CHAPTER 1
INTRODUCTION

1.1 PURPOSE AND SCOPE

This manual provides information on the capabilities, installation, operation, and programming of the RL01/RL02 disk subsystem. A basic subsystem is comprised of one RL11, RLV11, RLV12, or RL8A controller and up to four RL01 or RL02 disk drives.

This manual is intended primarily for operating and programming personnel. Service should be performed only by qualified Digital field engineering and maintenance personnel. A prerequisite for understanding this manual is a basic knowledge of PDP-8 and/or PDP-11 processors and peripherals.

1.2 REFERENCE DOCUMENTS

Table 1-1 lists the documents that provide the information necessary for a complete understanding of the function, theory, and maintenance of the RL01/RL02 disk drives and the controllers. The UNIBUS and LSI-11 Bus are described in the *PDP-11 Bus Handbook* (EB-17525). The OMNIBUS is described in the *PDP-8A Miniprocessor User's Manual* (EK-8A002-MM).

Table 1-1 Reference Documents

Title	Document No.
RL01/RL02 Disk Drive Technical Manual	EK-RL012-TM
RL01 Disk Drive Illustrated Parts Breakdown	EP-00016-IP
RL02 Disk Drive Illustrated Parts Breakdown	EP-00016-IP
RL01/RL02 Disk Subsystem Preventive Maintenance Manual*	EP-00008-PM
RL01/RL02 Disk Drive Pocket Service Guide	EK-RL012-PG
RL11 Controller Technical Description Manual	EK-0RL11-TD
RLV11 Controller Technical Description Manual	EK-RLV11-TD
RL8A OMNIBUS Controller Technical Manual	EK-0RL8A-TD
RLV12 Disk Controller User's Guide	EK-RLV12-UG
RLV12 Controller Technical Description Manual	EK-RLV12-TD

* This document is only available to Digital Equipment Corporation Service personnel.

1.3 SUBSYSTEM DESCRIPTION

The RL01/RL02 mass storage subsystem is based on the RL01K/RL02K disk cartridges, the RL01/RL02 drive unit(s), and an appropriate controller such as the RL11 (PDP-11), RLV11 or RLV12 (LSI-11), or RL8A (PDP-8). The basic subsystem is illustrated in Figure 1-1.

