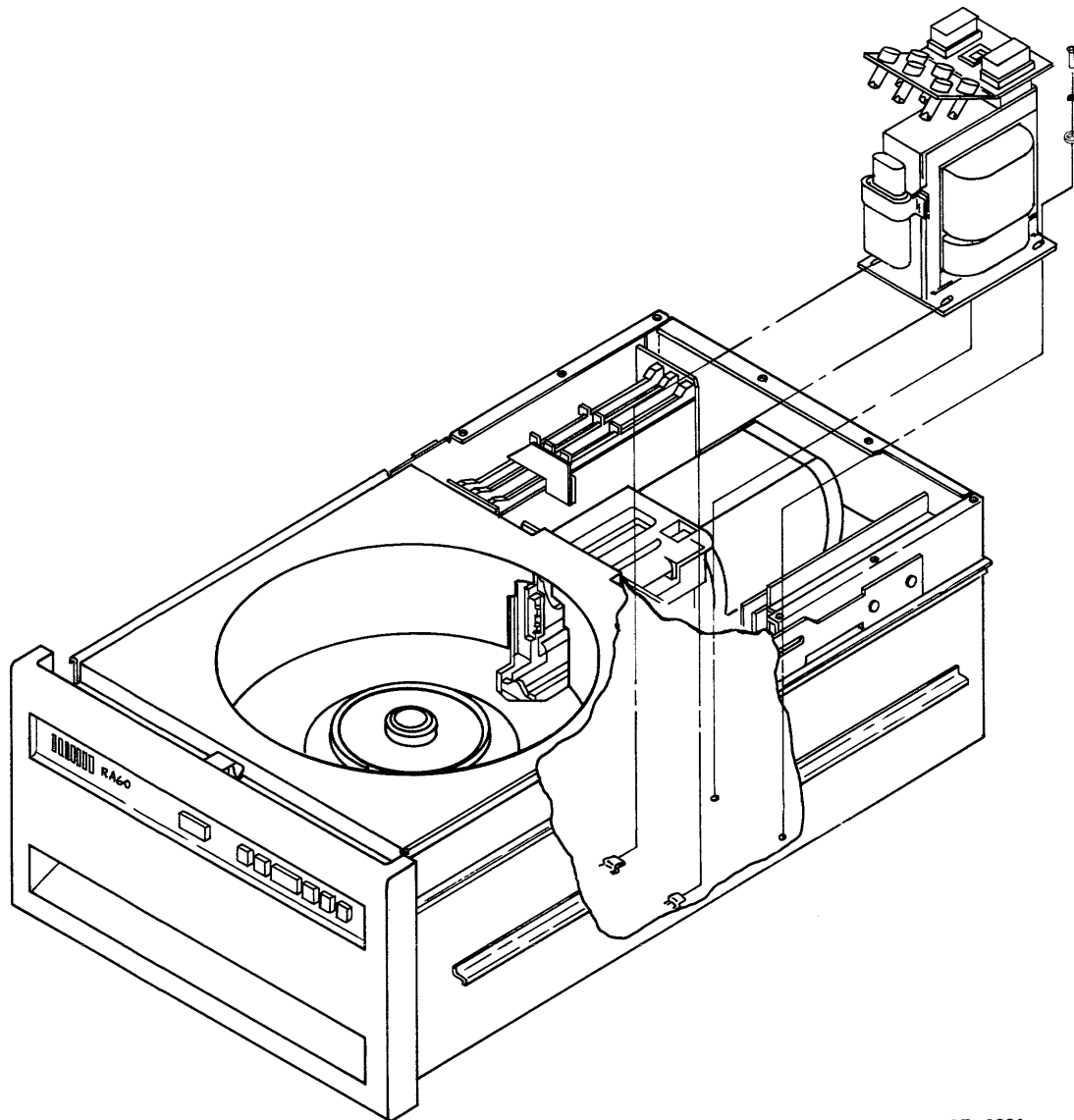


Figure 2-12 Removing the Power Module Assembly

2.18 REMOVING THE TRANSFORMER ASSEMBLY

Refer to Figures 2-12 and 2-12 while performing this procedure.

1. Turn off power to the drive.
2. Remove the rear cover and rear shield (Paragraph 2.11).
3. Remove the power module assembly (Paragraph 2.17).
4. Disconnect the harness connection J1 at the transformer assembly.
5. Remove the two screws and nylon washers holding the transformer assembly in place.
6. Disconnect the green/yellow ground wire from the chassis rear panel.
7. Slide the transformer assembly to the rear of the drive until the assembly is clear of the metal tabs holding it in place.
8. Disconnect the harness connector P501 at the cap/rectifier assembly.
9. Lift the transformer assembly out of the drive.



CZ-0861

Figure 2-13 Removing Transformer Assembly

2.19 REMOVING THE CAP/RECTIFIER ASSEMBLY

Refer to Figure 2-14 while performing this procedure.

1. Turn off power to the drive.
2. Remove the rear cover and rear shield (Paragraph 2.11)
3. Remove the power module assembly (Paragraph 2.17).
4. Remove the transformer assembly (Paragraph 2.18).
5. Unplug P502 from the cap/rectifier assembly.
6. Loosen the two screws on the cap/rectifier assembly next to the drive logic module. These screws are accessible through the top of the card cage.

Caution

These are not captive screws. Loosen only enough to slide the cap/rectifier assembly.

7. Slide the capacitor assembly from underneath the deck assembly.
8. Lift and rotate up to remove the cap/rectifier assembly from the drive.

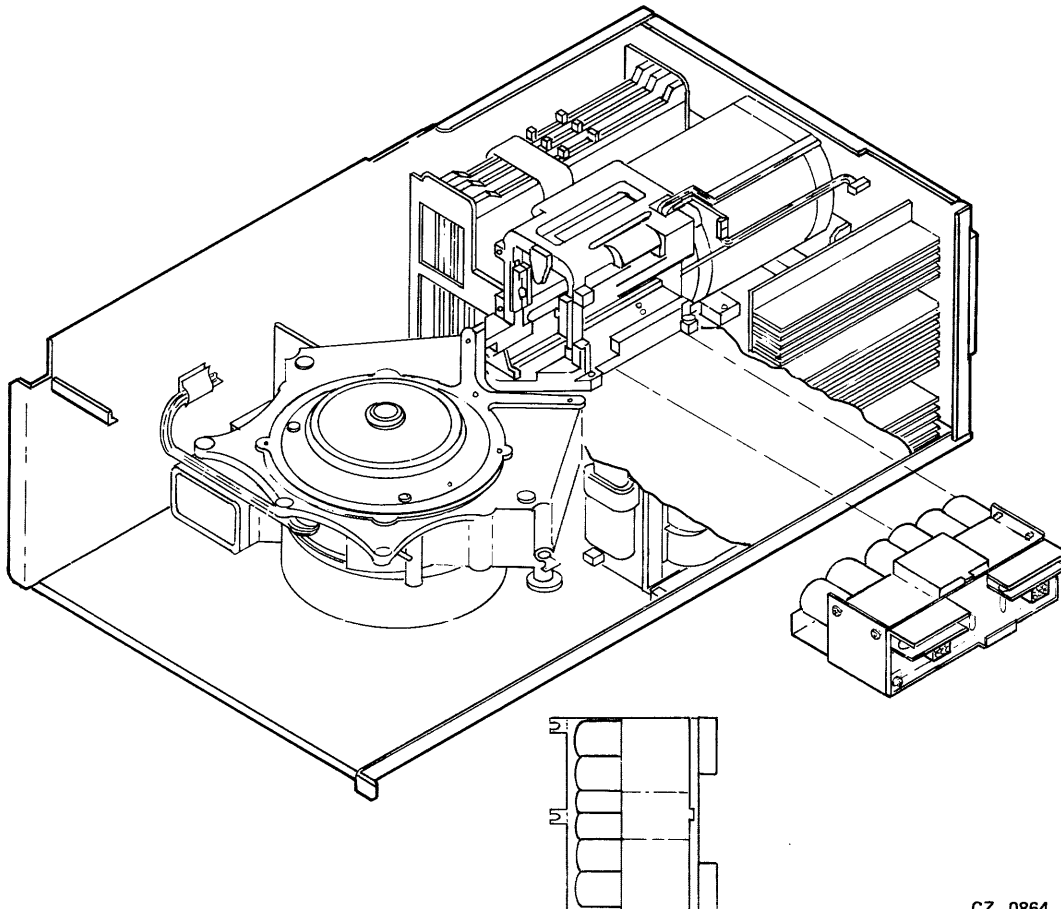


Figure 2-14 Removing Cap/Rectifier Assembly

CZ-0864

2.20 REMOVING THE READ/WRITE HEADS

Refer to Figures 2-15, 2-16, and 2-17 while performing this procedure.

1. Stop the drive from spinning by releasing the RUN/STOP switch.
2. Press the cover release button on the front of the drive and raise the front cover.
3. Remove the disk pack from the drive.
4. Turn off CB1 at the back of the drive.
5. Remove both the rear and front covers and the rear shield (Paragraph 2.11).
6. Disconnect the head cable of the desired read/write head from the preamp module.

Note

The power module assembly must be removed when the A side heads are removed (Paragraph 2.16). The transformer assembly must be moved toward the rear of the drive. The A side heads are located on the lower right side of the carriage assembly.

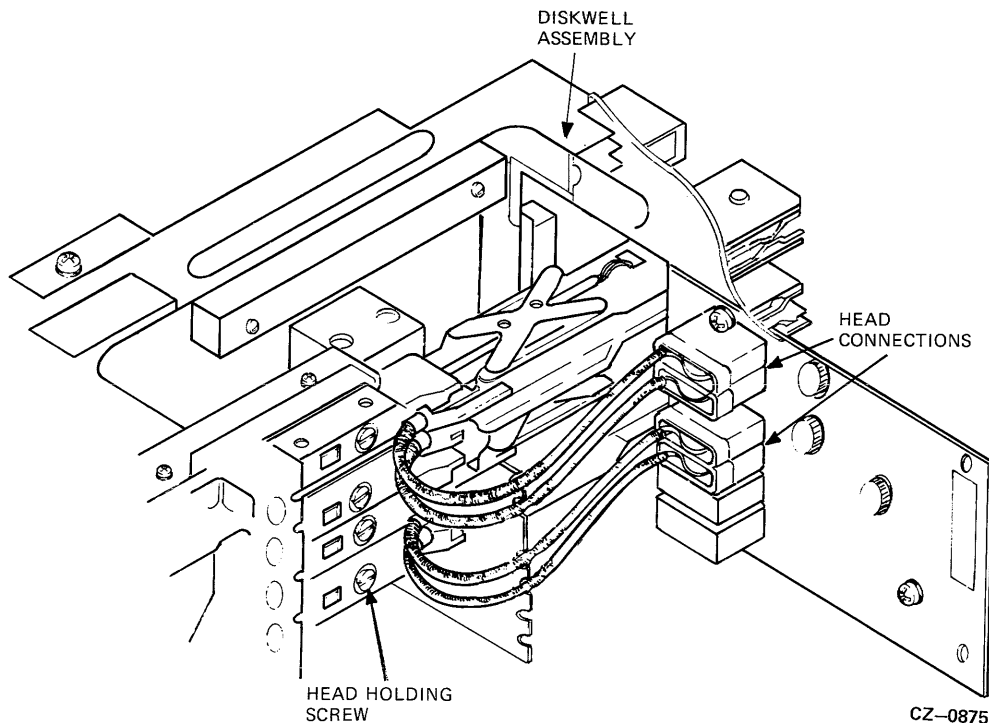


Figure 2-15 The Read/Write Heads

7. Install the head insertion/removal tool (DIGITAL part #29-24194-00) on the defective head. Refer to Figures 2-16 and 2-17.
8. Loosen the screw holding the desired read/write head to the positioner using the torque wrench.
9. Gently slide the desired read/write head forward and remove from the drive.
10. Remove the head insertion/removal tool.

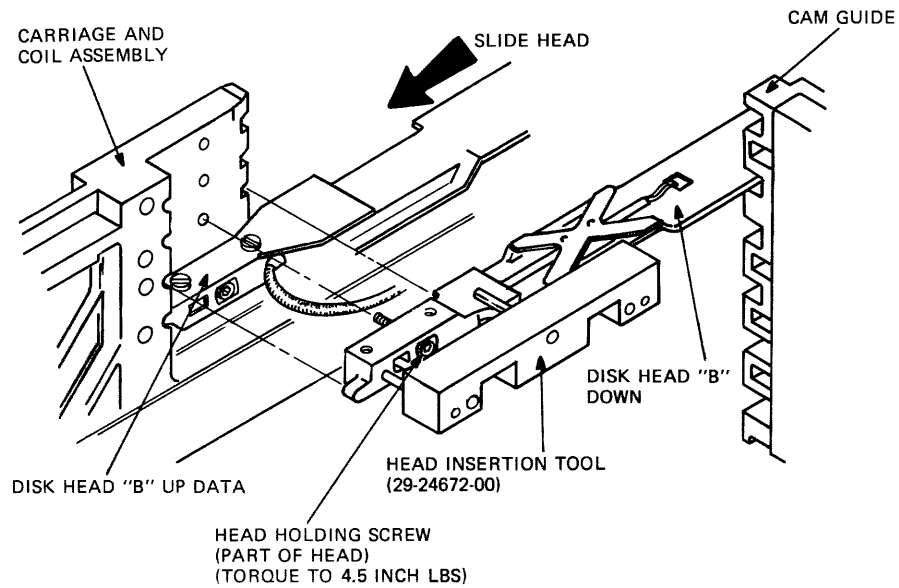
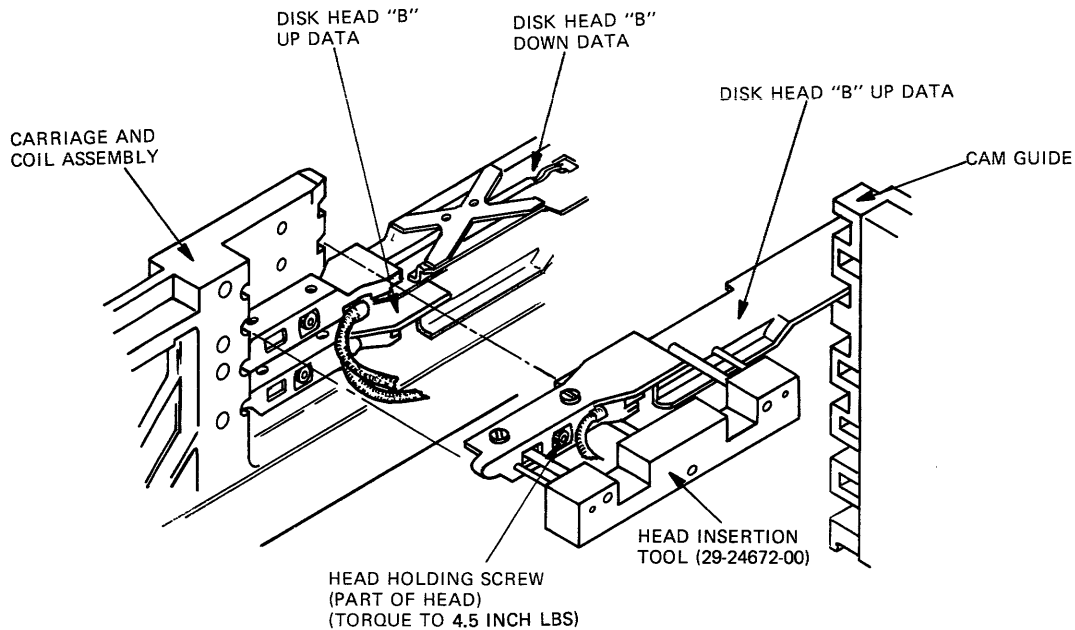


Figure 2-16 Position of Insertion Tool for Down Data Head



CZ-0836

Figure 2-17 Position of Insertion Tool for Up Data Head

2.21 REPLACING THE READ/WRITE HEADS

When replacing any read/write head, reverse the removal procedure (Paragraph 2.21).

Caution

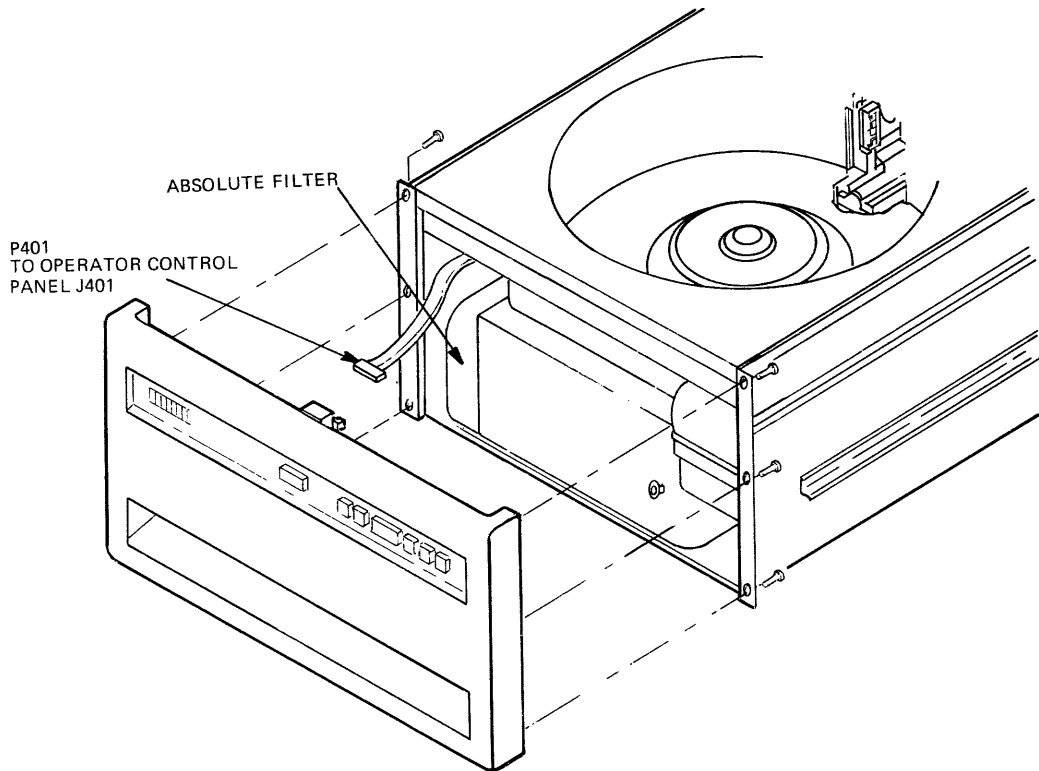
Be careful to keep the new head and the already installed heads from connecting.

1. Make sure that the new read/write head is completely inserted in the carriage and is flush with the back of the carriage.
2. Turn the new read/write head to 4.5 inch/pounds using the torque wrench. DIGITAL part #29-24194-00 .

2.22 REMOVING THE BEZEL

Refer to Figure 2-18 while performing this procedure.

1. Press the cover release button on the front of the drive and raise the front cover.
2. Turn off power to the drive.
3. Loosen the two captive screws at the back of the drive which hold it in place. Then slide the drive forward about six inches.
4. Remove the six screws holding the bezel in place.
5. Disconnect P401 from the front panel module.
6. Pivot the bezel so that the cover catch retainer will clear the chassis-cross brace.



CZ-0837

Figure 2-18 Removing the Bezel

2.23 REMOVING THE CONTROL PANEL

Refer to Figure 2-19 while performing this procedure.

1. Turn off power to the drive.
2. Remove the bezel (Paragraph 2.22).
3. Disconnect P401 from the operator panel.
4. Remove the screws holding the operator panel and the cover catch retainer to the bezel.
5. Remove the cover catch retainer.
6. Remove the operator panel from the bezel.

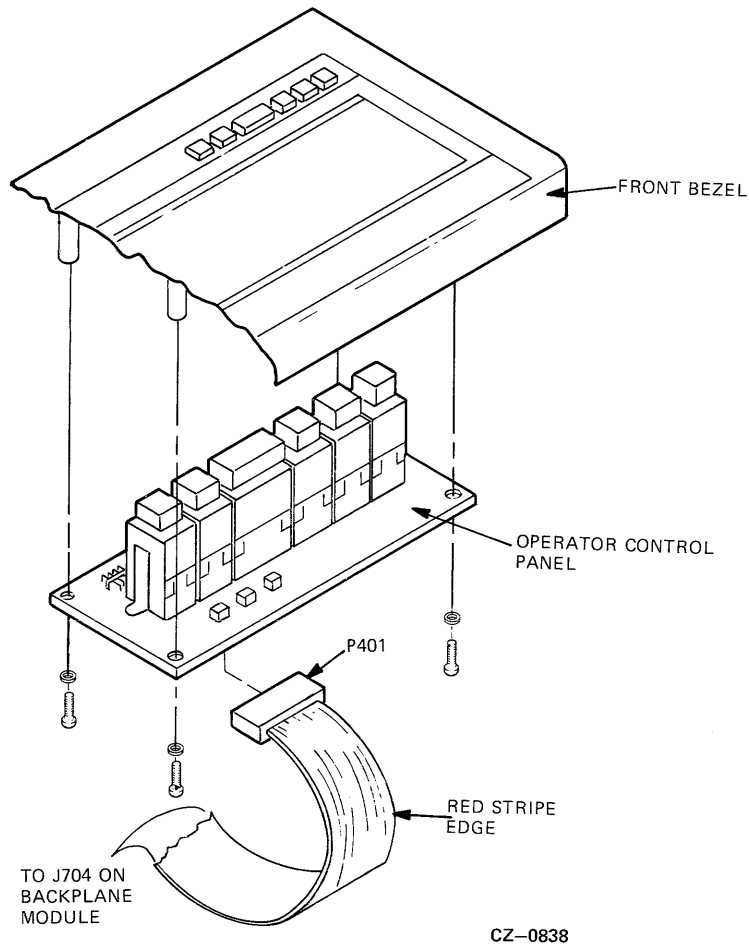


Figure 2-19 Removing the Control Panel

2.24 REMOVING THE AIR FILTER ASSEMBLY

Refer to Figure 2-19 while performing this procedure.

1. Turn off power to the drive.
2. Remove the bezel (Paragraph 2.22).
3. Disconnect the cable connector P401 from the operator panel.
4. Remove the filter clamp from the air filter assembly. This clamp is found at the right side of the filter.
5. Remove the air filter assembly by sliding it forward.

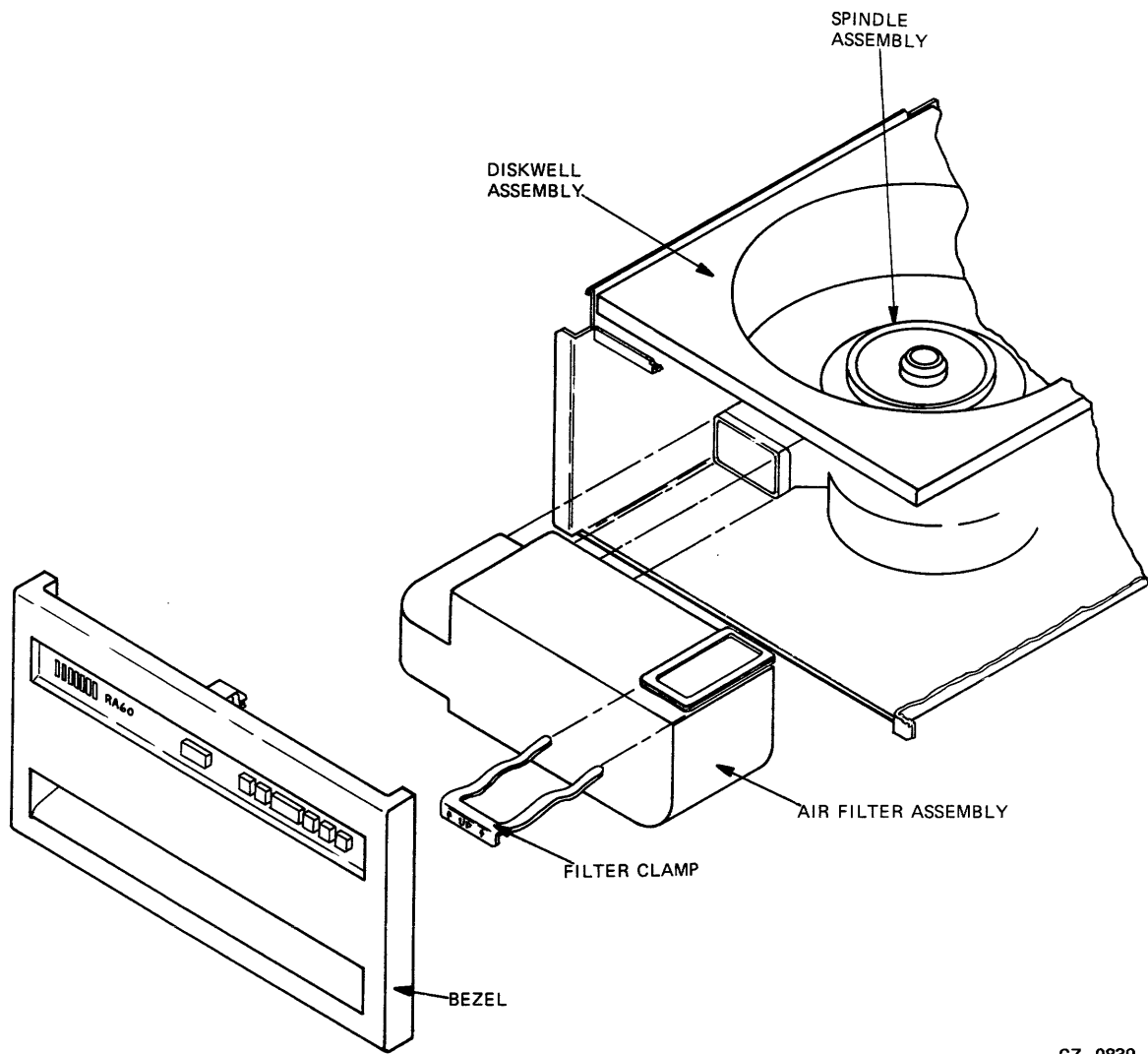
Caution

When replacing the air filter, be careful that the clamp does not get inserted upside down. Closely attend to “up” markings on the clamp. Ensure when the clamp is installed that the filter sealing gasket is compressed between the diskwell assembly and flange on the filter.

2.25 REMOVING THE DISKWELL ASSEMBLY

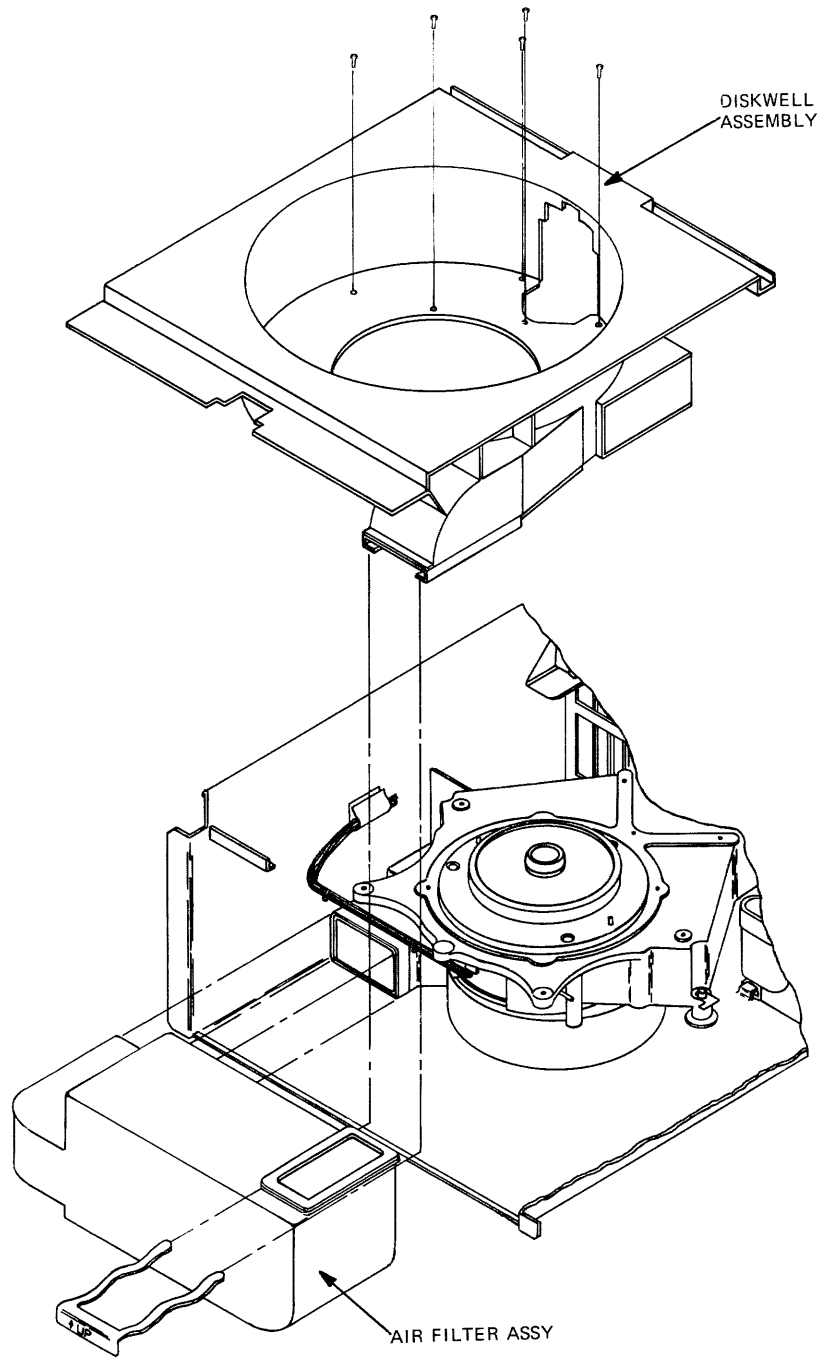
Refer to Figure 2-21 while performing this procedure.

1. Turn off power to the drive.
2. Remove the rear and front covers and rear shield (Paragraph 2.11).
3. Remove the bezel (Paragraph 2.22).
4. Disconnect P401 from the operator panel.
5. Remove the air filter assembly (Paragraph 2.24).
6. Remove the 11 screws holding the diskwell assembly in place.
7. Lift the diskwell assembly from the back. Slide the diskwell toward the back and lift out from the drive.



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Figure 2-20 Removing the Air Filter Assembly



CZ-0840

Figure 2-21 Removing the Diskwell Assembly

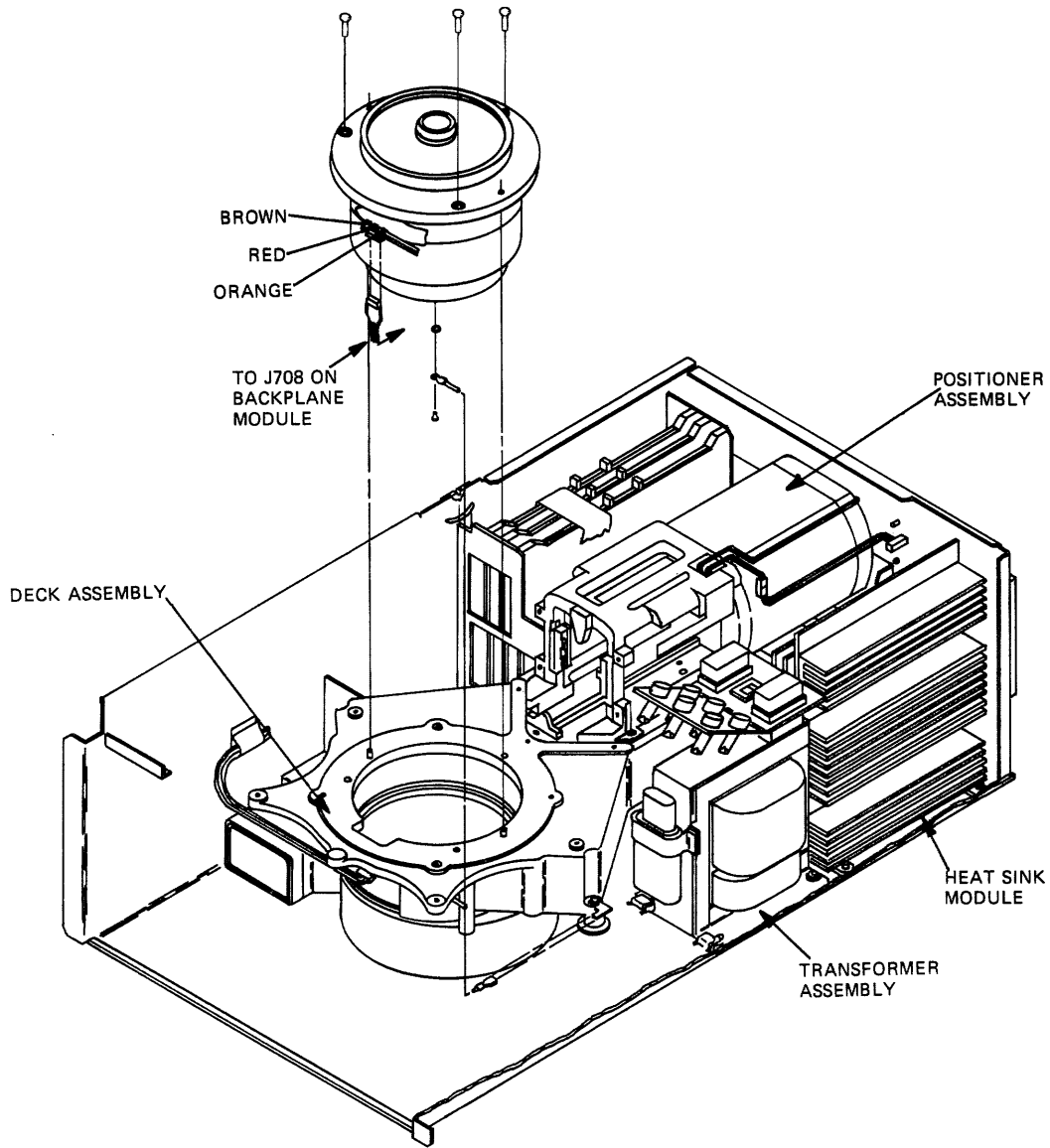
2.26 REMOVING THE SPINDLE ASSEMBLY

Refer to Figure 2-22 while performing this procedure.

1. Turn off power to the drive.
2. Remove the rear and front covers and rear shield (Paragraph 2.11).
3. Remove the bezel (Paragraph 2.22).
4. Disconnect P401 from the operator panel.
5. Remove the air filter assembly (Paragraph 2.24).
6. Remove the diskwell assembly (Paragraph 2.25).
7. Disconnect the three wires from the spindle assembly noting which wire corresponds to each tab.
8. Disconnect the ribbon cable from the spindle assembly.
9. Disconnect the ground wire from the right side of the deck mount going to the bottom of the spindle.
10. Remove the three screws which hold the spindle assembly in place.
11. Lift the spindle assembly straight up and out of the drive.

Caution

Be careful of the ground wire routing when replacing the spindle assembly.



