NCR ADP-55
SCSI TO QIC36 CONTROLLER
October 1986

SCOPE

This document is intended for use by OEM engineers, system integrators, and service technicians. It provides the information needed to install, configure, and operate the NCR ADP-55 SCSI TO QIC36 Controller Board.

REFERENCE DOCUMENTS

Small Computer System Interface: ANSC X3T9.2/82-2 Rev. 17B

APPLICABILITY

This document applies to Rev. B artwork of the board. The artwork can be identified by a [B] etched near the SCSI plug connector J2 or the solder side of the board.

REVISION RECORD

Revision	Date	Remarks/Affected Pages
A	Jul 86	Original release
B	Oct 86	Added 3 code meanings to Byte 12 - p. 17 Added 'UP' & 'DOWN' to option switch description of U53, U63 & U20 - p. 48 Corrected 'FACTORY SETTING' of sw's 6 & 8 p. 48 Corrected configuration of sw's 1 & 2 of U53 for Level 0 Diag. Code display - p. 51 Note: Changed lines are indicated by a '|' in left margin.

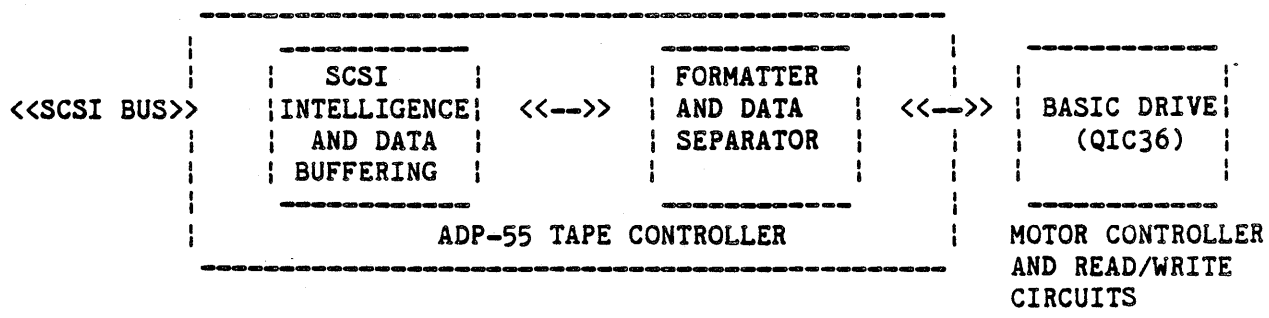
NCR ADP-55 SCSI TO QIC 36 CONTROLLER BOARD

GENERAL DESCRIPTION

Purpose of Product

The NCR ADP-55 is an intelligent controller designed to control one 1/4-inch data cartridge tape drive. It can be connected to cartridge tape drives that use the industry-standard QIC-36 interface. The controller communicates with a host system via the Small Computer System Interface (SCSI). It is designed to interface with a wide range of high- and low-performance host systems. The controller's intelligence supports read, write and copy operations.

Functional Block Diagram



Features

* Supports full SCSI:
  * Target and Initiator roles
  * Disconnect/Reconnect
  * Arbitration
  * Off-line copy to free host for other functions
  * Mandatory, extended, and many optional commands
* 64 KB buffer with parity
* Automatic error recovery
* Self-test diagnostics
* Controller includes:
  * Tape formatter chip with 2K buffer
  * PLL and data separator chip

Commands

* Test Unit Ready
* Rewind
* Request Sense
* Read Block Limits
* Read
* Write
* Mode Select
* Reserve Unit
* Release Unit
* Copy
* Erase
* Mode Sense

* Write File Mark
* Space
* Inquiry
* Recover Buffered Data
* Load/Unload
* Receive Diagnostics
* Send Diagnostics
* Verify

Options

ADP-55	SCSI Bus
-01	Single-Ended
-02	Differential

Technical Data

Performance Rates

NOTE: The following specifications are intended primarily for test purposes. They cannot be related directly to actual throughput and system performance, which depend on many factors external to the controller.

Assuming ideal conditions, the unit performs as follows.

* The ADP-55 when used with a 90 ips QIC-36 drive can backup or restore 45 M bytes in less than 10 minutes.
* The maximum SCSI transfer data rate is 1.1 M bytes per second; the average SCSI transfer data rate is 87.7 K bytes per second. A 64 K byte buffer in the controller is used to maximize the transfer rate between the tape and other SCSI controllers. If a data transfer request is greater than 16 K bytes, the controller divides this request into several SCSI bus transfer requests, with a maximum of 16 K bytes in each SCSI bus connection.
    * The transfer rate is measured by summing the ACK to ACK delay for a minimum of 50 bytes, then dividing it into the total number of bytes transferred.
    * Initiator device delays for REQ asserted to ACK asserted and for REQ deasserted to ACK deasserted must not exceed 108 ns each to meet the transfer rate specified earlier.
    * Target device delays for ACK asserted to REQ deasserted and for ACK deasserted to REQ asserted must not exceed 108 ns to meet the specified transfer rate while the Copy command is being performed.
* The average tape transfer rate is 87.7 K bytes per second.
* The tape speed is 90 inches per second.

Data Capacity

Two tape capacities (formatted maximum) are supported: 45 M bytes on a 450-foot tape cartridge and 60 M bytes a 600-foot tape cartridge.

Compatibility With Standards

* SCSI interface: Small Computer System Interface: ANSC X3T9.2/82-2 Draft Proposed Standard, Rev. 17B
* Tape cartridge: ANSI standard X3.55-1977
* SCSI commands: All SCSI standard commands are implemented, as well as many optional commands and some extended commands. (The commands implemented are listed in the "Commands And Statuses" section of this publication.)

Compatibility With Other Products

The unit is compatible with other products implementing the SCSI standard interface.

Form Factor

The form factor is standard 5 1/4-inch.

Reliability (based on the Archive Scorpion and ADP-55)

* Recoverable error rate: A maximum of 1 in 10^8 bits
* Nonrecoverable error rate: A maximum of 1 in 10^{10} bits
* Inconvenience failure rate: 1 in 50 000 power-on hours
* Mean time between failures for unit (integrated drive and controller): 18 749 power-on hours, assuming a 10% duty cycle of drive activity. (The duty cycle is the ratio of hours of drive activity to power-on hours.)
* Mean time between failures for mature controller (including design- and manufacturing-induced failures but not user- or service-induced failures): 47 587 power-on hours. (The controller is considered mature after 12 months of production.)
* Mean time between failures for tape drive: 30 873 power-on hours at a 10% duty cycle.
* Average workload: 8 hours per day, 250 days per year
* Design workload (workload of 90% of the entire production population): 13 hours per day, 365 days per year
* Service calls per year (including a user- and service-induced failure factor of 0.73): 0.146 based on the average workload
* Product life: At least 7 years at average workload; at least 5 years at design workload
* Mean time to repair: A maximum of 0.5 hour for the drive

Error Detection, Correction, And Diagnostics

The unit provides the following functions.

* Internal power-up diagnostics
* Extended diagnostics through the SCSI bus
* Automatic read-after-write error checking and recovery
* Retries on SCSI parity errors

Two sets of diagnostic software are used: SCSI diagnostic commands and power-up self-test diagnostics. The SCSI diagnostic commands are implemented through the SCSI bus; they are listed in the "Commands And Statuses" section of this publication. The self-test diagnostics, performed during power-up, test the hardware extensively before the controller can receive an SCSI function.

Security

Data security on tape cartridges is provided for. A signal from the drive to the controller indicates that the mounted cartridge is write-protected. The controller then prevents writing on that cartridge.

INTERFACES

Hardware

High-Level Description
The controller interfaces the tape drive to other peripherals or to the host though the Small Computer System Interface (SCSI) bus.

Target and Initiator Functions
The controller implements both target and initiator functions. A host on the SCSI bus originates the SCSI function and transfers it to the controller, which then interprets it.

* If the function is not a copy function, the controller, acting as a target, performs the function and then returns a status code to the host
* If a copy function is sent to the controller, the controller switches roles to become an initiator, then initiates the necessary functions with a direct access peripheral. When the function is complete, the controller switches back to the target role and returns a status code to the host system that originated the function.

Queuing of Host Request
The controller firmware contains two input/output command buffers (IOCBs). Therefore, requests from the host adapter can be queued. If only one of the requests is for a tape movement function, the requests can be performed in an interleaved fashion, depending on priority and resource allocation.

If an IOCB is available when the host selects the controller, the IOCB is used, and the function is transferred from the host immediately. However, if no IOCB is available, the host identification is stored with the unit number. When an IOCB becomes available, the host is reselected and function data is transferred from the host.

Data Transfers
The controller is responsible for monitoring the data transfers. It must collect status and sense data to be sent to the host. In addition, the data transfer to or from the tape must be performed, using as many SCSI transfers as needed to complete the data transfer function. Transfer is to or from the host, except for a Copy command. For a Copy command, the controller must do the following things.

* Receive the host request as a target
* Become an initiator
* Send a function to a direct-access peripheral
* Send data to or receive data from the peripheral
* Get a status from the peripheral

* Issue a request sense to the peripheral
* Become a target to the host system
* Return a status to the host system
* If requested, return sense data to the host system

Data transfer to the tape occurs by receiving data from the SCSI Protocol Controller chip, temporarily storing the data in the 64 K byte buffer, and then sending the data to the tape interface. Data transfer from the tape occurs in reverse order of these steps.

Unit Configuration
The ADP-55 can be mounted to a half-height 5 1/4-inch streaming tape cartridge drive with a QIC-36 interface. (See the board mounting hole drawing for dimensions)

The controller contains the following major modules.