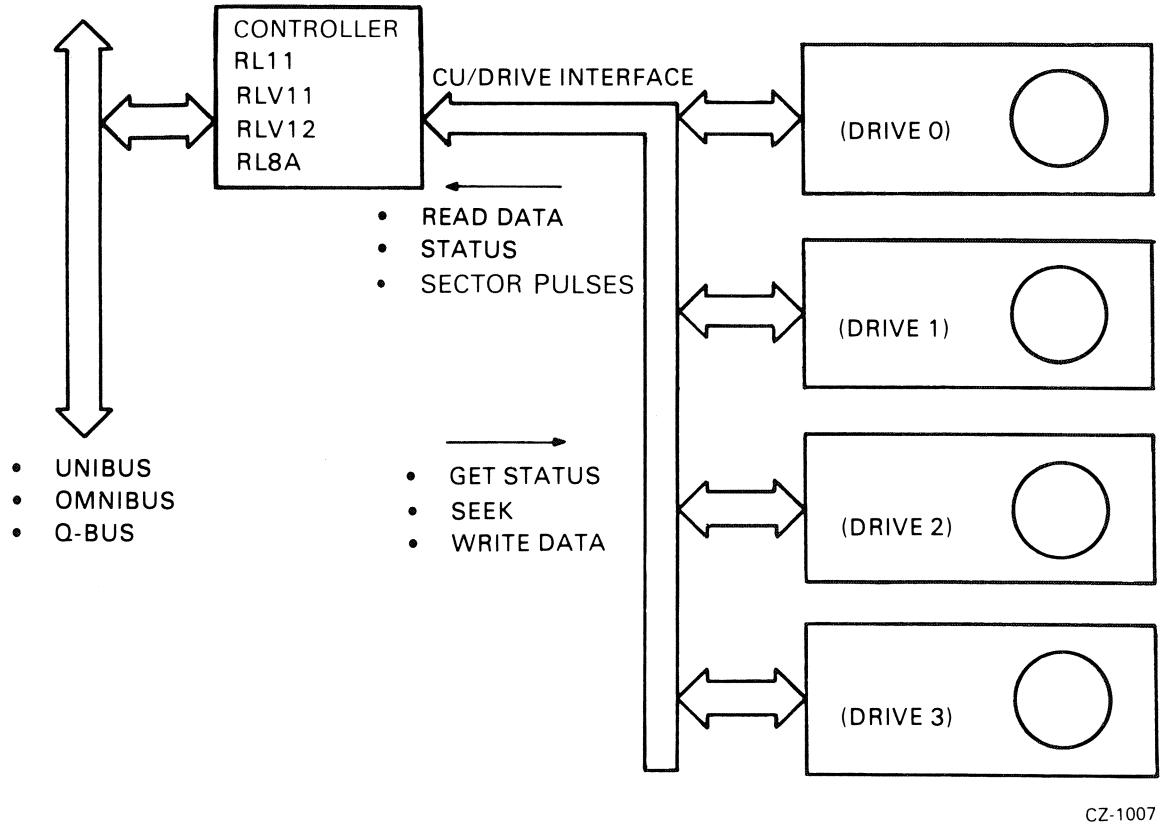

Figure 1-1 Typical RL01/RL02 Mass Storage Subsystem Configuration

1.3.1 RL01/RL02 Disk Drive

The RL01/RL02 drive unit is built into a chassis that slides out of the cabinet to allow operator access to the top cover for loading and unloading of the disk cartridge. If the stops on the slide are manually released, the chassis can be pulled farther out so that the rear top cover can be removed for servicing. The front panel contains operator controls and indicators.

The chassis contains a spindle, two read/write heads mounted on a positioner, logic modules, a power supply with an ac power cord and circuit breaker, a closed-loop clean air system, a cooling air system, appropriate safety interlocks, and connectors for the I/O cable(s).

The drive unit is shown in Figure 1-2.

The RL02 drive unit has a label reading "RL02" on the front panel. The RL01 drive currently does not have a label identifying it as an RL01.

1.3.2 RL Controllers

There are four controllers available for the RL01/RL02 subsystem. All can handle up to four drives and all feature Direct Memory Access (DMA) operation.

1.3.2.1 RL11 Controller Description – The RL11 controller consists of a single, hex-height Small Peripheral Controller (SPC) module designated M7762. It is used to interface the drive with the PDP-11 UNIBUS. The data is formatted in 16-bit words.