CZ-0841

Figure 2-22 Removing the Spindle Assembly

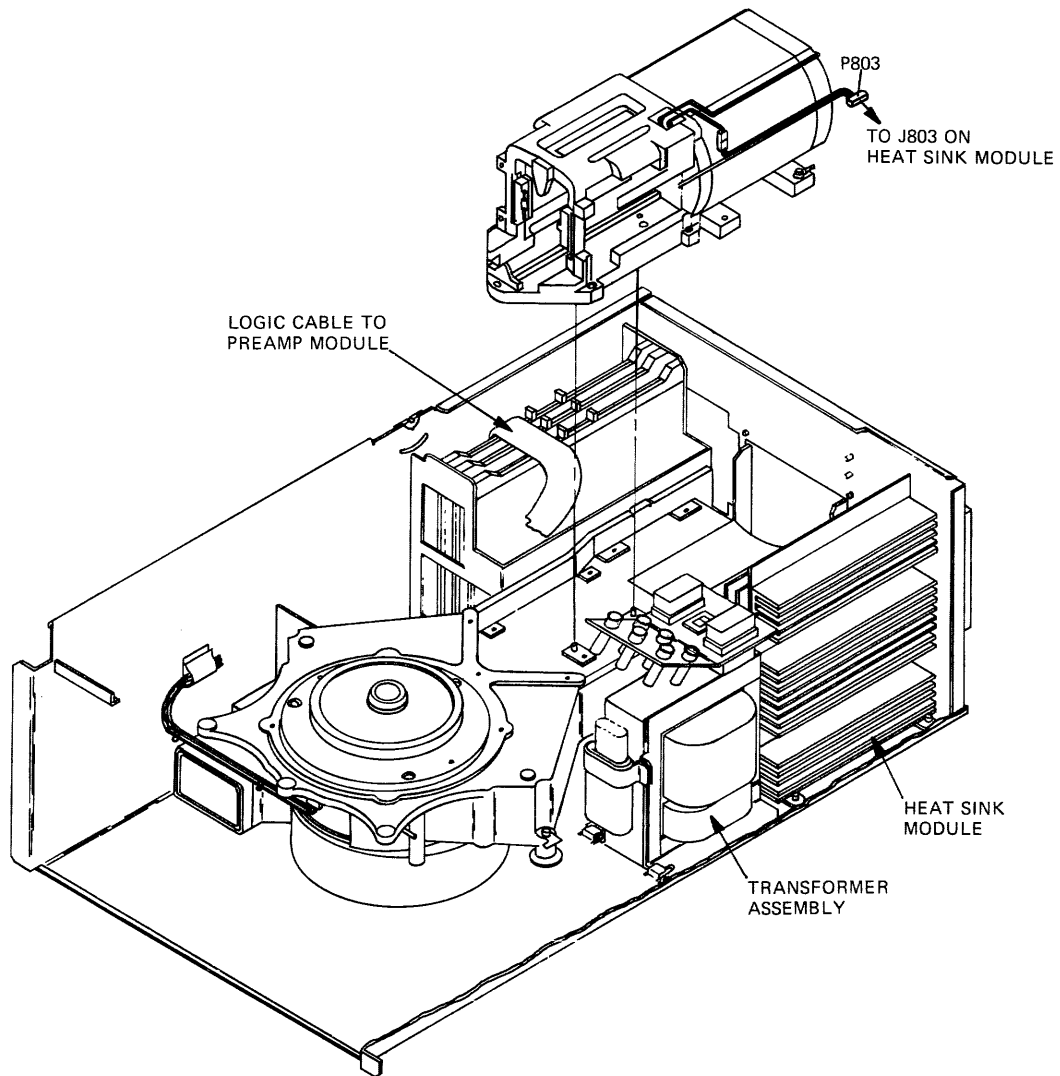
2.27 REMOVING THE POSITIONER ASSEMBLY

Refer to Figure 2-23 while performing this procedure.

1. Turn off power to the drive.
2. Remove the rear and front covers and rear shield (Paragraph 2.11).
3. Remove the bezel (Paragraph 2.22).
4. Disconnect P401 from the operator panel.
5. Remove the air filter assembly (Paragraph 2.24).
6. Remove the diskwell assembly (Paragraph 2.25).
7. Disconnect P706 from the backplane module.
8. Disconnect P803 from the heat sink module.
9. Pull the head locking pin from the storage hole on the positioner assembly and put it into the locking hole.
10. Remove the screws which hold the positioner assembly in place.
11. Lift the positioner assembly straight up and out from the drive.

Caution

When replacing the positioner assembly, ensure that the spindle ground harness is re-connected under the right rear mounting screw.



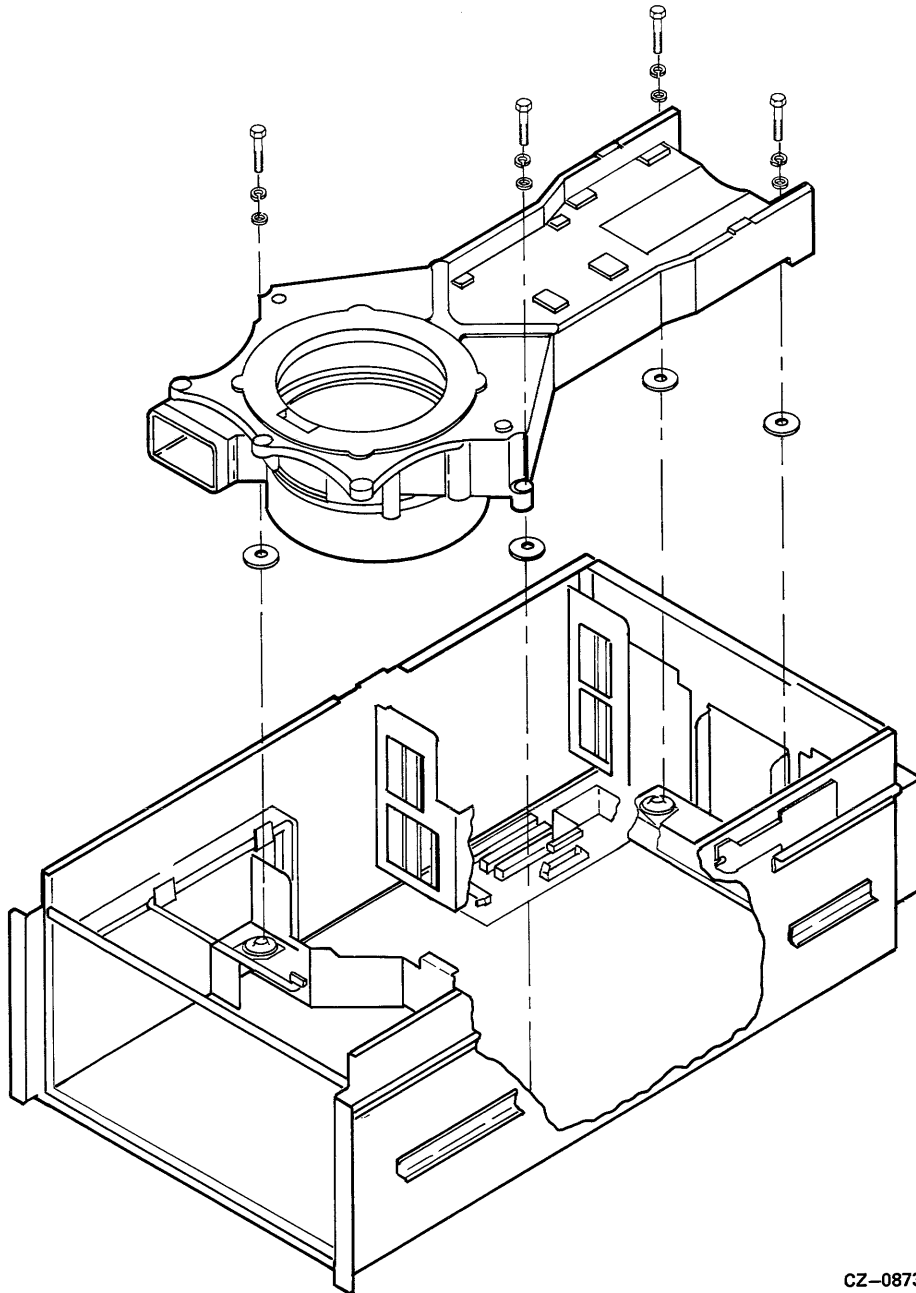
CZ-0842

Figure 2-23 Removing the Positioner Assembly

2.28 REMOVING THE DECK ASSEMBLY

Refer to Figure 2-24 while performing this procedure.

1. Turn off power to the drive.
2. Remove the rear and front covers and rear shield (Paragraph 2.11).
3. Remove the bezel (Paragraph 2.22).



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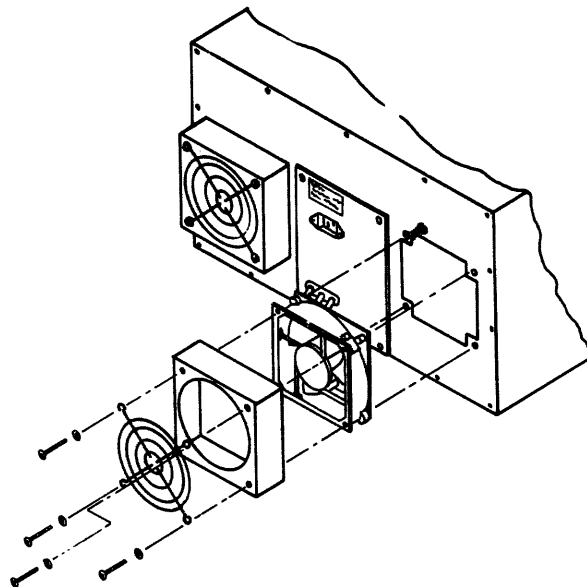
Figure 2-24 Removing the Deck Assembly

4. Disconnect P401 from the operator panel.
5. Remove the air filter assembly (Paragraph 2.24).
6. Remove the diskwell assembly (Paragraph 2.25).
7. Remove the positioner assembly (Paragraph 2.27).
8. Remove the spindle assembly (Paragraph 2.26).
9. Remove the screws holding the deck assembly in place.
10. Lift the deck assembly straight up and out of the drive.

2.29 REMOVING THE REAR FANS

Refer to Figure 2-25 while performing this procedure.

1. Turn off power to the drive.
2. Loosen the four screws holding the finger guard, fan housing and fan in place.
3. Disconnect the dc connector to the fans.
4. Remove the fan from the back of the drive.



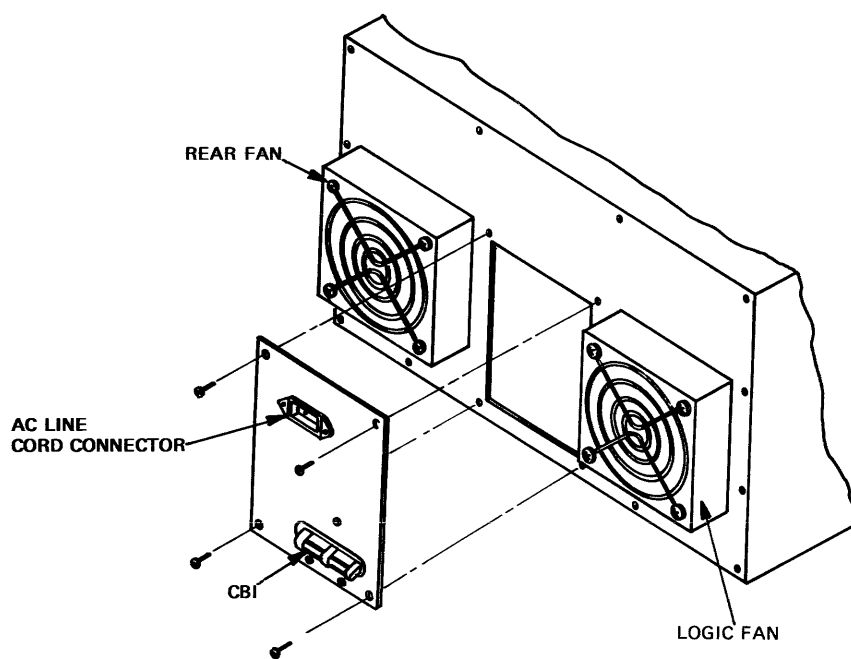
CZ-0863

Figure 2-25 Removing the Rear Fans

2.30 REMOVING THE SWITCH PLATE ASSEMBLY

Refer to Figure 2-26 while performing this procedure.

1. Turn off power to the drive.
2. Remove the rear cover and rear shield (Paragraph 2.11).
3. Disconnect the ac power cord from the switch plate assembly.
4. Remove the four screws holding the power switch assembly in place.
5. Disconnect the line filter ground.
6. Remove the switch plate assembly from the back of the drive.
7. Disconnect the three wires from the back of the power switch assembly. Remember which wire corresponds to each tab.



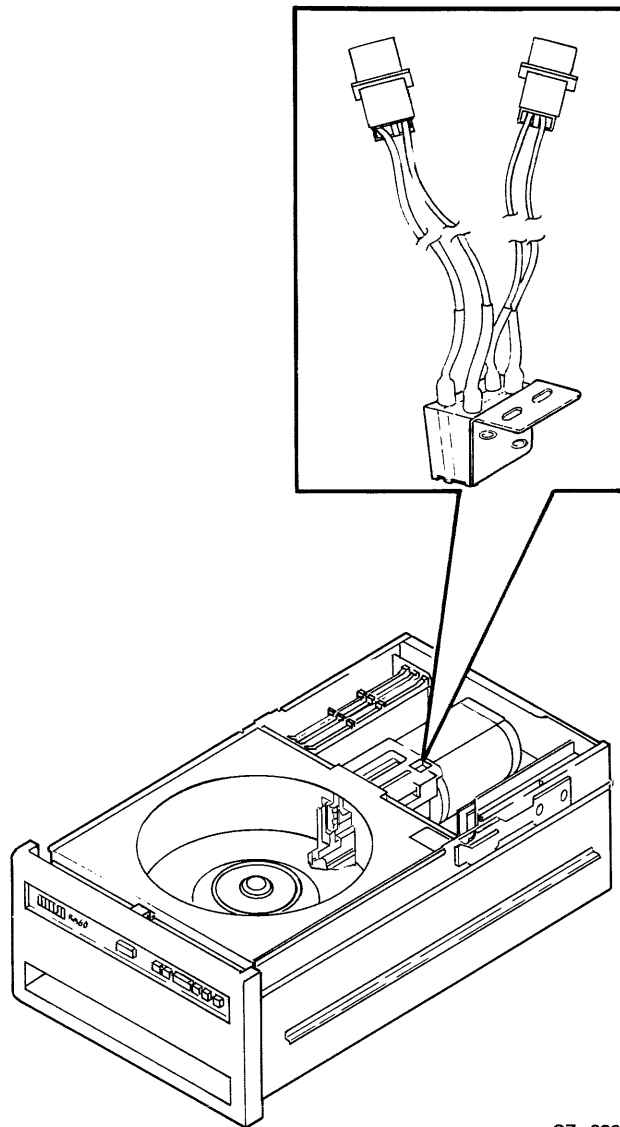
CZ-0843

Figure 2-26 Removing the Switch Plate Assembly

2.31 REMOVING THE HOME SWITCH ASSEMBLY

Refer to Figure 2-27 while performing this procedure.

1. Turn off power to the drive.
2. Remove the rear cover and rear shield (Paragraph 2.11).
3. Locate the home switch assembly on the top right side of the positioner assembly.
4. Disconnect the two pin connectors.
5. Remove the two screws holding the home switch assembly in place.
6. Remove the home switch assembly from the positioner assembly.



CZ-0862

Figure 2-27 Removing the Home Switch Assembly

CHAPTER 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.

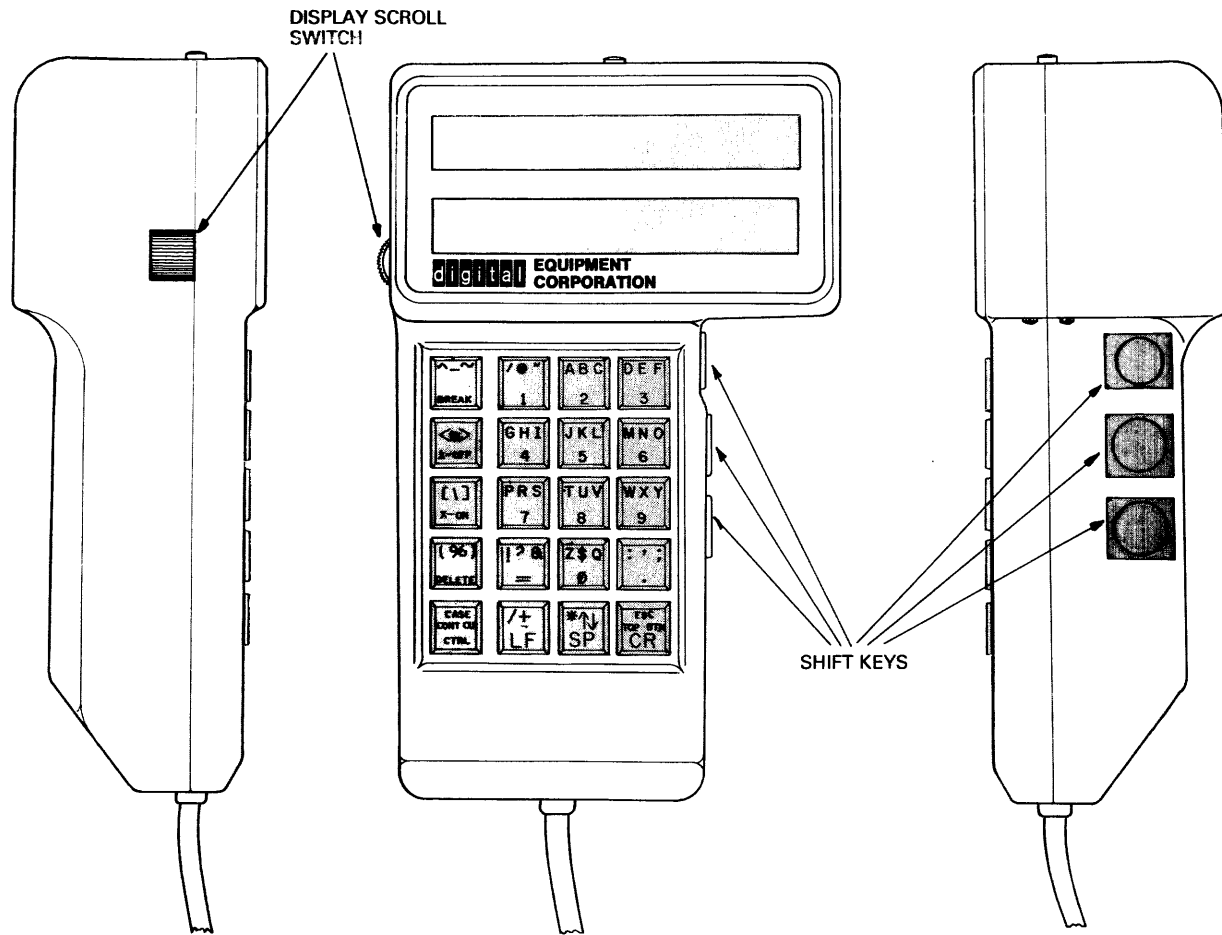
For example, when the middle shift key and the number five keybutton are pushed simultaneously, the letter K is displayed. Pushing the lower shift key and the zero keybutton results in the letter Q being displayed.

3.5 CONTROL CHARACTERS

A control character (e.g. ^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 ^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.



CZ-0768

Figure 3-1 Field Service Diagnostic Terminal

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.

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\F\G
```

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 5 of this manual contains the troubleshooting procedures enabling you to repair the RA60 Disk Drive.

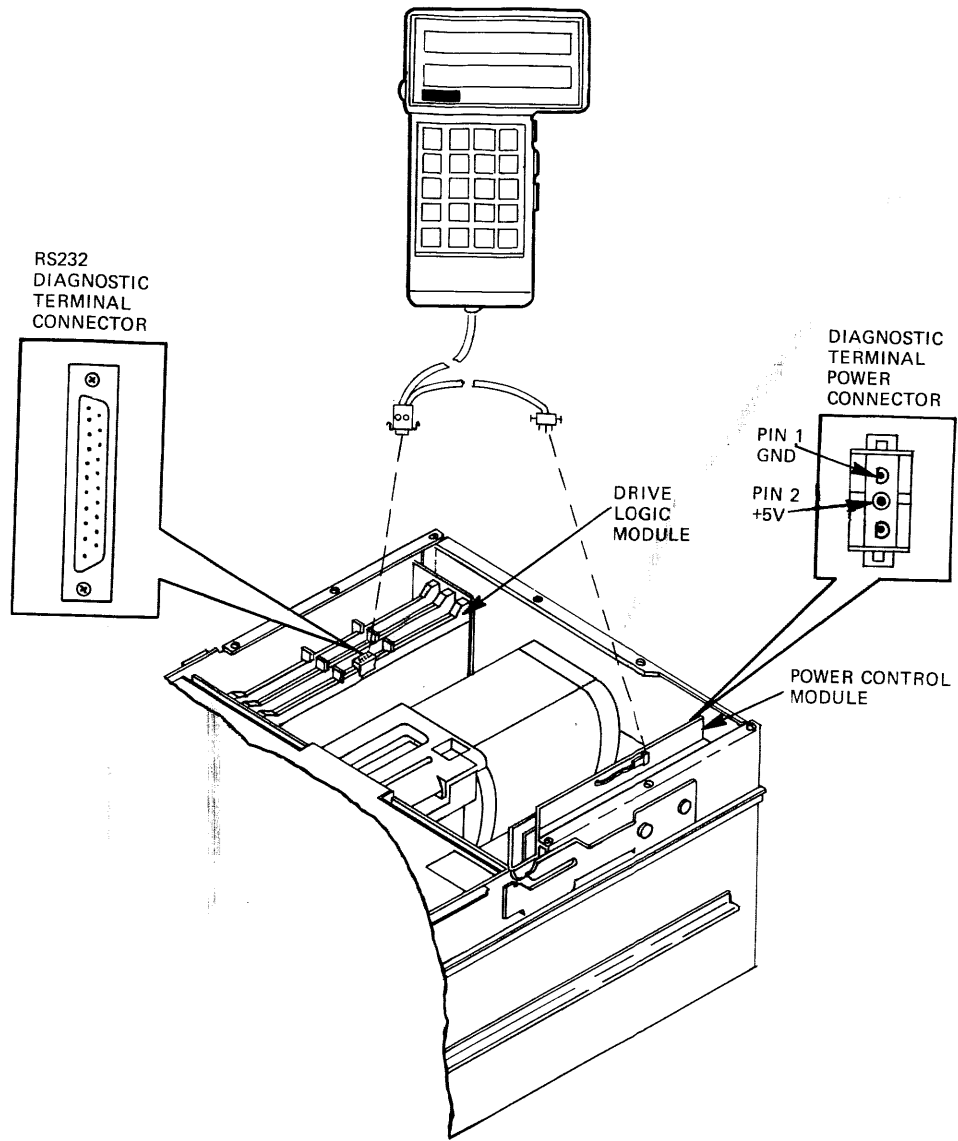
3.14 INSTALLING THE TERMINAL

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.

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.

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 >
```



CZ-0883

Figure 3-2 Diagnostic Terminal Connections

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

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 5, Table 5-2 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 5, Table 5-2 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 5, Table 5-2 of this manual.

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 5, Table 5-2 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 5, Table 5-2 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.