* NCR 5385E SCSI-B Protocol Controller Chip
* 64 KB buffer memory
* Memory Array Controller chip (MAC)
* 2 K x 8-bit Scratch-pad RAM
* 32 K x 8-bit EPROM
* 8031 Microprocessor
* 16 K x 1-bit block buffer RAM
* Formatter VLSI chip
* Data Separator VLSI chip

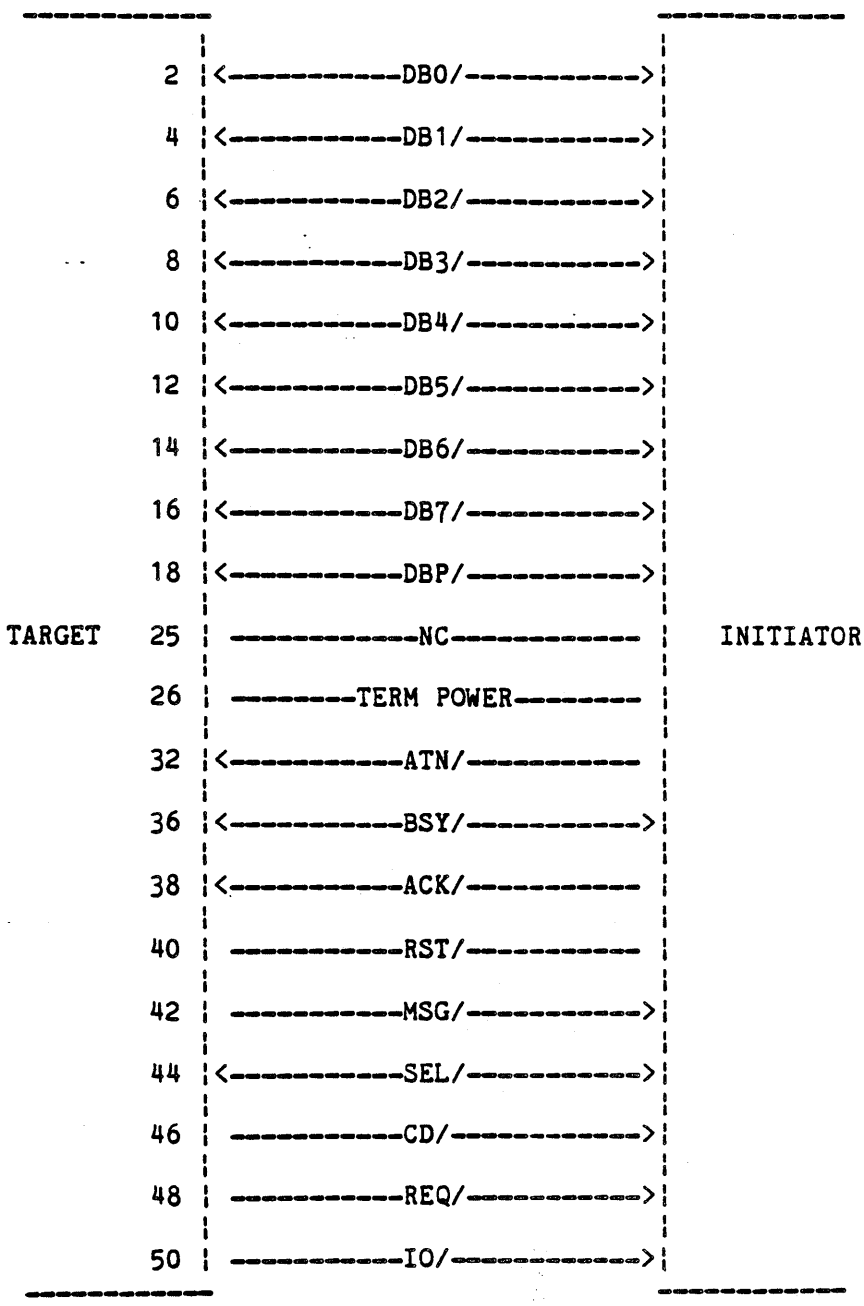
Electrical Protocol
The single-ended SCSI interface has active low electrical protocol.

Connecting Cables
The specifications for the connecting cables are shown in Table 1. Figures 1 and 2 show the pin assignments for the single-ended and differential versions of the ADP-55.

Purpose	Number of Pins	Connector Identifier	Connector Body Type	Amp Connector[1] Part Number	Maximum Length (m)
SCSI Bus	50	J2	Straight post header; 0.1-inch pin pitch	1-499662-00	6.0
DC Power					
Drive	4	J2		1-480426-90	
Controller	4	J3		1-480426-90	

[1] Equivalent connectors from other manufacturers can be used.

Table 1. Cable specifications



* All odd-numbered pins, except Pin 25, are connected to ground. Pins 19 through 24 and Pin 34 are also connected to ground.
* The / character indicates active low.

Figure 1. Single-ended pin assignments

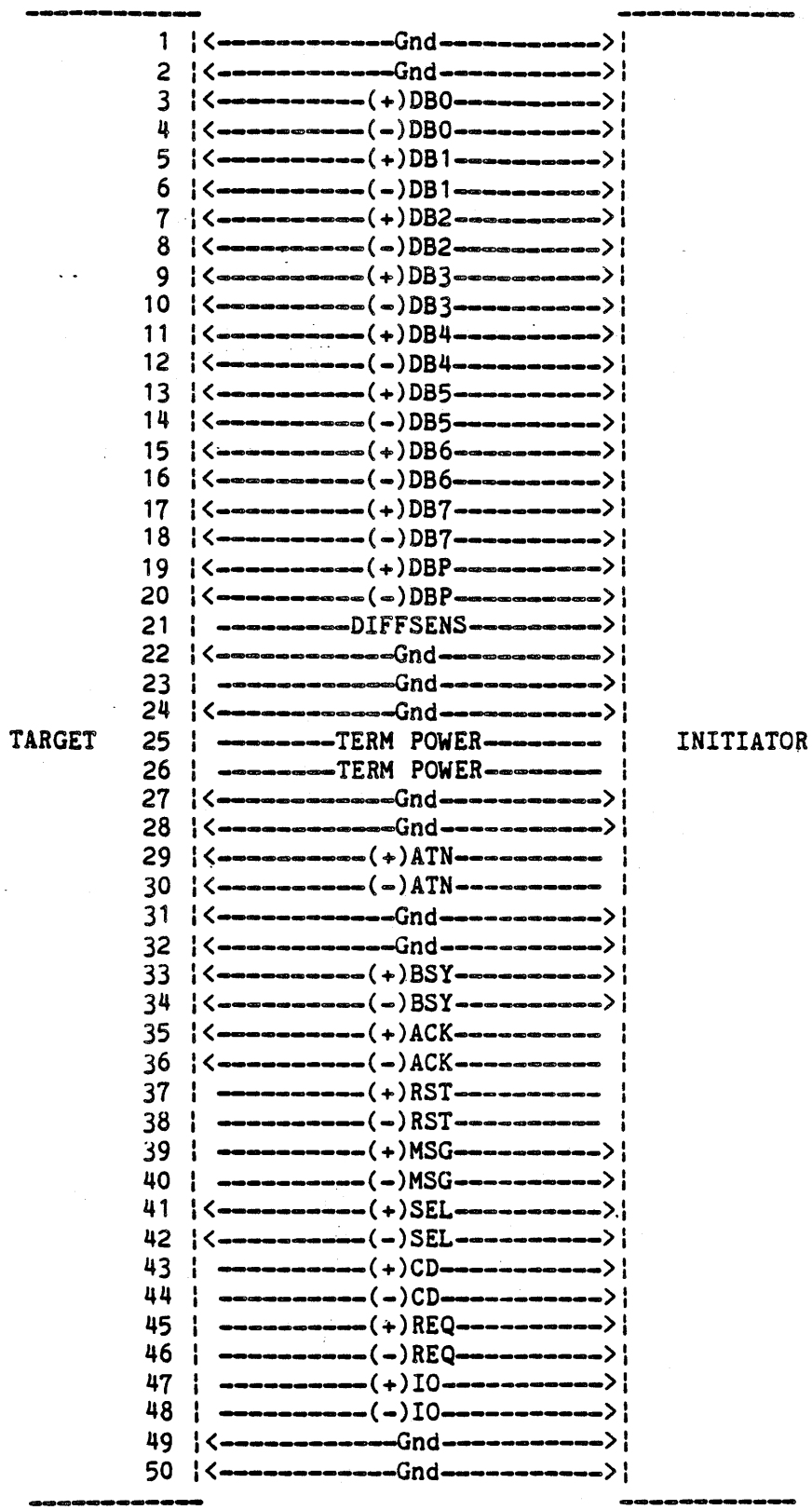


Figure 2. Differential pin assignments

Description of SCSI Signals

On the single-ended version, the signals are active low; when a signal is low, it is active (or true). On the differential version, all signals consist of two lines identified as (+) and (-). When the (+) signal is more positive than the (-) signal, the signal is true.

SHIELD Gnd
: Ground connection for cable shield

DB0
: Data-bit signal; least significant bit

DB1
: Data-bit signal

DB2
: Data-bit signal

DB3
: Data-bit signal

DB4
: Data-bit signal

DB5
: Data-bit signal

DB6
: Data-bit signal

DB7
: Data-bit signal; most significant bit

DBP
: Data parity bit; odd

DIFFSENS
: Optional active high enable for the differential drivers

NC
: (Not connected)

TERM POWER
: Optional terminator power (+5 V) - See Page 44

ATN
: An initiator signal for attention

BSY
: Indicates that the SCSI bus is being used

ACK
: An initiator signal acknowledging a REQ/ACK "handshake"

RST
: Reset signal

MSG
: A target signal during the Message phase

SEL
: Either an initiator signal to select a target or a target signal to reselect an initiator

C/D
: A target signal indicating whether the data bus contains control information or data.

REQ
: A target signal indicating a request for a REQ/ACK "handshake"

I/O
: A target signal controlling the direction of data movement on the data bus to or from the initiator. An active condition indicates input to the initiator. The signal is also used to distinguish between selection and reselection.

Timing Diagrams

For the timing diagrams, refer to Small Computer System Interface (SCSI) Specification (ANSC X3T9.2/82-2 REV.17B).

Software

High-Level Description

The streaming tape controller can function as either a target or an initiator. When an initiator issues a function to the controller, the function is examined and performed unless the copy function was issued. Before execution, the controller verifies certain fields in a command descriptor block and reports an error if they are invalid. A copy function causes the controller to switch to the initiator mode, transmit the appropriate function to another target, transmit or receive data and status, switch back to target mode, and send the results back to the initiator. Other functions are completed entirely within the controller, and data is sent to or received from an initiator. A status is sent directly to the initiator upon completion.

If there are multiple initiators, the controller has space for two commands which are executed one at a time except for priority commands which are executed concurrently. Other commands are queued in the form of logical unit number and initiator identifier. When space is available, the controller selects the next command in the queue and then requests that the initiator send function data. If the function cannot be executed immediately, a busy status is returned to the initiator. In general, no other function can execute while the streamer is busy except for Test Unit Ready, Inquiry, Request Sense and Read Block Limits. Only these four functions have highest priority. The initiators must coordinate operations to the tape to ensure that a consistent set of functions is requested.

Typically, an initiator reserves the streaming tape before attempting any tape-altering command. The initiator must also coordinate the other peripheral involved in the copy function. Files should not be altered during backup or restore. The controller does not perform any coordination during the copy function.

Status Block

Extended Sense Data

The general format of the Extended Sense data is shown in Figure 3. The formats of this data for the Copy Abort sense keys are shown in Figures 4 and 5. The data-value descriptions for the fields in the formats are shown in Tables 2 through 6.

The controller identifies the data. The initiator obtains this data by issuing a Request Sense command to the controller. The actual bytes and length of the data depends on the function issued and its error type. At least eight bytes of data are returned with each Request Sense command. These bytes, 0--7, are described in the SCSI standard.

Unit Self Test Diagnostics

The format of the unit self-test diagnostics is shown in Figure 6. The status bytes are described in Table 7. The initiator obtains this data by issuing a Send Diagnostics command followed by a Receive Diagnostics command.

Byte	Bit 7	6	5	4	3	2	1	0
0	Valid	Error Class (7)			Error Class (0)			
1	Number of Current Segment Descriptor for Copy Command							
2	Filemrk	EOM	ILI	Reservd	Sense Key			
3—6	Residue Count							
7	Additional Sense Length[1]							
8—11	0	0	0	0	0	0	0	0
12—13	Secondary Error Code							
14—15	0	0	0	0	0	0	0	0
16—19	1	1	1	1	1	1	1	1
20—21	0	0	0	0	0	0	0	0
22	1	1	1	1	1	1	1	1
23—24	Drive Status (See Table 6)							
25—26	Blocks Rewritten or Recoverable Read Errors							
27—28	Write or Read Underrun Count							
29—38	SCSI Command Descriptor Block							
42[2]	Parameter List Header (Mode Select or Copy command)							
42—54[2]	For Mode Select command: Block Descriptor List[3] For Copy command: Segment Descriptor List[3]							

[1]Length = 31 for any command other than Mode Select or Copy; Length = 31—43 for Mode Select; Length = 31—47 for Copy

[2]These fields may or may not be returned, depending on how far the controller progressed into the command before detecting the error.