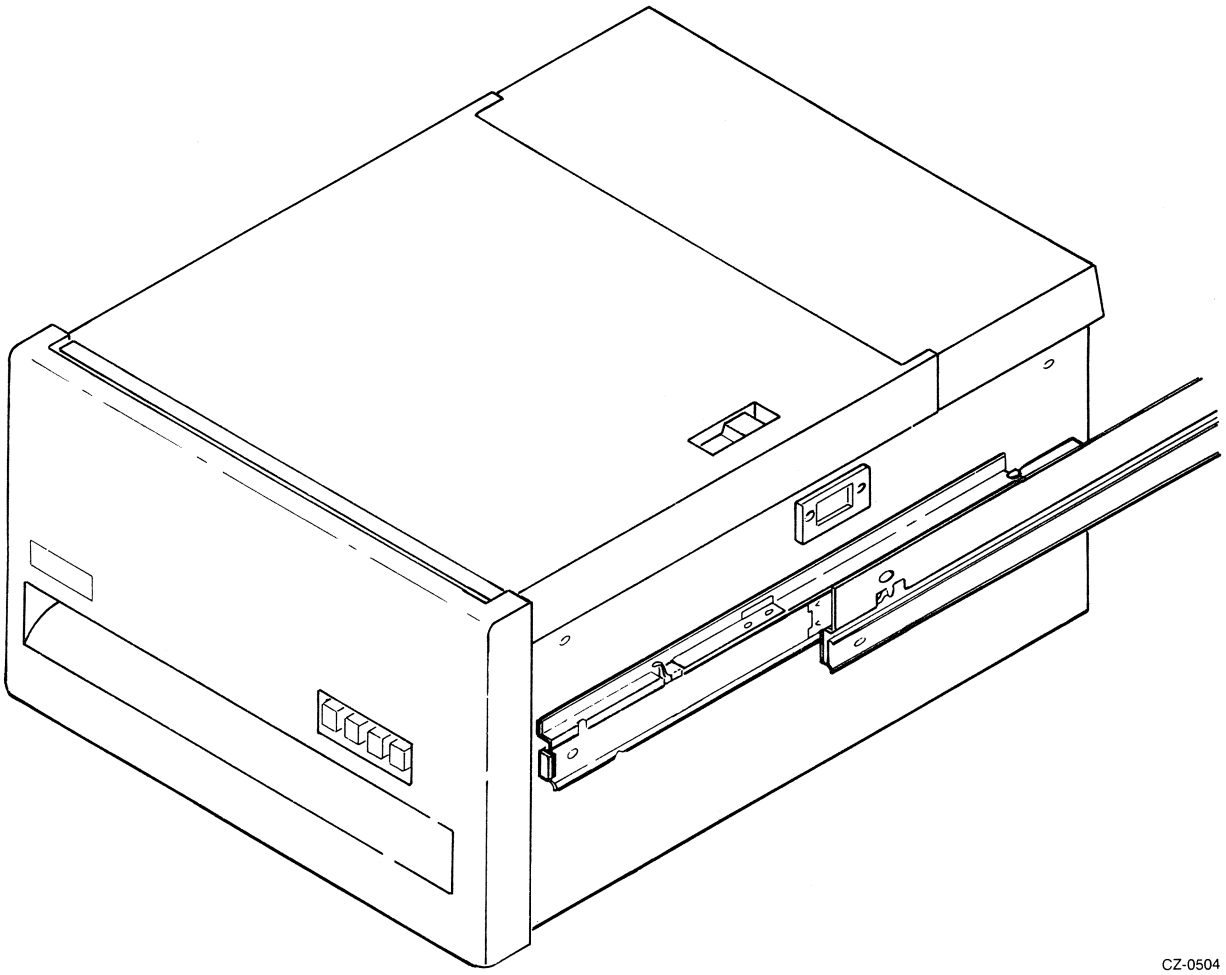

Figure 1-2 RL01/RL02 Disk Drive

1.3.2.2 RLV11 Controller Description – The RLV11 controller consists of two quad-height modules designated M8013 and M8014. This controller interfaces the drive with the LSI-11 Bus. The data is formatted in 16-bit words. The controller can handle any combination of up to four RL01/RL02 drives.

1.3.2.3 RL8A Controller Description – The RL8A controller consists of a single, hex-height module designated M8433. It is used to interface the drive with the PDP-8 OMNIBUS. The data can be formatted in either 8-bit bytes or 12-bit words. This controller has a jumper-determined choice of handling RL01 or RL02 drives. However, in the RL02-jumpered configuration, it can handle any combination of up to four RL01/RL02 drives.

1.3.2.4 RLV12 Controller Description – The RLV12 controller consists of a single, quad-height module designated M8061. It is used to interface the drive with either the extended LSI-11 Bus or the standard LSI-11 Bus. A jumper designates the 22-bit or 18-bit addressing scheme. The data is formatted in 16-bit words. This controller can handle any combination of up to four RL01/RL02 drives.

1.3.3 RL01K/RL02K Disk Cartridge

The RL01K or RL02K is a removable, top-loading 5440-type disk cartridge that is formatted in a manner unique to the RL01/RL02 subsystem. Both cartridges contain a single platter. The RL01K cartridge has a capacity of 5.2 megabytes of user data, and the RL02K cartridge holds 10.4 megabytes of data. Both sides of the platter are used for data. There are 256 tracks on each RL01K platter surface and 512 tracks on each RL02K platter surface. Each track is divided into 40 sectors. Each sector contains 256 bytes of data. The last track of the last surface is reserved for the cartridge serial number and bad sector information. Head positioning servo information and header information are prerecorded at the factory and cannot be reformatted in the field. This information, along with the data, is read by the read/write heads but the internal logic of the drive unit protects the servo and header information from being overwritten.

1.3.3.1 Interchangability – The RL01K and RL02K disk cartridges are not functionally interchangable although they are physically interchangable. It is possible to mount an RL01K cartridge on an RL02 drive, for example, but proper operation will not occur. An RL01K cartridge written on an RL01 unit can be read on any other RL01 unit even if that unit is controlled by a different type of controller. The limitation to this interchangeability is that if an RL8A controller is used to write data and the cartridge is to be used by an 11-Family controller, the RL8A must use the 8-bit byte mode of operation.

An RL02K cartridge written on an RL02 unit can be read on any other RL02 unit (assuming the same conditions mentioned above).

1.3.3.2 Sector Format – As shown in Figure 1-3, each sector contains:

- Servo information for head positioning,
- Header (address) information,
- Data (128 words of 16 bits or 256 bytes of 8 bits or 170 words of 12 bits).

Only the data portion of a sector can be written by the user. The servo and header information is protected by the drive logic and controller to ensure disk integrity and cannot be written in the field.

Each sector starts with a sector pulse that is produced by a sector transducer mounted on the drive unit. It senses the sector notches that are machined into the hub of the disk cartridge.

During the time that the sector notch passes by the sector transducer, the heads detect two servo pulse bursts (S1 and S2) that are prerecorded on the platter. These servo bursts are used by the drive logic for head positioning.

The header follows the servo pulse bursts. It consists of:

- A preamble of three words – 47 "0" bits and one "1" bit,
- A word that contains the address – sector, head, and cylinder,
- A word of all zeros,
- A word containing information created by the Cyclic Redundancy Check (CRC) logic,
- A one-word postamble of all zeros.