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 5, Table 5-2 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 >
```


CHAPTER 4 THEORY OF OPERATION

4.1 INTRODUCTION

This chapter describes the theory of operation of the RA60 Disk Drive. It also includes a general description of the drive, a functional description of the servo system, read/write commands, and the power supply functions.

4.2 RA60 GENERAL DESCRIPTION

The RA60 is a 205 megabyte removable media disk drive. It is the first removable media drive to become a part of the new Digital Storage Architecture (DSA) family. DSA defines the hardware interconnects and software protocols for attaching DSA disks to DIGITAL systems.

The RA60 Disk Drive operates on the intelligent UDA50 Disk Controller, which is the first controller implementation of the DSA architecture. The UDA50 can control up to four DSA-type disks such as the RA60, RA80 and RA81. Each drive is radially connected to the disk controller over separate Standard Disk Interconnect (SDI) cables.

The RA60 Disk Drive may be mounted in a H9642 AP/AR (120/240 volt) cabinet. This is a new 36 inch deep cabinet which can hold up to three disk drives. A power controller is located in the base of the cabinet which controls the ac power to all three drives.

4.3 RA60 DISK DRIVE FEATURES

The RA60 offers the following features:

- Advanced read/write system—The read/write system uses a unique $\frac{2}{3}$ rate tree encoding/decoding scheme which provides $\frac{1}{3}$ more storage capacity on the disk.
- Embedded servo positioning system—A unique servo code is embedded between sectors that is used for track following and track seeking. This embedded servo technique eliminates the need for a dedicated servo surface and head alignments.
- Dual microprocessor architecture—One microprocessor manages the I/O while the other controls the major drive functions.
- Automatic misalignment sensing—The drive automatically senses radial or axial misalignments in the head-to-disk surface.
- Optimized cylinder configuration—Disk tracks are organized into groups of four to form logical cylinders and increase data throughput.
- DC Spindle motor—A brushless dc spindle motor is used to drive the disk pack. This feature eliminates a pulley belt and reduces power consumption.

- Fault isolating microdiagnostics–ROM-resident diagnostics isolate failures to a field replaceable assembly. The microdiagnostics can be run locally with the disk off-line or remotely from the Digital Diagnostic Center through the host system.
- Automatic self-test–The drive automatically checks out its own functionality during power-up and initialization.
- Dual access–Allows the drive to be switched between two controllers on the same or different computer systems.

4.4 RA60 PERFORMANCE SPECIFICATIONS

The RA60 has the following performance specifications:

- Storage capacity: 205 MB per drive
- One cylinder seek latency: 7 ms maximum
- Maximum seek latency: 70.0 ms maximum
- Average seek latency: 42 ms maximum
- Head switch latency: 14 ms maximum
- Unbuffered transfer rate: 15.84 megabits per second
- Recoverable seek error rate: 1 misseek in 10^6 seeks
- Recoverable data error rate: 1 bit in 10^7 bits read
- Corrected data error rate: 1 bit in 10^{10} bits transferred
- Unrecoverable data error rate: 1 bit in 10^{12} bits transferred

4.5 RA60 POWER SPECIFICATIONS

The power specifications for each RA60 are as follows:

- Typical input power: 800 watts, 900 watts maximum
- Maximum VA rating: 1200 volt-amps
- Power factor: greater than .75
- Maximum inrush current for 120 VAC: 190 amps RMS for $\frac{1}{2}$ cycle

- Maximum inrush current for 240 VAC: 95 amps for ½ cycle
- Typical 120 volt running current: 7.0 amps
- Typical 240 volt running current: 3.5 amps
- 120 volt input range: 90-128 VAC at 60 Hz \pm 1 Hz
- 240 volt input range: 180-256 VAC at 50 Hz \pm 1 Hz
- Heat dissipation: 800 watts or 2728 Btu/hour

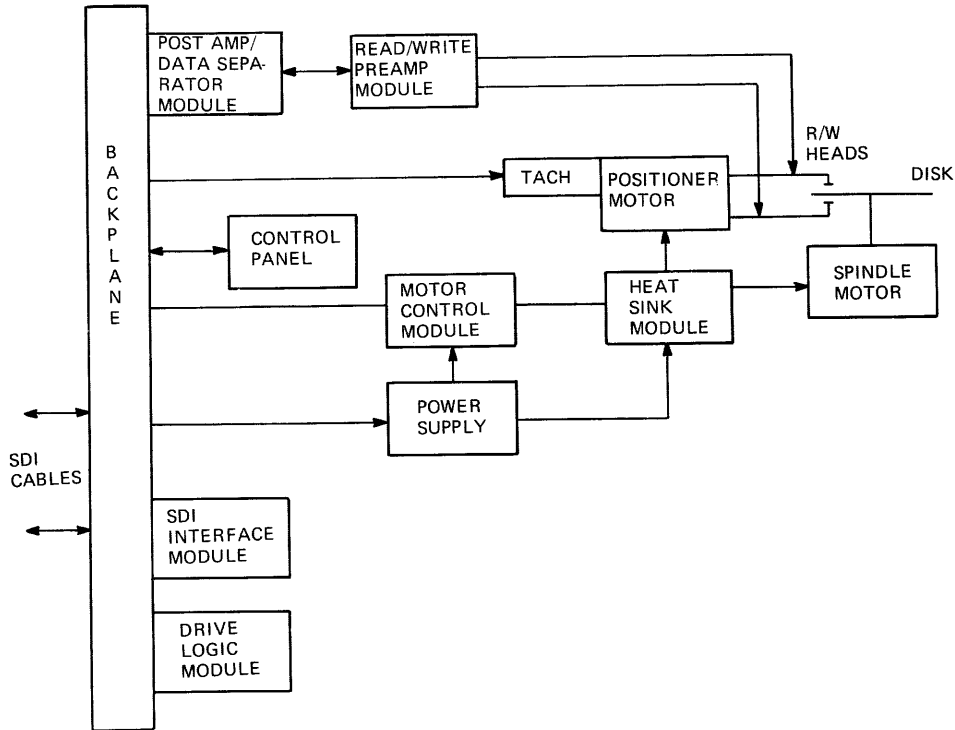
4.6 RA60 Options

The following basic RA60 options are available.

- RA60-AA: 205 MB disk 50/60 Hz, no cabinet
- RA60-CA: H9642-AP cabinet, 60 Hz
- RA60-CD: RA60-AA, H9642-AR cabinet, 50 Hz
- RUA60-AA: RA60-AA, UDA50 controller, no cabinet
- RUA60-CA: RA60-CA, UDA50 controller, w/cabinet
- RUA60-CD: RA60-CD, UDA50 controller, w/cabinet
- RUA60-JA: RA60-CA, (2) UDA50 controllers, w/cabinet
- RUA60-JD: RA60-CD, (2) UDA50 controllers, w/cabinet
- RA60-P: RA60 disk pack
- RA60-PA: lot of 10 RA60-P packs
- RA60-PB: lot of 5 RA60-P packs

4.7 RA60 TECHNICAL DESCRIPTION

This section describes the major modules and assemblies within the RA60 Disk Drive. Figure 4-1 shows how these major modules and assemblies are interconnected.



CZ-0844

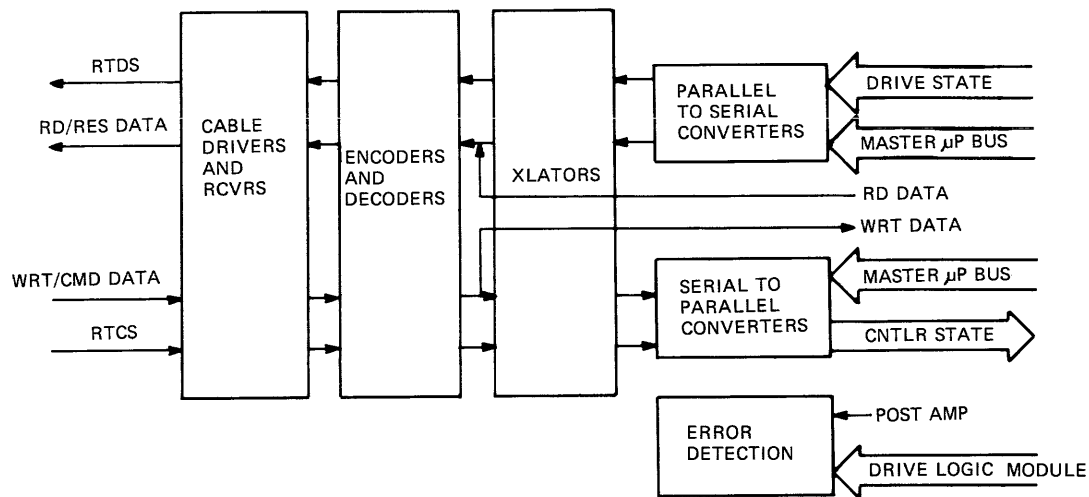
Figure 4-1 Simplified RA60 Block Diagram

4.7.1 SDI Interface Module

The SDI interface module converts the serial SDI messages sent by the disk controller into a parallel command format recognizable by the drive master microprocessor. In the process, it strips away the sync byte and frame bytes, leaving only the actual command bytes that are stored in RAM memory on the drive logic module.

The SDI interface module also encodes the parallel drive response messages into serial SDI format and transmits them to the controller. In the process, it adds the sync byte and frame bytes. This module also contains all the SDI cable receivers and drivers.

During write data transmission, the SDI interface module converts the SDI bipolar data into the NRZ data stored on the disks. When reading data from the disks, this module converts the NRZ data back into the SDI bipolar data required for transmission. Refer to Figure 4-2 for a block diagram of the SDI module.

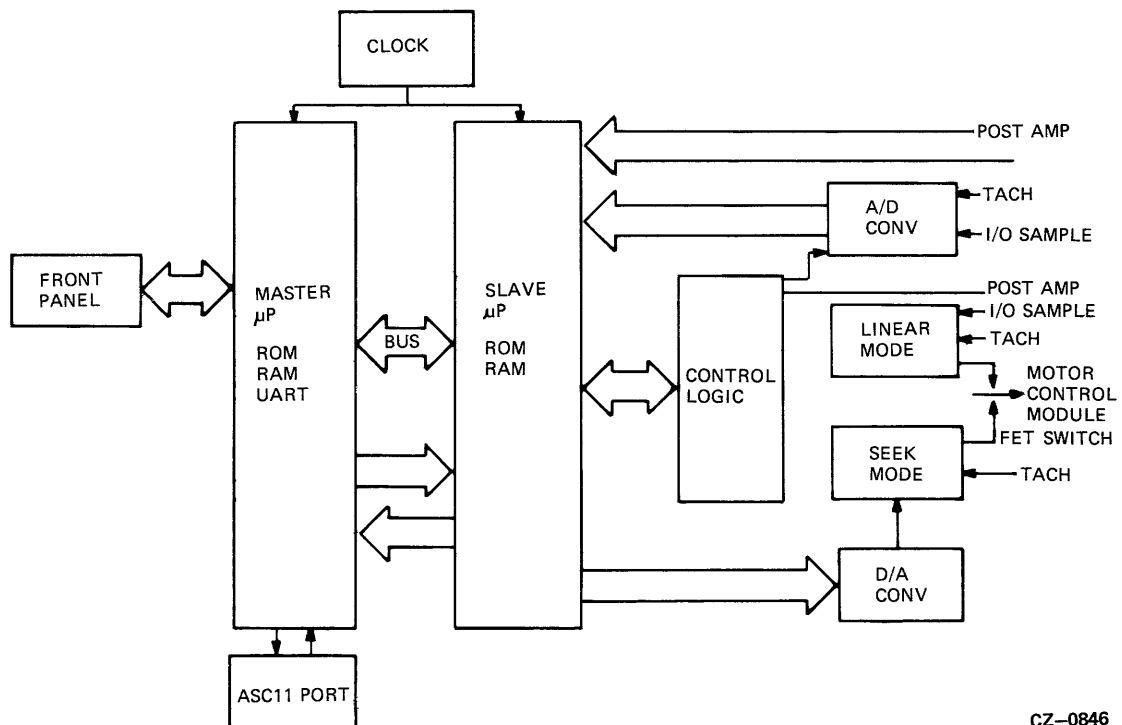


CZ-0845

Figure 4-2 SDI Module Block Diagram

4.7.2 Drive Logic Module

The drive logic module contains a master microprocessor, a slave microprocessor, some RAMs and ROMs, and some other servo associated logic. Refer to Figure 4-3 for a block diagram of the drive logic module.



CZ-0846

Figure 4-3 Drive Logic Module Block Diagram

The master microprocessor controls the SDI interface handshaking logic, the slave microprocessor, and the operator control panel. When command bytes are received from the SDI interface module and stored in RAM, the master microprocessor interprets them to determine how many more bytes are needed to complete that command sequence. When the full command sequence is received, the slave microprocessor executes them.

The slave microprocessor operates under the control of the master microprocessor. It controls the spindle motor, positioner motor, and the other real-time drive operations. An analog to digital converter changes the serial tachometer and disk track information into the parallel format needed by the slave microprocessor. Similarly, a digital to analog converter reformats the microprocessor parallel information back into the serial signals required by the seek mode circuits. More is explained about how the linear and seek mode operation works in the RA60 servo system section.

4.7.3 Post Amp/Data Separator Module

The post amp/data separator module performs both data read/write functions and some servo positioning functions. This module is included in the servo positioning loop because the read heads are used to detect the embedded servo bursts. Refer to Figure 4-4 for a block diagram of the post amp/data separator module.

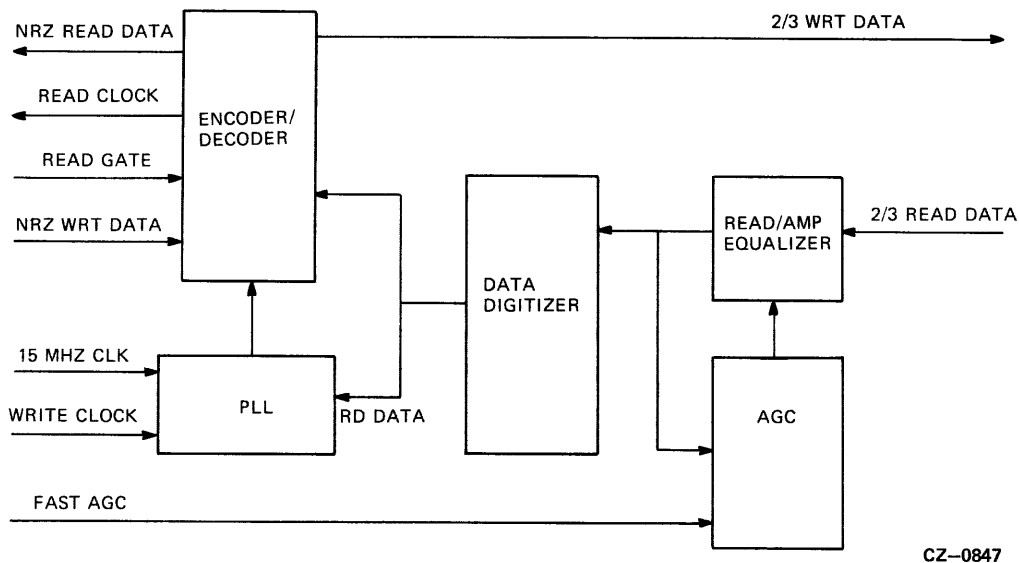


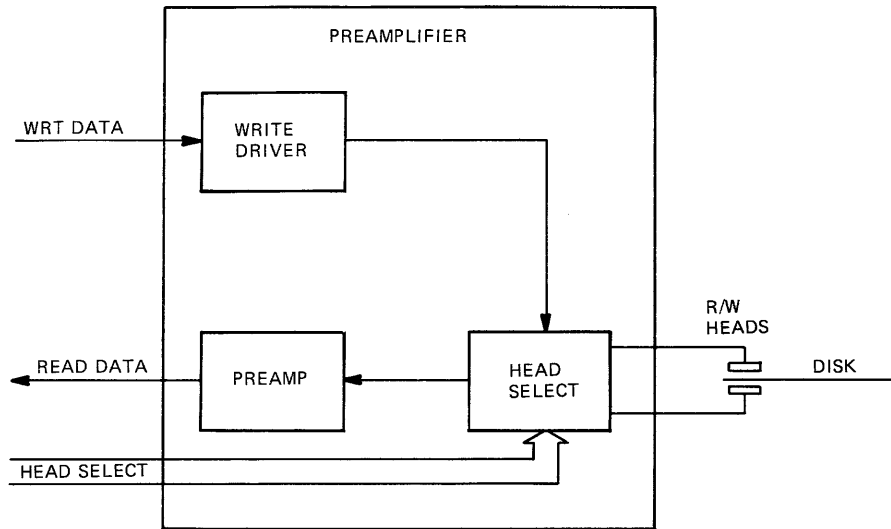
Figure 4-4 Post Amp/Data Separator Module Block Diagram

During the write operation, the $\frac{2}{3}$ encoder circuit transforms the incoming NRZ write data into the $\frac{2}{3}$ format to be written on the disk. When the data is read back, it is passed through an amplifier and equalizer circuit to slim the pulses and equalize their rise times. These equalized pulses are then converted into digital information in the data digitizer circuit. The read data out of the data digitizer is then passed through the $\frac{2}{3}$ decoder for conversion back to NRZ read data.

The Phase Lock Loop (PLL) oscillator may lock onto one of three different frequencies. It is normally locked onto the 15 MHz oscillator signal when the drive is neither reading or writing. During a write operation, the PLL oscillator locks onto the WRITE CLOCK signal. During a read operation, it locks onto the READ DATA signal.

4.7.4 Preamp Module

The preamp module contains the head select logic, the write drivers, and low noise read preamplifiers. Refer to Figure 4-5 for a block diagram of the preamp module.



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Figure 4-5 Preamplifier Module Block Diagram

4.7.5 Front Panel Module

The RA60 front panel consists of five switches and one switch cap (UNIT/READY). Under each indicator cap is a light that can be on or off regardless of the switch position. The state of each switch and light is periodically sampled and controlled by the master microprocessor.

The front cover interlock switch is mounted on the cover latch assembly. This switch prevents the drive from spinning up whenever the front cover is open. The state of this switch is sampled periodically by the master microprocessor.

4.7.6 Motor Control Module

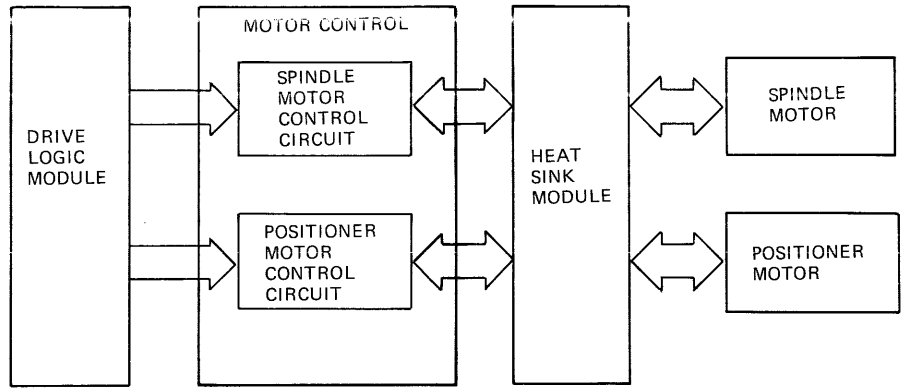
The motor control module contains a portion of the power amplifier circuits needed to drive the positioner motor voice coil. The power transistors for this function are located on the heat sink module.

The motor control module also contains the circuitry to control the spindle motor. Refer to Figure 4-6 for an overview block diagram

4.7.7 Positioner Motor

The positioner motor is a linear dc motor actuated by a voice coil. Its function is to move the read/write heads in and out across the disk tracks. On the rear of the positioner motor is a tachometer that converts the carriage velocity into an analog signal.

Also located on the positioner motor assembly is the home switch that informs the microprocessor and the power-down logic when the read/write heads are home (off the disk pack).



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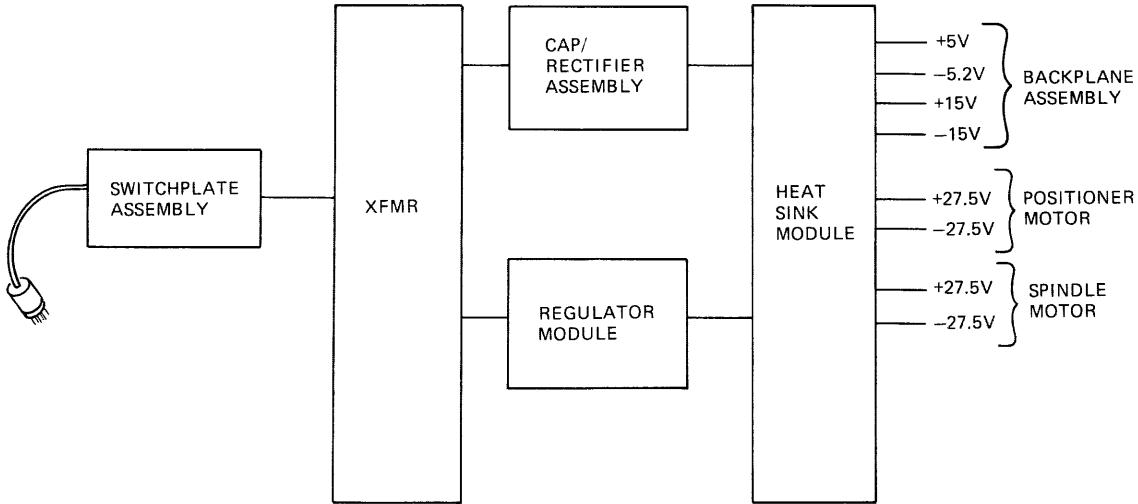
Figure 4-6 Motor Control Module Block Diagram

4.7.8 Spindle Motor

The spindle motor is the dc motor that rotates the disk spindle. In the RA60 Disk Drive, the spindle motor drives the disk spindle directly without any belt or pulley. The spindle motor also has a built-in encoder that converts the motor rotational speed into digital pulses. The output signals from this encoder are monitored by the slave microprocessor to determine disk speed.

4.8 POWER SUPPLY ASSEMBLIES

The RA60 power supply includes five assemblies. These are the switchplate assembly, transformer assembly, cap/rectifier assembly, regulator module, and heat sink module. Figure 4-7 shows a block diagram of the power supply.



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Figure 4-7 Power Supply Block Diagram

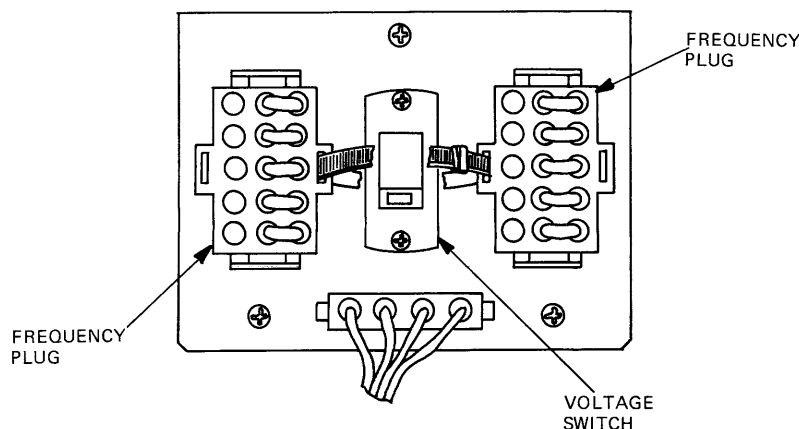
4.8.1 Switchplate Assembly

The switchplate assembly contains the main drive circuit breaker and an ac line filter. The circuit breaker has three poles rated at 12 amps, 6 amps and 6 amps respectively. Switch capacity is 12 amps at the 120 volt setting and 6 amps at the 240 volt setting.

4.8.2 Transformer Assembly

A ferro-resonant transformer is used in the RA60 to obtain good line voltage regulation. The raw output voltages from the transformer are fed to the cap/rectifier assembly for rectification. The transformer puts out raw ac voltages of 11 volts, 27.5 volts, and 20 volts.

The ac voltage range switch and frequency range plugs mounted on top of the transformer permit easy voltage and frequency range selections. The location of the ac voltage range switch and the frequency range plugs is shown in Figure 4-8.



CZ-0872

Figure 4-8 Voltage Range Switch and Frequency Plugs

Also located on the transformer assembly are six thermal circuit breakers that protect the output of the transformer from short circuits and overheating. The location of these circuit breakers for both the old and new style transformers are shown in Figures 4-9 and 4-10.

In addition to the six thermal circuit breakers located on the transformer, two 5 amp fuses are located on the regulator module to fuse the on-board raw ac 20 volt lines.

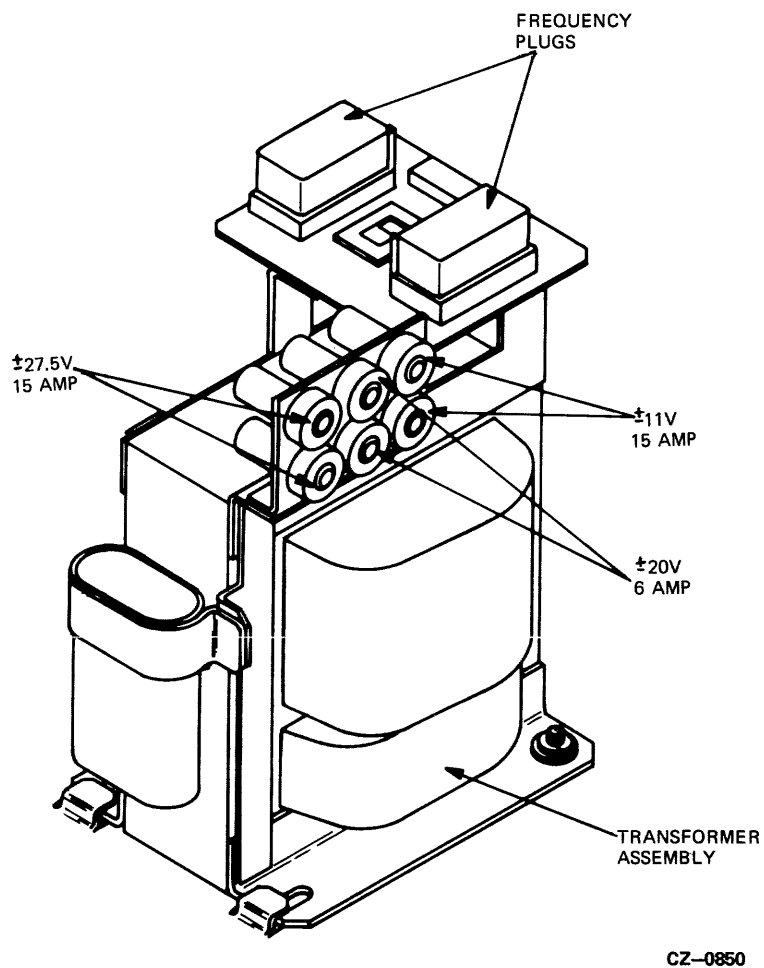


Figure 4-9 Location of Circuit Breakers (Old Style Transformer)

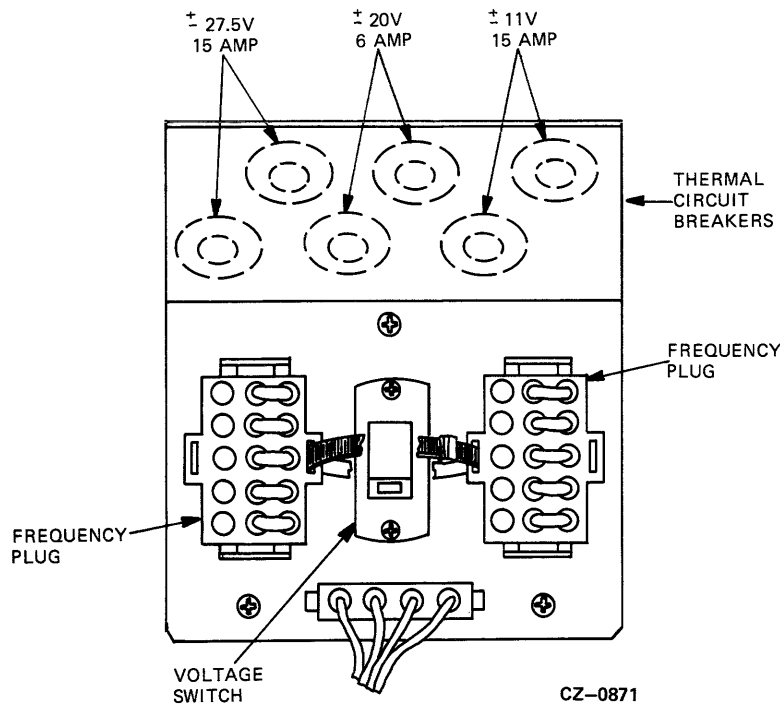


Figure 4-10 Location of Circuit Breakers (New Style Transformer)

4.8.3 Cap/rectifier Assembly

The cap/rectifier assembly rectifies the raw ac received from the transformer assembly. It puts out the following dc voltages: ± 11 volts, ± 20 volts, and ± 27.5 volts.

4.8.4 Regulator Module

The regulator module contains the low level circuitry to regulate the rectified dc voltages on the heat sink module. The regulator module also senses the dc voltage levels and controls the series regulating transistors located on the heat sink module.

The regulator module also contains all the ac and dc shutdown logic and the power resumption logic. See paragraph 4.13 for a description of the causes of power shutdown and the sequence of events that occur prior to shutdown.

Figure 4-11 shows a block diagram of the functions provided by the regulator module. It has an on-board power supply to provide dc voltages for its own logic circuits and reference voltages. Also located here is the fault circuitry to detect ac failures, dc overvoltage, and dc undervoltage conditions. There are also some timers to control power shutdown and resumption. Monitoring all these failure conditions is the fault control logic circuit. The regulator module also provides accurate voltage references for the regulator control circuits.

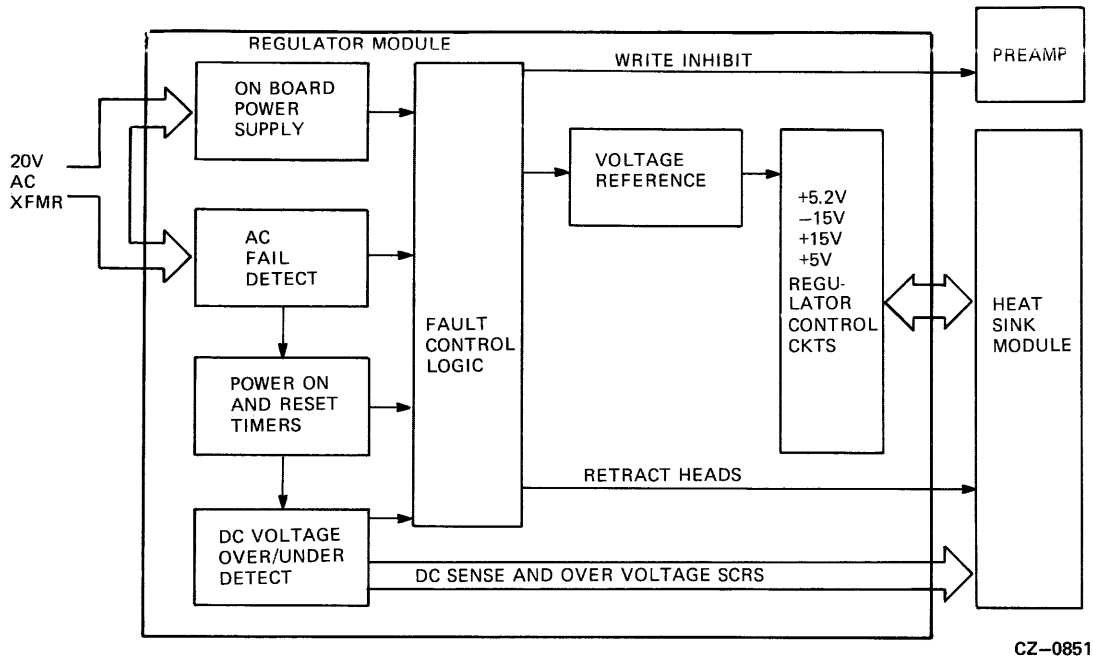


Figure 4-11 Regulator Module Block Diagram

4.8.5 Heat Sink Module

The heat sink module contains all the series pass transistors used for voltage regulation and the power transistors used for the motor control logic. All these power transistors share a common heat sink. The heat sink module supplies the backplane with the following dc regulated voltages: +5 volts, -5.2 volts and ±15 volts.

The heat sink module also supplies the motor control module with ±15 volts and ±27.5 volts. Power to the dc fans is also supplied from the heat sink module. Refer to Figure 4-12 for a block diagram of the heat sink module.

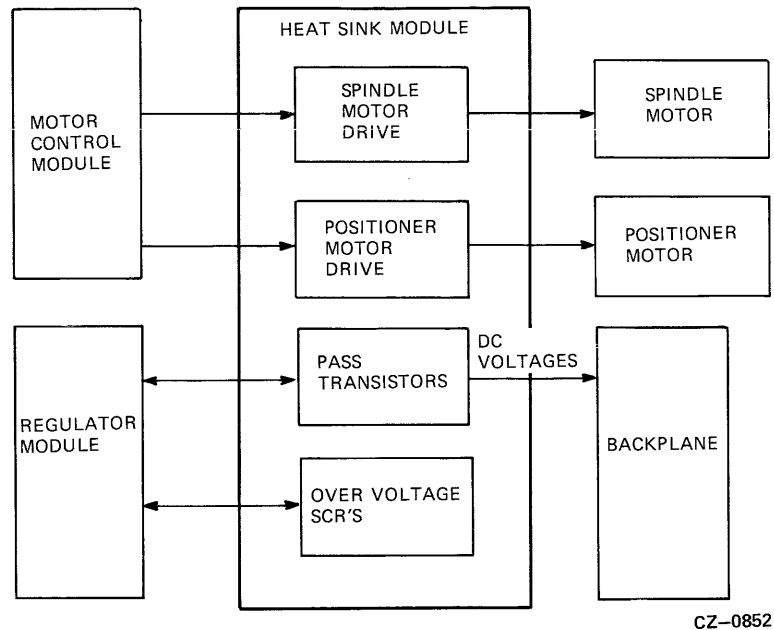


Figure 4-12 Heat Sink Module Block Diagram

4.9 RA60 FUNCTIONAL DESCRIPTION

This section describes the physical disk layout, physical sector format, logical disk format, and the operation of the RA60 servo system, read/write commands, and the power supply functions.

4.9.1 RA60 Physical Disk Layout

The RA60 operates with an RA60-P removable disk pack. This pack contains five disk platters. The three middle ones are used for data storage, while the two outer ones are for protection. The three data storage platters provide a total of six read/write surfaces. Each disk data surface has 1600 physical tracks. Each track contains 39 sectors with 18 bit data packs or 43 sectors with 16 bit data packs. The data field within each sector contains 256 data words regardless of whether it is written in 16 bit or 18 bit mode.

Note

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

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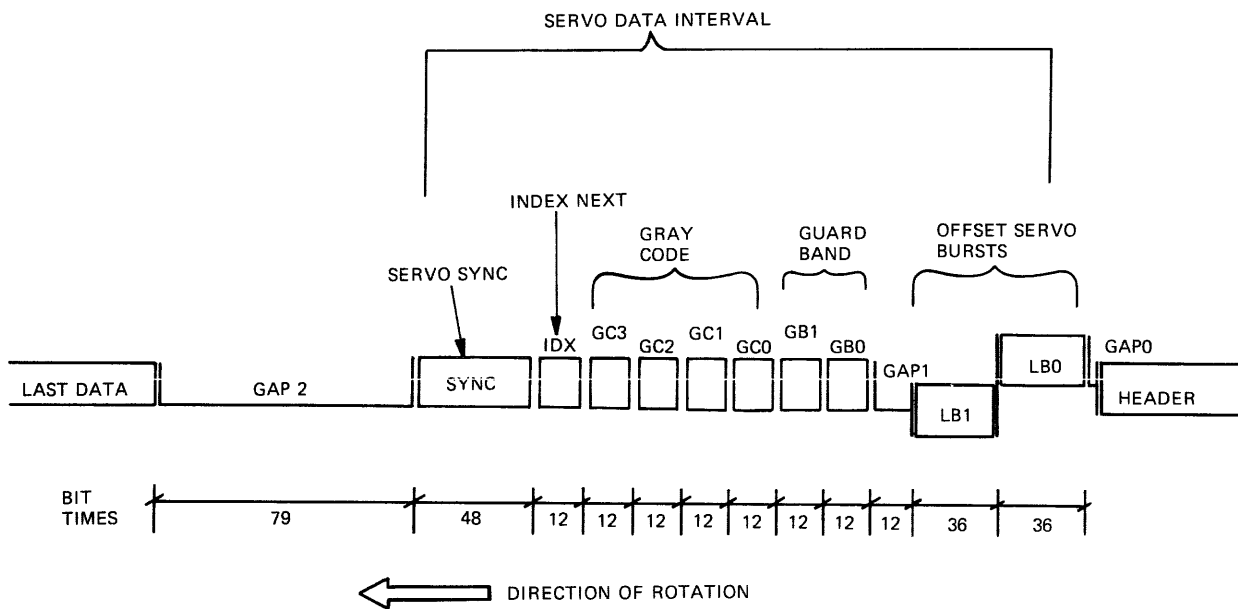
4.9.2 RA60 Physical Sector Format

Each RA60 sector begins with a servo data interval followed by the sector header, data field, their supporting preambles, postamble, and error correcting codes. These are described in greater detail in the following paragraphs.

4.9.3 Servo Data Interval

Since the RA60 Disk Drive uses an embedded servo system, each sector begins with a servo data interval. Pre-recorded in this servo data interval is the following information. Refer to Figure 4-13 for an illustration of the servo data interval.

- Servo sync pulse—to synchronize servo timing circuits
- Sector index next code—to mark sector zero on each track
- Module 16 gray code—to indicate track crossings
- Two guard band codes—to distinguish guard bands from the data area
- Two offset servo bursts—to indicate an offset from track centerline



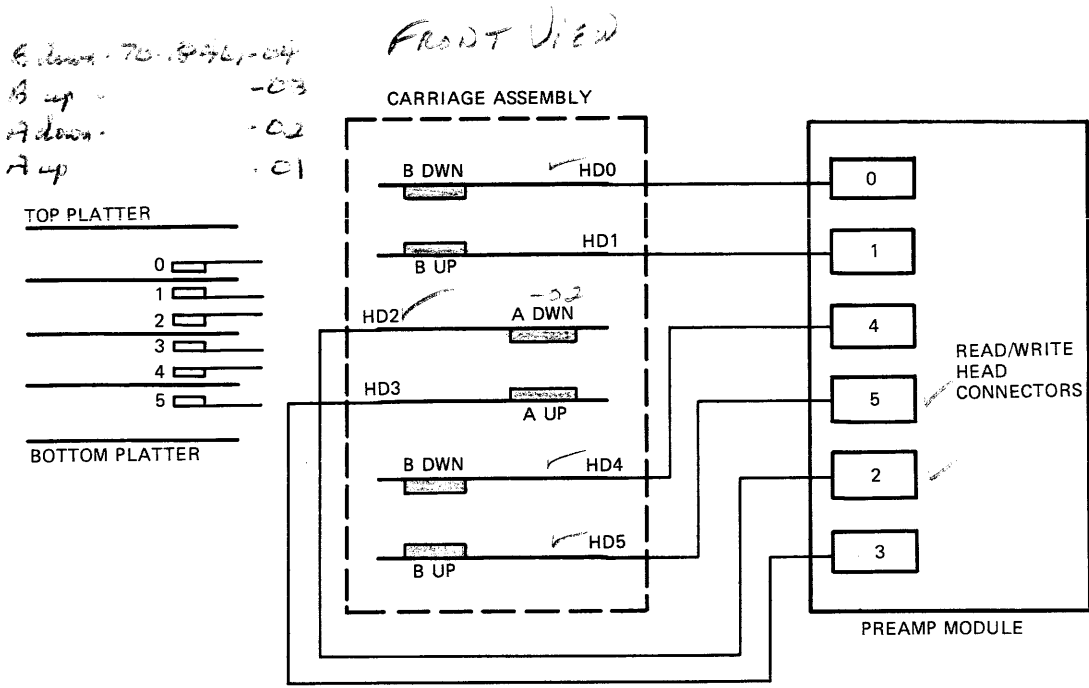
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Figure 4-13 Servo Data Interval Format

4.9.4 Head/Disk/Preamp Configuration

The RA60 read/write head to disk layout is straight forward. The layout of the head connectors on the preamp module is unusual. Refer to Figure 4-14 for the head/disk/preamp configuration.



CZ-0854

Figure 4-14 Head/Disk/Preamp Configuration

4.9.5 Sector Header and Data Field

After the servo data interval, the remainder of the sector contains the header preamble, header sync, header, data preamble, data sync, data field, error detection code (EDC), error correction code (ECC), and the data postamble. The sector byte format is shown in Table 4-1.

Table 4-1 Sector Byte Format

Description	Bytes
Servo data interval	Equivalent to 37 byte times
Header preamble	18 bytes maximum
Header sync	2 bytes
Header (repeated 4 times)	16 bytes
Data preamble	34 bytes maximum
Data sync	2 bytes
Data 16/18 bit words	512/576 bytes
Error detection code (EDC)	2 bytes
Error correction code (ECC)	22 bytes
Data postamble	2 bytes

4.9.6 Logical Disk Format

The RA60 disk pack logical format meets the criteria set forth in the Digital Standard Disk Format (DSDF) specification, which is DEC Standard 166. This standard describes how a physical disk is constructed into the logical format for SDI devices. It also describes the host view of mass storage device formats.

This specification redefines many of the old disk terms, such as track and cylinder, as a function of their access characteristics. The following terms will help you to understand the DSDF.

1. **Sector**—A sector is the smallest unit in which data is physically addressed. Sectors are available for reading or writing once per disk revolution.
2. **Track**—A track is a logical entity that represents sets of sectors occupying contiguous physical disk locations. This is a strictly logical entity that relates sectors to each other as a function of their access characteristics.
3. **Group**—A group is a logical entity that contains a set of tracks. Groups with the same physical sector address on each of the tracks are simultaneously available for reading or writing. Groups also have the property that any track within the group can be selected within the inter-sector rotation time. This definition of groups is independent of the physical construction of the device and relates tracks to each other as a function of their access characteristics.
4. **Cylinder**—A cylinder is a logical entity that represents a collection of groups. Individual groups on the same cylinder can be accessed in less than the minimum seek time. The selection of a new cylinder has the longest average positioning time.
5. **Physical Block Number (PBN)**—A PBN is a 28 bit number which identifies a physical sector's position within a set of sectors on a subunit.
6. **Logical Block Number (LBN)**—An LBN is a 28 bit number which identifies a physical sector's position within a set of sectors directly accessible to the host. These are used for host data storage and revector control information.
7. **Replacement Block Number (RBN)**—An RBN is a 28 bit number which identifies a physical sector's replacement position.
8. **Bad Block**—A bad block is a sector that contains a defect which exceeds the error correction capability of the subsystem.
9. **Bad Block Replacement**—The substitution of a spare sector (replacement block) for a bad sector.
10. **Bad Block Revectoring**—Locating the replacement block as a result of attempting to access a bad sector.
11. **Primary Replacement Block**—A replacement block with the lowest track RBN which has been allocated to replace a logical block on the same track.
12. **Secondary Replacement Block**—A replacement block which is allocated to replace a logical block on another track.
13. **External Block Number (XBN)**—A 28 bit number which identifies a physical sector's position within a set of sectors in the external format area of the subunit.

14. Diagnostic Block Number (DBN)—A 28 bit number which identifies a physical sector's position within the set of sectors in the diagnostic area of the subunit.

Using the above definitions, Figure 4-15 shows how the RA60 disk physical cylinders and sectors are organized into LBNs, XBNs, DBNs and RBNs.

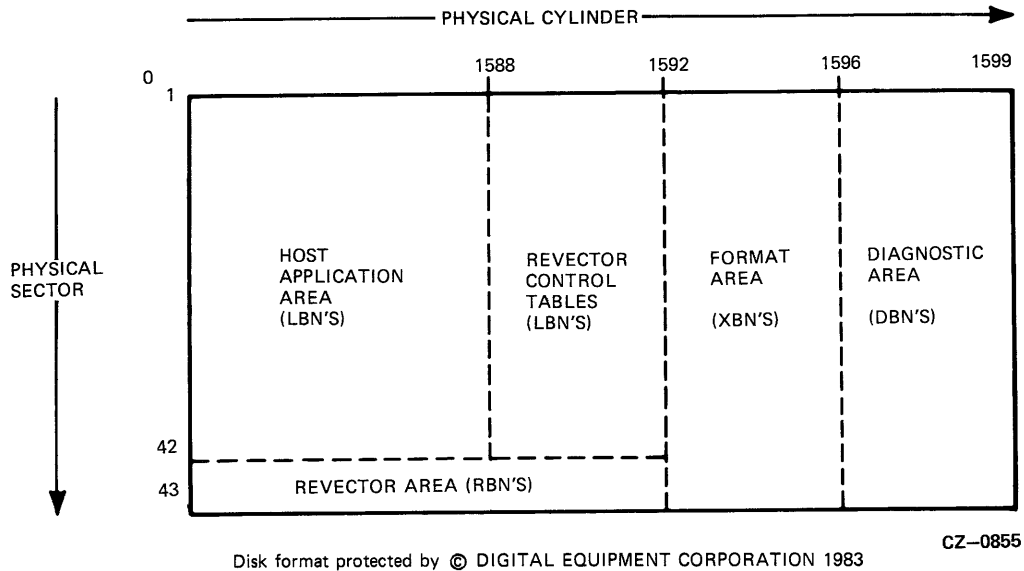


Figure 4-15 RA60 Overview of the 16 Bit Logical Disk Format

Note that in the RA60, four physical cylinders make up one logical cylinder. Also in the RA60, one physical cylinder is equivalent to a group so there are four groups in one logical cylinder. Figure 4-16 shows how the physical cylinders translate into logical cylinders.

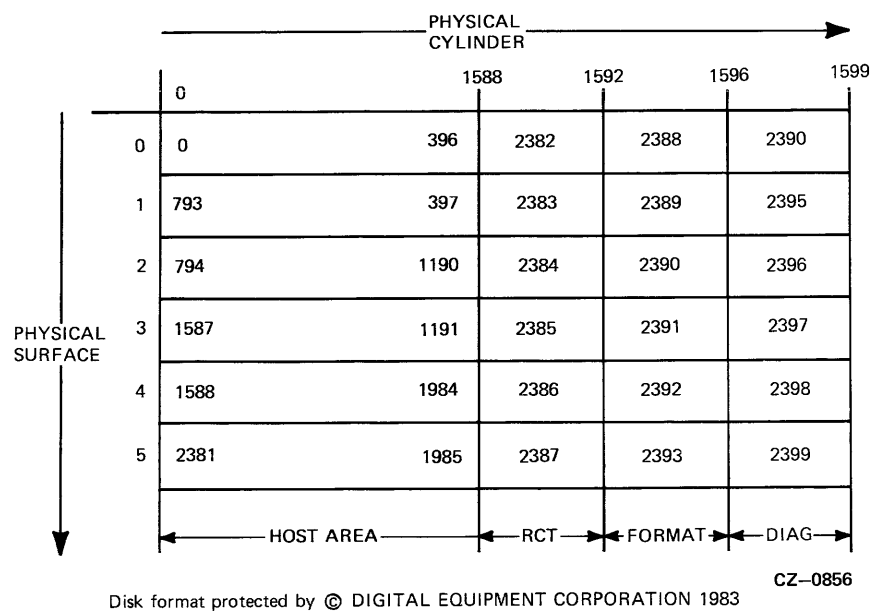
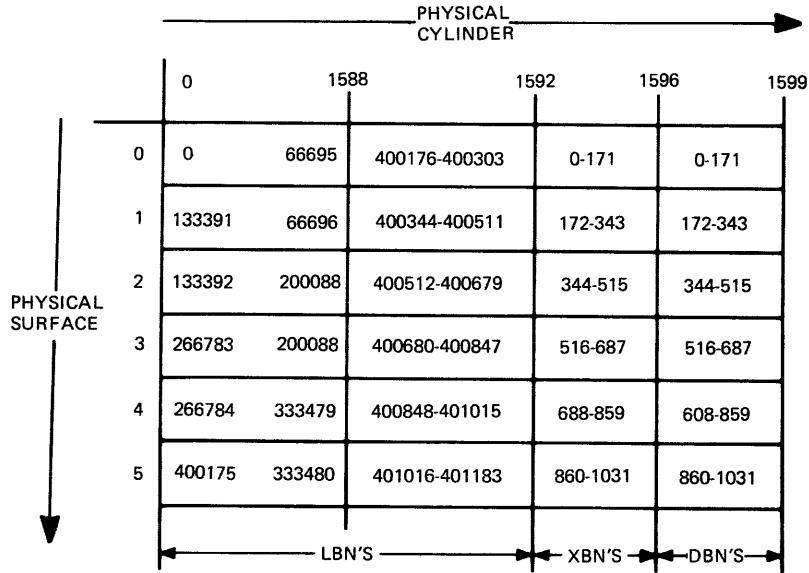


Figure 4-16 RA60 Physical to Logical Cylinder Translation

In the RA60, one LBN is equivalent to one physical sector. Thus there are forty-two logical blocks and one replacement block per physical cylinder. Figure 4-16 shows the physical location of block numbers for a 16 bit formatted disk. The logical block numbers are shown inside the squares of Figure 4-17.



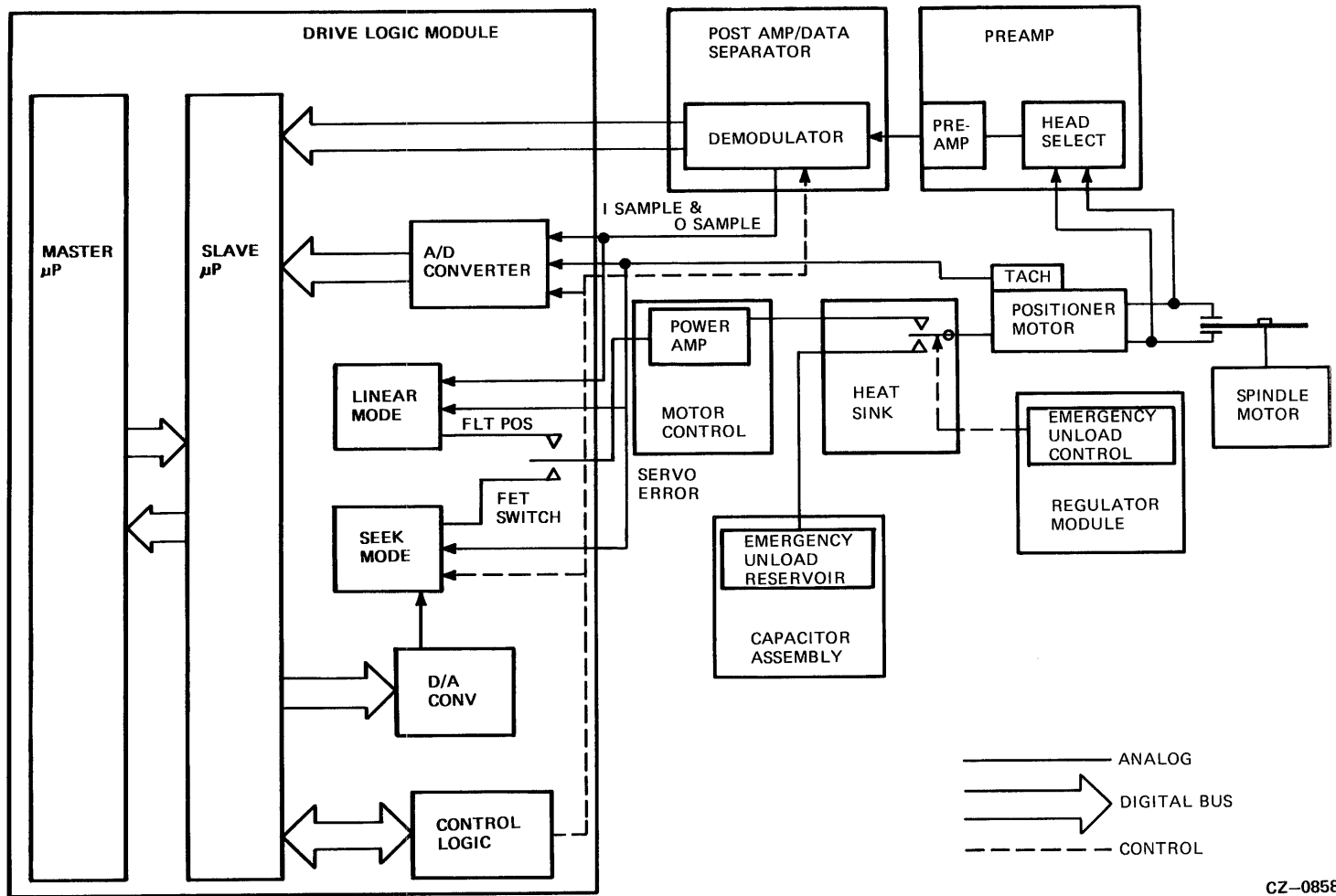
CZ-0857

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Figure 4-17 RA60 Physical Location of Block Numbers

4.10 RA60 SERVO SYSTEM

The RA60 Disk Drive does not have a dedicated servo module. Instead, the servo circuits are distributed over most of the electronic modules. The servo system has two modes of operation. These are the linear (or track centering) mode and the seek (or track crossing) mode. The major functional blocks in the servo control system are shown in Figure 4-18.



CZ-0858

Figure 4-18 Servo Control System Block Diagram

4.10.1 Servo Linear Mode