[3]Length is 8 bytes for Mode Select and 12 bytes for Copy.

Figure 3. General format for Extended Sense data

Byte	Bit 7	6	5	4	3	2	1	0
0	Valid	Error Class (7)			Error Class (0)			
1	Number of Current Segment Descriptor For Copy Command							
2	Copy Abort Sense Key (hexadecimal 0A)							
3--6	Residue Count for Current Segment							
7	Additional Sense Length (decimal 58)							
8	Source Device Offset[1]							
9	Destination Device Offset[2]							
10	Tape Completion Status							
11--39	Tape Sense Data[3]							
40--49	Copy Command Descriptor Block							
50--53	Copy Command Parameter List Header							
54--56	Current Segment Descriptor							

Either byte 8 or byte 9, but not both, contain a nonzero value.

[1]Points to tape drive sense area if the tape drive was the copy source; value = decimal 10. If the tape drive was not the copy source; value = 0.

[2]Points to tape drive sense area if the tape drive was the copy destination; value = decimal 10. If the tape drive was the copy source, value = 0.

[3]Same as bytes 0--28 of the general Extended Sense Data format.

Figure 4. Format for Extended Sense data for Copy error in tape unit

Byte	Bit 7	6	5	4	3	2	1	0
0	Valid	Error Class (7)			Error Class (0)			
1	Number of Current Segment Descriptor For Copy Command							
2	Copy Abort Sense Key (hexadecimal 0A)							
3—6	Residue Count for Current Segment							
7	Additional Sense Length (n + 29)							
8	Source Device Offset[1]							
9	Destination Device Offset[2]							
10	Disk Completion Status							
11—n	Disk Sense Data							
n+11—n+20	Copy Command Descriptor Block							
n+21—n+24	Copy Command Parameter List Header							
n+25—n+36	Current Segment Descriptor							

[1] Points to disk sense area if the disk was the copy source; value = decimal 10. If the disk was not the copy source, value = 0.

[2] Points to disk sense area if the disk was the copy destination; value = decimal 10. If the disk drive was the copy source, value = 0.

Figure 5. Format for Extended Sense data for Copy error in disk drive

Bit	Value	Meaning
7	1	Bytes 3-6 contain a valid residue count
6--4	7	Error Class 7 indicates an extended sense
3--0	0	Error Class 0 indicates SCSI standard extended sense format

Table 2. Field meaning: Extended Sense ID and Valid bit

Bit	Meaning
7	If set to 1: A filemark was found when performing the command.
6	If set to 1: The early-warning tape hole was found while writing on the tape.
5	Illegal Length Indicator. This bit indicates that the requested logical block length did not match the block length of the data on the tape.
4	(Not used; always zero)
3--0	Sense key

Table 3. Field meaning: Filemark, End-of-media, Illegal Length Indicator, and Sense Key

Hexadecimal Value	Meaning
0	No sense
1	Recovered error
2	Unit not ready
3	Media error
4	Hardware error
5	Illegal request
6	Unit attention
7	Write-protected
8	Blank check
A	Copy aborted
B	Aborted command
D	Volume overflow

Table 4. Meanings of sense keys

Byte 12:

Code	Meaning
00	No error occurred
20	Illegal command issued
43	Data buffer parity error occurred
4B	Power-up failed
50	The buffer contains active Read or Write data
51	A function did not complete in the specified time; tape interface was reset
52	Tape position error: the beginning-of-tape was not indicated after Read-after-Write, Load/Unload, or Erase commands
53	An error occurred before all requested tape-unit commands were completed
54	A long bit was not set on a SCSI Erase command
55	Read, Write, or Verify commands do not support variable-block mode
56	Error in data transfer from initiator to controller
57	Error in data transfer from controller to initiator
58	Verify command does not support byte-compare mode
5A	Buffer parity error occurred
5B	Command-sequence error
5C	Unit-select error
5D	Erase or Mode Select command issued when tape was not at the beginning-of-tape point or the buffer contains data from a previous Write or Read command
5E	Tape cartridge is not mounted
5F	Command-parameter error occurred
60	Status error from target while performing Copy command
61	Cannot copy: Initiator cannot disconnect from SCSI bus
63	Buffer level error
64	Tape interface failed to set exception after Reset
65	Timeout occurred on an automatic rewind or a rewind after tape interface reset
66	Drive detected Retries or Underruns
67	Controller detected Retries - Buffer Parity
68	Controller detected Retries - SCSI Parity

Byte 13: Level 0 diagnostics failure code (Byte 12=4B)

91	Checksum error
93	Error detected on 8031 processor
94	2K RAM error
97	Timer Test error
98	SCSI error
99	Formatter chip error
9B	MAC chip error
9C	8155 Port error
9E	Latch error
9F	64K Buffer (DRAM) error

Table 5. Meanings of secondary error codes

Byte	Bit	Meaning
0	7	Exception byte 0
	6	Tape cartridge not in place
	5	Unit not online
	4	Write-protected
	3	End of media
	2	Unrecoverable data error
	1	Erroneous byte not located
	0	File mark found
1	7	Exception byte 1
	6	Illegal command
	5	No data detected
	4	Eight or more read retries
	3	Beginning of media
	2	(Reserved)
	1	End-of-data found
	0	Reset/Power-up occurred

Table 6. Meaning of drive status bytes

	Bit						
Byte	7	6	5	4	3	2	1	0
0	(same as drive status byte 0)							
1	(same as drive status byte 1)							
2	STPASS	RDTEST	USFERR	CINERR	LTHERR	UTHERR	STLERR	MOTERR
3	PIAERR	PLLERR	BUFFER	LSIERR	BLKERR	STPERR	TK1ERR	TK0ERR
4	Track 0 Error Count							
5	Track 1 Error Count							

Figure 6. Format of Unit Self-test status

Byte 2:	Field	Description
	STPASS	If unit passed self test, set to 1
	RDTEST	Indicates that bytes 2 and 3 are Read phase test results: 0 = Read After Write test 1 = Read test
	USFERR	Unsafe sensor error
	CINERR	Cartridge-In sensor error
	LTHERR	Lower Tape Hole sensor error
	UTHERR	Upper Tape Hole sensor error
	STLERR	Stall Detected error
	MOTERR	Motor/tach error
Byte 3:		
	PIAERR	Peripheral Interface Adapter error
	PLLERR	Data Separator error
	BUFERR	16 K bit RAM buffer error
	LSIERR	LSI controller chip error
	BLKERR	Block Address error during either Read After Write or Read test
	STPERR	Stepper error during Read test
	TK1ERR	Track 1 error; excessive error count in Read After Write test[1]
	TK0ERR	Track 0 error; excessive error count in Read After Write test[1]
Byte 4:		Track 0 error count during Read After Write test[1]
Byte 5:		Track 1 error count during Read After Write test[1]

[1]Error count = Misread Complete + Cyclical Redundancy Check errors

Table 7. Description of unit self-test status bytes

COMMANDS AND STATUSES

COMMANDS

Commands are sent to the controller in the form of a Command Descriptor Block. The format of the Command Descriptor Block is defined in the Small Computer System Interface (SCSI) Specification (ANSC X3T9.2/82-2 Rev. 17B).

The commands that the controller accepts in target mode are shown in Table 8. The commands that the controller issues in initiator mode are shown in Table 9. The Format command is not implemented.

To clear a tape of sensitive data, a user can issue an Erase command to clear the tape. When the first track of a tape is written, the Erase circuitry is automatically enabled. If the first track is not full, however, no data is erased following the data that is written.

The controller has space for two commands and can perform one at a time. Other commands are queued in this form: logical unit number, initiator identifier. When space is available, the controller selects (in circular sequence) the next command, and then requests that the initiator send function data. If the function cannot be performed immediately, the controller returns a Busy status to the initiator.

In general, no other function can be performed while the streamer is busy except the functions Test Unit Ready, Request Sense, Inquiry, and Read Block Limits. These four functions have highest priority among all functions. The initiators must coordinate operations to the tape to ensure that a consistent set of functions is requested.

Typically, an initiator reserves the streaming tape before attempting any tape-altering command. The initiator must also coordinate the other peripheral involved in the copy function. Files should not be altered during backup or restore. The controller does not perform any coordination during the Copy function.

00 Test Unit Ready
01 Rewind
03 Request Sense
05 Read Block Limits
08 Read
0A Write
10 Write File Mark
11 Space
12 Inquiry
13 Verify
14 Recover Buffer Data
15 Mode Select
16 Reserve Unit
17 Release Unit
18 Copy
19 Erase
1A Mode Sense
1B Load/Unload
1C Receive Diagnostic Results
1D Send Diagnostic

Table 8. Target-mode commands implemented

03 Request Sense
08 Read
0A Write
26 NCR Read -- SLI or ECC
27 NCR Write -- SLI or ECC

Table 9. Initiator-mode commands implemented

TEST UNIT READY

The Test Unit Ready command returns the status of the drive and cartridge.

When the controller receives the command, exception statuses (Not Ready or Unit Attention) cause the controller to return the check bit status and save the extended sense data for that initiator.

The extended sense data contains a sense key of 02 for Not Ready and 06 for Unit Attention. For a Not Ready status, six drive status bytes are also returned in the sense data. The format of the sense data and drive status bytes are described in Figure 3.

REWIND

The Rewind command positions the tape to the beginning-of-tape point (load point).

Upon receiving the command, the controller checks the drive's status. Exception statuses such as Busy, Not Ready, or Unit Attention cause the controller to immediately report the statuses to the initiator.

Before the Rewind command is performed and if the Rewind command follows a Write command, the controller transfers all data remaining in the buffer to the tape.

After the rewind is initiated, the controller tests the Immediate bit of the Command Descriptor Block (bit 0 of byte 1). If this bit is 1, a complete status with no check bit is immediately returned. If the Immediate bit is 0, a disconnect-from-SCSI-bus order is issued and a five-minute timer is started.

When the rewind is completed, the controller again checks the drive's status. The initiator is reselected and the appropriate status is returned to it.

If the timer times out, a reset command is issued to the unit, the initiator is reselected, then a complete status with Check bit is returned to the initiator. A hardware error sense key is made available in addition to the six drive status bytes. The format of the sense data and drive status bytes are described in Figure 3.

REQUEST SENSE

The Request Sense command returns sense information to the initiator for the last check condition returned to the initiator.

The sense data returned uses the SCSI extended sense format and the additional sense information described in Figure 3.

Any time a check condition is returned, the controller saves the sense data. It is released only when the initiator receiving the status either performs a Request Sense command or issues another command to the unit.

There are two sense-data areas. If both are full, the controller returns a Busy status on new commands until the sense data is released.

READ BLOCK LIMITS

The Read Block Limits command returns the maximum and minimum data-block lengths supported.