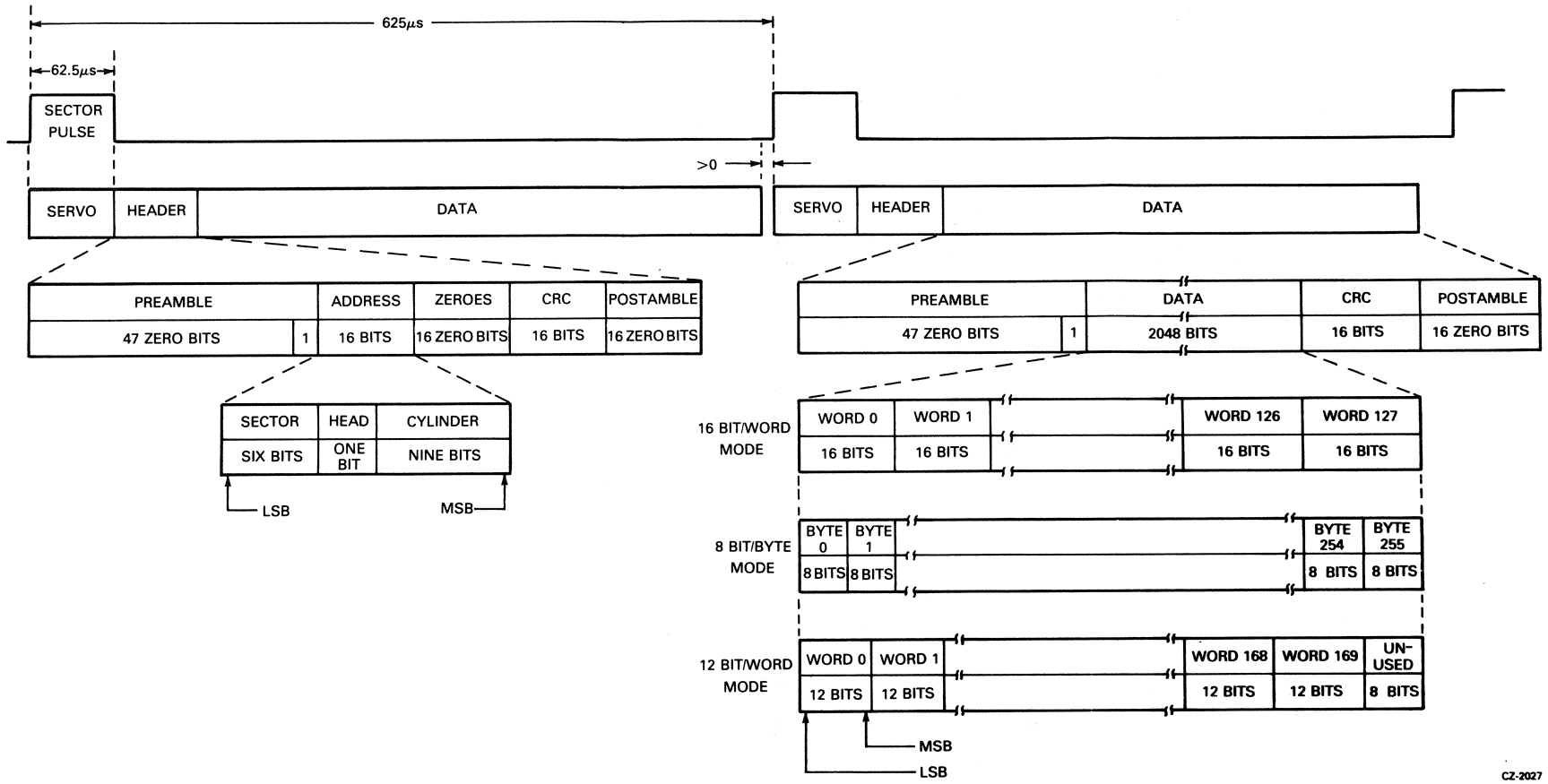

Figure 1-3 RL01K/RL02K Disk Cartridge Format

The user writeable data area follows the header. It consists of:

- A preamble of three words – 47 "0" bits and one "1" bit,
- Data (128 words of 16 bits or 256 bytes of 8 bits or 170 words of 12 bits),
- A word containing CRC-generated information,
- A one-word postamble of all zero bits.

Following each sector is a period of idle time that is simply a wait for the next sector pulse.

In addition to the data tracks, there are tracks both inside and outside of the data area that contain unique servo signals that define those areas as guard bands. If the read/write heads attempt to enter a guard band, the drive logic causes the positioner to retreat from the guard band and return to the data area.

The disk has a nominal rotational speed of 2400 rev/min. Therefore, the time for one revolution is 25 milliseconds. Since the revolution is divided into 40 sectors, the duration of each sector is 625 microseconds. This 625 microsecond period is divided into non-data (sector pulse, header, idle time) time and data time. The data time period is 500 microseconds. Thus, the data is transferred in 500 microsecond bursts that occur every 625 microseconds.