In the linear mode, the servo circuits use the embedded servo information on the disk to detect the head position relative to track centerline. This servo information consists of two bursts of high frequency signals that are offset in opposite directions from track centerline. As the read/write head passes over the servo bursts, amplitude of one burst will be greater than the other if the head is slightly off track centerline.

The servo burst information is detected by the read/write heads and is amplified on the preamp module. This servo information is then demodulated on the post amp/data separator module. Here these servo bursts go through a band pass filter to separate the servo burst signals from the rest of the data coming off the disk. Once separated, these servo bursts are rectified, integrated, and passed through sample and hold circuits. The two dc signals produced by this process are I SAMPLE (for the inner servo burst) and O SAMPLE (for the outer servo burst), which are sent to the drive logic module.

On the drive logic module, the I SAMPLE and O SAMPLE signals enter a differential amplifier in the linear mode circuits and produce an error signal called FLT POS. FLT POS is passed through a FET switch to produce two servo error signals, SVO ERR1 and SVO ERR2, which are sent to the motor control module.

The servo control signals are amplified by the motor control module and heat sink modules and drive the positioner motor through a relay contact on the heat sink module.

A difference signal is derived from the I SAMPLE and O SAMPLE signals entering the drive logic module. This difference signal is converted to a digital format by the A/D converter and is monitored by the slave microprocessor.

4.10.2 Servo Seek Mode

The servo system normally operates in linear mode to keep the read/write heads above track centerline. However, when the drive receives a seek command, the servo system is placed into seek mode. The slave microprocessor is given the number of tracks that the heads must cross, and it fetches a value from a velocity table to send to the seek mode circuits. This velocity value is converted into an analog voltage in the D/A converter and then applied to the velocity error circuits. The control logic on the drive logic module places the FET switch in the correct state to allow the seek mode signals to pass to the motor control module. The motor control module and heat sink module amplify the seek mode signal and start the positioner motor moving.

As the read/write heads cross tracks, the servo system detects the track crossings by monitoring a 4 bit gray code at the beginning of each sector. This gray code is demodulated and passed on to the slave microprocessor, where the number of track crossings is used to decrement a track counter.

The slave microprocessor is also monitoring the velocity of the positioner motor by reading the output voltage from the tachometer. An A/D converter changes the tachometer voltage to a digital format that can be read by the slave microprocessor.

As the heads get closer to the destination track, the slave microprocessor issues smaller velocity values to the D/A converter. When the destination track is reached, the servo system switches back to linear mode and centers the heads over the track.

4.11 RA60 READ/WRITE OPERATION

The following paragraphs describe the rate $\frac{2}{3}$ code, the write command and the read command.

4.11.1 The Rate $\frac{2}{3}$ Modulation Code

The RA60 uses a new rate $\frac{2}{3}$ modulation code for encoding the write data on the disk. This coding technique allows one-third more data to be stored on the disk than is possible with the former Modified Frequency Modulation (MFM) code. For a given data stream, the rate $\frac{2}{3}$ code spreads out the magnetic transitions on the disk, reducing the need for peak shift compensation. Since the data transitions are further apart due to the $\frac{2}{3}$ code, they can be electrically squeezed back together to obtain one-third more data than MFM would allow. The data transitions are not squeezed to the point where peak shift problems become significant.

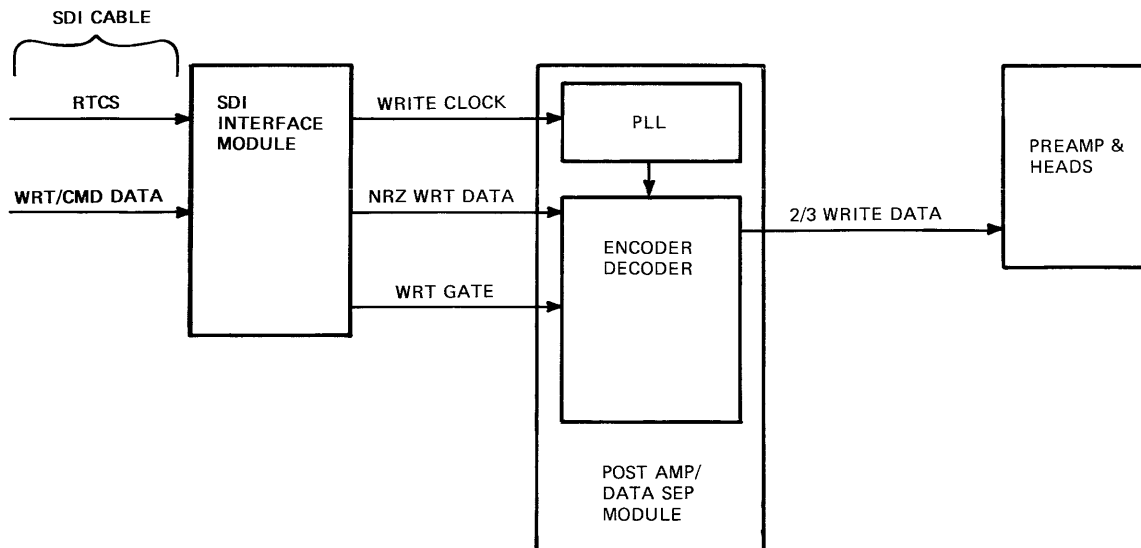
4.11.2 RA60 Write Commands

Figure 4-19 shows a simplified flow diagram for the RA60 write command. Use this diagram as a reference when reading the following description.

Prior to issuing the write command to the drive, the controller issues a seek command (if necessary) to position the heads onto the desired cylinder.

When a write command is issued by the disk controller, the drive sends the next encountered sector header to the controller. The disk controller reads the header and does a compare with the desired header. If they don't match, the write command is terminated. Otherwise, the controller asserts the WRITE GATE signal and sends the data.

The controller asserts WRITE GATE on the SDI cable Real Time Controller State (RTCS) line. The RA60 SDI interface module decodes the WRITE GATE signal and enables the Phase Locked Loop (PLL) oscillator on the post amp/data separator module. The PLL oscillator locks onto a multiple of the WRITE CLOCK frequency and begins clocking NRZ write data into the $\frac{2}{3}$ encoder. The $\frac{2}{3}$ encoded write data is then sent on to the preamp and write heads to be recorded on the disk. Because of the high data speeds, the microprocessors on the drive logic module do not get involved in the writing process.



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Figure 4-19 RA60 Simplified Write Command Diagram

4.12 RA60 READ COMMANDS

Figure 4-20 shows a simplified flow diagram of the RA60 read command. Use this diagram as a reference when reading the following description.

When a read command is issued by the disk controller, the drive sends the next encountered sector header to the controller. The disk controller reads the header and does a compare with the desired header. If they don't match, the read command is terminated. Otherwise, the controller asserts READ GATE and receives the data. READ GATE enables the $\frac{2}{3}$ decoder circuits on the post amp/data separator module. The $\frac{2}{3}$ READ DATA comes off the disk through the read heads and preamp module. This $\frac{2}{3}$ READ DATA is an analog waveform that is amplified and shaped in an equalizer circuit. The output of the read/amp equalizer circuit is then digitized in the data digitizer circuit. Once digitized, the read data is then decoded from its $\frac{2}{3}$ format back into the NRZ READ DATA which is sent to the SDI interface module for transmission to the disk controller.

4.13 Power Supply Functions

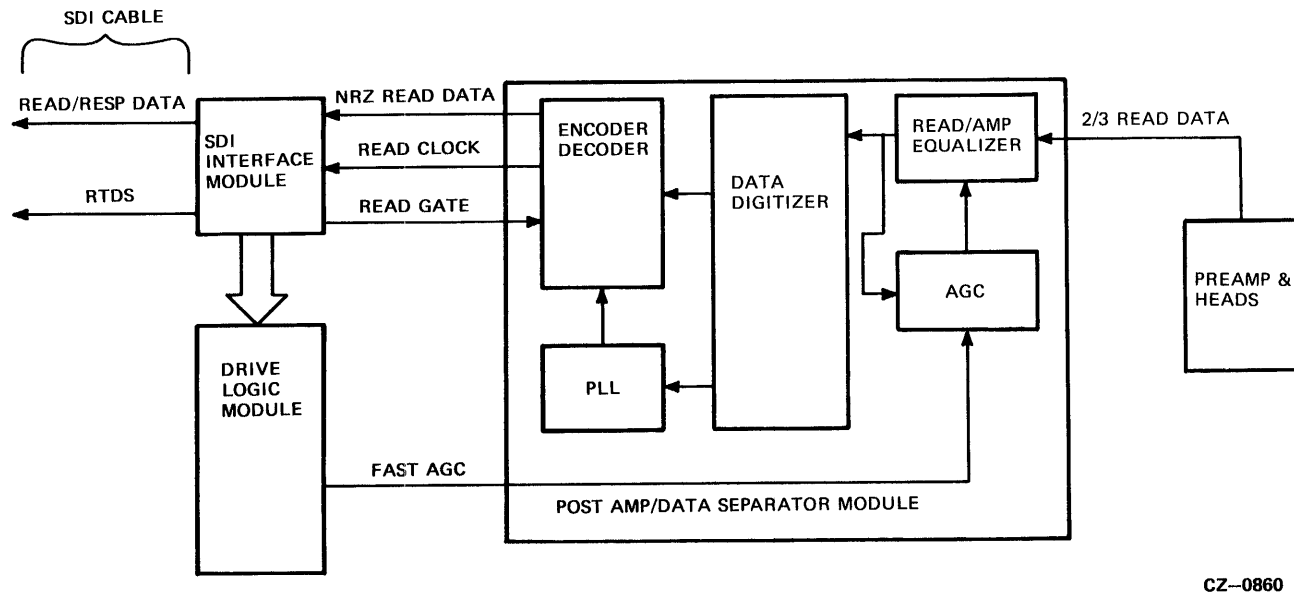
The RA60 power supply consists of the following five assemblies: switchplate assembly, transformer assembly, cap/rectifier assembly, regulator module, and the heat sink module. The power supply converts ac power into the regulated dc voltages needed by the RA60 circuits and motors. A power distribution diagram showing these voltages is illustrated in Figure 4-21.

The dc current ratings for the unregulated cap/rectifier assembly output voltages are:

- +11 volts at 8 amps
- -11 volts at 6 amps
- +20 volts at 2 amps
- -20 volts at 2 amps
- +27.5 volts at 8 amps average
- -27.5 volts at 8 amps average

All the regulated voltages have a tolerance of ± 5 per cent. The current ratings for the regulated voltages on the heat sink module are:

- +5 volts (4.75 volts to 5.25 volts) at 8 amps
- -5.2 volts (4.94 volts to 5.45 volts) at 6 amps
- -15 volts (14.25 volts to 15.75 volts) at 2 amps
- +15 volts (14.25 volts to 15.75 volts) at 2 amps



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Figure 4-20 RA60 Simplified Read Command Diagram

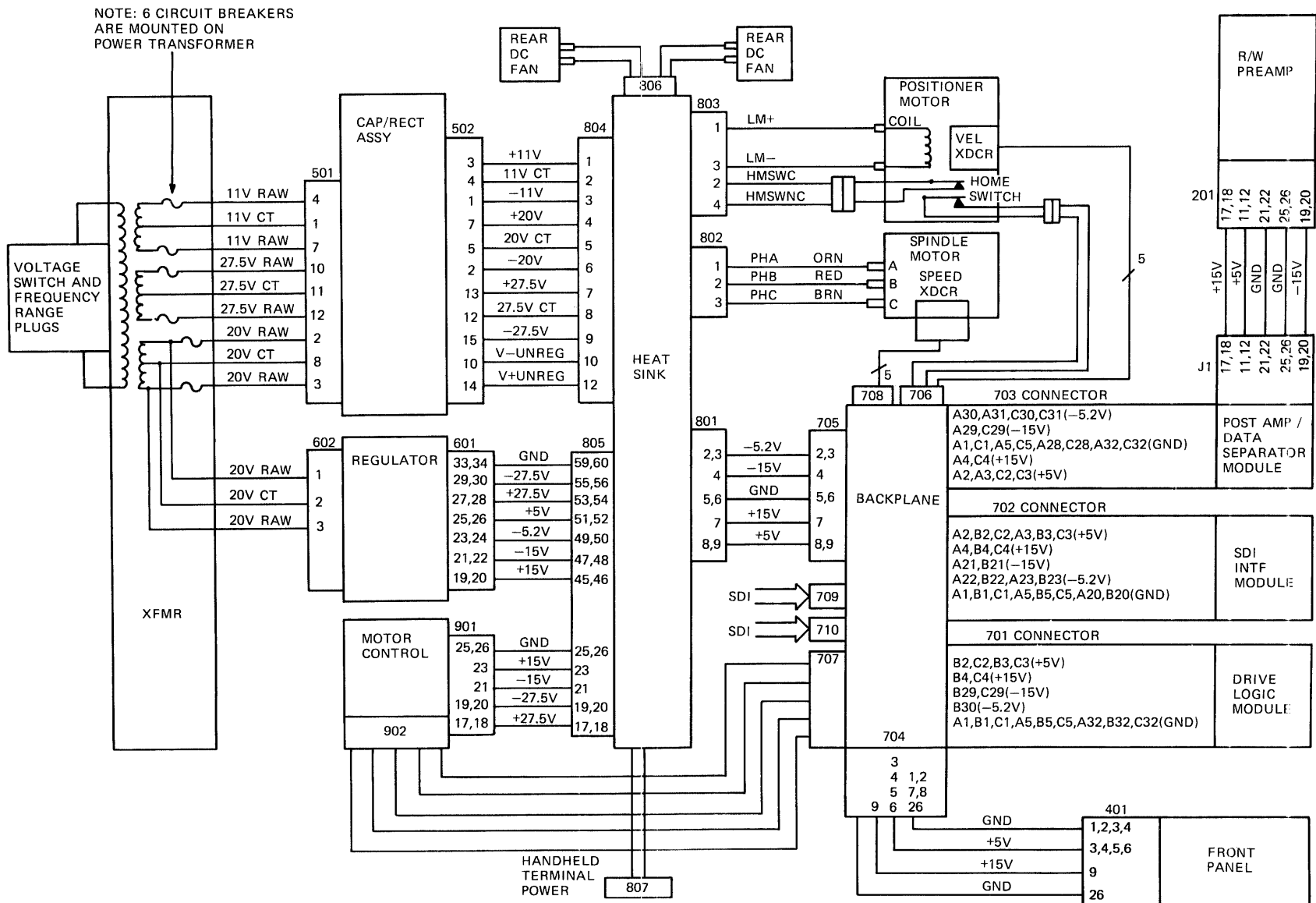


Figure 4-21 Detailed Power Distribution Diagram

4.14 POWER SHUTDOWN

In addition to supplying all the RA60 dc power, the shut-down and power-up logic that protects the storage data from ac or dc failures is on the regulator module.

In the RA60 Disk Drive, an ac failure occurs whenever power is lost for more than 20 milliseconds. This will cause the shut-down logic to implement the following ac shut-down activities.

- Wait for 20 milliseconds outage.
- Assert CMDINH signal to finish sector write command and ignore any pending write commands.
- Assert PSFLT signal to prevent writing on the disk.
- Assert NOT RETRACT signal to unload heads.
- Turn off regulated power.

When the ac power resumes, the logic will implement the following power resumption sequence.

- Assert the PSFLT signal to prevent writing on the disk.
- Assert NOT RETRACT signal to unload heads for 200 milliseconds.
- Turn on regulated power supplies.

In addition to ac shut-downs, the regulator board controls dc shut-downs. This is necessary to protect the power supply from momentary or permanent short circuits. There are three conditions that can cause a dc shut-down. These are a dc over-voltage condition, a dc under-voltage condition, and an over-current condition. A dc shut-down follows the same sequence as the ac shut-down, except there is no 20 millisecond delay. After a dc shut-down, the power supply will remain off until the fault is removed and the main circuit breaker is reset.

CHAPTER 5 FAULT ISOLATION

5.1 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.

5.2 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

5.2.1 Front Panel Codes

Figure 5-1 describes the fault codes, shows the front panel light configuration and the hex code of the lights.

Table 5-1 lists the fault codes, gives a description of the fault, and calls out the most likely failing FRUs.

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 5-1 Front Panel Fault Codes

Table 5-1 RA60 Front Panel Fault Codes

FRONT PANEL CODE	DESCRIPTION	MOST LIKELY FRU FAILURE
00	Microcode error (not sent front panel)	1. None
01	Heads home switch fault	1. Push heads home 2. Check P803 3. Heads home switch assembly
02	Front Panel Fault	1. Front panel module 2. Drive logic module 3. Front panel ribbon cable
03	Long spin-up time fault	1. Check Spindle motor connections 2. Heat sink module (<i>power module</i>) 3. Spindle Motor 4. Drive logic module
05	Bad servo samples fault	1. Pack 2. Post amp/data separator module 3. R/W preamplifier module 4. Heads
06	Bad velocity fault	1. Pack 2. Post amp/data separator module 3. R/W preamplifier module 4. Drive logic module 5. Positioner assembly
07	Linear mode fault	1. Pack 2. Post amp/data separator module 3. Drive logic module
08	Retry on seek fault	1. Pack 2. Post amp/data separator module 3. R/W preamplifier module 4. Drive logic module
09	Lost servo samples fault	1. Pack 2. Heads 3. Post amp/data separator module

Table 5-1 RA60 Front Fault Codes (Cont)

FRONT PANEL CODE	DESCRIPTION	MOST LIKELY FRU FAILURE
0A	Heads home switch will not open	<ol style="list-style-type: none">1. Shipping pin not removed2. Check P8033. Heads home switch assembly4. Heatsink module
10	Master processor fault	<ol style="list-style-type: none">1. Drive logic module2. SDI module3. Post amp/data separator module4. Backplane module
11	SDI faults	<ol style="list-style-type: none">1. SDI module2. Drive logic module3. SDI cable4. Backplane module
13	Invalid SDI level one command	<ol style="list-style-type: none">1. SDI module2. Post amp/data separator module3. R/W preamplifier module4. Backplane module
3F	Master processor fault	<ol style="list-style-type: none">1. Drive logic module2. SDI module3. Post amp/data separator module4. Backplane module

5.2.2 RA60 Error Messages

Refer to Table 5-2 for the RA60 error messages. They are displayed on the hand held terminal when internal diagnostics are run or are printed out on the system console when running host diagnostics. Table 5-2 shows the error code, description of the error, and the most likely failing FRU.

Table 5-2 RA60 Error Messages

ERROR CODE	DESCRIPTION	MOST LIKELY FRU FAILURE
01	Command cannot be executed with the drive in its current state	1. Drive logic module
02	Nonexistent head or cylinder requested with seek	
03	Opcode is not one of six valid opcodes	
04	Cover open when run command is issued	
06	Program error during head load	
08	Heads not home when run command is issued	1. Push heads home
09	Heads home switch open during spin-up	2. Check P803
0A	Heads home switch will not close during unload	3. Heads home switch assembly
0B	Cover or lid lock open during head load	
OC	Spin-up L high during spin-up	1. Front panel module 54-15272-01
10	Lid lock open during spin-up	2. Drive logic module 54-15266-01
11	Cover open during spin-up	3. Front panel ribbon cable 70-19257-01
12	Cover or lid lock open during head load	
13 & 14	Lid unlocked when run command is issued	
18	Spin-up too lengthy	1. Check spindle motor connections
19	Motor sample will not change during spin-up	2. Heat sink module
20	Spin-up too brief	3. Spindle motor
24	Too long to acquire spindle speed control on head load	4. Drive logic module
26	More than 32 sectors to settle on track	1. Pack
27	More than 32 sectors to settle on track retry failure	2. Post amp/data separator module
28	Too many bad servo samples during RTZ	3. R/W preamplifier
29	Too long to acquire good samples on head load	4. Heads
2A	Head load seek does not return to track 0	
2B	Bad servo samples when bumping guard band on head load	
2C	Bad servo samples during RTZ on head load	
2D	Bad samples during linear mode	
2E	Off speed when in linear mode	

Table 5-2 RA60 Error Messages (Cont.)

ERROR CODE	DESCRIPTION	MOST LIKELY FRU FAILURE
2F	Off track in linear state	1. Pack 2. Post amp/data separator module 3. R/W preamplifier module 4. Drive logic module 5. Positioner assembly
40	Retry on seek due to bad servo samples	1. Pack
41	Retry on seek due to bad servo samples failing	2. Post amp/data separator module
42	Retry on seek due to bad guard band flags	3. R/W preamplifier module
43	Retry on seek due to bad guard band flags, retry failed	4. Drive logic module
44	Retry on seek due to wrong polarity entering linear mode	
45	Retry on seek due to wrong polarity entering linear mode, retry failed	
46	Retry on seek due to wrong grey code	1. Pack
47	Retry on seek failing due to wrong grey code	2. Heads
48	Lost servo samples	3. Post amp/data separator module
50	Too long for heads home switch to open on head load	1. Shipping pin not removed 2. Check P803 3. Heads home switch assembly 4. Heatsink module
81	Initializes and test control panel module	1. Drive logic module
82	Checks processor registers	2. SDI module
83	Test RAM #0	3. Post amp/data separator module
84	Test ROM #0	4. Backplane module
85	Tests ROM #1	
86	Tests ROM #2	
87	Verify ROM version numbers	
88	Tests the SDI clear interface bit	
89	Tests the SDI control/status register	1. Drive logic module
8A	Test front panel and serial number ROM	2. SDI module
8B	Initializes the UART	3. Post amp/data separator module
8C	Tests the error registers	4. Backplane module
8D	Tests the 8155 timer	
8E	Tests the slave control port	
8F	Slave diagnostics	
90	Command available or slave done already set when issuing a new slave command	
91	Slave command receiver timeout on opcode	

Table 5-2 RA60 Error Messages (Cont.)

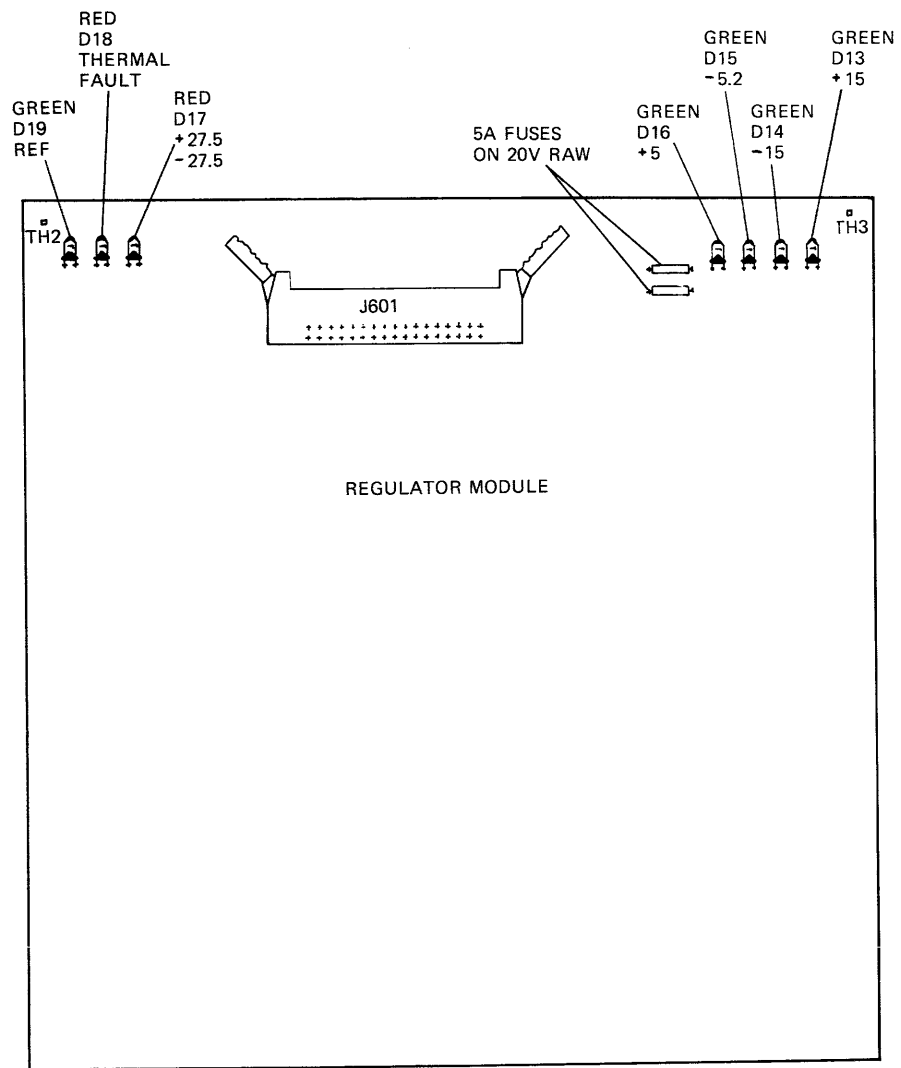
ERROR CODE	DESCRIPTION	MOST LIKELY FRU FAILURE
92	Slave attention timeout	1. Drive logic module
93	Slave done timeout to slave stop (TOSTP)	2. SDI module
94	Slave done timeout to status (1 ms)	3. Post amp/data separator module
95	Slave done timeout	4. Backplane module
96	Slave attention timeout	
97	Solenoid release timeout	1. Drive logic module
98	Watchdog timer detects master insane	2. Post amp/data separator module
99	Watchdog timer detects slave insane	3. SDI module
9A	Run switch or cover invalid at spin-up	4. Backplane module
9B	Spindle not ready during recalibrate command	
9C	SDI transfer error from DC703	1. SDI module
9D	Write or format when write-protected	2. Post amp/data separator module
9E	Format when format-disabled	3. R/W preamplifier module
9F	Transfer command during drive error	4. Backplane module
A0	Sector read/write overrun error	
A1	Transfer command during read/write error	
A2	SDI command checksum error	1. SDI module
A3	SDI frame error	2. Drive logic module
A4	SDI command parity error	3. Post amp/data separator module
A5	SDI command out of range	4. Backplane module
A6	SDI command length error	
A7	SDI error status byte in non-zero	
A8	Slave done timeout to seek command	1. Drive logic module
A9	Slave done timeout to RTZ command	2. SDI module
AA	Slave response error to RTZ command	3. Post amp/data separator module
AB	Slave done timeout during first pass	4. Backplane module
AC	Command receiver timeout during diagnostic stop or ASCII port command time = todgn 2	
AD	Slave done timeout during diagnostic stop or ASCII port time = 1MS	
AE	Drive off-line	1. Drive logic module
AF	Command bytes 4 & 5 are not zero	2. Post amp/data separator module
B0	Invalid group number	3. SDI module
B1	Invalid head-select number	4. Backplane module
B2	Invalid cylinder range	
B3	Spindle not ready	

Table 5-2 RA60 Error Messages (Cont.)

ERROR CODE	DESCRIPTION	MOST LIKELY FRU FAILURE
B4	Controller timeout = 0	1. Drive logic module
B5	Spindle not ready	2. Post amp/data separator module
B6	Illegal memory region	3. SDI module
B7	DD bit set	4. Backplane module
B8	Tried to clear hard fault	
B9	Slave done timeout (1 MS) to get status	
BA	Non-zero level	1. Drive logic module
BB	Wrong subunit error	2. Post amp/data separator module
BC	Diagnostic command, memory region high, not zero	3. SDI module 4. Backplane module
BD	Diagnostic command, invalid parameters	
BE	Write enable a write-protect drive	
BF	Setting S7 = 7	

5.3 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 5-2. Use the chart in Table 5-3 to help isolate power supply problems.



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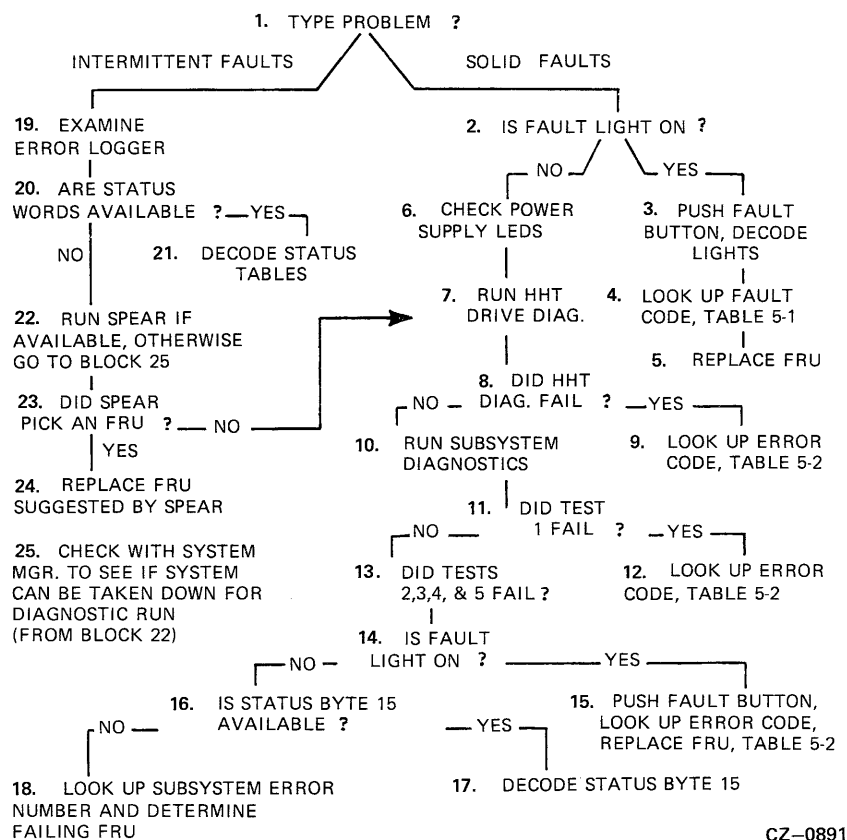
Figure 5-2 Regulator Module LEDs

Table 5-3 Regulator LED Fault Codes

REGULATOR LEDES							POSSIBLE CAUSES
Green D19 REF	Red D18 Thermal Fault	Red D17 +27.5 -27.5	Green D16 +5	Green D15 -5.2	Green D14 -15	Green D13 +15	Listed in order of most likely
1	0	0	1	1	1	1	Normal state
0	0	0	0	0	0	0	Suspect voltage reference on regulator 1. Check AC cabling and switch plate assembly 2. Transformer 3. Regulator 4. Cap/rec assembly
0	0	1	1	1	1	1	+27.5 volt failure 1. Heat sink module 2. Cap/rec assembly 3. Transformer 4. Regulator
0	0	0	----at least one off----				Suspect a short circuit 1. Logic module shorts 2. Heat sink module
0	0	0	0	0	1	1	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
0	0	0	1	1	0	0	Suspect shorts to +15 v 1. Logic module shorts 2. Check circuit breaker 3. Heat sink module 4. Capacitor module 5. Regulator module
0	1	0	1	1	1	1	Thermal shutdown 1. Check fans 2. Regulator module
0	1	0	----at least one off----				Thermal shutdown with faulted supply 1. Check fans 2. Heat sink module 3. Regulator module

5.4 RA60 FAULT ISOLATION FLOWCHART

Use the RA60 fault isolation flowchart in Figure 5-3 as a guide to isolating disk subsystem problems. The description of each block is keyed by numbers.



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Figure 5-3 RA60 Fault Isolation Flowchart

5.4.1 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 5-3.

5.4.2 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.

5.4.3 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 5-1 assists in interpreting the front panel lights.

5.4.4 Block 4 - Look Up The Fault Code

The fault code can be found in Table 5-1. This table also gives the most likely failing FRUs for that fault code.

5.4.5 Block 5 - Replace The Failing FRU

Replace the most likely failing FRU indicated in Table 5-1. Since more than one FRU can be the cause of a fault code, the most likely is listed first. Always replace that FRU first.

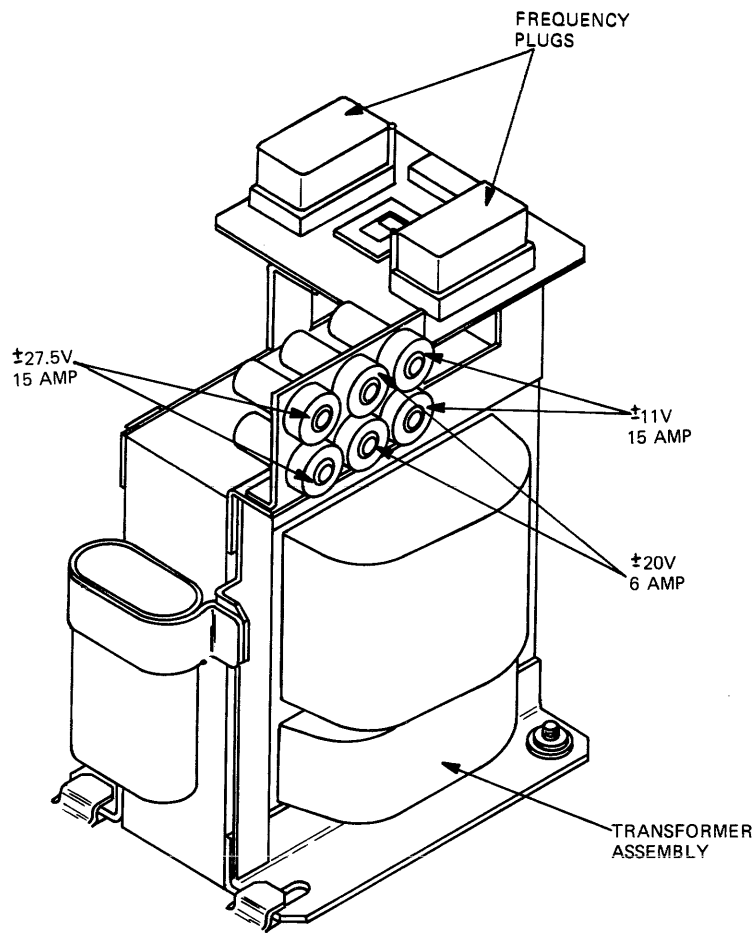
5.4.6 Block 6 - Check Power Supply LEDs

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 5-2 shows the location of these LEDs. Look up the light pattern of these LEDs in Table 5-3 to determine if the power supply is at fault. If Table 5-3 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 5-4 and 5-5 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.



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

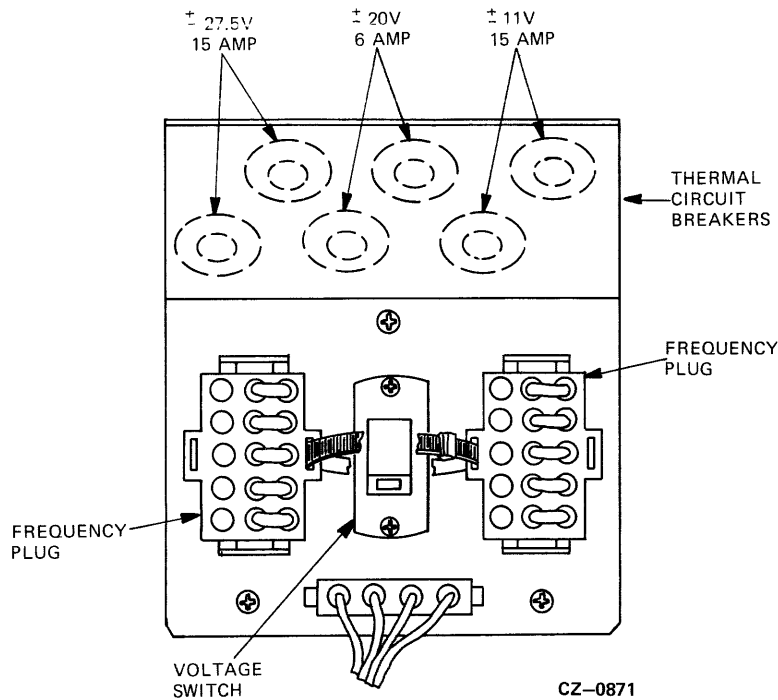


Figure 5-5 Location of Circuit Breakers
(New Style Transformer)

5.4.7 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.

5.4.8 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.

5.4.9 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 5-2 and replace the most likely failing FRU first.

5.4.10 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 customer data area if desired.

5.4.11 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.

5.4.12 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.

5.4.13 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.

5.4.14 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.

5.4.15 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 5-1 to convert the front panel light into an error code. Then look up this error code in Table 5-1 and replace the suggested FRU.

5.4.16 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.

5.4.17 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 5-2.

The error code 9C in Table 5-2 is described as an SDI transfer error from the DC703 chip. Table 5-2 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 5-2, 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.

5.4.18 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.

5.4.19 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.

5.4.20 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.

5.4.21 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.

5.4.22 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.

5.4.23 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.

5.4.24 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.

5.4.25 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.

5.5 THE STATUS MESSAGE

The last line of the sample error message printout shown below gives the status message. The status message is a result of the controller issuing a get status command to the drive.