This controller supports only a fixed-size block length of 512 bytes. Therefore, it returns both maximum and minimum values of hexadecimal 0200. The values are returned in six

bytes in the format shown in Table 10.

Byte	Content	Description
0	00	(Reserved)
1	00	MSB of Maximum Block Length
2	02	Maximum Block Length
3	00	LSB of Maximum Block Length
4	02	MSB of Minimum Block Length
5	00	LSB of Minimum Block Length

MSB = Most significant byte
LSB = Least significant byte

Table 10. Block-limit description bytes

READ

The Read command transfers data from the streaming-tape cartridge to the initiator.

The controller accepts only SCSI Read commands with the fixed block bit set to 1 (bit 0 in byte 1 of the Command Descriptor Block).

Upon receiving the command, the controller checks the drive's status. If an exception status is returned (such as Busy, Cartridge Not In Place, Unit Attention, or Read After Write), the controller returns a check condition with the specific data reported in the extended sense field.

If the controller receives a Read command with a block count of 0, the command is treated as a no-operation, with completion status returned immediately. The controller starts no data transfer and no tape motion.

The requested number of data blocks to be read are grouped into individual SCSI transfers, with a maximum of 32 blocks (16 K bytes). The controller disconnects from the initiator after each 16 K byte transfer, unless the initiator has specified that disconnects are not allowed. If disconnects are not allowed, the SCSI connection exists throughout command performance.

The initiator can specify in three ways that disconnects are not allowed.

* By not asserting ATN during selection
* By not placing its ID on the SCSI bus during selection
* By not setting on bit 6 of the Identify message

The following process is used for the SCSI data transfer

to read the requested data blocks from tape.

Buffer Check And Data Transfer

The buffer data level is checked to determine whether it contains enough data to satisfy the individual data-transfer request.

* If enough data is available, the transfer from buffer to initiator is made.
* If not enough data is available, the initiator is disconnected from the SCSI bus, and data is read from the tape. When enough data is available for the data transfer request, the initiator is reselected and the requested data is transferred from the buffer to the initiator.

More Than 16 K Bytes

If the requested number of blocks to read is greater than 16 K bytes, the buffer-check and data-transfer process is repeated until all requested data is transferred to the initiator. If all data has been transferred to the initiator and no errors have been detected, the controller returns a good completion status to the initiator; this terminates the Read command.

Tape-Halt Conditions

Once the tape is started in the read mode, only three conditions cause the tape reading and tape motion to stop: a file mark being read, the buffer being filled, or a nonrecoverable error.

Tape Block Count Exceeds Request

If the data record on tape contains more data blocks than requested by the Read command, the data transfer and tape motion continue until one of the tape-halt conditions occurs.

Tape Block Count Equals Request

If the data record on tape contains the same number of data blocks as requested by the Read command, all data is transferred and no file-mark status is given (even though the tape is positioned behind the file mark). On the next Read command issued to the controller, the file-mark status and residue count will be indicated because the buffer is empty and the file mark passed.

File Mark Detected

If a file mark is detected while reading the tape, all data read from the tape record is transferred to the initiator and a complete status with a check bit

is returned. The extended sense data contains the following information:

* File-mark bit set to 1 with a sense key of No Sense or Recovered Error. (The Recovered Error key is used when a recoverable read error and/or read underruns have occurred since the beginning-of-tape point or since the last file mark was read.)
* Residue count
* Six bytes of drive status. (They contain the number of recoverable read errors and read underruns.)

Parity Error Detected

A Recovered Error sense key with a secondary error code of Data Buffer Parity Error (hexadecimal 43) indicates two things: First, that the controller detected a parity error on data being transferred out of the buffer during the last Read command; second, that the controller recovered the data by retries. Retrying a buffer parity error depends on the initiator's ability to accept both the Save Data Pointer and Restore Pointers messages. If both are supported, the controller retries the last data transfer to the initiator. If either message is not accepted, the error is not recoverable; a Check Condition status is returned to the initiator, with a Hardware Error sense key saved.

Media Error Detected

A Media Error sense key indicates that one of the following tape errors occurred.

* Physical end of media
* Unrecoverable data error
* No data detected
* Eight or more read retries on a specific block

End Of Recorded Media Detected

If the tape drive detects the End Of Recorded Media condition during a Read command, the command is terminated with a Check Condition with status and a sense key of Blank Check. The End Of Recorded Media condition is defined as a file mark followed by at least 45 inches (114 cm) of erased tape. This condition is also indicated in the drive status bytes.

WRITE

The Write command transfers data from the initiator to the streaming tape cartridge.

The controller accepts only SCSI Write commands with the

fixed-block bit set (bit 0 in byte 1 of the Command Descriptor Block).

Upon receiving the command, the controller checks the status of the tape drive. If an exception status is returned (such as Busy, Cartridge Not In Place, Unit Attention, or Write Protected), the controller returns a check condition with the specific data reported in the extended sense field.

If the controller receives a Write command with a block count of 0, the command is treated as a no-operation, with a completion status immediately returned. The controller starts no data transfer and no tape motion.

The requested number of data blocks to be read are grouped into individual SCSI transfers, with a maximum of 32 blocks (16 K bytes) for each connection.

The following process is used for the SCSI data transfer to write the requested data blocks to tape.

Buffer Check And Data Transfer

The buffer data level is checked to determine whether it can contain the data specified in the individual data-transfer request.

* If enough space is available, the transfer from buffer to initiator is made.
* If not enough space is available, the initiator is disconnected from the SCSI bus, and a physical write is made from the buffer. When enough space is available for the data transfer request, the initiator is reselected and the requested data is transferred from the initiator to the buffer.

More Than 16 K Bytes

If the requested number of blocks to write is greater than 16 K bytes, the buffer-check and data-transfer process is repeated until all requested data is transferred to the buffer.

Tape-Halt Conditions

Once the tape is started in the write mode, only two conditions cause the tape writing and tape motion to stop: early warning End Of Media or empty buffer. If the buffer becomes empty and no additional SCSI Write commands are issued, the tape drive performs the underrun sequences and stops the tape motion. On the next SCSI Write command, the buffer will be empty and the buffer-check and data-transfer process will be repeated.

Buffered Write Mode

If the data from one or more Write commands does not fill the buffer, a physical tape write is not performed and no data is transferred to the tape. To complete the data transfer to tape and the Write sequence, the initiator must issue a SCSI Write File Mark command.

Unbuffered Write Mode

All data transferred to the buffer is also transferred to the tape interface before a completed status is sent. If the requested data did not fill the buffer, the initiator is disconnected from the SCSI bus and a Write command is issued to the tape. When the buffer is emptied, the initiator is reselected and a completion status is returned. After each SCSI Write command, the tape drive performs a write underrun sequence.

Completion Status

It is possible that a completion status could be returned before all data is physically written on the tape. This situation results from the use of the four-block buffer used in the tape interface to prevent frequent underrun sequences.

End Of Media Detected

If the early warning End Of Media condition is detected, the data transfer between buffer and tape is terminated, and a completion status with check byte is returned. The extended sense data returned contains the following information.

* End Of Media bit set to 1, with a sense key of either No Sense or Volume Overflow (The No Sense key results when no data is detected in the buffer; the Volume Overflow key results when the buffer contains data.)
* Residue block count (This count consists of two things. First, all data blocks not written to the tape -- blocks remaining in the buffer as well as blocks requested by the Write command and not yet transferred to the buffer. Second, the unwritten File Mark count if a write was started by an issued Write File Mark command.)
* Six bytes of tape drive status (These bytes contain the number of recoverable read errors and read underruns.)

When the End Of Media with Volume Overflow condition occurs, no other Write or Write File Mark command is allowed until the buffer has been emptied. To empty the buffer and recover the data, a Recover Buffered Data command can be issued. The data blocks to be recovered from the buffer can be at any number, from

1 to 128 blocks.

To ensure that all data records are written to tape after the End Of Media status, the following procedure should be followed.

1. Issue Recover Buffered Data commands to clear all data from the buffers.
2. Issue a Write File Mark command to close the previous data record.
3. Issue no more than two blocks of data to be written to the tape.
4. Issue one or two File Marks to be written.

Parity Error Detected

If a buffer parity error is detected, a Hardware Error sense key with a secondary error code is returned. The residue count reflects all blocks not yet transferred to tape in the current Write command sequence (all Write commands issued since the beginning-of-tape condition or the last file mark, whichever is last on the tape), including the erroneous block. All data in the current Write sequence up to but not including the erroneous block is written to tape. Subsequent Write or Write File Mark commands will start at that point.

Media Error Detected

A Media Error sense key indicates that a tape-drive error, such as one of the following errors, occurred.

* Physical end of media
* Unrecoverable data error

WRITE FILE MARK

The Write File Mark command completes any SCSI Write or Copy command in progress and/or writes one or more file marks on the streaming tape.

Upon receiving the command, the controller checks the status of the tape drive. If an exception status is returned (such as Busy, Not Ready, Unit Attention, or Write Protected), the controller returns a check bit completion status with an extended sense key. The specific data is reported in the extended sense field.

If the controller receives a Write File Mark command with a file mark count of 0, the command is treated as a no-operation, with a completion status immediately returned. No file marks are written on the tape.

The following process is used for the SCSI data transfer to write the requested data blocks to tape.

Buffer Check And Data Transfer

The buffer data level is checked to determine whether it contains data. If the buffer contains data, the controller disconnects from the SCSI bus, then the data is written to the tape. After all the data has been written, the Write File Mark sequence is started.

Write File Mark Sequence

The Write File Mark sequence consists of a SCSI disconnection, followed by writing a single file mark to the tape. A five-minute timer is started. When the file mark is written, the requested number of write file marks is decremented. The file mark sequence is repeated for each file mark requested. Once all file marks are written, the initiator is reselected and a completion status is returned.

End Of Media Detected

If the early warning End Of Media condition is detected on the Write or Write File Mark, the data transfer between buffer and tape is terminated, and this status is reported along with any residue counts of data blocks and file marks.

Media Error Detected

A Recoverable Error sense key is reported along with the drive status if any blocks are rewritten or the number of write underruns exceeds the number of SCSI Write or Copy commands issued.

SPACE

The Space command provides a means of positioning the tape to a specific data block, to the data record following following a specific file mark, or to a series of sequential file marks.

The controller accepts Space commands that position the tape either forward or backward. The count bytes of the Command Descriptor Block determine the direction of the Space command. A positive value indicates forward spacing (beginning-of-tape to end-of-tape); a negative value indicates backward spacing (end-of-tape to beginning-of-tape).

The code field and count bytes determine the controller operations. If the controller receives a Space command with a count of 0, the command is treated as a no-operation, with a completion status immediately returned.

Upon receiving the command, the controller checks the status of the tape drive. If an exception status is returned (such as Busy, Cartridge Not In Place, or Unit Attention), the controller returns a check condition with the specific data reported in the extended sense field.

The Space command has the following options.

Block Option

A Space Block forward code causes the controller to perform the same function described in the Read command, except that no data is transferred to the initiator. The operation is as follows. The data is read from the tape and is transferred into the buffer. The buffer pointers are adjusted to skip the number of data blocks requested in the Space command. When the count is satisfied, the command is completed. Occurrences of file marks and errors are reported as described in the Read command.