For 16-bit word mode there are 128 words of data in a sector so the peak transfer rate is 3.9 microseconds per word and the average transfer rate is 4.9 microseconds per word.

For 8-bit bytes (256 bytes per sector), the peak transfer rate is 1.9 microseconds per byte and the average transfer rate is 2.4 microseconds per byte.

For 12-bit word mode (170 words per sector), the peak transfer rate is 2.9 microseconds per word and the average transfer rate is 3.7 microseconds per word.

1.4 SECTOR LOCATION

The RL01K/RL02K disk cartridges do not have a physical index notch (occurring once per revolution) machined into the hub as some cartridges do. The controller determines the rotational position of the disk cartridge by reading, from the header, the sector address as well as the head (surface) and cylinder (track) addresses. Thus, the cartridge does not need a physical index. The sectors are relocated to optimize the data transfer rate when it becomes necessary to perform a seek during a data transfer.

A head switch to the other surface is considered a seek because the RL01/RL02 subsystem uses servo information that is recorded on each track. The newly selected head will position itself over the center of the track. There is no hardware-controlled implicit seek on the RL01/RL02 subsystem. All seeks, including spiral (mid-transfer) seeks, must be programmed into the software. The correct head must be selected and positioned over the correct track by a seek operation before the software can initiate a data transfer.

When the end of a track is reached and the data transfer has not been completed, the software must do one of two things. It must switch to the head that is over the corresponding track on the other surface (6.5 milliseconds average, 8 milliseconds maximum) or the software must issue a seek to the next cylinder (15 milliseconds). If the head is to be switched also, the seek and the head switching are normally combined. Once the unit has completed the seek operation, the software can continue the data transfer.

To reduce the rotational latency following a head switch seek, surface one is offset by 17 sectors from surface zero. The eight milliseconds head switch corresponds to 13 sectors of this offset and the additional four sectors allow for software overhead.

To reduce the rotational latency following a one cylinder seek (with head switch), surface 0 of a cylinder is offset by 29 sectors from surface 1 of the previous cylinder. The 15 millisecond seek time takes 24 sectors of this offset and five more sector times are allowed for software overhead.

These two offset patterns are illustrated in Figures 1-4 and 1-5.