```
CZUDC SFT ERR 00006 DN UNIT 00 TST 004 UB 000 PC: 021044
DISK EXERCISER DM PC:5324 UDA AT 172150 DRIVE 032 RUNTIME 0:00:37
TIMEOUT OF DRIVE DURING WRITE ATTEMPT
WRITE ATTEMPT RETRIES: 0
L/DBN NUMBER 5252
ACTUAL L/R/DBN )
TRK 1 GRP 0 CYL 6
ORIGIN OF LAST SEEK WAS CYL 5 GROUP 1
REAL TIME DRIVE STATE 8001
STATUS: 9C01 1100 0000 0A00 0000 0613 1020
```

5.5.1 LAYOUT OF THE STATUS MESSAGE

The status message consists of 28 numbers arranged into seven groups of four hexadecimal digits. Each group of four hexadecimal digits can be decoded into two status bytes as shown in Figure 5-6. Only bytes 2 through 15 are printed in the status message error printout. Status bytes 2 through 8 give some general status information about the drive and the controller. Status bytes 9 through 15 give drive specific information about the RA60 drive under test.

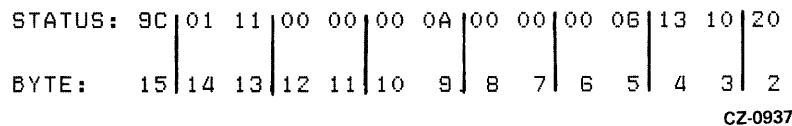


Figure 5-6 Separating the Status Message into Bytes

After separating the two hexadecimal digits in each status byte, use the bit map chart in Figure 5-7 to decode the bit mnemonics (letter abbreviations). Since each hexadecimal digit is represented by four binary bits, you will find a total of eight binary bits in each status byte of Figure 5-6.

Decode the bit mnemonics present in the drive status message and use Table 5-4 to look up the meaning of the mnemonics.

	MSB									LSB
BYTE 1	RESPONSE CODE									
BYTE 2	UNIT									
BYTE 3	SUBUNIT MASK				HI UNIT					
BYTE 4	0A	RR	DR	SR	EL		PS	RU		
BYTE 5	W4	W3	W2	W1	DD	FO	DB	S7		
BYTE 6	DE	RE	PE	DF	WE					
BYTE 7	S4	S3	S2	S1	C1	C2	C3	C4		
BYTE 8	RETRY COUNT/FAILURE CODE									
BYTE 9	PREVIOUS LOW PHYSICAL CYLINDER ADDRESS									
BYTE 10	PREVIOUS HIGH PHYSICAL CYLINDER ADDRESS									
BYTE 11	PREVIOUS HEAD ADDRESS									
BYTE 12	CURRENT LOW PHYSICAL CYLINDER ADDRESS									
BYTE 13	CURRENT HIGH PHYSICAL CYLINDER ADDRESS									
BYTE 14	CURRENT HEAD ADDRESS									
BYTE 15	DRIVE ERROR CODE									

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Figure 5-7 Bit Map of the Drive Status Message Bytes

Table 5-4 Bit Description of Status Message Bytes

STATUS BYTE	DESCRIPTION
Byte 1	Response Code Field — Byte 1 is the response code to a controller command. Byte 1 is not printed out in the status message.
Byte 2	Unit Number — The unit number consists of two hexadecimal digits representing the unit number of the selected disk drive returning the status (0-254). On RA drives, the unit address is set by the front panel READY plug.
Byte 3	Subunit Mask — The subunit mask is a four-bit representation of the subunit that is returning the status message. The right-most bit position represents subunit 0. The left-most bit position represents subunit 3. Only one bit can be set at a time. UDA50 subsystems can handle only drives with up to two subunits (multiple packs or software groups). Therefore, the valid numbers in this status byte can only be a hexadecimal 1 or 2. For drives that contain no subunits (e.g. the RA80, RA81, and RA60), the right-most bit position is always set indicating subunit 0.
Byte 3	High Unit Number — Byte 3 contains the upper four bits to a 12-bit (three hexadecimal digits) unit number. For example, if the drive unit number were 136, the hexadecimal 1 would be present in byte 3.
Byte 4	OA — A logical 1 in this position indicates the drive is unavailable to the UDA50. A logical 0 indicates the drive is available to the UDA50.
Byte 4	RR — A logical 1 in this position indicates that the drive requires an internal readjustment. Some drives do not use this bit.
Byte 4	DR — A logical 1 in this position indicates that there is a request for a diagnostic to be loaded in the drive microprocessor memory. A logical 0 indicates that no diagnostic is being requested of the host system.
Byte 4	SR — A logical 1 in this position indicates that the drive spindle is up to speed. A logical 0 indicates the drive spindle is not up to speed.
Byte 4	EL — A logical 1 in this bit position indicates that there is drive specific information available in the extended status area of drive memory. This extended status area information is found in bytes 9 through 15 in the VAX/VMS error report SDI message. In the RSTS/E error report, the extended status area information is found in words 24 through 27 of the MSCP packet message field. A logical 0 indicates that no information is available in the extended status area.
Byte 4	PS — A logical 1 in this bit position indicates that the drive port select switch for this controller is pushed in (selected). A logical 0 indicates that the port switch is out.
Byte 4	RU — A logical 1 in this position indicates that the RUN/STOP switch is pushed in (RUN). A logical 0 indicates the switch is out (STOP).
Byte 5	W4-W1 — Logical 1s in any of these four bit positions represent the write-protect status for the sub-unit represented. (e.g., a 0001 indicates that sub-unit 0 within the selected drive is write-protected.) RSTS/E does not support sub-units.
Byte 5	DD — A logical 1 in this bit position indicates that the drive has been disabled by a controller error routine or diagnostic. The FAULT light is on when this bit is set. A logical 0 indicates that the drive was enabled by a controller error routine or diagnostic.
Byte 5	FO — A logical 1 in this position indicates that the drive can be formatted.

Table 5-4 Bit Description of Status Message Bytes (Cont.)

STATUS BYTE	BIT DESCRIPTION
Byte 5	DB — A logical 1 in this position indicates that the diagnostic cylinders on the drive can be accessed.
Byte 5	S7 — A logical 1 in this bit position indicates that the 576 byte sector format (18 bit words) is selected. A logical zero indicates that the 512 byte sector format (16 bit words) is selected. RSTS/E and VMS have 512 bytes per sector.
Byte 6	DE — A logical 1 in this position indicates that a drive error has occurred and the drive FAULT light may be on.
Byte 6	RE — A logical 1 in this position indicates that an error occurred in the transmission of a command between the drive and the UDA50. The error could be a checksum error or an incorrectly formatted command string.
Byte 6	PE — A logical 1 in this position indicates that improper command codes or parameters were issued to the drive.
Byte 6	DF — A logical 1 in this position indicates a failure in the initialization routine of the drive.
Byte 6	WE — A logical 1 in this position indicates a write lock error has occurred.
Byte 7	S4-S1 — This is a four-bit representation of the subunits have their attention-available messages suppressed in the UDA50. The right-most bit position represents subunit 0. The left-most bit position represents subunit 3. RSTS/E does not support subunits. If one of the (S4-S1) bits is set, it indicates that the controller is not to interrupt the host CPU with an attention available message when the specified subunit raises its available real-time drive status line to the UDA50. The S4-S1 bits reflect the results of a change controller flags command in which attention-available messages are not desired for certain subunits.
Byte 7	C1-C4 — This is a four-bit drive status code indicating various states of drive operation. At the present time, only three codes are valid. A code of 0000 = drive normal operation. A code of 1000 = the drive is off-line due to being under control of a diagnostic. A code of 1001 = the drive is off-line due to another drive having the same unit identifier (e.g. serial number, drive type, class etc.).
Byte 8	RETRY COUNT/FAILURE CODE — This 8-bit byte contains one of two types of information depending upon the status of the DF bit (byte 6). The DF bit monitors the drive initialization process. The DF bit remains a 0 if initialization is successful. Byte 8 contains the retry count from the previous operation. For example, if a seek operation required fourteen retries to be successful, byte 8 would contain the number 14. When the DF bit is set, it indicates that the drive initialization failed and therefore byte 8 now contains a specific drive error code. This error code can be looked up in the appropriate drive service manual.
Byte 9 to Byte 15	Byte 9 through Byte 15 are self-explanatory, and are related to drive specific information about the RA60 under test.

CHAPTER 6 INSTALLATION

6.1 INTRODUCTION

This chapter describes the procedures necessary for RA60 installations. It includes safety precautions, site preparation and planning, joining disk cabinets, cabling, and checkout.

Warning

Hazardous voltages are present inside this equipment. Installation and servicing should be performed by a qualified and trained service person. Bodily injury or equipment damage may result from incorrect servicing.

6.2 SITE PREPARATION AND PLANNING

Some site preparation and planning is necessary before installing an RA60 disk subsystem. The paragraphs that follow discuss some of the things to consider.

6.2.1 Cleanliness

Cleanliness is always an important consideration when working with disk drives. The close tolerances between the read/write heads and the media make disk drives very sensitive to dust and other particulates. The RA60 is designed to operate in an office or light industrial environment. The air particulates should not exceed five million particles of 0.05 micron per cubic foot of air.

6.2.2 Floor Loading

The weight of one RA60 in a cabinet is 159.64 kg (352 lbs). The weight of each additional disk drive is approximately 68.95 kg (152 lbs). This should not place any abnormal stress on a raised computer room floor. However, the weight of existing equipment should be considered before installing additional drives.

6.2.3 Heat Dissipation

The heat dissipation of each RA60 is approximately 2730 Btu/hour. To calculate the total heat dissipation of each drive cabinet, multiply the above Btu/hour by the number of drives it contains.

6.2.4 Temperature and Humidity

The operating temperature range for the RA60 is between 10° C (50° F) and 40° C (104° F). The relative humidity range is between 10% and 90% with a wet bulb temperature of 28° C (82° F).

6.3 EQUIPMENT UNPACKING AND EXTERNAL INSPECTION

Before unpacking a carton, inspect it for external damage. Report any damage to the DIGITAL field service or sales office and the local carrier. If no external damage exists, the disk drive may be unpacked using the following procedure.

1. Remove the external packing material shown in Figure 6-1.

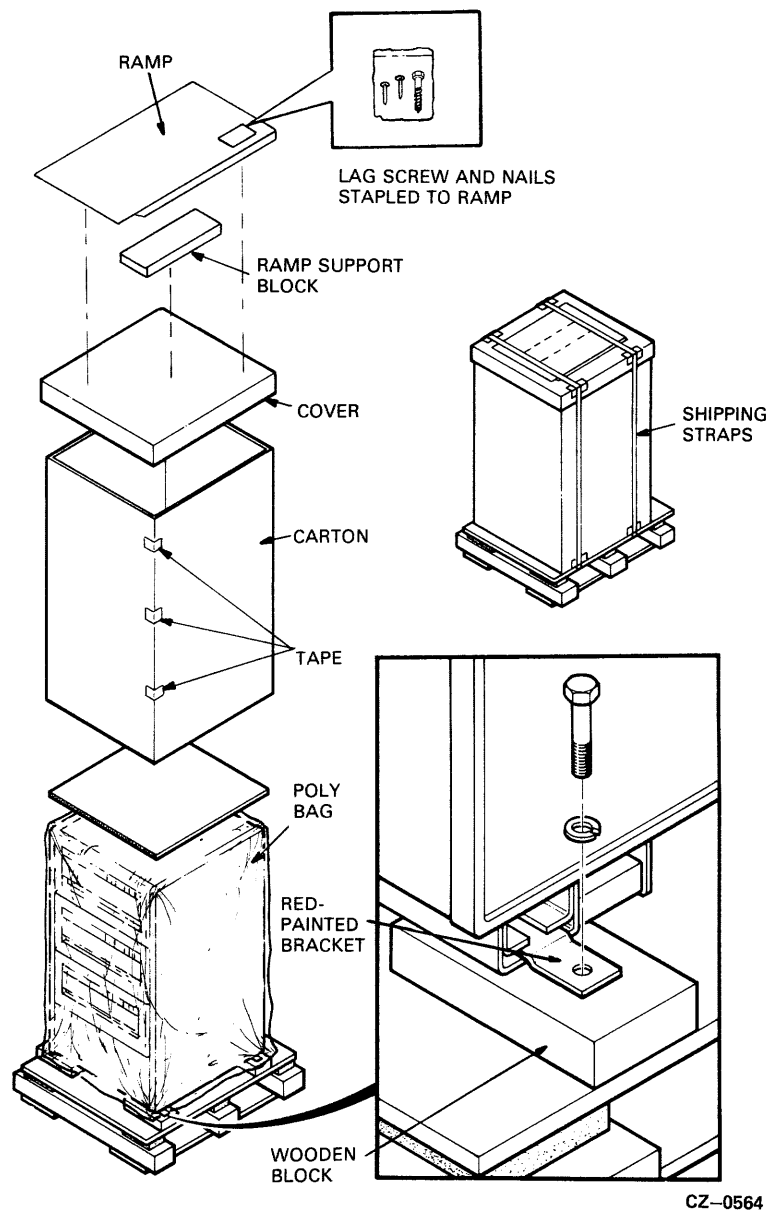


Figure 6-1 Unpacking the Disk Subsystem

2. Remove the four shipping bolts that fasten the drive cabinet to the pallet. See insert in Figure 6-1.
3. Build the ramp to roll the disk cabinet off the pallet. Use the lag screw and nails in the plastic bag stapled to the ramp. Figure 6-2 shows how the ramp is assembled.

Warning

At least two persons will be needed to perform the next step of this procedure.

4. Remove the four wooden blocks from under the disk cabinet.
5. Carefully roll the drive cabinet down the ramp.

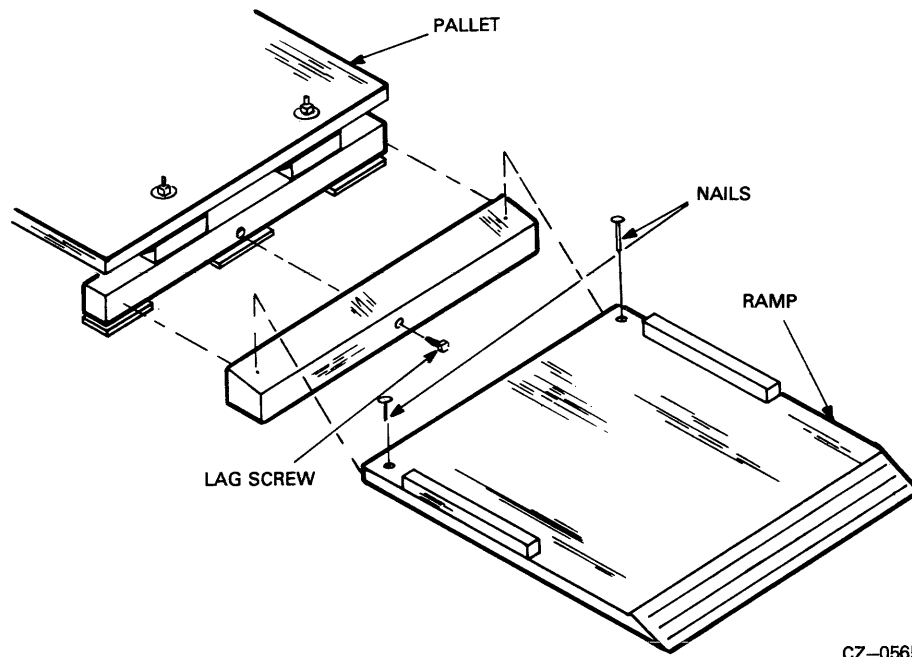


Figure 6-2 Ramp Construction

6.4 RA60 INSTALLATION CHECKLIST

The installation procedure for the RA60 requires the placement of leveler feet and SDI cables. The head locking pin must be removed and the drive must be set up for the right voltage and frequency ranges. The drive unit address plug must also be programmed and a shipping retainer bracket must be released. If cabinets are to be joined, this should be done first. If only one cabinet is being installed, go to Paragraph 6.6.

Use the following installation checklist to perform the RA60 installation. The list indicates the Paragraph number where each procedure is described.

- Joining cabinets (6.5) _____
- Installing the leveler feet (6.6) _____
- Installing the SDI cable (6.7) _____
- Setting the voltage and frequency (6.9) _____
- Removing the locking pin (6.10) _____
- Programming the unit address plug (6.11) _____
- Removing the retaining bracket screw (6.12) _____
- Plugging in the power cable (6.13) _____
- Installing add-on drives (6.14) _____
- Performing drive checkout procedures (6.15) _____

6.5 JOINING CABINETS

The H9642 AP/AR (120/240 volt) cabinet will hold up to three disk drives. It comes equipped with two side panels for standalone use. If more than three drives are required, a second drive cabinet may be joined to the first. The H9642 BP/BR (120/240 volt) expansion cabinet comes with a joiner panel and no side panels. This expansion cabinet may be joined to the first cabinet by removing one of the side panels on the first cabinet and placing it on the outer side of the expansion cabinet. Figure 6-3 shows the side panel and joiner panel locations.

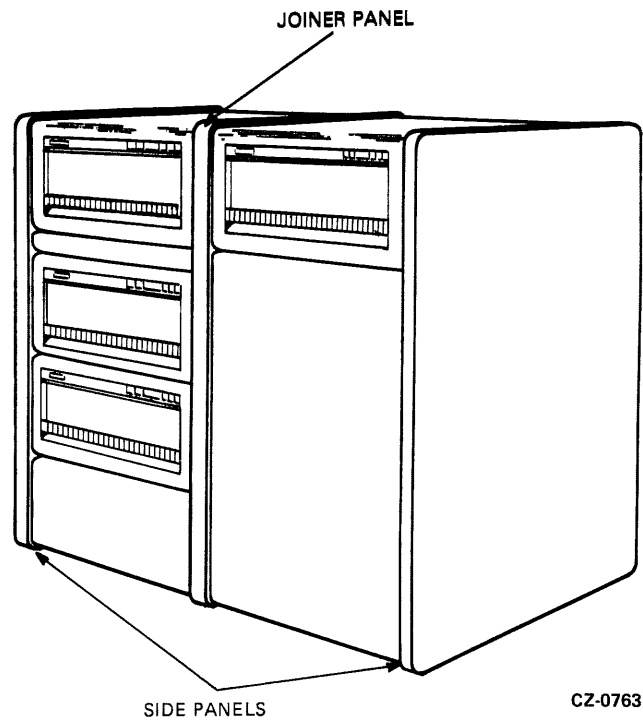


Figure 6-3 Side Panels and Joiner Panels

Use the following procedure to join disk cabinets.

1. Open the rear door on the cabinet by turning the hex lock counterclockwise. Refer to Figure 6-4.

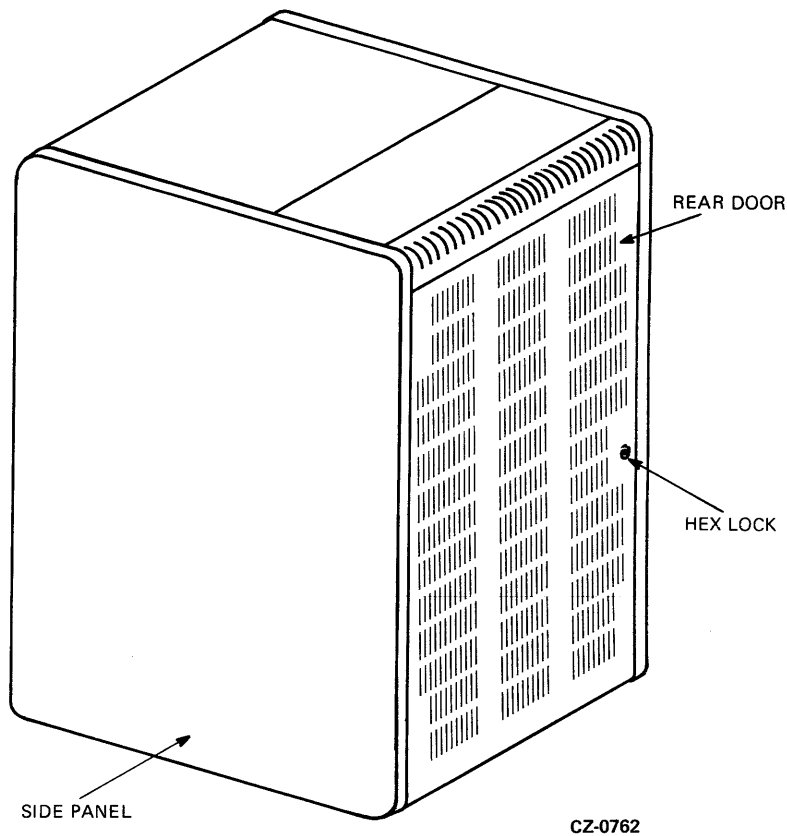


Figure 6-4 Opening the Rear Door

2. Remove the rear door by unscrewing the ground wire from the door and then pulling down on the top door latch. The door should now be free to lift off of the bottom end panel lock. Refer to Figure 6-5.

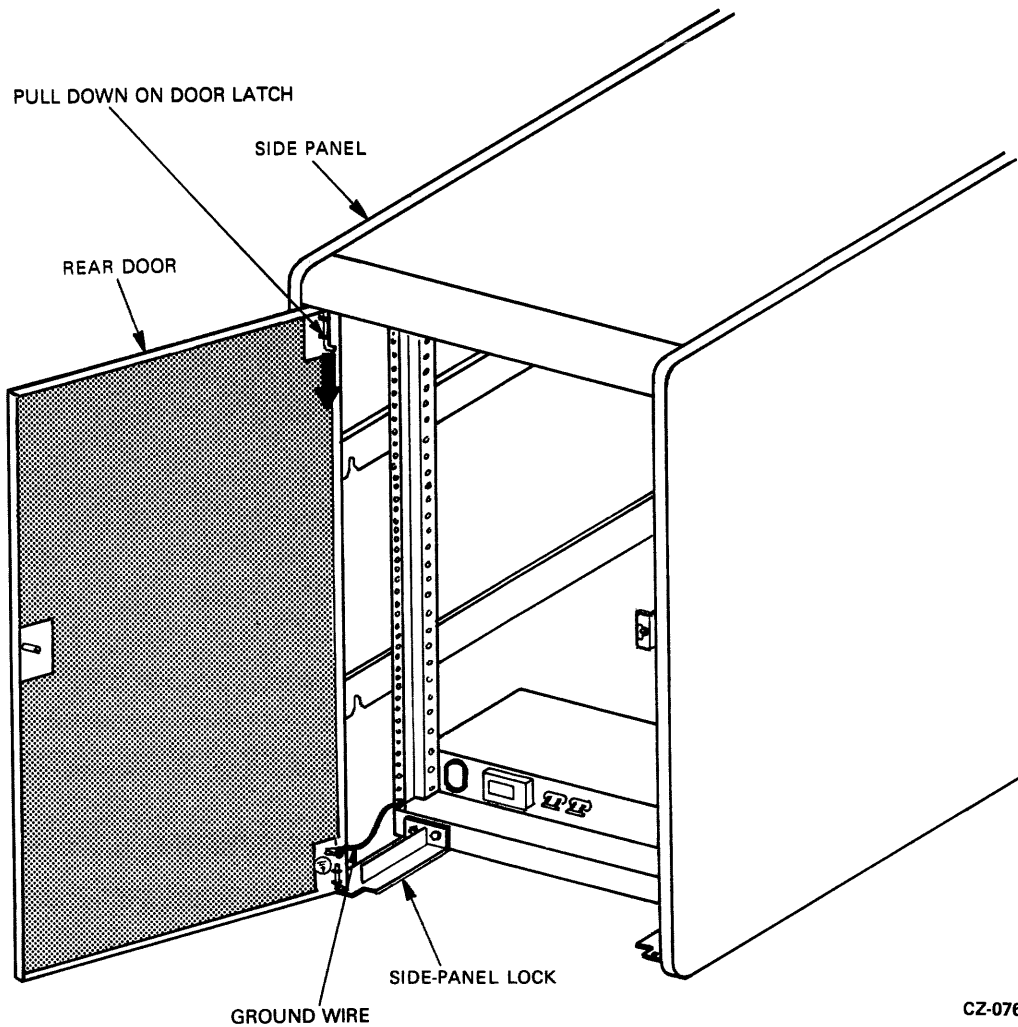


Figure 6-5 Rear Door and Side Panel Lock Removal

3. Loosen the two hex screws that secure the end panel lock to the base of the disk cabinet. Then lift the end panel lock off. Refer to Figure 6-5.
4. Remove the side panel by lifting it vertically to disengage it from the four key buttons on the side of the cabinet frame. Unscrew the ground wire attached to the side panel. Refer to Figure 6-6.

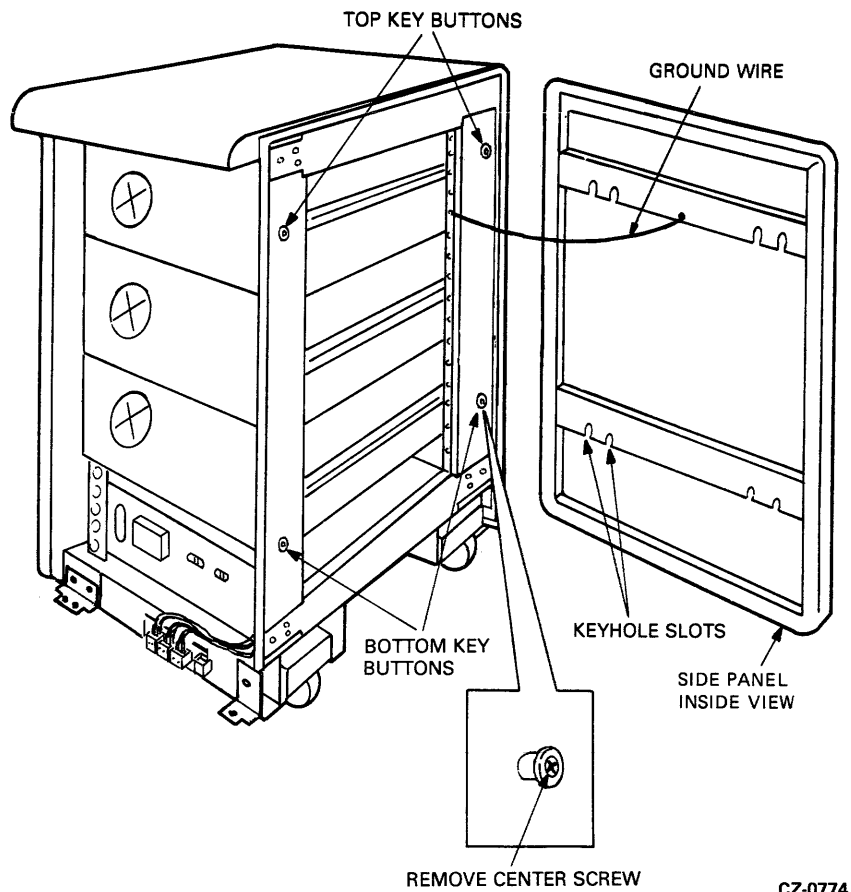


Figure 6-6 Side Panel and Bottom Key Button Removal

5. Install the side panel just removed from the first cabinet on the open side of the expansion cabinet. Begin by removing the back end panel lock from the expansion cabinet. Next, attach the ground wire just removed from the first cabinet to the exposed side frame of the expansion cabinet. Attach the other end of the ground wire to the side panel being installed. Then lower the side panel over the keyhole buttons on the cabinet. Secure the side panel by replacing the end panel lock. Refer to Figure 6-6.
6. Disconnect the two lower key buttons from the open side of the first drive cabinet by removing the screws in the center of the key buttons. Refer to Figure 6-6.

7. Join the two cabinets together as shown in Figure 6-7. Engage the top two key buttons on the first drive cabinet into the keyhole slots on the expansion cabinet joiner panel. Adjust the cabinets until their fronts are flush.

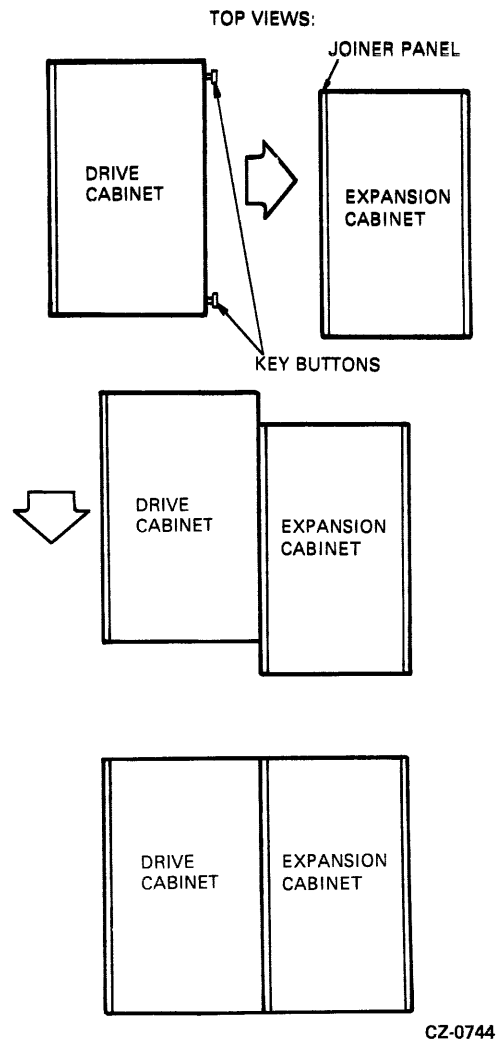


Figure 6-7 Joining the Cabinets

8. Disconnect the bottom trim panels from the front of the cabinets by removing the two screws at the base of each. Refer to Figure 6-8.

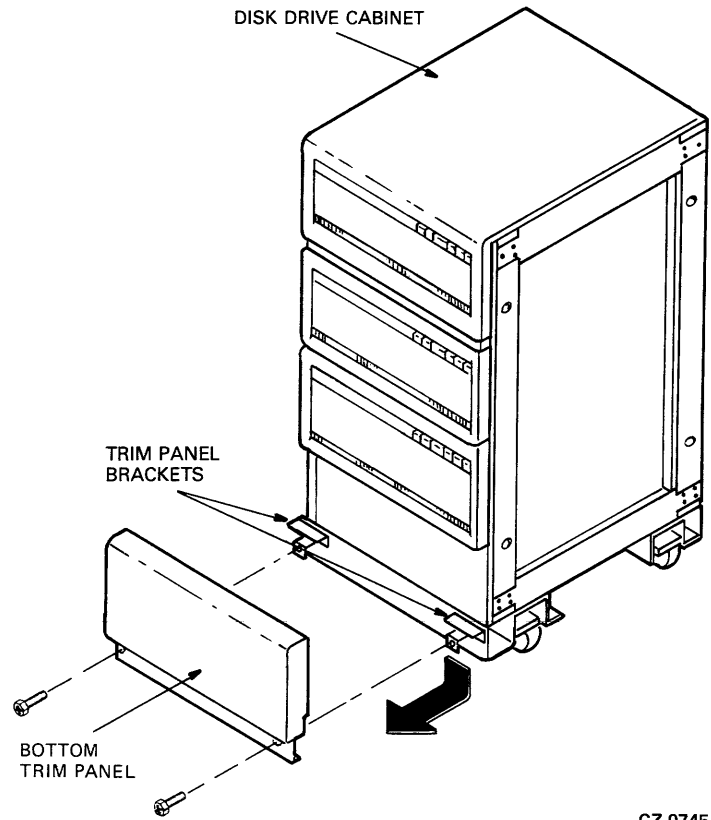
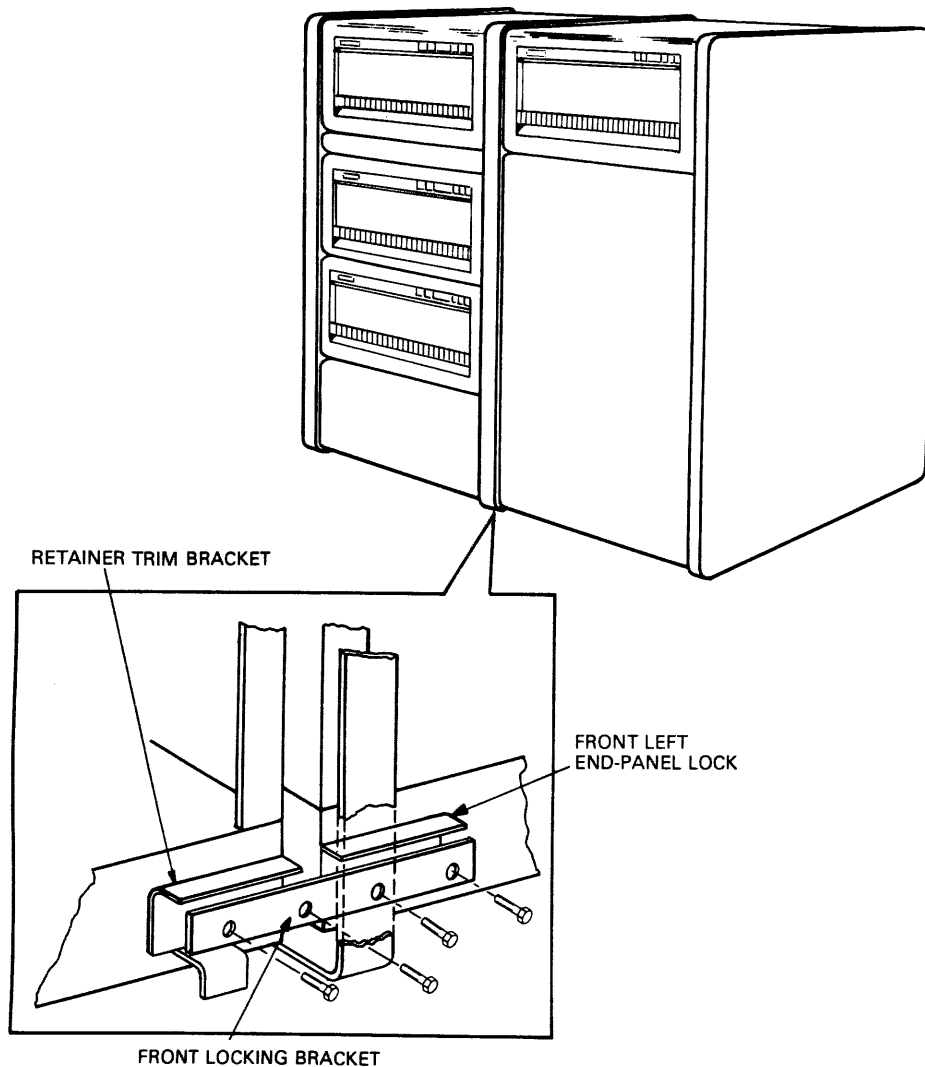


Figure 6-8 Bottom Trim Panel Removal

9. Remove the screws that hold the two retainer trim brackets at the point where the two cabinets are joined. Refer to Figure 6-9.

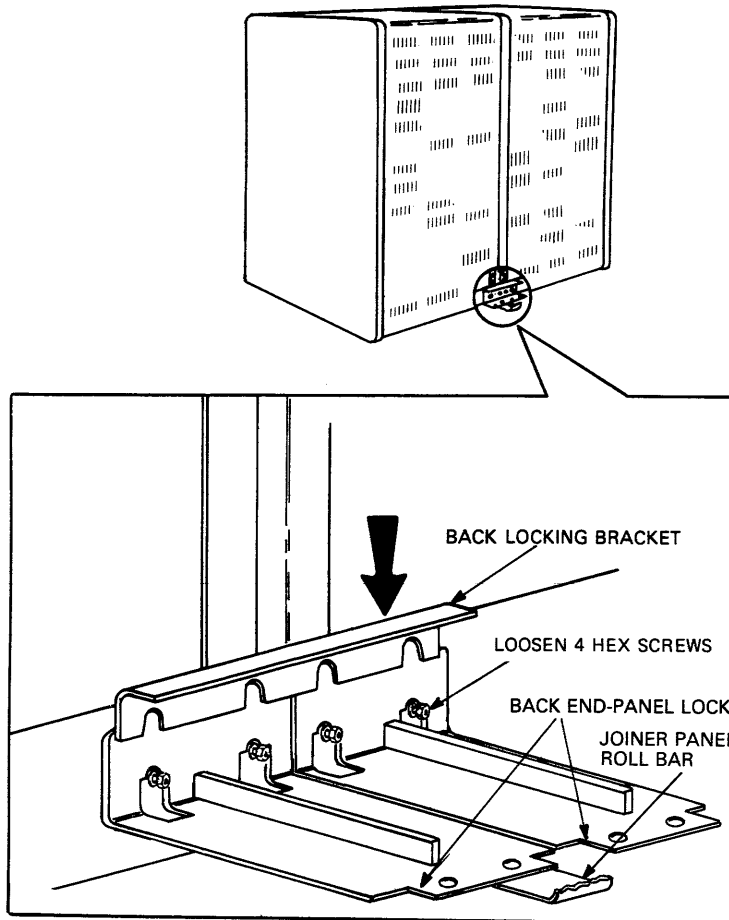


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Figure 6-9 Installing the Front Locking Bracket