A Space Block backward code determines the tape position before causing tape movement. First, the current tape position, in relation to the data contained in the buffer, is determined. The controller also determines whether a file mark was passed and not reported on the preceding command. If a file mark was passed, a backspace is performed to position the tape in front of the file mark. A backspace is performed for each block of data contained in the buffer, then the buffer is cleared. Next, a backspace command is performed for each requested block.

File Mark Option

A Space File Mark forward code causes the controller to search for file marks on the tape. The count bytes determine the number of file marks to be found.

A Space File Mark backward code determines the tape position before causing tape movement, as follows. First, the current tape position is determined, in relation to a file mark being read and not reported on the preceding command. If a file mark was passed, a backspace is performed to position the tape in front of the file mark, then the buffer is cleared. Next, a backspace command is performed for each requested file mark, ignoring all data blocks and counting only the file mark blocks.

Sequential File
Mark Option

A Space Sequential File Mark command causes the controller to perform the following sequence to determine the requested number of sequential file marks. First, the controller finds the first file mark. Second, a block is read. Third, the controller determines whether the block is a data block or a file mark.

* If it is a data block, then it is not a sequential file mark; another file mark will be found.
* If it is a file mark, then additional blocks are read until the sequential-file-mark count is satisfied or until another data block is found. If another data block is found, the action sequence is repeated.

End Of Data Option

A Physical End-Of-Data code causes the controller to read file marks until it detects no more data on the tape.

INQUIRY

The Inquiry command causes the controller to assemble 44 bytes of data to identify the tape unit. The format of this data is shown in Table 11.

Offset	Length	Value	Description
0	1	01	Device type (logical unit 0 only)
		7F	Device type (logical units 1--7)
1	1	C6	Qualifier byte: 1/4 inch data cartridge, QIC-11 or QIC-24 data
2	1	00	SCSI version
3	1	00	(Reserved)
4	1	27	Additional bytes
5	1	C1	Features: NCR commands with ECC and SLI; SCSI Extended commands
6	1	xx	Controller microcode change level
7	1	xx	Controller hardware change level
8	4	Note[1]	Manufacturer name
12	16	Note[2]	Controller identification
28	16	Note[3]	Unit identification

Offset and length are in bytes.
[1]NCR<space>
[2]6343-ADP55-CNTLR
[3]6343-UNIT

Table 11. Inquiry-command result format

MODE SELECT

The Mode Select command provides a means of specifying the media, unit, and device parameters. The Block Descriptor list used for the parameters is shown in Table 12. A Mode Select command issued with an incorrect Block Descriptor list is rejected with an Illegal Request sense key.

The controller supports the following mode selection parameters.

* Buffered or unbuffered mode of writing data
* Density selection for the tape
* A fixed block size of 512 bytes

Buffered And
Unbuffered Mode

In the buffered mode, the controller reports a Good status on Write commands as soon as all data has been transferred to the controller's buffer. One or more blocks of data may be buffered prior to writing the blocks to tape.

In the unbuffered mode, all data for the Write command is written to tape prior to reporting a Good status for the command. Writing in the unbuffered mode greatly reduces the data capacity of the tape; the controller performs an underrun sequence at the completion of each Write command.

The buffered mode is selected at power-up and also after a reset is issued to the controller.

Density Selection

The density parameter is used to select between the QIC-11 and QIC-24 tape data formats. Format selection that changes the format is only allowed when the tape is at the beginning-of-tape point. This restriction prevents a data cartridge from being recorded in multiple formats.

The QIC-24 data format parameter for density is selected at power-up and also after a reset is issued to the controller.

Offset	Value	Description
0	04	Density code: QIC-11 data format
	00 or 05	Density code: QIC-24 data format
1	00	MSB of Number of blocks
2	00	Number of blocks
3	00	LSB of Number of blocks
4	00	(Reserved)
5	00	MSB of Block size
6	02	Block size
7	00	LSB of Block size

Offset is in bytes.

MSB = Most significant byte
LSB = Least significant byte

Table 12. Block Descriptor format

VERIFY

The Verify command performs a media check of data blocks on the tape without transferring data between the initiator and the controller.

The controller accepts only a Verify command with the fixed block bit set to 1 (bit 0 in byte 1 of the Command Descriptor Block). The controller does not support the byte compare mode (bit 1 in byte 1).

Upon receiving the command, the controller checks the status of the tape drive. If an exception status is returned (such as Busy, Cartridge Not In Place, or Unit Attention), the controller returns a check condition with the specific data reported in the extended sense field.

The Verify command causes the controller to perform the same function described in the Read command, except that no data is transferred on the SCSI bus. The data is then read from the tape and is transferred into the buffer. The buffer pointers are adjusted to skip the number of data blocks requested in the Verify command. When the count is satisfied, the command is completed. File marks and errors are reported as described in the Read command.

RECOVER BUFFERED DATA

The Recover Buffered Data command recovers data that was written to the buffer and not transferred to the tape.

The controller accepts only Recover Buffered Data commands with the fixed block bit set to 1 (bit 0 in byte 1 of the Command Descriptor Block). A Recover Buffered Data command with a block count of 0 is treated as a no-operation, with a completion status immediately returned.

All data blocks requested are transferred from the buffer to the initiator in one SCSI bus connection. The block count can be from 1 to 128 blocks to be transferred.

All errors or differences between the requested number of blocks and the actual buffer contents result in a completion status with the check bit set. The extended sense data, in that case, identifies the condition which created the check status. A Hardware Error sense key is returned if a parity error occurs in the buffer.

RESERVE UNIT

The Reserve Unit command is used to reserve a unit attached to the controller; a reserved unit cannot be used by any other initiator.

The controller does not support the extended feature of the Reserve Unit command.

Any attempt to reserve or access a reserved unit results in a Reserved status being returned to the requesting initiator. If the unit is reserved by the same initiator attempting a second reserve, a Good status is returned to it. The user is responsible for releasing the unit when the need for its exclusive use has passed. No Reserve Unit command (except third party) should be issued to the disk being copied to or from the tape. The user is responsible for coordinating disk and tape use to ensure that inconsistent data is not being backed up and that multiple initiators are not using the tape illegally.

RELEASE
The Release command frees a unit attached to the controller from being reserved. It is the complementary command for the Reserve Unit command.

In order to allow other initiators access to the tape drive, the user must always release the tape drive after any function, during which the drive was reserved by a Reserve Unit command.

A Release command issued by an initiator that did not reserve the unit or one issued to an unreserved unit returns a completion status.

COPY
The Copy command allows an initiator to cause the controller to copy data to or from another device attached to the SCSI bus. Third-party data transfers are not allowed, so the streaming tape must be a part of the copy.

The controller allows copying from disk drives to tape drives and vice versa, with some vendor-unique codes to allow for NCR-specific disks. The codes and functions are shown in Table 13.

Code	Function
00	Block read from disk to tape[1]
08	Block write to disk from tape[1]
80	Read with ECC from disk to tape (521 byte)
88	Write with ECC to disk from tape (521 bytes)
90	NCR Read from disk to tape (514 bytes)
98	NCR Write to disk from tape (514 bytes)

[1]The disk data block size is determined by the controller issuing a one-sector Read to the specific disk unit and counting the number of bytes transferred.

Table 13. Copy command function codes

At first, an initiator selects the controller (acting as a target); if space is available, the SCSI function is transferred into the controller memory. If another copy is in progress, or if any tape-movement function is currently active, a Busy status is returned. If there are no errors of the following types during the command transfer, the data block definition is brought across the bus.

* Parity error on the SCSI bus
* Invalid command code
* Invalid logical-unit number

After the data block is read and has been verified as a valid copy function, the first segment descriptor is received from the initiator. This data is checked for the following errors.

* Invalid source or destination identification
* Invalid source or destination logical-unit number
* Invalid tape block size
* Invalid number of blocks for disk
* Invalid starting address for disk

After the data for the segment is received, the controller disconnects from the initiator and switches to an initiator role to begin the data transfer. A SCSI command descriptor block is selected, based on the copy function. Then, the correct target is selected. Next, the command is transferred to the target disk. An internal timer is started; if the timer expires, the target returns a Busy status. If a SCSI error occurs on the transfer, the copy function is terminated with a Bad status.

When the target accepts the command and starts to transfer data, the following action sequence occurs, depending upon the function.

Copy Disk To Tape

1. The read function is sent to the disk for a 16 K byte or less block of data.
2. The hardware data path from SCSI to the buffer is set up.
3. The block of data is transferred into the buffer.
4. The buffer-to-tape hardware data path is set up.
5. The following loop is performed until the segment data transfer is complete.

    * Transfer buffer data to tape; tape is always moving
    * Send 16 K byte read to disk
    * Transfer data into buffer

Tape error recovery is not possible with the controller. A write to the tape is not recoverable by the controller if the tape interface is unable to recover the error. If any other error is detected by the hardware, there is no way to backspace the tape or rewind to the beginning of the current segment descriptor. Because the rewind-and-search-back time is excessive (2.5 minutes) with little possibility of recovery, the recovery decision is left to the initiator. However, a parity error on the SCSI bus is recoverable, using the following algorithm.

* Stop the data transfer from buffer to tape
* Verify that the 16 K byte block with the parity error has not started transferring to tape from the buffer. If the block move has begun, no recovery is possible.
* In byte-by-byte mode, move the buffer data to the tape until the block in error boundary is found.
* Discard the last block.
* Restart the data transfer, starting with the segment in error.

Copy Tape To Disk

1. The write function is sent to the disk for a 16 K byte or less block of data.
2. The hardware data path from the tape to the buffer is set up.
3. The block of data is transferred into the buffer.
4. The following loop is performed until the segment data transfer is complete.

    * Transfer tape data to buffer; tape is always moving
    * Transfer 16 K bytes of data to disk
    * Send a 16 K byte write command to the disk

No error recovery is possible when the data movement is from tape to disk. Hardware errors in the controller cannot be recovered for the same reasons as the disk-to-tape copy.

ERASE

The Erase command erases all the data on a mounted tape cartridge.

An Illegal Request sense key is returned if any of the following conditions exist.

* The Long bit (bit 0 in byte 1 of the Command Descriptor Block) is not set to 1
* The tape is not positioned at the beginning-of-tape or load point
* The buffer contains data from a previous command

Upon receiving the command, the controller checks the status of the tape drive. If an exception status is returned (such as Busy, Not Ready, Unit Attention, or Write Protected), the controller immediately reports the status.

When the command is performed, the controller starts erasing the tape, disconnects from the SCSI bus, and starts a five-minute timer.

When the Erase command is completed, the controller again checks the drive's status. The initiator is reselected, and the appropriate status is returned.

If the timer is exhausted, the controller issues a reset to the tape interface, reselects the initiator, and sends a completion status with check bit. A Hardware Error sense key is available in addition to the drive status bytes.

MODE SENSE

The Mode Sense command allows the controller to report its media, unit, and device parameters.

The Mode Sense data shown in Table 14 is transferred to the initiator.