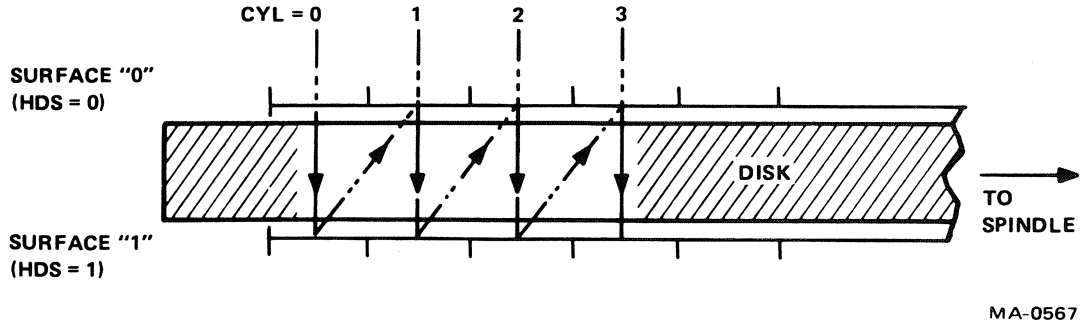

Figure 1-4 Access Method for Sequential Transfers

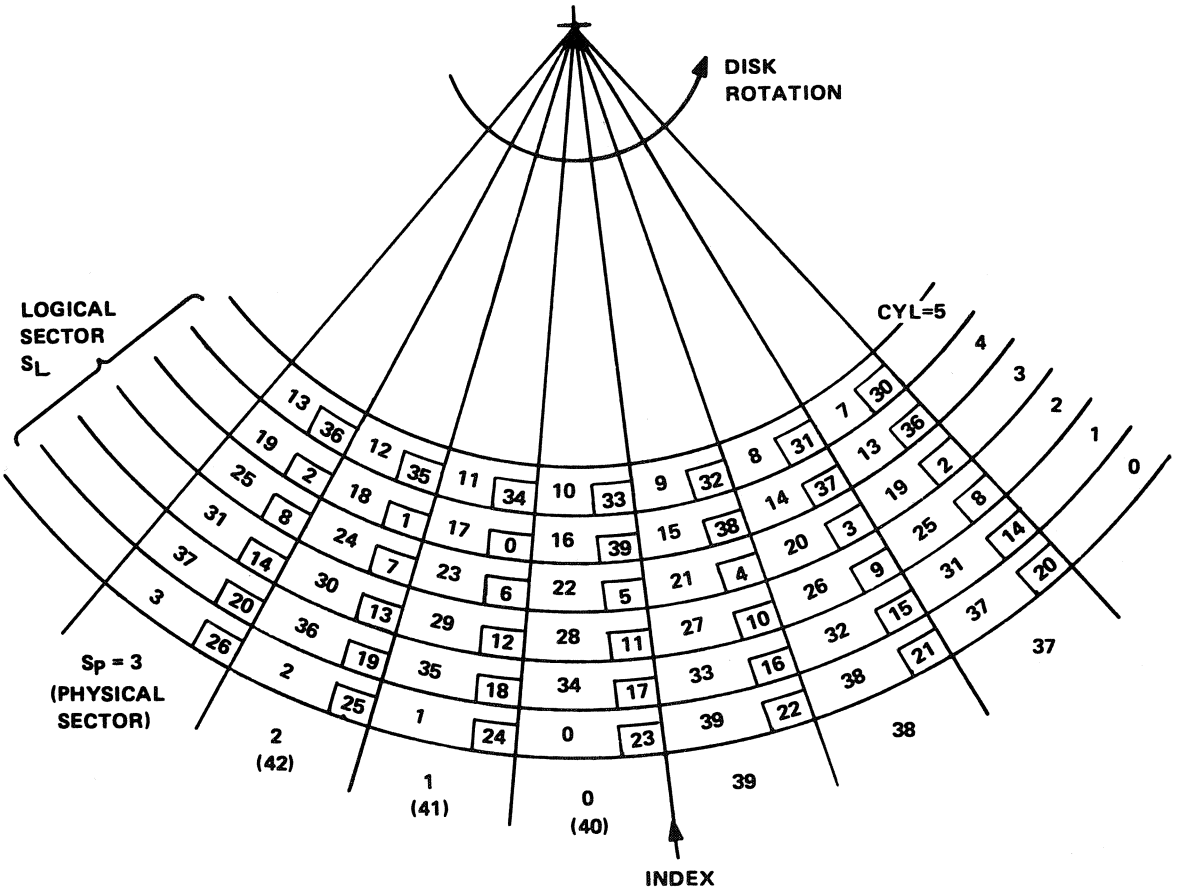

Figure 1-5 Sector Relocation

1.5 BAD SECTOR FILE

The Bad Sector File is a list of all bad sectors found on an RL01K/RL02K disk cartridge. It also contains the cartridge serial number. The operating system uses this information to avoid allocating bad sectors to a user's files.

If there is an error in a header, or if there are 16 consecutive read/write errors within one sector, that sector is defined as a bad sector.

This file is recorded on surface 1, track 255 (decimal) of an RL01K cartridge, and surface 1, track 511 (decimal) of an RL02K cartridge. The file consists of 40 sectors of 128 words each. Figure 1-6 shows the format of the Bad Sector File.

There is room in the file for 128 entries written by the factory and for 128 entries that can be written in the field if bad sectors develop during field use.