10. Place the front locking bracket over the retainer trim brackets and bolt the two cabinets together with the existing hardware.
11. Replace the two bottom trim panels previously removed from the front of the cabinets.

12. Open the back doors of the cabinets and loosen the screws that hold the two back end panel locks at the point where the two cabinets are joined. Slide the locking bracket over the end panel locks and tighten the four screws. Refer to Figure 6-10.



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Figure 6-10 Installing the Back Locking Brackets

13. Replace the back door and any end panel locks removed in this procedure.

6.6 INSTALLING LEVELER FEET

Use the following procedure to install the leveler feet.

1. Remove the four red shipping brackets and leveler nuts shown in Figure 6-11.

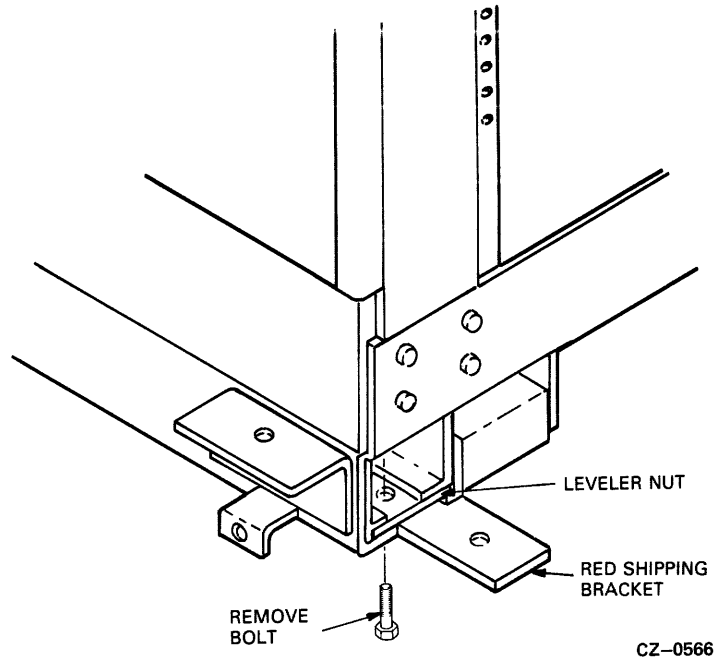


Figure 6-11 Shipping Bracket Removal

2. Assemble the four leveler feet as shown in Figure 6-12. Screw the leveler foot into the leveler nut far enough that the nut may be slid into place without raising the drive cabinet.

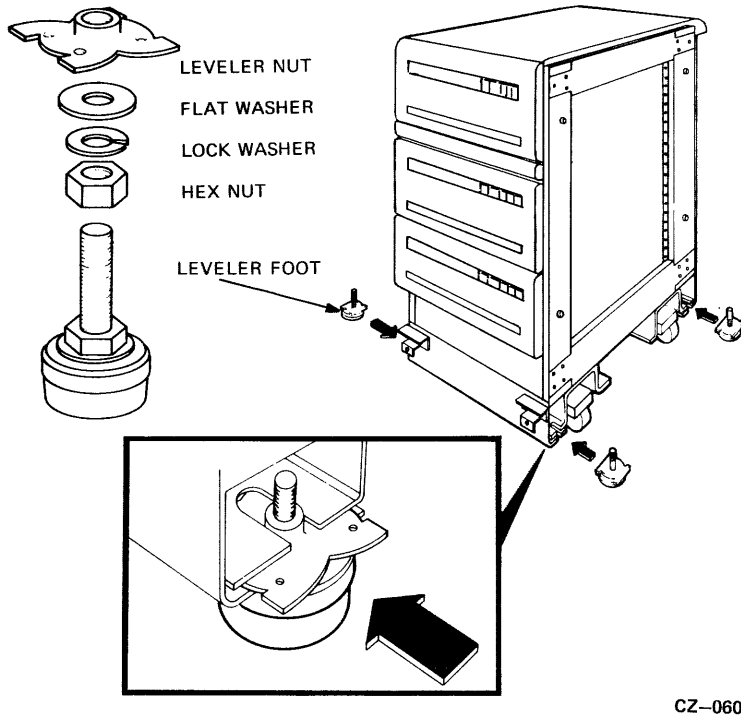


Figure 6-12 Leveler Feet Installation

3. Slide the leveler nut into the slots in the cabinet as shown in Figure 6-13. Wheel the disk cabinet to its final location before making the final leveler feet adjustments.
4. Screw the leveler feet down until they make firm contact with the floor. Adjust the four leveler feet until the drive cabinet is level.

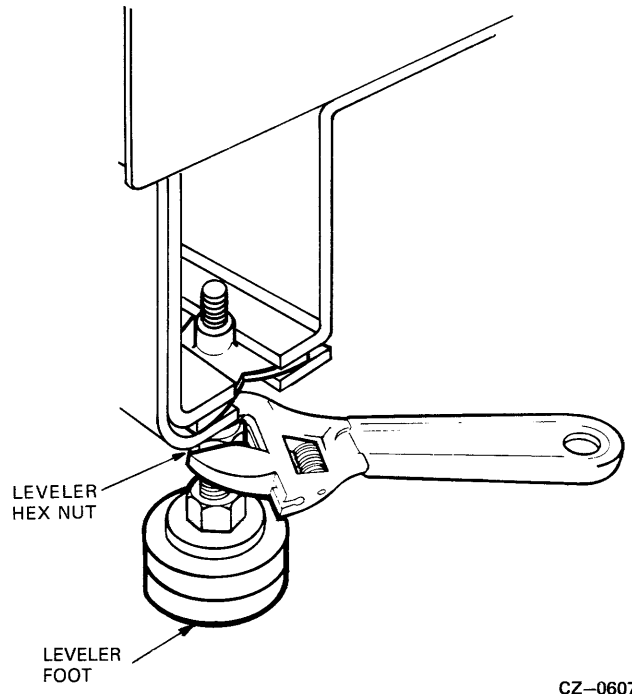


Figure 6-13 Leveler Feet Adjustments

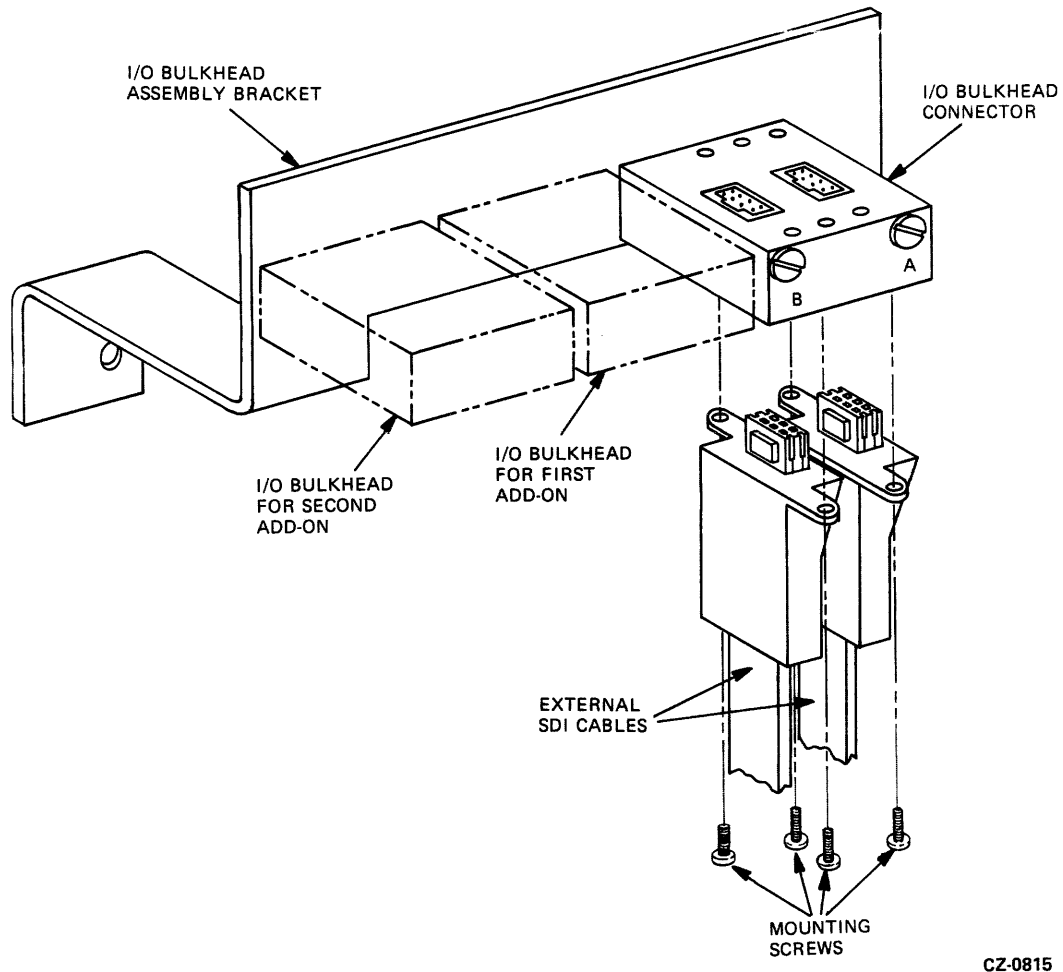
6.7 INSTALLING SDI CABLES

Both the internal and external SDI cables are mounted in the I/O bulkhead. Internal SDI cables connect to the top of the bulkhead and external SDI cables connect to the bottom.

6.7.1 Installing the External SDI Cables

The external SDI cables coming from the central processing unit (CPU) are connected to the bottom of the I/O bulkhead. Refer to Figure 6-14. Use the following procedure to install the external SDI cables:

1. Loosen the two screws holding the I/O bulkhead connector to the bracket.
2. Plug the external SDI cable from the disk controller into the Port A connector on the bottom of the I/O bulkhead. Note the orientation key on the SDI cable.
3. Install the two screws that hold the SDI cable shield terminator in place. Refer to Figure 6-14.
4. Clamp the external SDI cable to the cable entry retainers below the I/O bulkhead with either a hose clamp or tie wrap.



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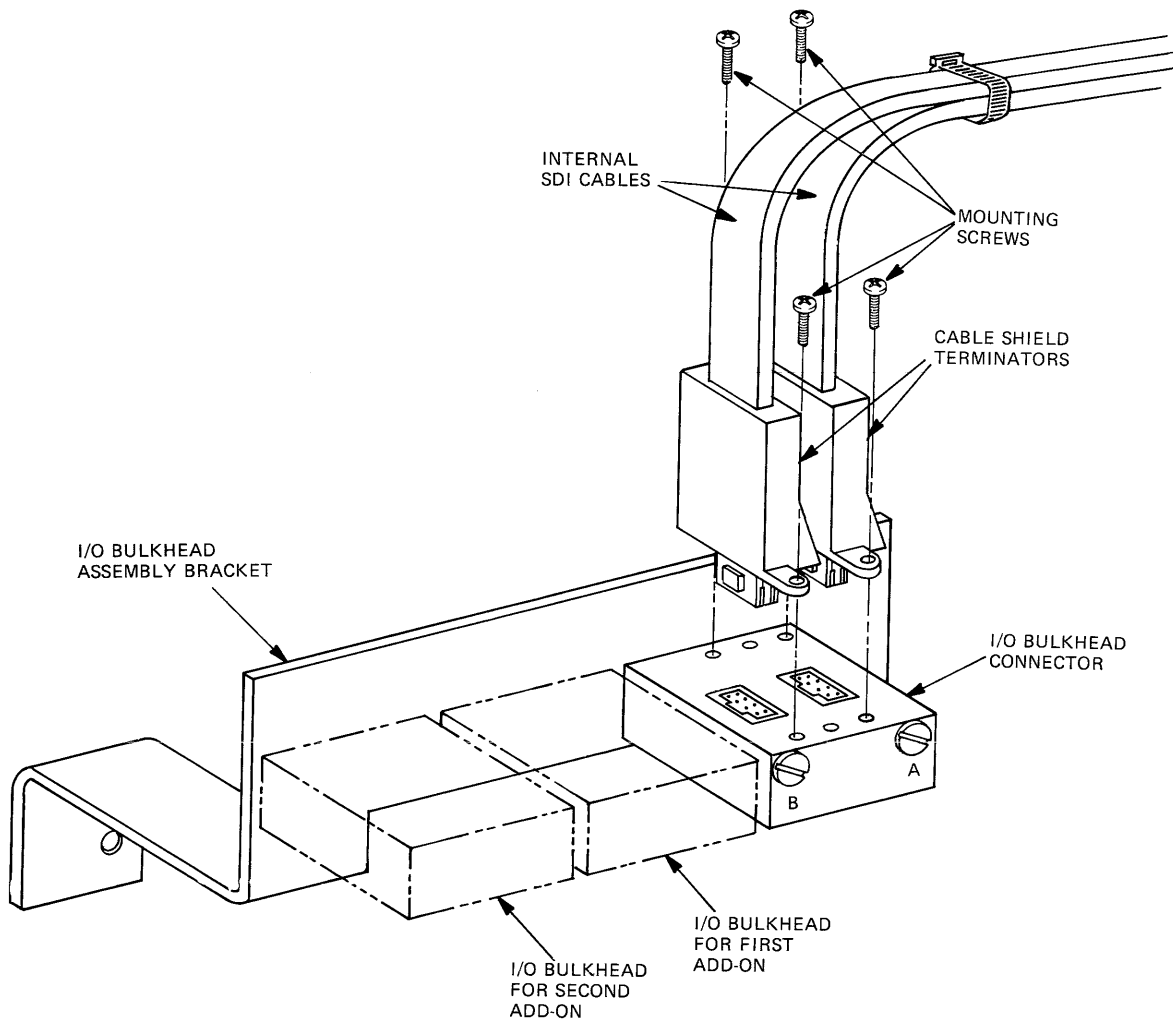
Figure 6-14 External SDI Cable Installation

5. If a second disk controller is used, mount its SDI cable into the Port B connector on the bottom of the I/O bulkhead. Note the orientation key.
6. Repeat Steps 2, 3, and 4 for the Port B SDI cable.
7. Reconnect the I/O bulkhead connector to the bracket.

6.7.2 Internal SDI Cable Installation

The two internal SDI cables that exit from the back of the drive connect to the top of the I/O bulkhead. Refer to Figure 6-15. Use the following procedure to install the internal SDI cables:

1. Locate the Port A SDI cable where it exits the back of the disk drive. Plug the end of the Port A connector on the top of the I/O bulkhead. Note the orientation key on the SDI cable.
2. Install the two screws that hold the SDI cable shield terminator in place. Refer to Figure 6-15.
3. Repeat Steps 1 and 2 for the Port B SDI cable.

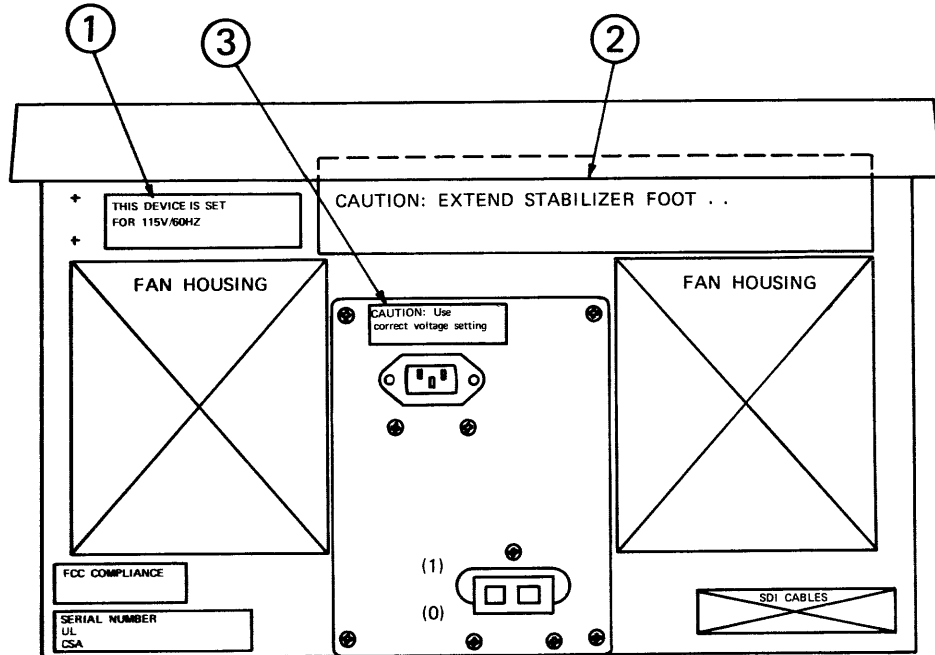


CZ-0816

Figure 6-15 Internal SDI Cable Installation

6.8 RA60 SAFETY LABELS

There are three safety labels on the back of the RA60. Be sure to read these safety labels before installing an RA60. Refer to Figure 6-16 for their location.



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Figure 6-16 RA60 Safety Labels

6.8.1 Safety Label Information

Each of the safety labels located on the back of the RA60 is printed in four languages.

1. Label #1 gives voltage and frequency settings for the drive.
2. Label #2 is a CAUTION reminder to extend the stabilizer foot before pulling the drive out to the full service position.
3. Label #3 is a CAUTION reminder to use the correct voltage and frequency settings. Refer to Paragraph 6.9.

6.9 SETTING THE VOLTAGE AND FREQUENCY

The RA60 contains a universal power supply that may be used for 120/240 volt ac and 50/60 Hz operations. Use the following procedure to set the voltage and frequency to the desired range.

1. Remove the rear cover and shield from the disk drive. Refer to Figure 6-17.

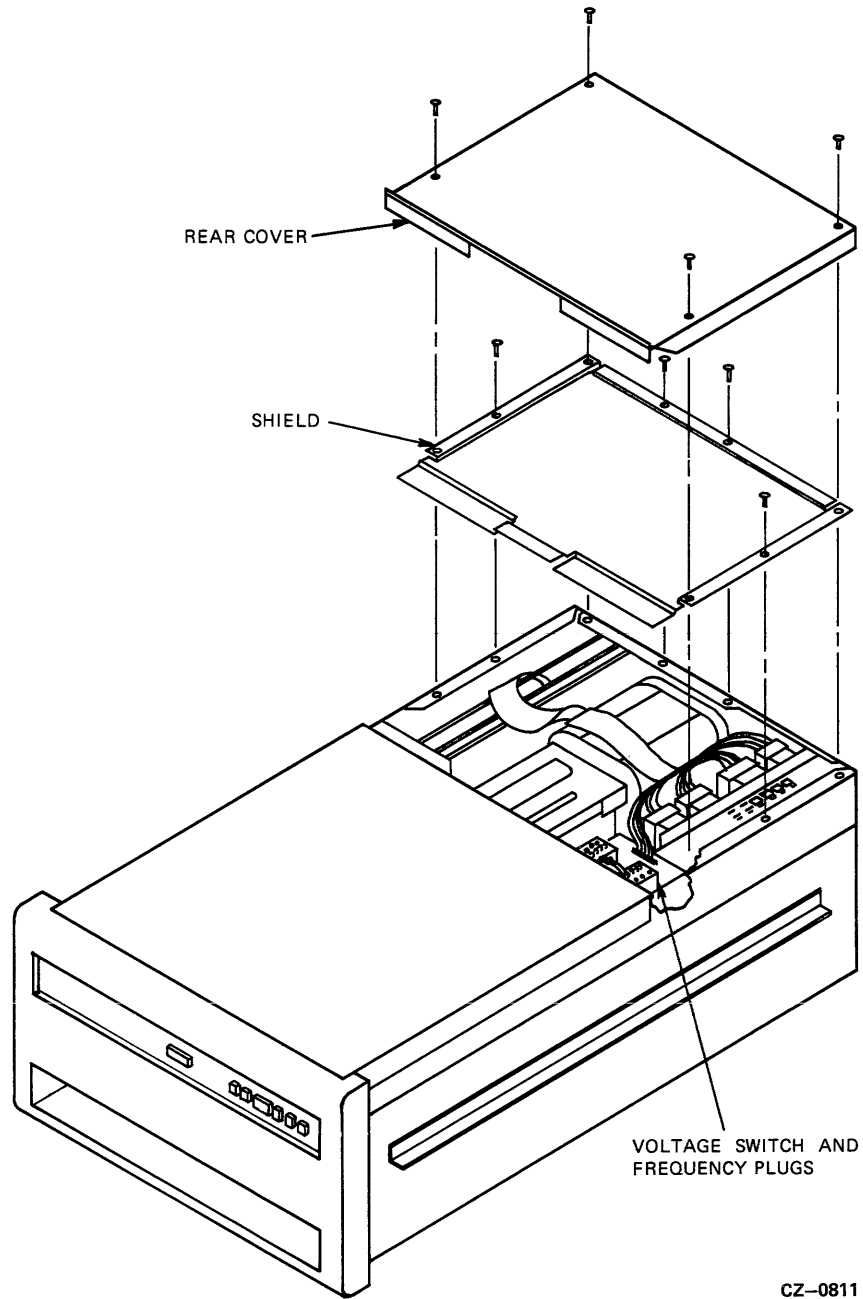
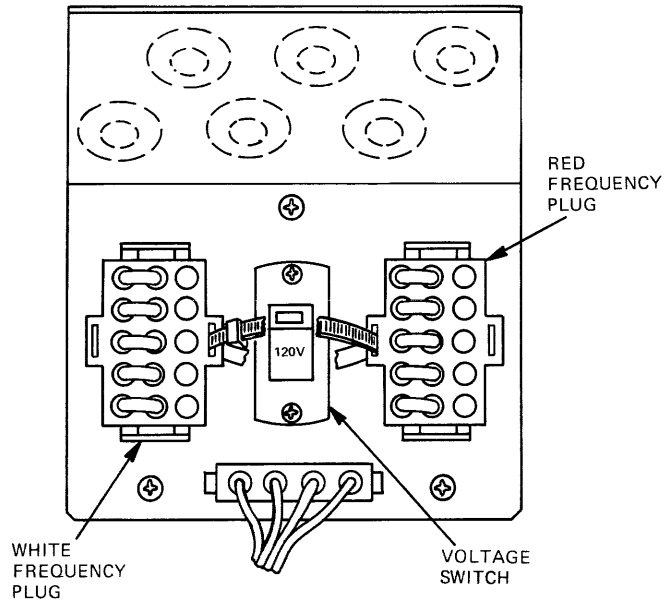


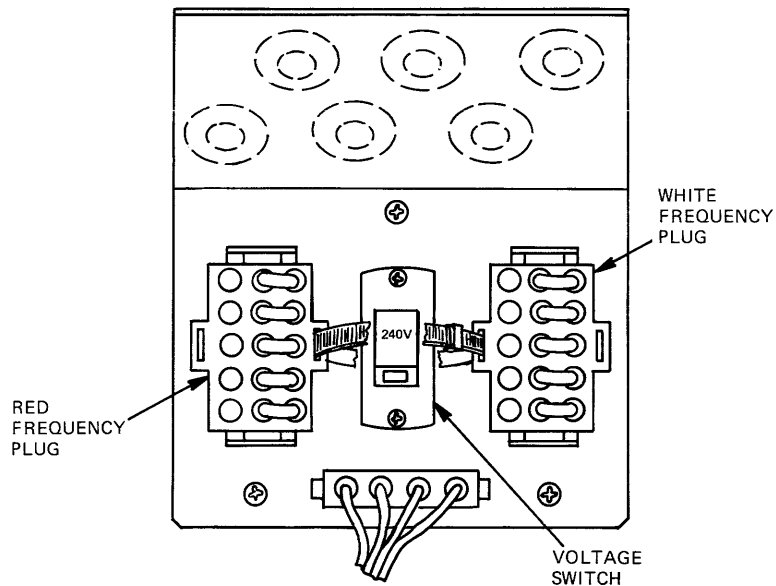
Figure 6-17 Removing the Rear Covers

2. Locate the voltage switch and frequency plugs located on top of the transformer assembly. See Figures 6-18A and 6-18B.



CZ-0814

Figure 6-18A 120V/60Hz Voltage/Frequency Configuration



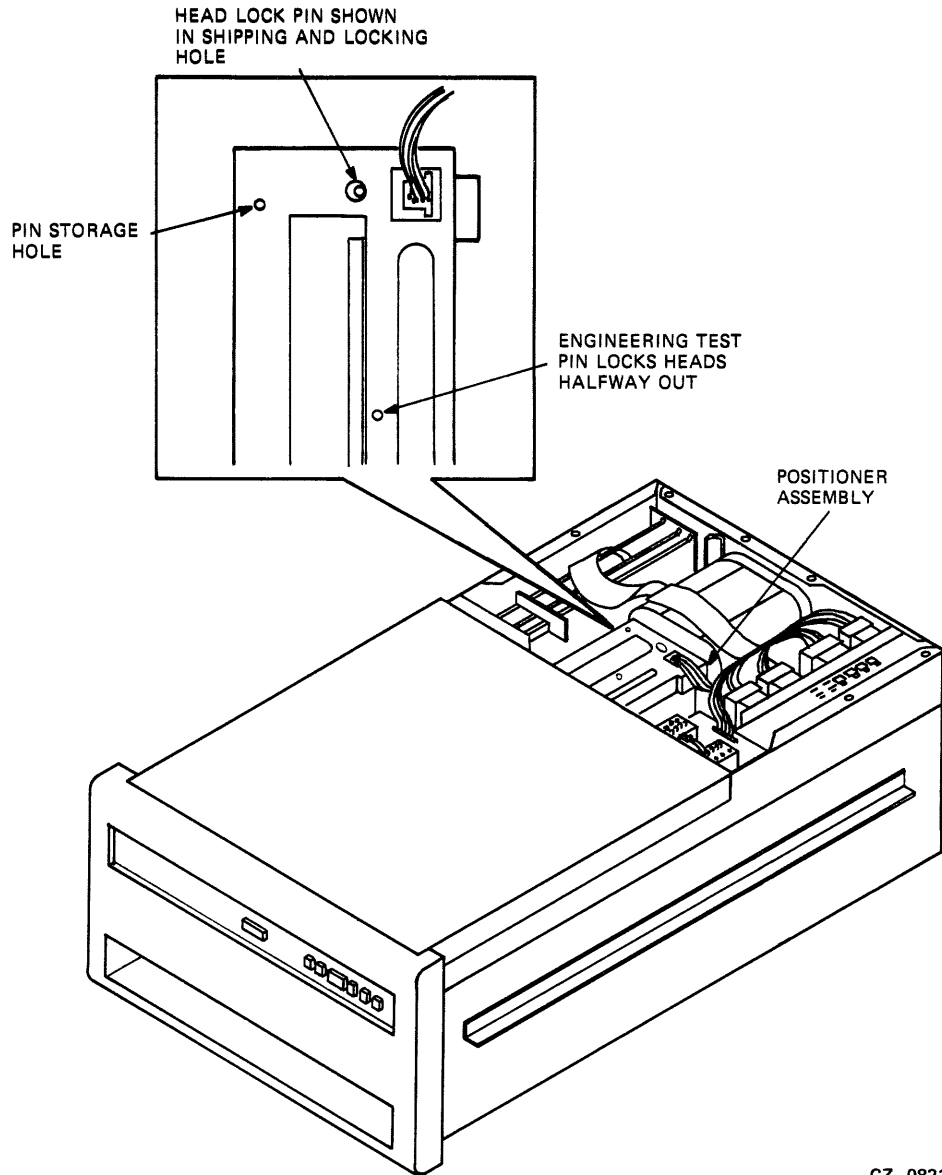
CZ-0814

Figure 6-18B 240V/50Hz Voltage/Frequency Configuration

3. Place the voltage switch into the needed 120- or 240-volt position. The 120-volt position will handle an ac voltage range of 90 to 128 volts. The 240-volt position will handle an ac voltage range of 180 to 254 volts.
4. Select either 50- or 60-cycle drive operation by installing the red and white frequency plugs in one of the configurations shown in Figure 6-18A or Figure 6-18B.
5. Leave the back cover and shield off the drive to remove the head locking pin described in the next paragraph.

6.10 REMOVING THE HEAD LOCKING PIN

The head locking pin is used to lock the head assembly in place during shipment. It must be removed before the read/write heads can move. Assuming that the back cover and shield have been removed to perform the voltage settings above, pull the head locking pin out of its locking hole on the positioner assembly and store it in the storage hole. Refer to Figure 6-19. Replace the back cover and shield when this operation is completed.



CZ-0821

Figure 6-19 Head Locking Pin Removal

6.11 PROGRAMMING THE UNIT ADDRESS PLUG

The READY switch cap on the operator control panel is also the drive unit address plug. A drive unit number from 0 to 654 can be programmed into this plug. To set the drive unit number, remove the READY switch cap from the control panel and cut off the tabs that add up to the required number. Figure 6-20 shows the binary value represented by each tab.

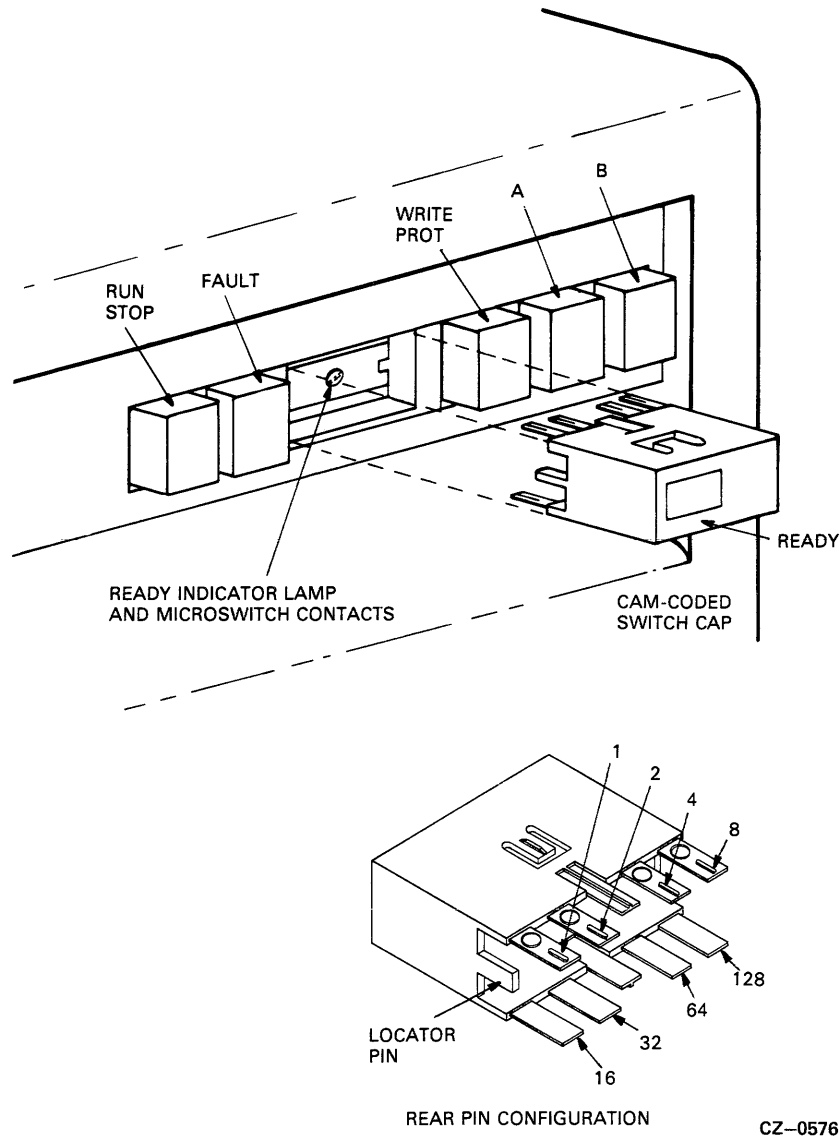


Figure 6-20 Drive Ready Switch and Unit Address Plug

If you wish to set a specific drive to a unit number of 7, for example, cut tabs 1, 2, and 4 off of the switch cap.

After the drive unit number has been selected, place the gummed label with the corresponding number onto the recessed area of the READY switch cap and replace the cap on the drive.

6.12 REMOVING THE RETAINING BRACKET SCREW

A retaining bracket will be found on the back of all disk drives shipped in a cabinet. This retaining bracket serves to keep the drives from sliding out of the cabinets during shipment. Once at the customer site, the screws securing the drive to this retaining bracket must be removed as follows.

1. Open the back door of the disk cabinet by turning the hex lock clockwise.
2. Loosen the retaining bracket captive screws shown in Figure 6-21.

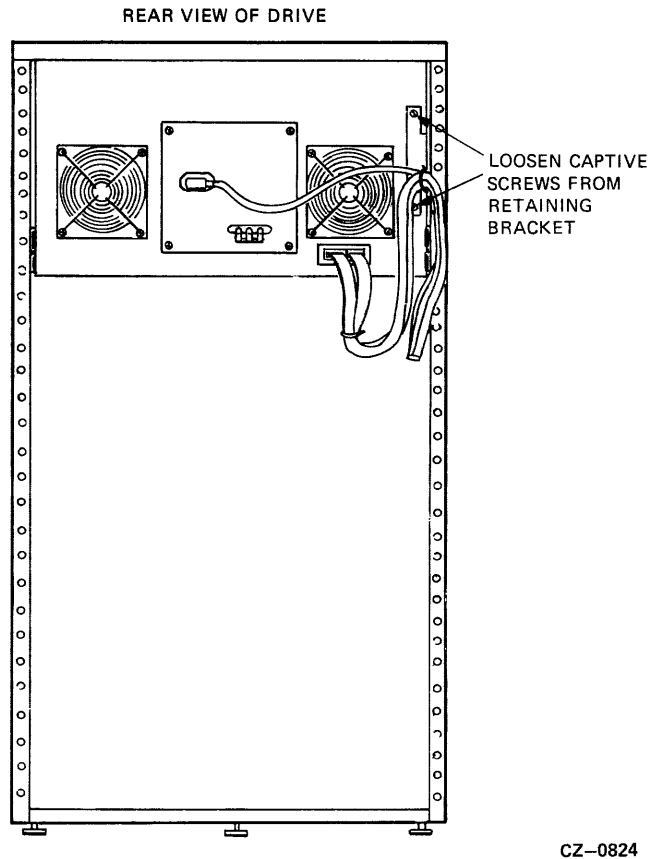
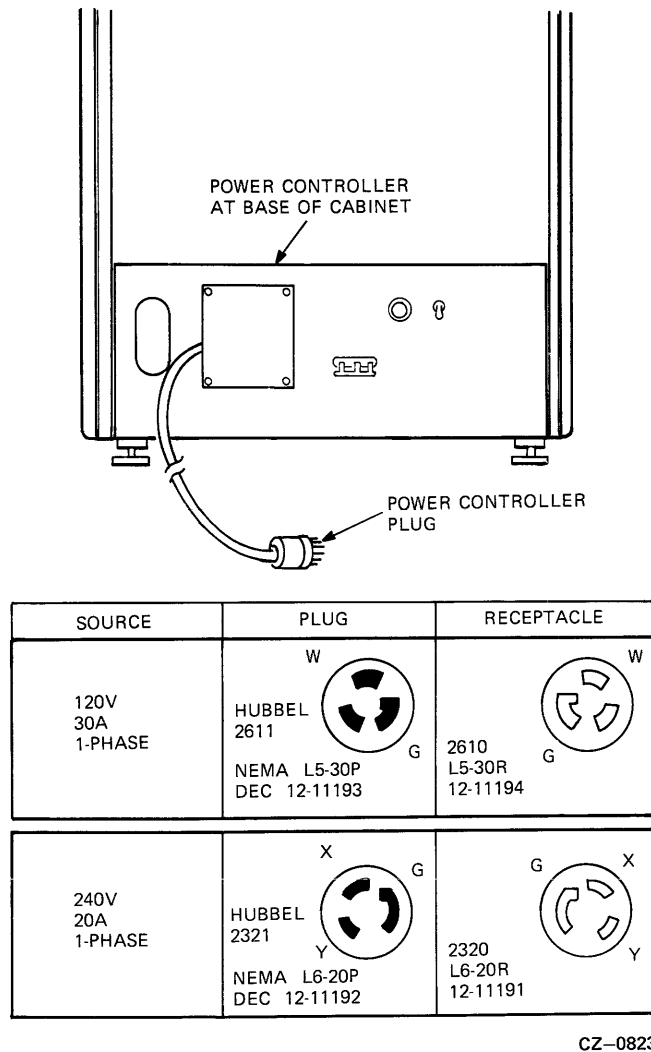


Figure 6-21 Removing the Retaining Bracket Screws

6.13 PLUGGING IN THE POWER CABLE

The power cables from each disk drive are already plugged into the power controller at the base of the drive cabinet. Only the ac power cord from the power controller needs to be plugged into an external power source. Figure 6-22 shows the power plugs and receptacle types that are used in this power controller. Access to the power cord is gained through the back door of the disk cabinet. Do not switch on the circuit breaker on the power controller until you reach the drive checkout procedure.



CZ-0823

Figure 6-22 Power Controller Plugs and Receptacles

6.14 INSTALLING ADD-ON DRIVES

In its basic configuration, the RA60 subsystem comes with only one disk drive in a cabinet. Use the following procedure to install a second or third drive in a cabinet.

Caution

Because of the weight of the disk drives, do not try to complete the add-on installation without the help of a lifting device.

6.14.1 Removing the Front Filler Panel

The first add-on drive should be placed in the center bay of the cabinet and the second in the bottom bay. Remove the filler panel at the proper location by unscrewing the four 10-32 hex nuts that hold it to the cabinet frame. These nuts can be reached through the back of the cabinet. Refer to Figure 6-23.

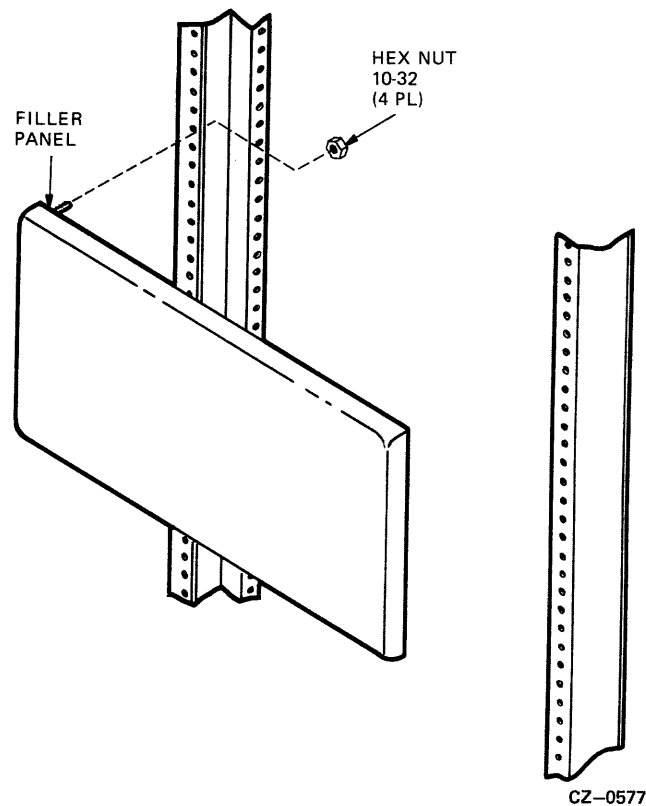
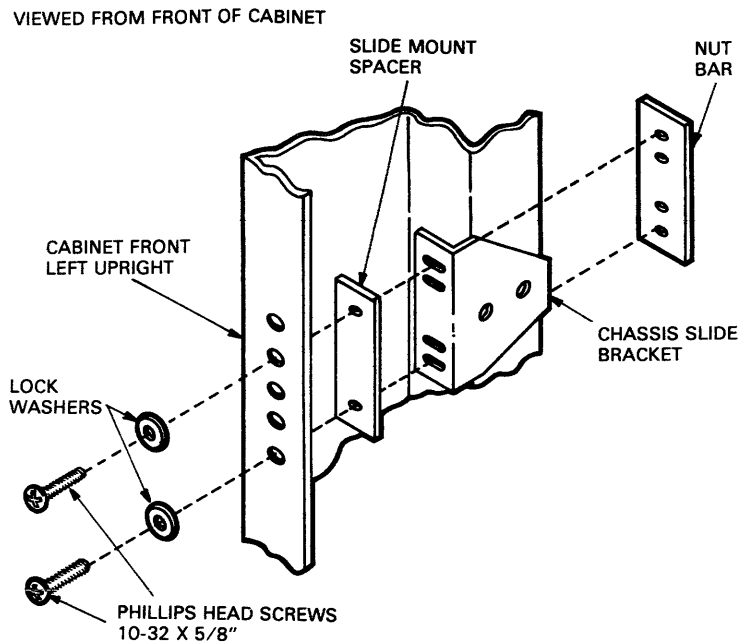


Figure 6-23 Removing Cabinet Filler Panels

6.14.2 Installing the Slide Assembly

Each RA60 add-on must be mounted in the drive cabinet on a slide assembly. Use the following procedure to install the slides on the drive cabinet.

1. Find the left and right chassis slides. Slide brackets are already attached.
2. Set aside the following hardware:
 - Eight Phillips head sems screws—10-32 x ½ inch
 - Four nut bars
3. Mount the chassis slides to the front vertical upright as shown in Figure 6-24. If this is a first add-on drive (middle drive), use mounting holes 26 and 29, counting from the bottom. If this is a second add-on drive (bottom drive), use mounting holes 8 and 11, counting from the bottom.



NOTE
1. REPEAT FOR FRONT RIGHT UPRIGHT.

CZ-0822

Figure 6-24 Mounting Chassis Slide to Front Upright

4. Mount the chassis slides to the back vertical uprights as shown in Figure 6-25. Use the same mounting holes as specified in step 3 above.

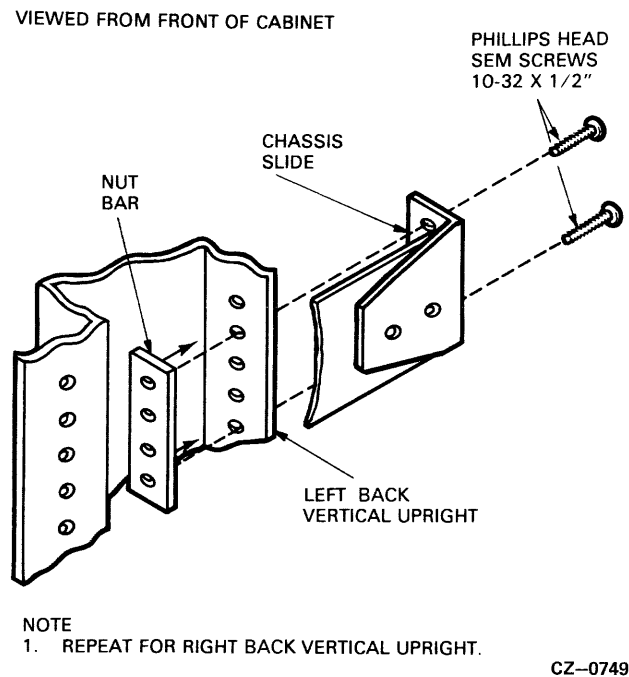


Figure 6-25 Mounting Chassis Slide to Back Upright

6.14.3 Mounting the RA60 Drive on the Slides

Use the following procedure to mount the drive on its slides.

1. Extend the stabilizer foot as shown in Figure 6-26.

Caution

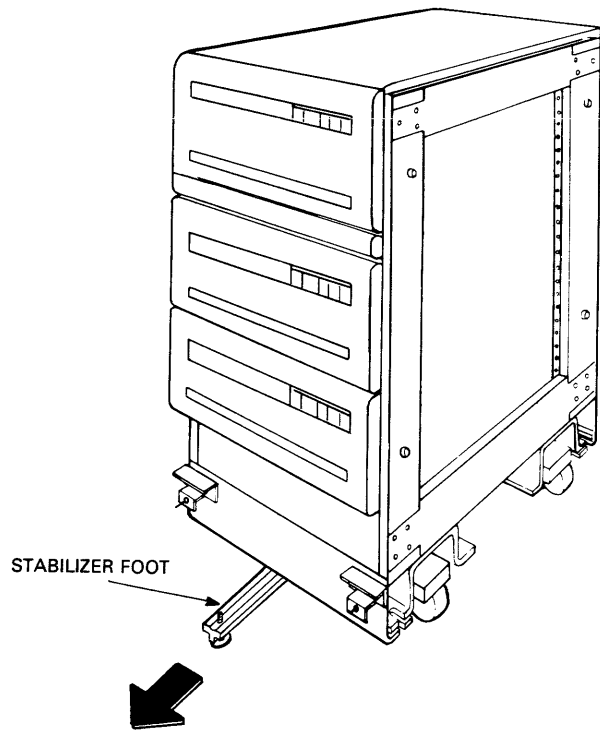
Failure to pull out the stabilizer foot can cause the drive cabinet to tip over when the disk drive is fully extended to its service position.

2. Extend each chassis slide all the way forward until it locks (Figure 6-27.)

Warning

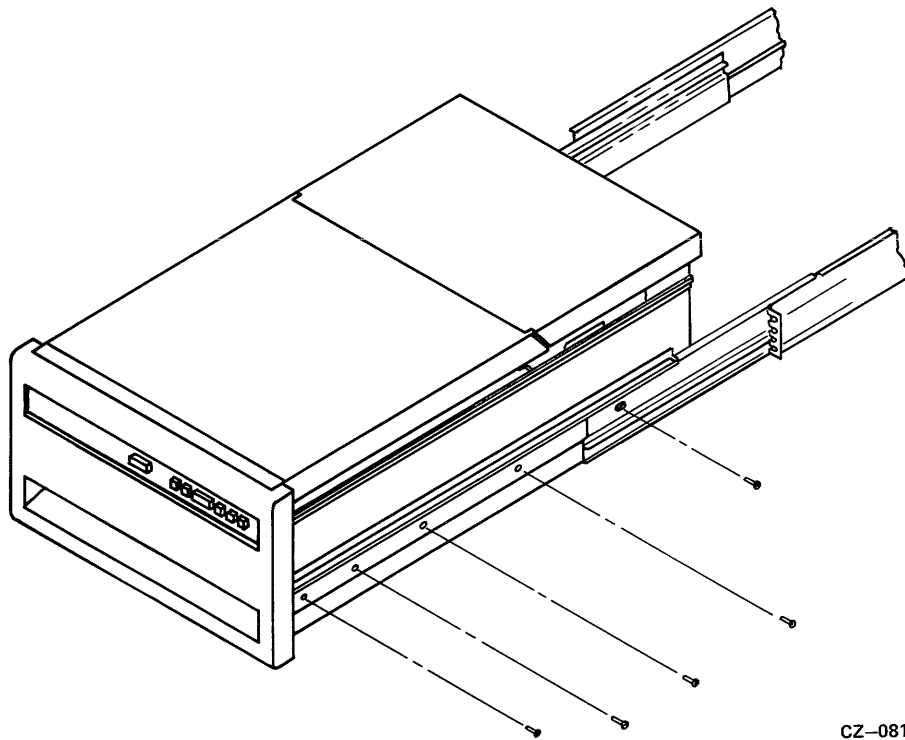
Because of the weight of the disk drive, a lifting device will be needed to place the drive on the chassis slides.

3. With the help of a lifting device, place the drive on top of the chassis slides as shown in Figure 6-27. Push the drive toward the back of the slides until the mounting rails touch the stop.
4. Fasten the drive to the chassis slides using five 8-32 x 1/4 inch Phillips pan head screws as shown in Figure 6-27.



CZ-0608

Figure 6-26 Extending Cabinet Stabilizer Foot



CZ-0817

Figure 6-27 Mounting the Chassis Slides

6.14.4 Extending the Drive on the Slide

The slides on the RA60 have a restraint mechanism which prevents the drive from being fully extended inadvertently. To slide the drive all the way forward use the following procedure.

1. Extend the stabilizer foot as show in Figure 6-26.
2. Extend the drive until the restraint mechanism engages. Refer to Figure 6-28.

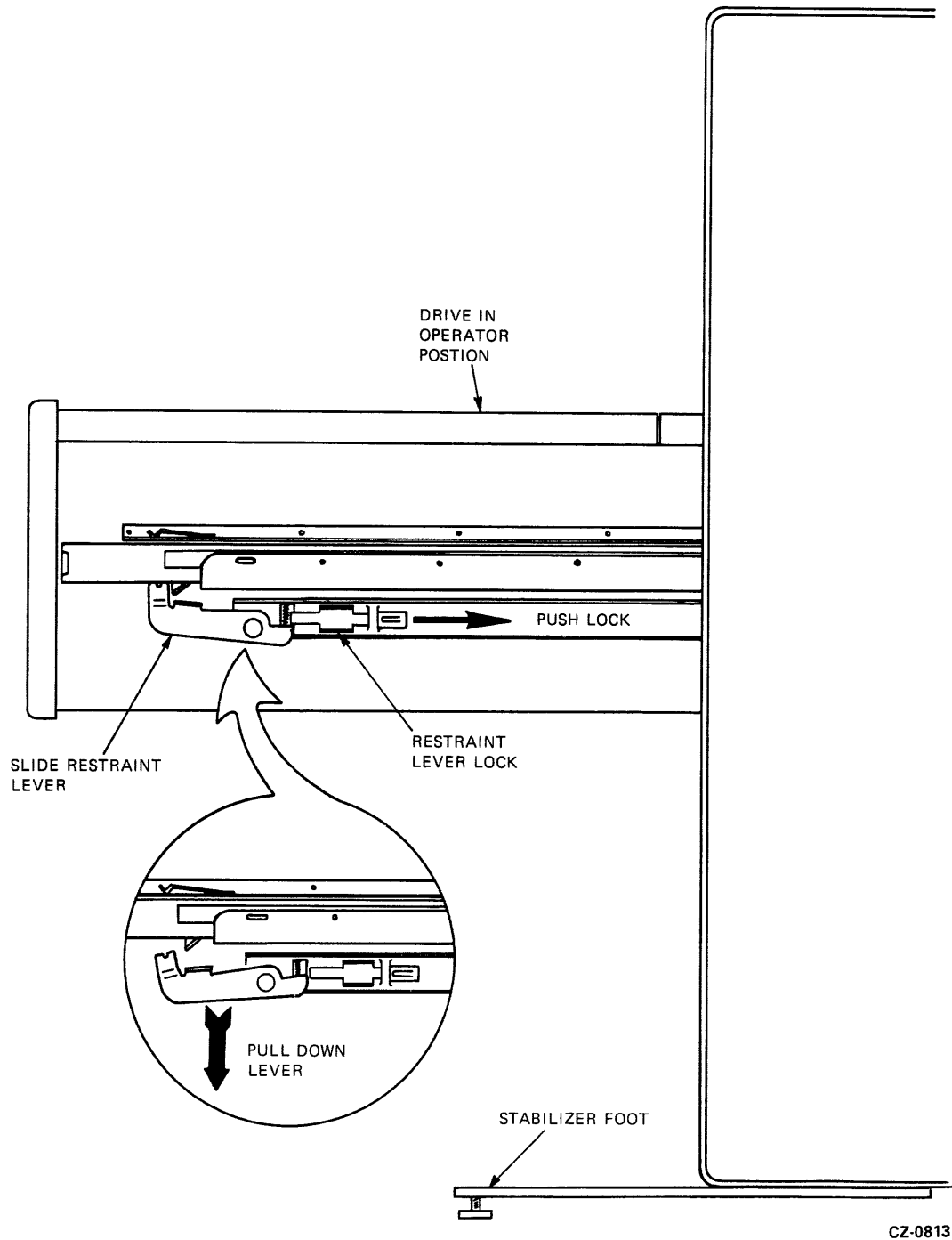


Figure 6-28 Extending the Drive

3. Insert a flat-bladed screwdriver under the restraint lever lock and push the lock toward the back of the slide. Refer to Figure 6-28.
4. Push down on the restraint lever and extend the drive to the service position. Refer to Figure 6-28.
5. After completing service on the drive, be sure to re-engage (lock) the slide restraint mechanism.

Caution

Make certain that the restraint locks are fully engaged so the drive cannot be pulled to the full service position inadvertently.

6.14.5 Set Drive AC Voltage and Frequency

The RA60 Disk Drive contains a universal power supply that may be used for 120/240 volt ac and 50/60 Hz operations. The only requirement is that you preset the voltage and frequency to the desired range. Refer to Paragraph 6.9 and to Figures 6-17, 6-18A and 6-18B to perform this procedure.

6.14.6 Remove the Head Locking Pin

The head locking pin is used to lock the head assembly in place during shipment. Refer to Paragraph 6.10 and Figure 6-19 to perform this procedure.

6.14.7 Program the Drive Unit Address Plug

The READY switch cap on the operator control panel is also the drive unit address plug. A drive unit number from 0 to 254 can be programmed into this plug. To properly program the drive unit address plug, refer to Paragraph 6.11 and to Figure 6-21.

6.15 RA60 CHECKOUT PROCEDURE

Use the following checkout procedure after installing each RA60.

6.15.1 Applying Power

1. Verify that the ac circuit breaker on the power control unit is off. Also verify that the circuit breaker on each disk drive is off.
2. If this is an add-on drive, plug the RA60 power cord into the ac power outlet on the power control unit at the bottom of the cabinet.
3. Plug the ac power cord from the power control unit into an external ac receptacle.
4. Switch on the ac circuit breaker on the power control unit.

6.15.2 Drive Checkout Procedure

The following procedure is used to check out each RA60.

Caution

This checkout procedure should be used only by trained maintenance personnel.

1. Verify that the head locking pin has been removed (Paragraph 6.10).
2. Verify that the voltage and frequency has been properly set (Paragraph 6.9).
3. Switch on the ac circuit breaker on the RA60.

4. Open the front cover on the RA60 by pushing in the latch release on the front of the drive.
5. Load the disk pack on the RA60. Refer to Paragraph 3.4.1.
6. Press the RUN/STOP switch on the front of the RA60.

6.15.3 Internal Diagnostics

Run the six internal diagnostics to check-out the status, recalibrate, and seek capability of the RA60. Refer to Chapter 3 of the *RA60 Service Manual* or the *RA60 Maintenance Guide* for instructions on running these diagnostics.

6.15.4 Subsystem Diagnostics

Run the following diagnostics when the RA60 is connected to a PDP-11 system.

CZUDCC0 (UDA and disk drive diagnostic)

Run the following diagnostics when the RA60 is connected to a VAX system.

ZZ-EVLRA (UDA50 disk subsystem diagnostic)

TECHNICAL DOCUMENTATION
CHANGE NOTICE

RA60 Disk Drive Service Manual
Addendum

This information is a supplement to the RA60 Disk Drive Service Manual. This addendum notifies the DIGITAL Field Engineers of the changes to the RA60 Disk topology and RA60 Error Codes.

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CHAPTER 4

Replace pages 4-16, 4-17, 4-18 and Figures 4-15, 4-16 and 4-17 in the existing RA60 Disk Drive Service Manual (EK-ORA60-SV-001,) with the following paragraphs and figures.

4.9.6 RA60 Physical Disk Layout

The RA60 disk pack (RA60-P) contains five disk platters. The three middle platters are used for data storage, while the two outer ones are used for protection. The three data storage platters provide a total of six read/write data surfaces, each containing 1600 physical data tracks. Each track contains 39 sectors on 18-bit data packs or 43 sectors on 16-bit data packs. The last sector on each track in the host operating systems area is always reserved for revector control information. The data field within each sector contains 256 data words regardless of whether the information is written in 16-bit or 18-bit words.