Offset	Value	Description
0	0B	Length (bytes) of the Mode Sense data
1	00	Media type
2	xyyyzzzz	x: 1 = Write-protected yyy: 000 = Unbuffered; 001 = Buffered zzzz: 0000 = Default speed
3	08	Length (bytes) of the Block Descriptor list (Refer to Table 12)

Offset is in bytes

Table 14. Mode Sense data format

LOAD/UNLOAD

The Load/Unload command either rewinds or retensions the tape, depending on the setting of the retension bit (bit 1 in byte 4 of the Command Descriptor Block).

Upon receiving the command, the controller checks the status of the tape drive. If an exception status is returned (such as Busy, Not Ready, or Unit Attention), the controller immediately reports the status.

* If the retension bit is set to 0, the command is interpreted as a standard Tape Rewind command.
* If the retension bit is set to 1, the command is interpreted as a tape Retension command. Tape retensioning consists of rewinding the tape to the beginning-of-tape point, then winding the tape to the end-of-tape point, then rewinding the tape to the beginning-of-tape point.

Upon receiving the command, the controller checks the Immediate bit (bit 0 in byte 1 of the Command Descriptor Block). If the bit is set to 1, the controller immediately returns a completion status without a Check bit after the function is initiated. If the bit is set to 0, the controller disconnects from the SCSI bus and starts a five-minute timer.

When a Retension command is completed, the controller again checks the drive's status, then reselects the initiator, then returns the appropriate status.

If the timer is exhausted, the controller issues a reset to the tape interface, reselects the initiator, and sends a completion status with check bit. A Hardware Error sense key is available in addition to the drive status bytes.

SEND AND RECEIVE DIAGNOSTICS

The SCSI Send Diagnostics command and Receive Diagnostics command are used to perform the diagnostic functions on the controller.

A diagnostic file associated with each command contains the required information. The files for the two commands have the formats shown in Tables 15 and 16.

The commands cause the controller to perform the diagnostic functions shown in Table 17. These functions are described in the following paragraphs.

Offset	Length	Description
0	2	Length (bytes) of diagnostic file: 10-byte format description plus length of data field (m)
2	1	Zero-filled
3	1	Diagnostic function code (refer to Table 17)
4	3	Zero-filled
7	1	Block offset value (hexadecimal 0--7F)
8	2	Number of bytes in data field
10	m	Data field for Test Buffer function

Offset and length are in bytes

Table 15. Data-file format for Send Diagnostic command

Offset	Length	Description
0	1	Valid-data flag: 0 = valid data
1	1	(Reserved)
2	2	Number of bytes in the data field (m)
4	m	Data field
4+m	1	Number of bytes in the extended sense field (n)
4+m+1	n	Extended sense field

Offset and length are in bytes

Table 16. Data-file format for Receive Diagnostic command

Code	Function
D0	Diagnostic Inquiry
D1	Test buffer
E3	Drive: Self-test group 1
E4	Drive: Self-test group 2
E5	Drive: Read residual block count
E6	Drive: Dump internal random-access memory
E7	Drive: Dump external random-access memory

Table 17. Diagnostic function codes

Diagnostic Inquiry

The Diagnostic Inquiry function returns 64 bytes of information about the controller. This information is stored in the data field of the Receive Diagnostic data file. The Inquiry field consists of the buffer size, which is the first two bytes, containing hexadecimal FFFF. All other fields are zero-filled because they are not used in the controller.

Test Buffer

The Test Buffer function tests the 64 K byte buffer. The logical block offset value is supported. The value offsets into the buffer the number of bytes equal to the number of blocks given. The data is then transferred accordingly for the command, as follows.

* Send Diagnostics: transfer data from the initiator to the buffer
* Receive Diagnostics: transfer data from the buffer to the initiator

Self Test Group 1

The Drive Self Test Group 1 causes the selected device to perform the following controller diagnostic tests.

* LSI controller chip test
* 16 K byte random-access memory chip (buffer) test
* Data separator logic test

These tests are controller tests; therefore, they do not read or write data on the tape. When the tests are completed, six status bytes are returned to the initiator. The format of these bytes is shown in Figure 6.

Self Test Group 2

The Drive Self Test Group 2 causes the selected device to perform the following drive diagnostic tests.

* Cartridge-In (CIN) and Unsafe (USF) sensors
* Upper Tape Hole (UTH) and Lower Tape Hole (LTH) sensors
* Motor and tach operation
* Stepper motor operation
* Read, Write, and Erase heads
* Drive logic

These tests are drive tests; therefore, they write on the mounted tape. When the tests are completed, six status bytes are returned to the initiator. The format of these bytes is shown in Figure 6.

Read Residual Block Count

The Read Residual Block Count function causes the selected device to transfer six bytes of information to the initiator. The information supplied by this command is valid only after an Unrecoverable Write Error has occurred. The last byte contains the number of blocks (including file marks) that were not written to tape.

Dump Internal RAM

The Dump Internal RAM function provides information about the selected device for isolating faults. The initiator issues this function. The device transfers 128 bytes of vendor-unique status information to the initiator.

Dump External RAM

The Dump External RAM function transfers 256 bytes of data from the 8155's memory in the selected device to the initiator, using the same RDY/REQ protocol used to transfer status bytes.

Statuses

Standard Statuses

The SCSI messages shown in Table 18 are supported. One status byte is transmitted in the target mode and received in the initiator mode. During a Copy function, a status byte is received from the other device, then any sense data is collected. The controller then returns a status byte to its initiator. The sense data saved for the current command includes the status byte from the other device and its sense data. The list of SCSI status codes is shown in Table 19.

00	Command Complete
02	Save Data Pointer
03	Restore Pointer
04	Disconnect
05	Initiator Detected Error
06	Abort
07	Message Reject
08	No Operation
09	Message Parity Error
0C	Bus Device Reset

Table 18. SCSI messages supported

Hexadecimal Value	Meaning
00	Good
02	Check condition
08	Busy
18	Reservation conflict

Table 19. SCSI status codes

Vendor-Unique Error Statuses

The results of Drive Self Test Groups 1 and 2 are returned in the format shown in Figure 6. The abbreviations used are explained in Table 7. The diagnoses for the different statuses are described in Table 23, in the "Troubleshooting" section of this publication.

SCSI Bus Reset

A SCSI bus reset to the controller causes level 0 (power-up) diagnostics to be performed. These diagnostics test as much of the board hardware as possible. If the optimum is selected, successful completion is indicated on the board LED's by a hex 90. A failure is indicated by an error code described in the Troubleshooting section or in Table 5. This sequence takes approximately 9 seconds due to a 64K Byte RAM check. This time will be reduced to less than one second in a future firmware revision.

The controller executes level 0 diagnostics by

1. A SCSI Bus Reset
2. A manual controller Reset
3. A controller power-up Sequence

The controller will reset all devices on the bus during the above conditions unless switches 3 and 4 at U53 (ADP-55-01) or U63 (ADP-55-02) are set so the SCSI bus is not reset.

INSTALLATION

Before installing the unit, you must perform the following procedures on the controller board in the unit. The unit can be installed in a subsystem in a maximum of 30 minutes.

SCSI Bus Termination

Single-ended Version

The controller contains socketed SCSI bus terminators. A SCSI system configuration should contain only two devices which contain the bus terminators. These devices must be at each end of the SCSI bus. If this controller is not located at the end of the bus then the socketed SCSI bus terminators must be removed.

On the single-ended version of the ADP-55, the SCSI bus termination is provided by two 220/330 ohm resistor networks in controller board locations U49 and U51.

* If the unit is on the end of a SCSI daisy-chain configuration, leave the networks installed.
* If the unit is not on the end of a SCSI daisy-chain configuration, remove the networks.

Differential Version

On the differential version of the ADP-55, the SCSI bus termination is provided by 330/150/330 resistor networks in locations U60, U61, and U62.

* If the unit is on the end of a SCSI daisy-chain configuration, leave the networks installed.
* If the unit is not on the end of a SCSI daisy-chain configuration, remove the networks.

SCSI Bus Terminator Power

The controller supplies terminator power through a diode to its socketed SCSI bus terminators. This power is also supplied to SCSI bus connector J2 Pin 26 on ADP-55-01 or J2 Pins 25 and 26 on ADP-55-02 for powering a terminator on the opposite end of the bus. This provides for signal integrity if that device lost its internal power. Additionally, external terminator power into this controller can be provided through a diode into SCSI bus connector J2 Pin 26 on ADP-55-01 or J2 Pins 25 and 26 on ADP-55-02. This allows for signal integrity if this controller lost power.

Switch Settings

Diagnostic Options and SCSI ID, Parity Enable, Bus Reset

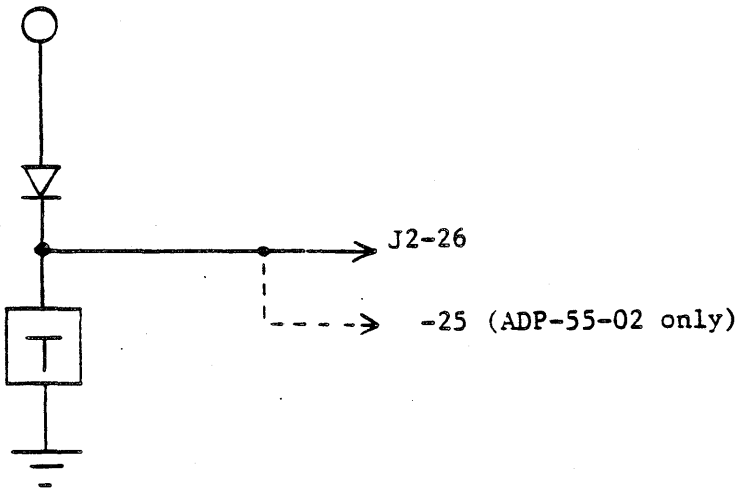
Set the desired options by selecting the corresponding switch settings defined in Table 20. The switch bank

is located as follows:

Single-ended Version (ADP-55-01)
The switch pack is at location U53 on the controller board.

Differential Version (ADP-55-02)
The switch pack is at location U63 of the controller board.

PLL Adjust, Drive Type Select
Set the desired options by selecting the corresponding switch settings defined in Table 21. The switch bank is located at U20 for both single-ended and differential versions.