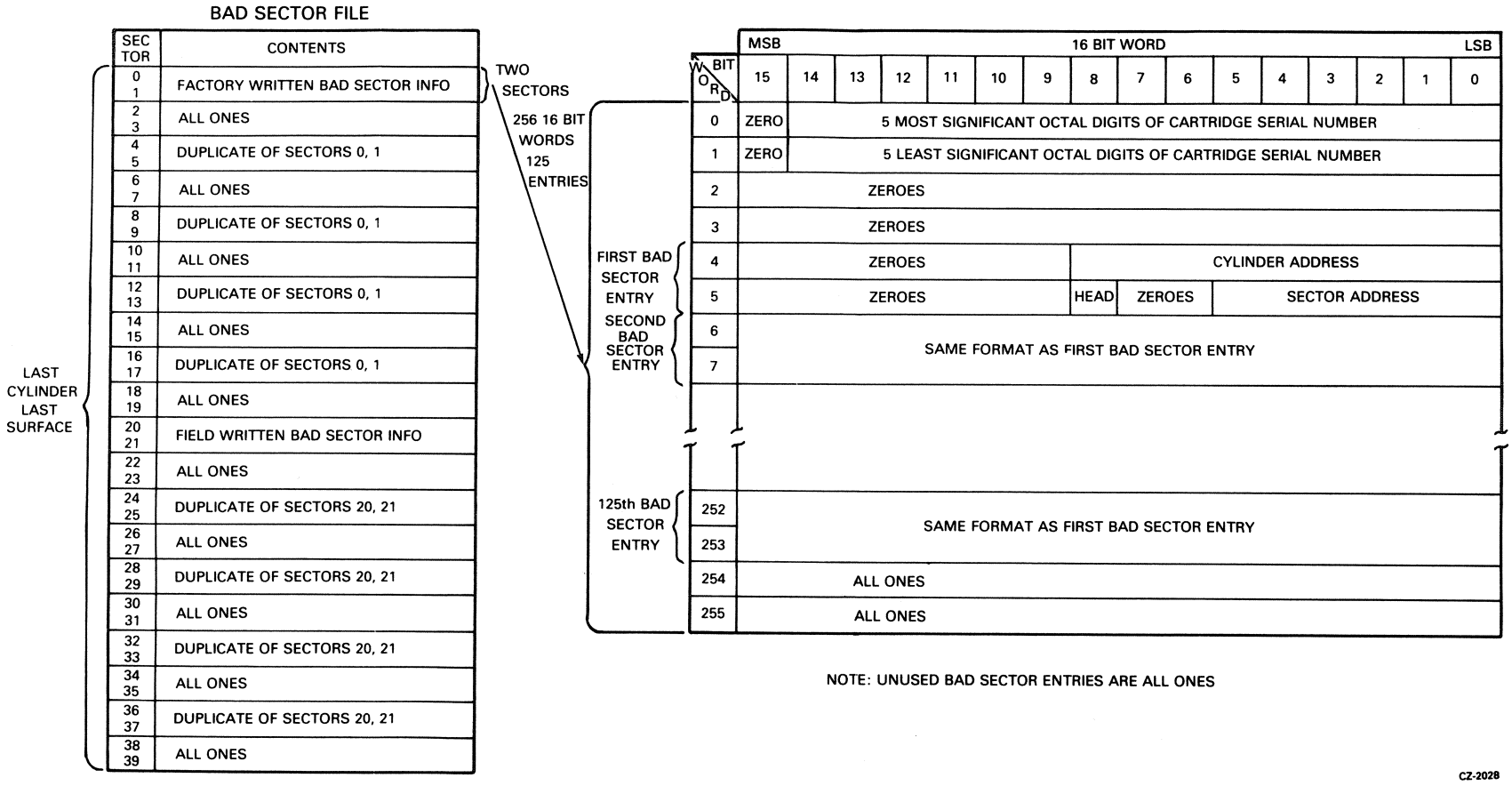

Figure 1-6 Bad Sector File Format

1.6 RL01/RL02 SPECIFICATIONS

The following tables list the specifications of the RL01/RL02 drives and the RL01K/RL02K cartridges.

1. Table 1-2 RL01/RL02 Disk Drive Physical and Environmental Specifications
2. Table 1-3 RL01K/RL02K Disk Drive Operational Specifications
3. Table 1-4 RL01K/RL02K Disk Cartridge Specifications

Table 1-2 RL01/RL02 Disk Drive Physical and Environmental Specifications

Characteristics	Specifications
Width	Compatible with 19 inch RETMA rack
Depth	63.5 cm (25 in) behind bezel
Height	26.52 cm (10.44 in)
Weight	34 kg (75 lb)
Mounting	The drive mounts on chassis slides
Power Source	90-127 Vac (47.5-63 Hz) 180-256 Vac (47.5-63 Hz) (Manually selectable)
Input Power	160 W max at 115 Vac, 60 Hz
Power Factor	Greater than 0.85
Starting Current	3.5A (rms) max @ 90 Vac/47.5-63 Hz 5.0A (rms) max @ 127 Vac/47.5-63 Hz 1.75A (rms) max @ 180 Vac/47.5-63 Hz 2.5A (rms) max @ 254 Vac/47.5-63 Hz
Heat Dissipation	546 Btu/hr max
Power Cord and Connector	A molded line cord compatible with the drive operating voltage and the 861 power control for 120 Vac is attached to the drive. The power cord is 2.74 m (9 ft) long and the plug is NEMA 5-15P. The 230 Vac plug to be attached to high voltage drives is NEMA 6-15P.

Table 1-2 RL01/RL02 Disk Drive Physical and Environmental Specifications (Cont)

Characteristics	Specifications
Safety	The RL01/RL02 disk drive is UL listed and CSA certified.
Interlocks	Interlocks are used where potential exists for damage to drive, media, operators, or service personnel.
Temperature/ Humidity	**Operating:** Temperature: 10° C (50° F) to 40° C (104° F) Note: Maximum allowable operating temperatures are reduced by a factor of 1.8° C/1000 meters (1° F/1000 feet) for operation above sea level. Relative Humidity: 10 to 90 percent with maximum wet bulb temperature 28° C (82° F) and minimum dew point 2° C (36° F) **Nonoperating:** Temperature: −40° C (−40° F) to 66° C (151° F) Relative Humidity: 10 to 95 percent, noncondensing
Altitude	**Operating:** 2440 m (8,000 ft) max **Nonoperating:** 9144 m (30,000 ft) max
Shock	**Operating:** Half sine shock pulse of gravity peak and 10 ± 3 ms duration applied once in either direction of three orthogonal axes (3 pulses total) **Nonoperating:** Half sine shock pulses of 40 gravity peak and 30 ± 10 ms duration perpendicular to each of six package surfaces.
Vibration	**Operating:** Sinusoidal vibration (sweep rate 1 octave/min) 5-50 Hz, 0.002 in displacement amplitude 50-500 Hz, 0.25 gravity peak 500-50 Hz, 0.25 gravity peak 50-5 Hz, 0.002 in displacement amplitude