4.9.7 DIGITAL Standard Disk Format

The RA60 disk pack logical format meets the criteria set forth in the DIGITAL Standard Disk Format (DSDF) specification, which is DEC Standard 166. This standard describes how a physical disk is constructed into the logical format for Standard Disk Interconnect (SDI) devices. It also describes the host view of mass storage device formats. This specification redefines many of the classical disk terms, such as sector, track, and cylinder, as a function of their access characteristics. It also introduces the concept of groups as a fixed number of tracks. The following terms will help you to understand the Digital Standard Disk Format.

1. Sector - A sector is the smallest unit by which data is physically addressed. It is available for reading or writing once per disk revolution.
2. Track - A track is a logical entity that represents sets of sectors occupying contiguous physical disk locations and relates sectors to each other as a function of their access characteristics.

3. Group - The DSDF Specification defines a group as a logical entity that contains a set of tracks. The sectors with the same physical address are simultaneously available for reading and writing. Groups also have the property to select any track within the group during the inter-sector rotation time. This definition of groups is independent of the physical construction of the device and relates tracks to each other as a function of their access characteristics. In the case of the RA60, there is only one track per group.
4. Cylinder - A cylinder is a logical entity that represents a collection of groups. Cylinders have the property of allowing access to individual groups on the same cylinder in less than the minimum seek time. The selection of a new cylinder has the longest average positioning time. In the RA60, one logical cylinder equals four groups.
5. Physical Block Number (PBN) - A PBN is a 28-bit number identifying a physical sector's position within a set of sectors on a subunit.
6. Logical Block Number (LBN) - An LBN is a 28-bit number identifying a physical sector's position within a set of sectors directly accessible to the host. LBN's are used for host data storage and revector control information.
7. Replacement Block Number (RBN) - An RBN is a 28-bit number identifying a physical sector's replacement position.
8. Bad Block - A bad block is a sector that contains a defect which exceeds the error correction capability of the subsystem.
9. Bad Block Replacement - Bad block replacement is the substitution of a spare sector (replacement block) for a bad sector.
10. Bad Block Revectoring - The replacement block is located as a result of attempting to access a bad sector.
11. Primary Replacement Block - A primary replacement block with the lowest track RBN is used to replace a bad block on the same track.

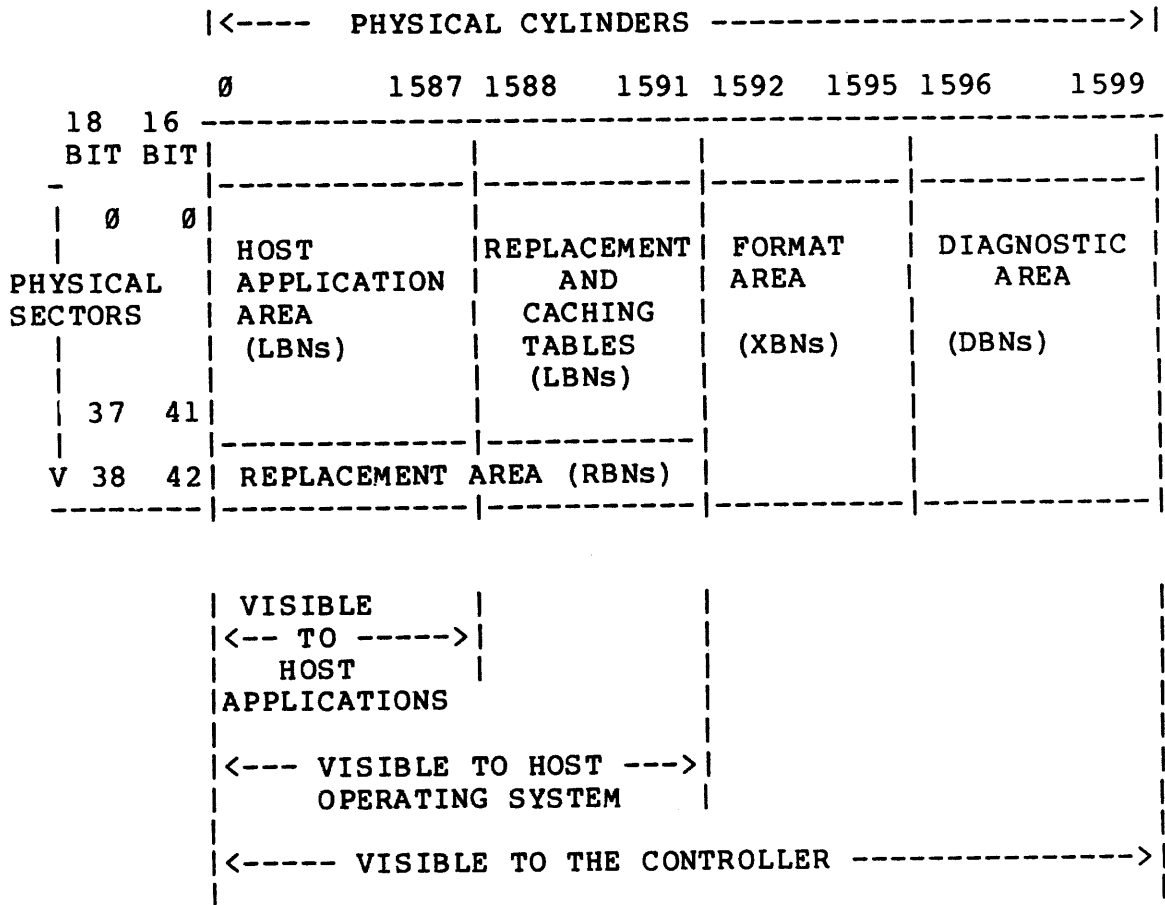
12. Secondary Replacement Block - A secondary replacement block replaces a bad block when the primary replacement block is in use. The secondary replacement block may be located on another track as defined by the bad block revectoring table.
13. External Block Number (XBN) - An external block number is a 28-bit number identifying a physical sector's position within a set of sectors in the external format area of the subunit.
14. Diagnostic Block Number (DBN) - Diagnostic block number is a 28-bit number identifying a physical sector's position within the set of sectors in the diagnostic area of the subunit.

4.9.8 RA60 Logical Disk Format

This section describes how the RA60 disks are organized into the new Digital Standard Disk Format. This disk organization is at times referred to as the RA60 disk topology. Figure 4-15 provides an overview of the RA60 logical disk format. Note that the X axis shows the physical sectors for both the 16 and 18-bit data formats. Note, also, the last sector is always reserved for replacement information. This is similar to the skip sector concept used in the RM80 Disk Drive to replace bad blocks. The Y axis gives the physical cylinder numbers defining the boundaries of the major logical areas on the disk. These physical cylinders are defined as six vertical tracks, one on each of the six disk data surfaces.

Note that the 1600 physical cylinders on an RA60 disk surface are divided into the following four logical areas.

- o Host applications area (cylinder 0 - 1587)
- o Replacement/caching tables (cylinder 1588 - 1591)
- o Format area (cylinder 1592 - 1595)
- o Diagnostic area (cylinder 1596 - 1599)



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Figure 4-15 RA60 Overview of the Logical Disk Format

4.9.9 Host Applications Area

The host applications area is the space available to normal customer host activities. Each sector in this area is assigned a logical block number (LBN). The only exception is the last sector on each track, which is assigned a replacement block number (RBN). If the controller encounters a bad block, (a block header that cannot be read), it skips that block and stores the information in the last sector on the track, the RBN.

Bad blocks are detected when a disk pack is manufactured. These blocks are always replaced when the disk packs are formatted. Other blocks become bad during normal use and must be replaced dynamically. During dynamic bad block replacement, the host accesses and updates the replacement and caching tables and informs the disk controller. This allows the controller to reformat the disk to reflect the bad block replacement.

4.9.10 Replacement/Caching Tables

The replacement and caching area of the disk also contains LBNs and RBNs. This area is used to store the revector addresses for the RBNs in the host applications area. It contains a reference table for the controller to locate revector information.

The revector information may be stored in the RBN at the end of the track if it has not been used to replace a bad block. If it has been used, then the bad blocks may be stored in RBNs on adjacent tracks.

4.9.11 Format Area

The format area is only visible to the controller and has addresses known as external block numbers (XBNs). The format tables store manufacturing format control information and media error lists. This area is inaccessible to the host. It is always written in 512 byte format and is used when formatting the disk in either 512 or 576 bytes.

4.9.12 Diagnostic Area

The diagnostic area contains blocks used for controller-resident diagnostics. These blocks have addresses known as diagnostic block numbers (DBNs). The DBNs are visible only to the disk controller.

The diagnostic area occupies the last four cylinders in the pack. They are used by the drive-resident diagnostic tests to verify the drive's ability to read and write data. They are also used in test four of the UDA50 subsystem diagnostics to exercise the disk without endangering customer data.

4.9.13 RA60 Disk Topology

The RA60 disk topology defines how the physical cylinders, tracks, and sectors of the disk pack are organized into logical addressable units to be accessed in the most efficient manner. These logical units are:

- o Groups
- o Logical cylinders
- o Logical block numbers
- o Replacement block numbers

4.9.14 RA60 Groups

In the RA60 Disk Drive, a group is defined as one track. Other drives may have more tracks per group.

4.9.15 Logical Cylinders

In the RA60 Disk Drive, a logical cylinder is defined as four groups. The number four is chosen on the basis of most efficient access times for the RA60 drive characteristics. Several other logical cylinder sizes were tested. The final choice was affected by the fact that it takes longer to do a head switch than a one-track seek in the RA60. A head switch requires a level one SDI command from the disk controller.

The way that the logical cylinders are organized in the RA60 disk pack is somewhat determined by how the RA60 disk drives will be used. When first developed, it was thought the drives would be used mostly as a backup disk for the RA80 and RA81. For this reason, the old topology used in the pre-production RA60 disk drives aligned the logical cylinders sequentially along one disk surface (from 0 to 396), and then dropped vertically to 397 on the next disk surface and so on. The entire disk was arranged as one long sequential file. However, this disk topology prevented the use of seek optimization by the SDI disk controllers, which operates most efficiently with randomized data. When it became obvious that the RA60 would also be used in system operations as well as for data backup, a new RA60 disk topology became imperative for greater data access speeds.

The new RA60 disk topology is shown in Figures 4-16 (16-bit format), and 4-17 (18-bit format). Notice the logical cylinders, shown inside parentheses, are arranged in vertical order from top to bottom disk. After the bottom disk is reached, the next sequential logical cylinder starts at the top again. This arrangement allows for seek optimization by the disk controller and can increase system throughput by 10 to 20% depending on the systems application.

PHYSICAL CYLINDERS

	0	1588	1592	1596-1599
	(0)	(2376)	(2382)	(2388) (2394)
0	0-167 [0-3]	399168-399335 [9504-9507]	400176-400343 [9528-9531]	0-171 0-171
P	(1)	(2377)	(2383)	(2389) (2395)
H 1	168-335 [4-7]	399336-399503 [9508-9511]	400344-400511 [9532-9535]	172-343 172-343
S	(2)	(2378)	(2384)	(2390) (2396)
C 2	336-503 [8-11]	399504-399671 [9512-9515]	400512-400679 [9536-9539]	344-515 344-515
L	(3)	(2379)	(2385)	(2391) (2397)
S 3	504-671 [12-15]	399672-399839 [9516-9519]	400680-400847 [9540-9543]	516-687 516-687
R	(4)	(2380)	(2386)	(2392) (2398)
A 4	672-839 [16-19]	399840-400007 [9520-9523]	400848-401015 [9544-9547]	688-859 688-859
E	(5)	(2381)	(2387)	(2393) (2399)
S 5	840-1007 [20-23]	400008-400175 [9524-9527]	401016-401183 [9548-9551]	860-1031 860-1031
		(LOG. CYL.)	(LOG. CYL.)	
		LBN'S	XBN'S	DBN'S
		[RBN'S]		

NOTE: (X-XXXX) = LOGICAL CYLINDER NUMBERS
 X-XXXXXX = LOGICAL BLOCK NUMBERS (LBN'S)
 [X-XXXX] = REPLACEMENT BLOCK NUMBERS (RBN'S)

LOGICAL CYLINDERS SEQUENCE VERTICALLY DOWNWARD THROUGH THE DISK SURFACES. AFTER THE BOTTOM SURFACE HAS BEEN REACHED, THE NEXT LOGICAL CYLINDER STARTS ON THE TOP SURFACE. FOR EXAMPLE: LOGICAL CYLINDER (6) IS ON SURFACE ZERO.

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Figure 4-16 RA60 Disk Topology for 16-Bit Format

PHYSICAL CYLINDERS

	0	1588	1592	1596-1599
	(0)	(2376)	(2382)	(2388) (2394)
0	0-151 [0-3]	361152-361303 [9504-9507]	362064-362215 [9528-9531]	0-155 0-155
P	(1)	(2377)	(2383)	(2389) (2395)
H 1	152-303 [4-7]	361304-361455 [9508-9511]	362216-362367 [9532-9535]	156-311 156-311
Y				
S				
I	(2)	(2378)	(2384)	(2390) (2396)
C 2	304-455 [8-11]	361456-361607 [9512-9515]	362368-362519 [9536-9539]	312-467 312-467
A				
L				
S 3	(3)	(2379)	(2385)	(2391) (2397)
U	456-607 [12-15]	361608-361759 [9516-9519]	362672-362823 [9540-9543]	468-623 468-623
R				
F	(4)	(2380)	(2386)	(2392) (2398)
A 4	608-759 [16-19]	361760-361911 [9520-9523]	362672-362823 [9544-9547]	624-779 624-779
C				
E				
S 5	(5)	(2381)	(2387)	(2393) (2399)
	760-911 [20-23]	361912-362063 [9524-9527]	362824-362975 [9548-9551]	780-935 780-935
		(LOG. CYL.)		(LOG. CYL.)
		LBN'S		XBN'S DBN'S
		[RBN'S]		

NOTE: (X-XXXX) = LOGICAL CYLINDER NUMBERS
 X-XXXXXX = LOGICAL BLOCK NUMBERS (LBN'S)
 [X-XXXX] = REPLACEMENT BLOCK NUMBERS (RBN'S)

LOGICAL CYLINDERS SEQUENCE VERTICALLY DOWNWARD THROUGH THE DISK SURFACES. AFTER THE BOTTOM SURFACE HAS BEEN REACHED, THE NEXT LOGICAL CYLINDER STARTS ON THE TOP SURFACE. FOR EXAMPLE: LOGICAL CYLINDER (6) IS ON SURFACE ZERO.

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Figure 4-17 RA60 Disk Topology for 18-Bit Format

4.9.16 Logical Block Numbers

Logical block numbers (LBNs) are the smallest addressable units. Each physical sector in the host applications and replacement area of the disk is assigned an LBN. These LBNs are arranged sequentially over the four groups (tracks) in each logical cylinder. After the last LBN in logical cylinder zero is reached, the next LBN begins in logical cylinder one. In Figures 4-16 and 4-17, the LBNs are given in the middle positions with no parentheses or brackets. In 16-bit formatted packs, the LBNs run from 0 to 401183. In 18-bit formatted packs, the LBNs run from 0 to 362975.

In 16-bit formatted packs, there are 168 LBNs per logical cylinder. This is the product of four tracks times 42 sectors per track. In 18-bit formatted packs, there are only 152 LBNs per logical cylinder. This is the product of four tracks times 38 sectors.

4.9.17 Replacement Block Numbers

The replacement block occupies the last sector on each track. This replacement block is assigned a replacement block number (RBN). Since there are four tracks in each logical cylinder, there are also four RBNs per logical cylinder. Figures 4-16 and 4-17 show these RBN numbers in square brackets. There are a total of 9551 RBNs in an RA60 disk pack.

4.9.18 Converting RA60 LBNS To Head Numbers

It may be necessary sometimes to correlate an LBN number with a read/write head number to determine which head is bad. This conversion is done by a two step process. First, find the logical cylinder number where the LBN is located. Divide the LBN number by the number of LBNS in a logical cylinder. For 16-bit formatted packs, divide the LBN by 168. For 18-bit formatted packs, divide the LBN by 152.

EXAMPLE: FIND LOGICAL CYLINDER FOR 16-BIT FORMATTED RA60 PACKS:

LBN NO. 361470 / 168 = LOGICAL CYLINDER 2151.6071

EXAMPLE: FIND LOGICAL CYLINDER FOR 18-BIT FORMATTED RA60 PACKS:

LBN NO. 361470 / 152 = LOGICAL CYLINDER 2378.0921

In the above divisions, only the whole number part of the answer is important. The whole number gives you the logical cylinder address in which the LBN is located. The results show that in 16-bit formatted packs, an LBN of 361470 is located in logical cylinder 2151. For 18-bit formatted packs, it is located in logical cylinder 2378.

The second step of the process involves converting the logical cylinder address to a disk surface. Divide the logical cylinder address by the number of read/write heads. Since the RA60 has six read/write heads, you divide by six. In this division, the decimal part of the answer is more important.

EXAMPLE: FIND HEAD SURFACE FOR 16-BIT FORMATTED RA60 PACKS:

LOGICAL CYLINDER 2151 / 6 = 358.5

EXAMPLE: FIND HEAD SURFACE FOR 18-BIT FORMATTED RA60 PACKS:

LOGICAL CYLINDER 2378 / 6 = 396.3333

In the above divisions, the decimal part of the answer is the disk surface (or head) the logical cylinder is on. Ignore the whole number and convert the decimal part of the answer to a fractional part of a sixth and obtain the disk surface number. For example, $.5 = 1/2 = 3/6$, or head surface 3. For example the decimal $.3333$ yields $1/3 = 2/6$ or a head surface of 2.

4.10 RA60 SERVO SYSTEM