SCSI BUS TERMINATION

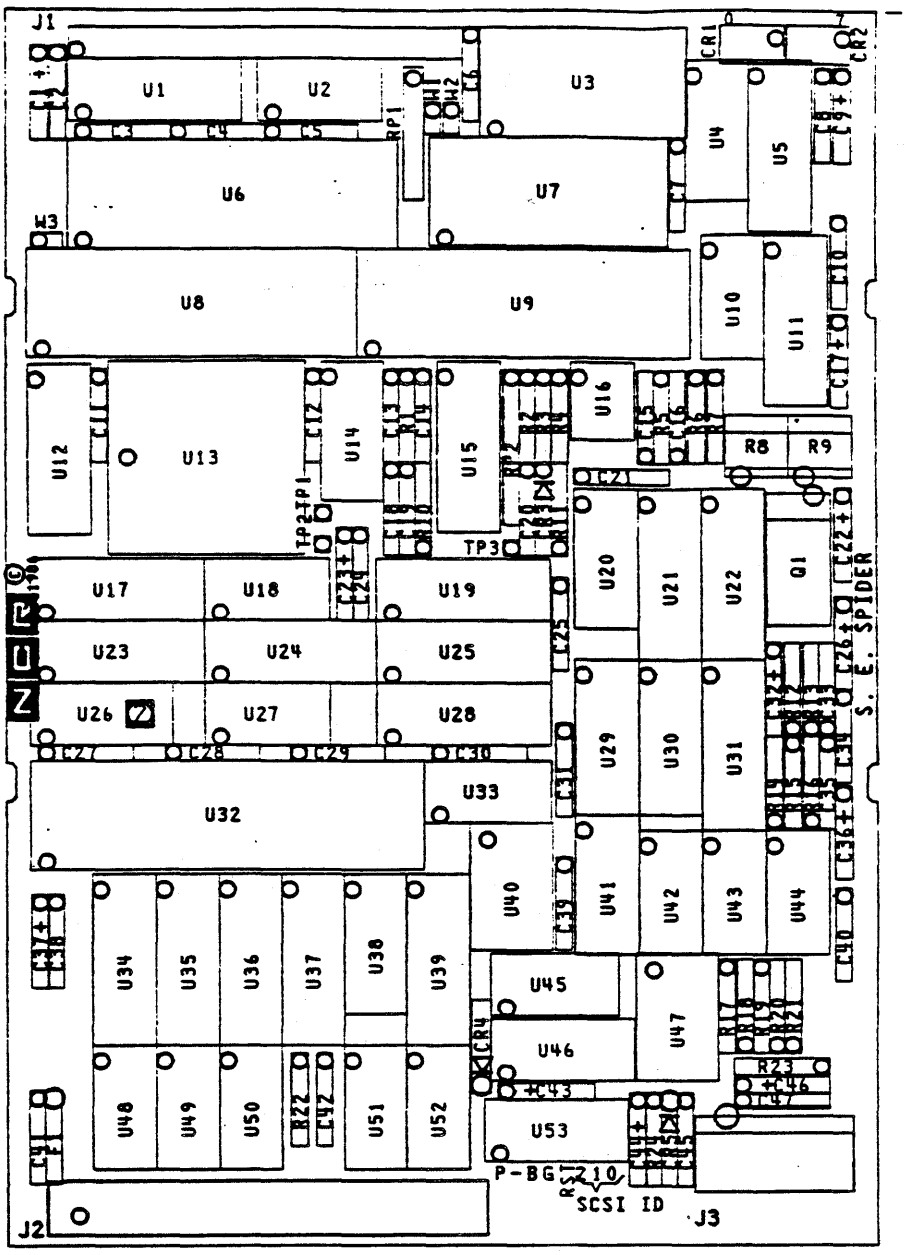


Figure 7. Component locations on single-ended version ADP-55-01

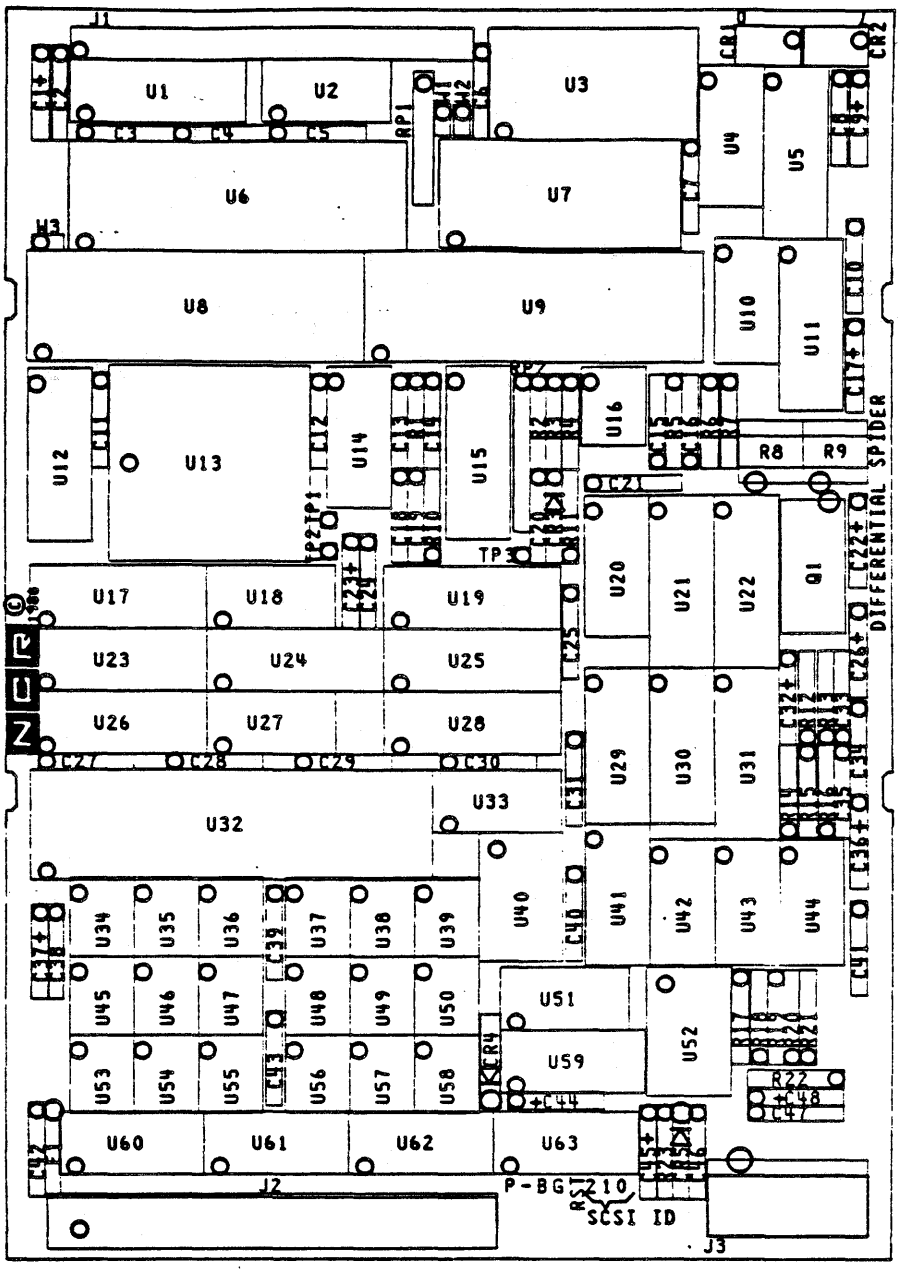


Figure 8. Component locations on differential version ADP-55-02

TABLE 20 SWITCH BANK U53 (ADP-55-01) 0 = OPEN = UP
SWITCH BANK U63 (ADP-55-02) 1 = CLOSED = DOWN

POSITION	DESCRIPTION	FACTORY SETTING
1,2	00 Display Level 0 Diagnostic Code 01 Repeat Level 0 Diagnostics 10 SCSI Parity Disabled 11 SCSI Parity Enabled	CLOSED,CLOSED
3,4	00 = INVALID 01 = Reset Bus on Power-Up 10 = Do Not Reset Bus on Power-Up 11 = INVALID	OPEN,CLOSED
5	Hardware Reset	OPEN
6	SCSI ID: Most Significant Bit	OPEN
7	SCSI ID: Middle Bit	CLOSED
8	SCSI ID: Least Significant Bit	CLOSED

NOTE: Positions 8-6 form a 3-bit binary code (0-7) for the SCSI Buss Device ID. The factory setting as shown above forms a SCSI ID of "3". All settings are 0 = OPEN 1 = CLOSED.

TABLE 21 SWITCH BANK U20 (ADP-55-01) 0 = OPEN = UP
SWITCH BANK U20 (ADP-55-02) 1 = CLOSED = DOWN

POSITION	DESCRIPTION	FACTORY SETTING
8,7	00 = Drive Type 1 01 = Drive Type 2 10 = Drive Type 3 11 = PLL Adjust	00
6	Not Used	1
5	Testability	1
4	Not Used	1
3	Testability	1
2	Testability	1
1	PLL Adjust	0

NOTE: Drive type 2 and drive type 3 are reserved for future use.

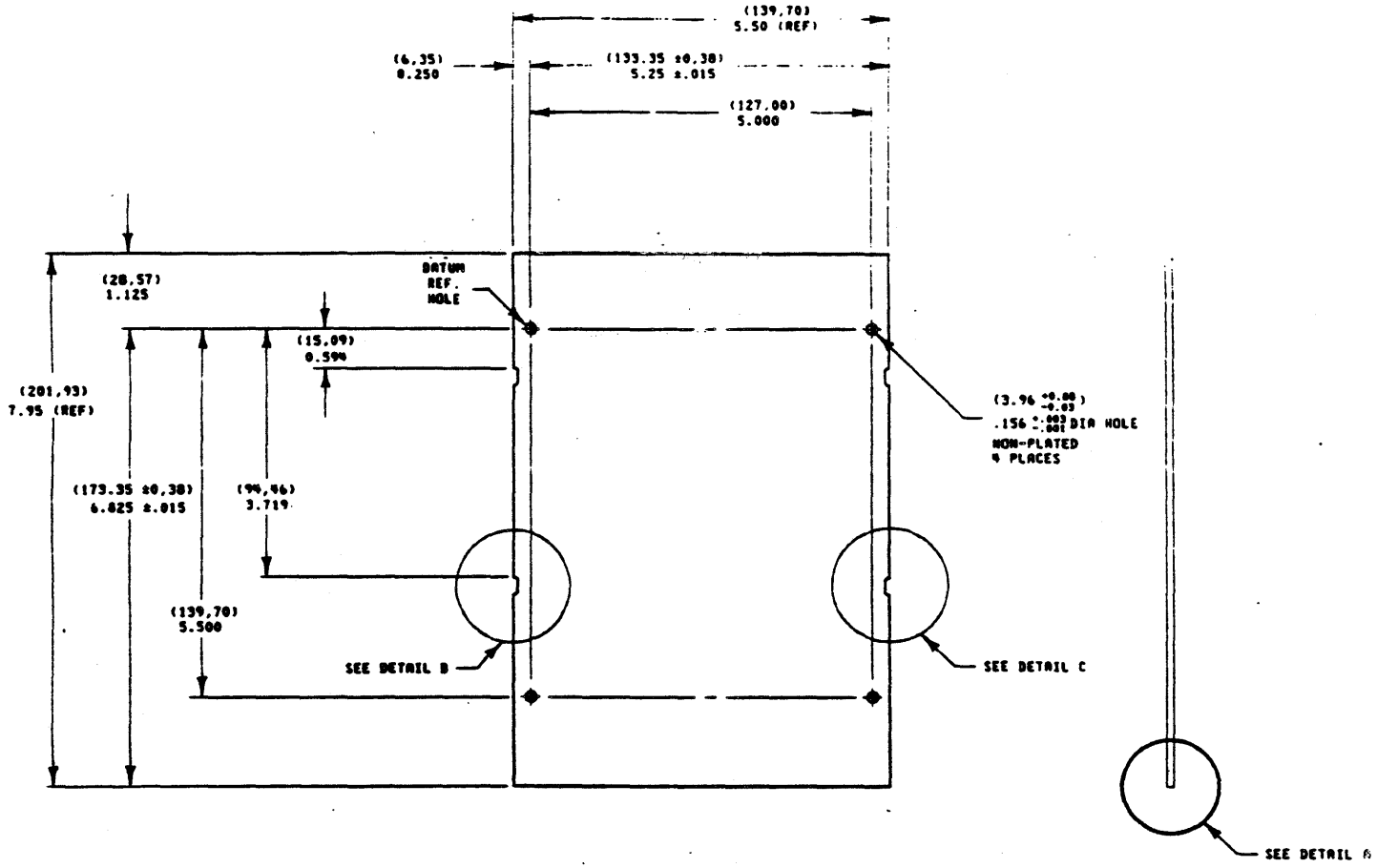
DC Power Connectors

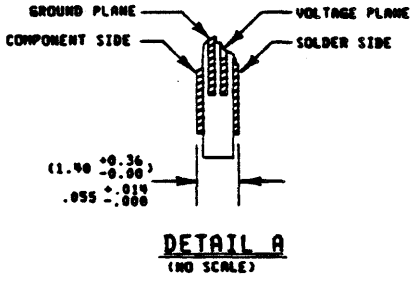
The DC power connector is located at J3 on the controller and J2 on the drive. The connectors are AMP Part Number 1-480426-90 or equivalent. They require mating connectors AMP Part Number 1-480424-0 or equivalent, with female contacts AMP Part Number 606019-1 or equivalent.