Table 1-2 RL01/RL02 Disk Drive Physical and Environmental Specifications (Cont)

Characteristics	Specifications
Vibration	**Nonoperating:** Vertical Axis Excitation – 1.40 gravity (rms) overall from 10 to 300 Hz; power spectral density of 0.029 g^2/Hz from 10 to 50 Hz, with 8 dB/octave rolloff from 50 to 300 Hz Longitudinal and Lateral Axis Excitation – 0.68 gravity (rms) overall from 10 to 200 Hz; power spectral density of 0.007 g^2/Hz from 10 to 50 Hz, with 8 dB/octave rolloff from 50 to 200 Hz
EMI	Meets DEC Standard 102, Section 7.
Dust	The drive will operate in an ambient atmosphere of less than 5 million particles 0.5 microns or larger per cubic foot of air. The drive is intended to run in a light industry or cleaner environment.
Attitude	Maximum pitch: ± 15 degrees Maximum roll: ± 15 degrees

Table 1-3 RL01/RL02 Disk Drive Operational Specifications

Characteristics	Specifications
General	Linear bit density: 147 bits/mm (3725 bits/in) at innermost track
	16-bit words per sector: 128
	Number of sectors per track: 40
	Track density: 4.9/mm (125/in) for RL01K, 9.8/mm (250/in) for RL02K
	Number of tracks per surface: 256 for RL01K, 512 for RL02K
	Number of surfaces: 2
	Formatted capacity (megabytes): 5.2 for RL01K, 10.4 for RL02K
	Encoding method: Modified Frequency Modulation (MFM)
Transfer Rate (Unbuffered Values)	Bit rate: 4.1 megabits/second ± 1 percent Bit cell width: 244 ns ± 1 percent Word transfer rate (16-bit words): 256 kilowords/second ± 1 percent
Latency	Rotational frequency: 2400 rev/min ± 0.25% Average latency: 12.5 ms ± 0.25% Maximum latency: 25.0 ms ± 0.25%
Seek Time	Average seek time: 55 ms max (85 tracks for RL01, 170 tracks for RL02)
	One cylinder/track seek time: 15 ms max
	Maximum seek time: 100 ms max (256 tracks for RL01, 512 tracks for RL02)
Start/Stop Time	Start time: 45 seconds Stop time: 30 seconds
Data Format	Refer to Figure 1-3

Table 1-4 RL01K/RL02K Disk Cartridge Specifications

Characteristics	Specifications
Operating Environment	The cartridge will operate over a temperature range of 4° C to 48° C (40° F to 120° F), at a relative humidity of 8 to 80 percent. The wet bulb reading must be less than 25° C (78° F). Before a cartridge is placed in operation, it should be conditioned within its cover for a minimum of 2 hours in the same environment as that in which the disk drive is operating. (The above specified ranges do not necessarily apply to the disk drive.)
Storage Environment	The cartridge should be stored at a temperature between −40° C to 65° C (−40° F to 150° F), with a wet bulb reading not exceeding 29° C (85° F). For wet bulb temperatures between 0.56° C and 29° C (33° F and 85° F) the disk cartridge will withstand a relative humidity of 8 to 80 percent. The stray magnetic field intensity shall not exceed 50 Oersteds.
Dimensions (Cartridge)	The external diameter of the top cover is 38.35 cm (15.1 in). The external diameter of the protection cover is 37.03 cm (14.58 in). The external height of the cartridge is 6.19 cm (2.44 in).
Maximum Speed	The rotating parts of the disk cartridge are capable of withstanding the effect of stress created while rotating at 2,500 rev/min.
Track Geometry	There are 256 discrete concentric tracks per data surface for the RL01K, 512 tracks per data surface for the RL02K.
Identification of Data Location	Data Track Identification – Data tracks are numbered by consecutive decimal numbers (000 – 255, RL01K; 000 – 511, RL02K) starting at the outermost data track of each data surface. Data Surface Identification – The upper data surface is numbered 0 and the lower surface is numbered 1, to correspond with the head numbers.

Table 1-4 RL01K/RL02K Disk Cartridge Specifications (Cont)

Characteristics	Specifications
	Cylinder Address – A cylinder is defined as both data tracks (on either surface) with a common data track identification. Data Track Address – A 16-bit word defines the data track address. Bits 0 – 5 define the sector, bit 6 defines the surface, and bits 7 – 15 define the cylinder address. This information is in word 1 of each sector's header.