The RA60 Disk Drive does not have a dedicated servo module. Instead, the servo circuits are distributed over most of the electronic modules. The servo system has two modes of operation. These are the linear (or track centering) mode and the seek (or track crossing) mode. The major functional blocks in the control system are shown in Figure 4-18.

CHAPTER 5

Replace Tables 5-1 and 5-2 in the existing RA60 Disk Drive Service Manual (EK-ORA60-SV-001), with the following tables.

Table 5-1 RA60 Front Panel Fault Codes

Front Panel Codes	Description	Most Likely FRU Failure
00	Microcode error (not sent to front panel)	1. None
01	Heads home switch fault	1. Push heads home 2. Check P803 3. Heads home switch assembly
02	Front panel fault	1. Front panel module 2. Drive logic module 3. Front panel ribbon cable
03	Long spin-up time fault	1. Check spindle motor connections 2. Heat sink module 3. Spindle motor 4. Drive logic module
05	Bad servo samples fault	1. Pack 2. Post amp/data separator module 3. R/W preamplifier module 4. Heads

TABLE 5-1 RA60 Front panel Fault Codes (cont)

Front Panel Codes	Description	Most Likely FRU Failure
06	Bad velocity fault	<ol style="list-style-type: none"> 1. Pack 2. Post amp/ data separator module 3. R/W preamplifier module 4. Drive logic module 5. Positioner assembly
07	Linear mode fault	<ol style="list-style-type: none"> 1. Pack 2. Post amp /data separator module 3. Drive logic module
08	Retry on seek fault	<ol style="list-style-type: none"> 1. Pack 2. Post amp/ data separator module 3. R/W preamplifier module 4. Drive logic module
09	Lost servo samples fault	<ol style="list-style-type: none"> 1. Pack 2. Heads 3. Post amp/ data separator module
0A	Heads home switch would not open	<ol style="list-style-type: none"> 1. Shipping pin not removed 2. Check P803 3. Heads home switch assembly 4. Heatsink module

TABLE 5-1 RA60 Front panel Fault Codes (cont)

Front Panel Codes	Description	Most Likely FRU Failure
10	Master processor fault	<ol style="list-style-type: none"> 1. Drive logic module 2. SDI module 3. post amp/ data separator module 4. Backplane module
11	SDI Faults	<ol style="list-style-type: none"> 1. SDI Module 2. Drive logic module 3. SDI cable 4. Backplane module
13	Invalid SDI level 1 command	<ol style="list-style-type: none"> 1. SDI module 2. Post amp/ data separator module 3. R/W preamplifier module 4. Backplane module
3F	Master processor fault	<ol style="list-style-type: none"> 1. Drive logic module 2. SDI module 3. Post amp/ data separator module 4. Backplane module

5.2.2 RA60 Error Messages

Refer to Table 5-2 for the RA60 error messages. They are displayed on the hand held terminal when internal diagnostics are run or are printed out on the system console when running host diagnostics. Table 5-2 shows the error code, description of the error, and the most likely failing FRU.

Table 5-2 RA60 Error Messages

ERROR CODE	DISCRIPTION	MOST LIKELY FRU FAILURE
08	Heads not home when run command is issued	1. Push heads home
09	Heads not home during spin-up	2. Check P803
0A	Heads home switch will not open during unload	3. Heads home switch assembly
0C	Spin-up L high during spin-up	1. Front panel module
10	Lid lock open during spin-up	2. Drive logic module
11	Cover open during spin-up	3. Front panel ribbon cable
12	Cover or lid lock open during head load	
13	Lid unlocked when run command is issued	
18	Spin-up too lengthy	1. Check spindle motor
19	Motor sample will not change during spin-up	2. Heat sink module
24	Too long to acquire spindle speed control on head load	3. Spindle motor
		4. Drive logic module

Table 5-2 RA60 Error Messages(cont.)

ERROR CODE	DISCRIPTION	MOST LIKELY FRU FAILURE
26	More than 32 sectors to settle on track	1. Pack 2. Post amp/data separator module
27	More than 32 sectors to settle on track retry failure	3. R/W preamplifier 4. Heads
28	Too many bad servo samples during RTZ	
29	Too long to aquire good samples on head load	
2C	Bad servo samples during RTZ on head load	
2D	Bad samples during linear mode	
2E	Off speed when in linear mode	
2F	Off track in linear state	1. Pack 2. Post amp/data separator module 3. R/W preamplifier module 4. Drive logic module 5. Positioner assembly
30	Spin-up too brief	1. No pack installed

Table 5-2 RA60 Error Messages (cont.)

ERROR CODE	DISCRIPTION	MOST LIKELY FRU FAILURE
40	Retry on seek due to bad servo samples	1. Pack
41	Retry on seek due to bad servo samples failed	2. Post amp/data separator module
42	Retry on seek due to bad guard band flags	3. R/W preamplifier module
43	Retry on seek due to bad guard band flags, retry failed	4. Drive logic module
44	Retry on seek due to wrong polarity entering linear mode	
45	Retry on seek due to wrong polarity entering seek mode, retry failed	
46	Retry on seek due to wrong grey code	1. Pack
47	Retry on seek failing due to wrong grey code	2. Heads
48	Lost servo samples	3. Post amp/data separator module
50	Too long for heads home switch to open on head load	1. Shipping pin not removed
		2. Check P803
		3. Heads home switch assembly
		4. Heatsink module

Table 5-2 RA60 Error Messages (cont.)

ERROR CODE	DISCRIPTION	MOST LIKELY FRU FAILURE
61	Command cannot be executed with the drive in its current state	1. Drive logic module 2. Cover open
62	Nonexistent head or cylinder requested with seek	
63	Opcode is not one of six valid opcodes	
64	Cover open when run command is issued	
65	Program error during head load	
81	Initializes and tests control panel	1. Drive logic module 2. SDI module
82	Checks processor register	3. Post amp/data separator module
83	Tests RAM #0	4. Backplane module
84	Tests ROM #0	
85	Tests ROM #1	
86	Tests ROM #2	
87	Verify ROM version numbers	
88	Tests the SDI clear interface bit	
89	Tests the SDI control/status register	1. Drive logic module 2. SDI module
8A	Tests front panel and serial number ROM	3. Post amp/data separator module
8B	Initializes the UART	4. Backplane module
8C	Tests the error registers	
8D	Tests the 8155 timer	
8E	Tests the slave control port	
8F	Slave Diagnostics	
90	Command available or slave done already set when issuing a new slave command	
91	Slave command receiver timeout on opcode	

Table 5-2 RA60 Error Messages (cont.)

ERROR CODE	DISCRIPTION	MOST LIKELY FRU FAILURE
92	Slave attention timeout	1. Drive logic module
93	Slave done timeout to slave stop	2. SDI module
94	Slave done timeout to status (1 ms)	3. Post amp/data separator module
95	Slave done timeout	4. Backplane module
96	Slave attention timeout	
97	Solenoid release timeout	1. Drive logic module
98	Watchdog timer detects master insane	2. Post amp/data separator module
99	Watchdog timer detects slave insane	3. SDI module
9A	Run switch or cover invalid at spin-up	4. Backplane module
9B	Spindle not ready during recalibrate command	
9C	SDI transfer error from DC703	1. SDI module
9D	Write or format when write protected	2. Post amp/data separator module
9E	Format when format disabled	3. R/W preamplifier module
9F	Transfer command during drive error	4. Backplane module
A0	Sector read/write overrun error	
A1	Transfer command when read/write error	
A2	SDI command checksum error	1. SDI module
A3	SDI frame error	2. Drive logic module
A4	SDI command parity error	3. Post amp/data separator module
A5	SDI command out of range	4. Backplane module
A6	SDI command length error	
A7	SDI error status byte is non-zero	

Table 5-2 RA60 Error Messages (cont.)

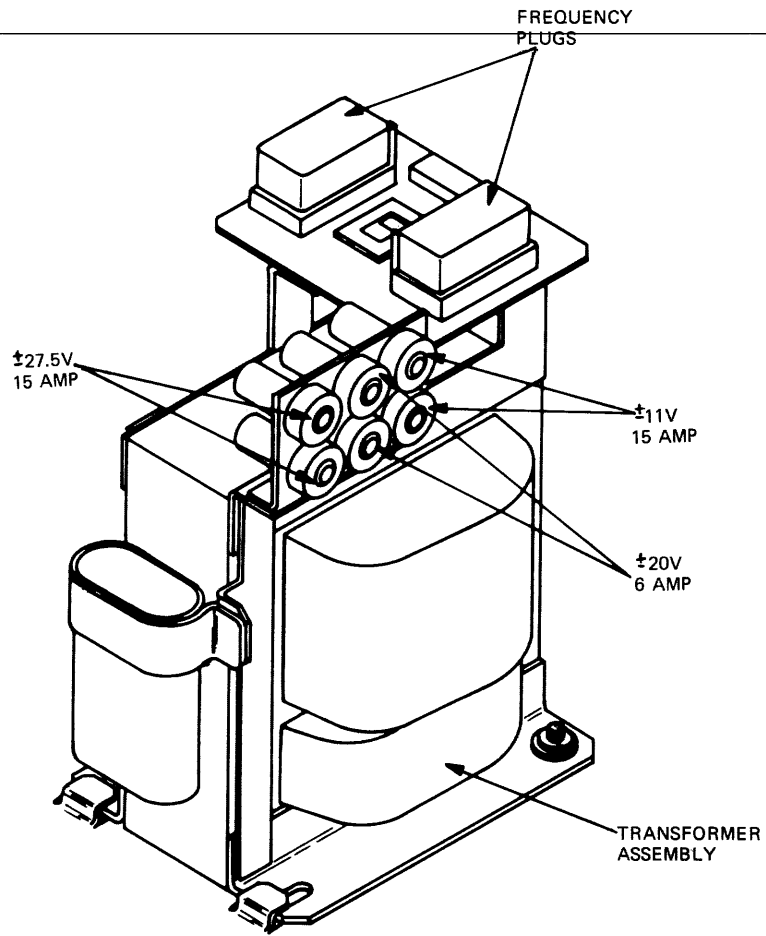
ERROR CODE	DISCRIPTION	MOST LIKELY FRU FAILURE
A8	Slave done timeout to seek command	1. Drive logic module
A9	Slave done timeout to RTZ command	2. SDI module
AA	Slave response error to RTZ command	3. Post amp/data separator module
AB	Slave done timeout during first pass	4. Backplane module
AC	Command receiver timeout during diagnostic stop or ASCII port command time = TODGN 2	
AD	Slave done timeout during diagnostic stop or ASCII port time = 1MS	
AE	Drive off-line	1. Drive logic module
AF	Command byte 4 & 5 are not zero	2. Post amp/data separator module
B0	Invalid group number	3. SDI module
B1	Invalid head select number	4. Backplane module
B2	Invalid cylinder range	
B3	Spindle not ready	
B4	Controller timeout = 0	1. Drive logic module
B5	Spindle not ready	2. SDI module
B6	Illegal memory region	3. Post amp/data separator module
B7	DD bit set	4. Backplane module
B8	Tried to clear a hard fault	
C0	Slave done timeout (1 MS) to get status	
C1	Error response to GET STATUS	
C2	Invalid group number	
C3	Microcode fault errors	
C4	No watchdog interrupt	
C5	Slave done timeout (ASCII Port)	
C6	Slave command received error (ASCII port)	
C7	Invalid 'TT' bit	

Table 5-2 RA60 Error Messages (cont.)

ERROR CODE	DISCRIPTION	MOST LIKELY FRU FAILURE
C8	Read/Write error - multi-head select	<ol style="list-style-type: none"> 1. R/W preamplifier module 2. Post amp/data separator module 3. SDI module
BA	Non-zero level	1. Drive logic module
BB	Wrong subunit error	2. SDI module
BC	Diagnostic command, memory region high not zero	3. Post amp/data separator module
BD	Diagnostic command, invalid parameters	4. Backplane module
BE	Write enable a write protect drive	
BF	Setting S7 = 1	

5.3 POWER REGULATOR MODULE LEDES

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 5-2. Use the chart in Table 5-3 to help isolate power supply problems.



CZ-0850

Figure 4-9 Location of Circuit Breakers (Old Style Transformer)

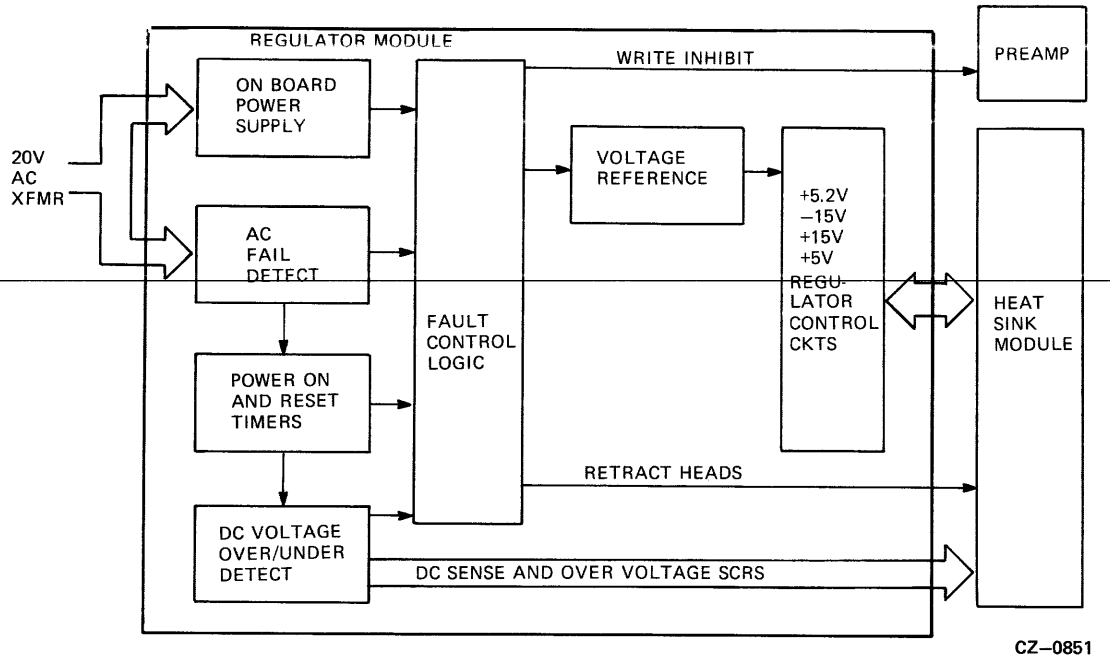
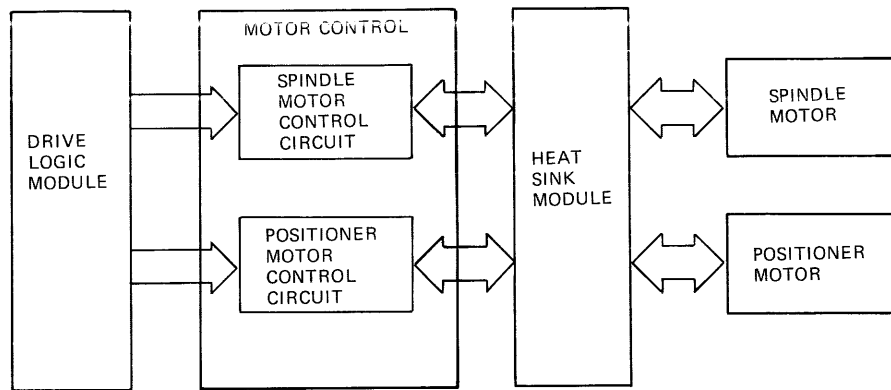


Figure 4-11 Regulator Module Block Diagram

4.8.5 Heat Sink Module

The heat sink module contains all the series pass transistors used for voltage regulation and the power transistors used for the motor control logic. All these power transistors share a common heat sink. The heat sink module supplies the backplane with the following dc regulated voltages: +5 volts, -5.2 volts and ±15 volts.

The heat sink module also supplies the motor control module with ±15 volts and ±27.5 volts. Power to the dc fans is also supplied from the heat sink module. Refer to Figure 4-12 for a block diagram of the heat sink module.



CZ-0848

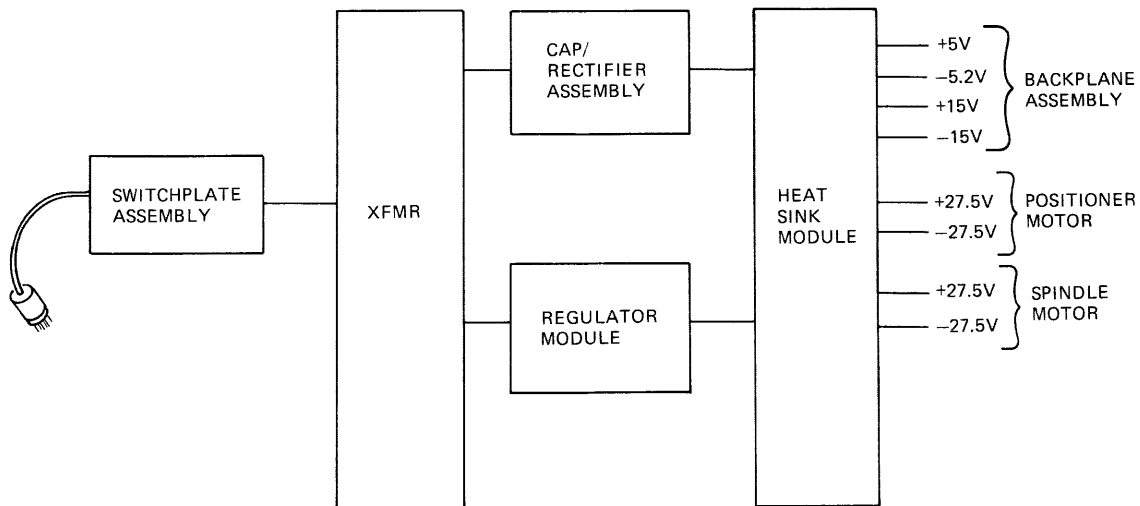
Figure 4-6 Motor Control Module Block Diagram

4.7.8 Spindle Motor

The spindle motor is the dc motor that rotates the disk spindle. In the RA60 Disk Drive, the spindle motor drives the disk spindle directly without any belt or pulley. The spindle motor also has a built-in encoder that converts the motor rotational speed into digital pulses. The output signals from this encoder are monitored by the slave microprocessor to determine disk speed.

4.8 POWER SUPPLY ASSEMBLIES

The RA60 power supply includes five assemblies. These are the switchplate assembly, transformer assembly, cap/rectifier assembly, regulator module, and heat sink module. Figure 4-7 shows a block diagram of the power supply.

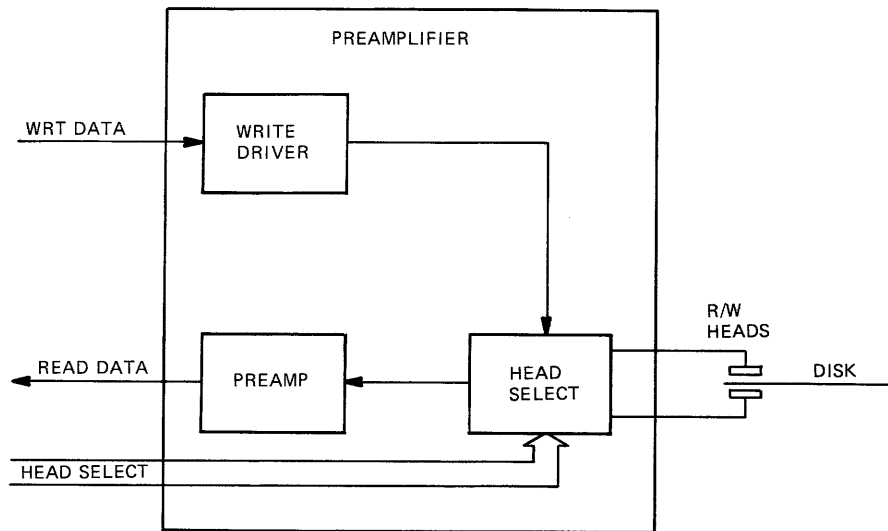


CZ-0849

Figure 4-7 Power Supply Block Diagram

4.7.4 Preamp Module

The preamp module contains the head select logic, the write drivers, and low noise read preamplifiers. Refer to Figure 4-5 for a block diagram of the preamp module.



CZ-0869

Figure 4-5 Preamplifier Module Block Diagram

4.7.5 Front Panel Module

The RA60 front panel consists of five switches and one switch cap (UNIT/READY). Under each indicator cap is a light that can be on or off regardless of the switch position. The state of each switch and light is periodically sampled and controlled by the master microprocessor.

The front cover interlock switch is mounted on the cover latch assembly. This switch prevents the drive from spinning up whenever the front cover is open. The state of this switch is sampled periodically by the master microprocessor.

4.7.6 Motor Control Module

The motor control module contains a portion of the power amplifier circuits needed to drive the positioner motor voice coil. The power transistors for this function are located on the heat sink module.

The motor control module also contains the circuitry to control the spindle motor. Refer to Figure 4-6 for an overview block diagram

4.7.7 Positioner Motor

The positioner motor is a linear dc motor actuated by a voice coil. Its function is to move the read/write heads in and out across the disk tracks. On the rear of the positioner motor is a tachometer that converts the carriage velocity into an analog signal.

Also located on the positioner motor assembly is the home switch that informs the microprocessor and the power-down logic when the read/write heads are home (off the disk pack).

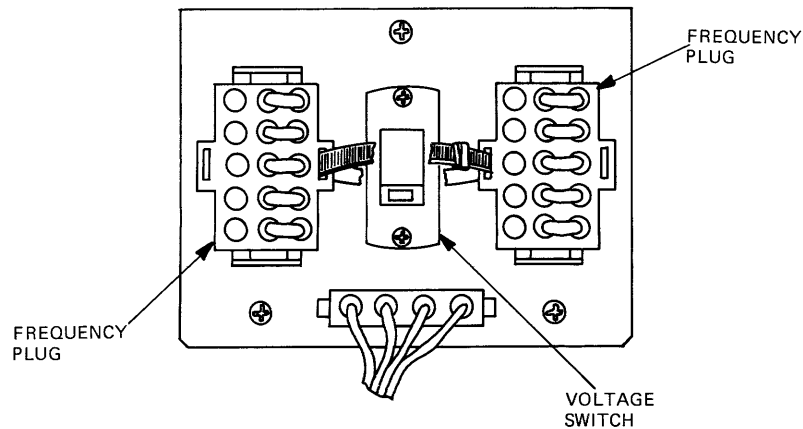
4.8.1 Switchplate Assembly

The switchplate assembly contains the main drive circuit breaker and an ac line filter. The circuit breaker has three poles rated at 12 amps, 6 amps and 6 amps respectively. Switch capacity is 12 amps at the 120 volt setting and 6 amps at the 240 volt setting.

4.8.2 Transformer Assembly

A ferro-resonant transformer is used in the RA60 to obtain good line voltage regulation. The raw output voltages from the transformer are fed to the cap/rectifier assembly for rectification. The transformer puts out raw ac voltages of 11 volts, 27.5 volts, and 20 volts.

The ac voltage range switch and frequency range plugs mounted on top of the transformer permit easy voltage and frequency range selections. The location of the ac voltage range switch and the frequency range plugs is shown in Figure 4-8.



CZ-0872

Figure 4-8 Voltage Range Switch and Frequency Plugs

Also located on the transformer assembly are six thermal circuit breakers that protect the output of the transformer from short circuits and overheating. The location of these circuit breakers for both the old and new style transformers are shown in Figures 4-9 and 4-10.

In addition to the six thermal circuit breakers located on the transformer, two 5 amp fuses are located on the regulator module to fuse the on-board raw ac 20 volt lines.

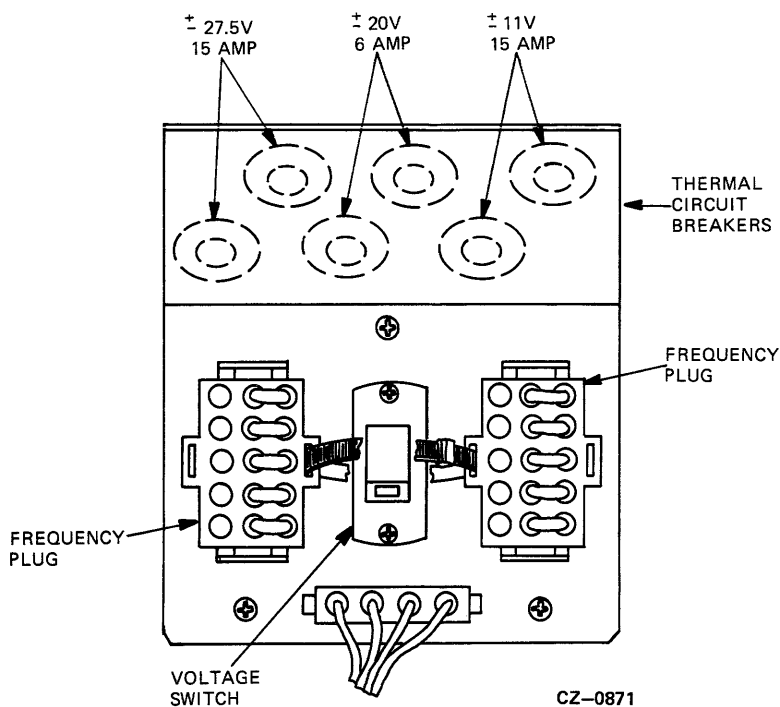


Figure 4-10 Location of Circuit Breakers (New Style Transformer)

4.8.3 Cap/rectifier Assembly

The cap/rectifier assembly rectifies the raw ac received from the transformer assembly. It puts out the following dc voltages: ± 11 volts, ± 20 volts, and ± 27.5 volts.

4.8.4 Regulator Module

The regulator module contains the low level circuitry to regulate the rectified dc voltages on the heat sink module. The regulator module also senses the dc voltage levels and controls the series regulating transistors located on the heat sink module.

The regulator module also contains all the ac and dc shutdown logic and the power resumption logic. See paragraph 4.13 for a description of the causes of power shutdown and the sequence of events that occur prior to shutdown.

Figure 4-11 shows a block diagram of the functions provided by the regulator module. It has an on-board power supply to provide dc voltages for its own logic circuits and reference voltages. Also located here is the fault circuitry to detect ac failures, dc overvoltage, and dc undervoltage conditions. There are also some timers to control power shutdown and resumption. Monitoring all these failure conditions is the fault control logic circuit. The regulator module also provides accurate voltage references for the regulator control circuits.

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