The power connections for the drive and controller PCB are shown in Table 22.

Pin	Voltage
	ADP-55
1	+12 V
2	+12 VRET
3	+5 VRET
4	+5 V

Table 22. Pin descriptions for DC power connections





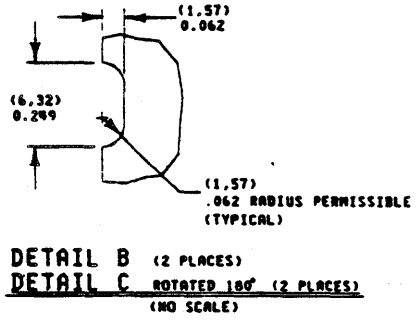


Figure 9. Dimensional Drawing of ADP-55

TROUBLESHOOTING

Error Diagnostics Features

Two sets of diagnostic software are used: SCSI diagnostic commands and power-up self-test diagnostics. The SCSI diagnostic commands are implemented through the SCSI bus. These commands are listed in the "Commands And Status" section of this publication. The self-test diagnostics, performed during power-up, test the hardware extensively before the controller can receive an SCSI function. These steps are performed in the following order.

* Disable SCSI
* ROM sum check
* Test 8031 MPU -- Registers and memory commands
* Test controller RAM
* Test timer
* Test SCSI chip
* Formatter Tests
* Test Memory Array Controller chip
* 8155 Tests
* Latch Tests
* DRAM Tests

An error causes execution to transfer to a common execution point. If the power-up self-test diagnostics fail, then the clear power-up flag remains set, and the first request sense function results in the error sense data being returned, if the SCSI chip has passed power-up diagnostics. If the power-up phase passed without error, the power-up flag is cleared. Next, all the data structures are initialized, interrupts are enabled, and the firmware goes into an idle loop until an SCSI function is sent from an initiator.

LED Indicators

The LED indicators are located on the J1 connector edge of the board. If switches 1 and 2 of switch bank U53 (ADP-55-01) or U63 (ADP-55-02) are set to Open, Open (00) then the Level 0 Diagnostics result code will be displayed: 90 if Level 0 diagnostics passed or codes listed below if a failure occurred:

Code (MSb = leftmost LED)	
91	Checksum Error
93	Error detected on 8031 processor
94	2K RAM Error
97	Timer Test Error
98	SCSI Error
99	Formatter Chip Error
9B	MAC Chip Error
9C	8155 Port Error
9E	Latch Error
9F	64K Buffer DRAM Error

Drive Self Test Group 2

R B L B S T T D U S L T T F I Z P 1 0 E E E E E E E S R R R R R R T R R R R R R	Possible Diagnosis
0 1 x x x x x	Buffer problem[1]
0 x x x x 0 1	Defective track-0 Read or Write head; logic circuits perhaps functional[2]
0 x x x x 1 0	Defective track-1 Read or Write head; logic circuits perhaps functional[2]
0 x x x x 1 1	Defective Read, Write, or Erase logic circuits, including head[3]
0 x x 1 x x x	Erase or Write perhaps defective; Read channel functional
1 1 x x x x x	Buffer problem[1]
1 x x x 1 x x	Stepper problem: wrong track address
1 0 1 x x x x	Defective LSI chip; buffer synchronizer circuit
1 x x x x 1 1	Erase head perhaps defective; enable always unknown

[1] Condition should also be detected by POC (power on check) or Drive Self Test Group 1

[2] Decide using track 0 and 1 error counts (bytes 4 and 5 of Self Test status bytes)

[3] Potential diagnosis:
- * PLL (phase locked loop) out of adjustment
- * Defective tape cartridge
- * Read channel out of adjustment
- * Head dirty or worn out

Table 23. Diagnoses of Drive Self Test Group 2 statuses

Phase Locked Loop Adjustment

Set Up

1. Note switch settings of switches 7 and 8 of switch bank U20.
2. Close switches 7 and 8 of switch bank U20.
3. Reset the Controller

Gain Adjustment

1. Set the oscilloscope to 2 Vdc/Div.
2. Set the sweep time to .1u sec.
3. Connect to RCLK at TP1. (should see a square wave)
4. With the help of the Variable time/Div. knob, adjust the scope display to get one cycle in nine divisions.
5. Close SW1 of switch bank U20.

6. Adjust R9 (located closest to edge of board) such that the jitter is equal to or slightly less than 1.3 divisions.
7. Open SW1 of switch bank U20.

VCO Balance

1. Connect oscilloscope to the ladder network output at TP3.
2. Set vertical scale to .5 volts/Div.
3. Insure 0 volts reference by switching channel coupling from DC to ground (adjust for 0 if necessary) and back to DC.
4. Adjust R8 (located furthest from edge of board) for 2.4 volts at TP3. (A meter will not work here because there is a slight AC component to the signal plus once a second LOCK/ goes high for one millisecond and TP3 changes radically then.)
5. Restore switches 7 and 8 of switch bank U20 to their normal positions.
6. Reset the controller again to start normal operation.

APPENDIXES

Glossary

byte
A group of eight contiguous bits.

Command Descriptor Block
The structure used to communicate requests from an initiator to a target.

connect
The function that occurs when an initiator selects a target to start an operation.

disconnect
The function that occurs when a target releases control of the SCSI bus, allowing it to go to the BUS FREE phase.

initiator
An SCSI device (usually a host system) that requests an operation to be performed by another SCSI device.

logical unit
A physical or virtual device addressable through a target.

LSB
Least Significant Byte or Least Significant Bit.

LUN
Logical Unit Number

MSB
Most Significant Byte or Most Significant Bit.

PCB
Printed-circuit board

reconnect
The function that occurs when a target selects an initiator to continue an operation after a disconnect.

reserved
The term used for bits, bytes, fields, and code values that are set aside for future use.

SCSI
Small Computer System Interface

SCSI Address
The octal representation of the unique address (0-7) assigned to an SCSI device. This address would normally be assigned and set in the SCSI device during system installation.

SCSI ID
: The bit-significant representation of the SCSI address referring to one of the signal lines.

SCSI device
: A host computer adapter or peripheral controller or an intelligent peripheral that can be attached to the SCSI bus.

target
: An SCSI device that performs an operation requested by an initiator.

Mechanical Specifications

Physical Dimensions

The outside dimensions of the controller are as follows, and are shown in detail in Figure 9.

* Height: less than 0.375 inches (0.95 cm)
* Width: 5.75 inches (14.61 cm)
* Depth: 8.00 inches (20.32 cm)
* Tolerance for listed dimensions: plus or minus 0.02 inches (0.05 cm)

Environment

Ambient Temperature

The operating range for ambient temperature is 40 degrees Fahrenheit to 113 degrees Fahrenheit (5 degrees Centigrade to 45 degrees Centigrade).

Temperature Change

The operating range for temperature change is 18 degrees Fahrenheit (10 degrees Centigrade) per hour.

Relative Humidity

The operating range for relative humidity is 10%--90%.

Barometric Pressure (Altitude)

The maximum operating altitude is 9850 feet (3000 meters) above sea level.

The non-operating (transit) range is 1000 feet (305 meters) below sea level to 15 000 feet (4570 meters) above sea level.

Electrical Power

The parameters of the unit's electrical power are shown in Table 24.

Voltage	+12 Volts	+5 Volts
Tolerance	+ or - 5%	+ or - 5%
Maximum Ripple	200 mV	200 mV
Maximum Current:		
Operational	2.55 A	3.5 A (2.5A typical)
Tape Start Surge[1]	4.15 A	2.5 A

[1] 300 ms maximum

Table 24. Electrical power parameters

Power Dissipation

The typical power dissipation is 43 W. The dissipation at the tape start surge is 62 W.

Grounding

When mounting the ADP-55 to a drive, logic (or DC) ground and frame ground should be isolated by at least 1 K ohms in the unit. There is a 0.1 microfarad capacitor between logic and frame ground in the unit to aid in EMI suppression.

Electrical Approval

The controller meets spacing requirements of UL 478 for low voltage. The bare board meets UL 94V-1 flammability requirements and meets VDE and IEC electrical requirements.

COMMAND RESTRICTIONS

A restriction will be placed on the sequence of commands issued to the tape controller. These restrictions are due to the characteristics of the tape interface and the allowable commands which control the data written to or read from the tape.

A check condition status will be returned on any restricted command issued and the extended sense key will be 'Illegal Request'.

A Rewind or Load command will nullify any command restriction.

READ AFTER WRITE

Any read type command (Read, Verify, Space, or Copy-restore) issued after a Write, Write File Mark, or Copy-backup is considered a restricted command.

WRITE AFTER READ (DATA APPEND)

A Write, Write File Mark, or Copy-backup issued after a read type command is considered a restricted command unless the last read command terminated with a 'Blank Check' sense key or the last command was a Space End of Data command. Data may be appended after logical end of data.

MODE SELECT

A Mode Select command is restricted if the command is issued to change the tape Write density and the tape is not positioned at B.O.T.

DIAGNOSTIC COMMANDS

All diagnostic commands except Diagnostic Inquiry are restricted if the controller's buffer contains any data from a previous read or write command. If the Device-off-line or Unit-off-line bits are set in the Send Diagnostic command, then the data in the buffer will be destroyed and the command will execute.

EXAMPLES

ILLEGAL OPERATIONS

1. Write a block/s
   Space Reverse
   Read and Compare

2. Write a block/s plus two filemarks
   Space filemark reverse
   Write new data

ACCEPTABLE OPERATIONS

1. Write a block/s plus filemark/s
   Rewind
   Read or Space to end of last filemark (end of recorded media) written on tape
   Write (append) new data or filemark/s
   Note: Controller can only write after 'blank check' or a successful space end-of-media operation.

2. Write data plus filemark/s
   Rewind
   Space or Read until 'blank check' received
   Append Data or filemarks

3. Write data plus filemark/s
   Rewind
   Space-end-of-media
   Append Data or filemarks

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