A Specification for a Tape Drive

Automation Controller Interface

Version	Change	By	Date
1.0	First Version	Brett Mortensen	12-Mar-98
2.0	First Official Release	Steve Jerman	14-Jan-99
2.1	Comments from review of release: - Typos etc - Low level protocol improvements	Steve Jerman	15-Jan-99
3.0	Added SCSI Surrogate Commands	Steve Jerman	8-Feb-99
3.1	Added - Load/Unload Immediate Mode - Command Timing - Primitive Get Drive Info Command	Ladawan Johnson	18-Mar-99
3.2	Added - Finished defining SCSI Surrogate (FC Host ID and Configure) - Some typos and other comments included	Steve Jerman	05-Apr-99
3.3	Comments from internal review	Steve Jerman	22-Apr-99
3.4	Final comments before release	Steve Jerman	28-Apr-99
3.5	Updated from external review, see list. Added Protocol Error Handling section.	Bob Lang, Ladawan Johnson	15-Sep-99
3.6	Updated - Protocol Timing & Error Handling - CMD_DATA field size - Get Error Info Response RDATA - Einstein Specifics - See list for other minor changes - Packet Order Table - Changes from list of questions on 3.5	Ladawan Johnson	21-Dec-99
3.7	Updated - XON/XOFF - Busy - Abort - Response Acknowledgement - Time before next command - Delay after library receives a NAK before command retransmission - ACI Initialization - No Op CMD_DATA and RDATA Length fields - Reset - Send Firmware Image, command/response sequence	Ladawan Johnson	20-June-00
3.7.2	Clarifications to Section 1 through 4	Michael Banther	4-Oct-00
3.8	Clarifications to Section 5. Firmware Update enhancement.	Michael Banther	22-Jan-01
4.0	Functional and robustness enhancements.	Michael Banther	2-Apr-01
4.0.1	Remove ‘HP Restricted’ label	Michael Banther	1-Nov-01
4.0.2	Add T10 document number and copyright statement	Michael Banther	7-Dec-01

1 Introduction

1.1 Overview

The Automation Controller Interface (ACI) consists of a serial bus, additional control lines, and the necessary protocols to connect a tape drive to an automation controller in a tape auto-changer or library. The ACI provides the following fundamental functions:

1. Coordination of automation controller and tape drive for Load and Unload operations.
2. Retrieval of information from the tape drive by the automation controller.
3. Limited configuration of the tape drive.

In addition, tape drives may optionally support:

4. Upload and download of firmware images.
5. Access to Media Auxiliary Memory contents.
6. A protocol for passing SCSI commands from an automation controller to a tape drive over the interface.
7. A protocol for passing SCSI commands from a host computer to an automation controller via a tape drive.

1.2 Conventions

Sections 3, 4, 5, and 6 contain the ACI specification. Within these sections, some comments and explanatory material appear which do not form a part of the specification. This additional material has been clearly marked as “Example,” “Introduction,” or “Notes.”

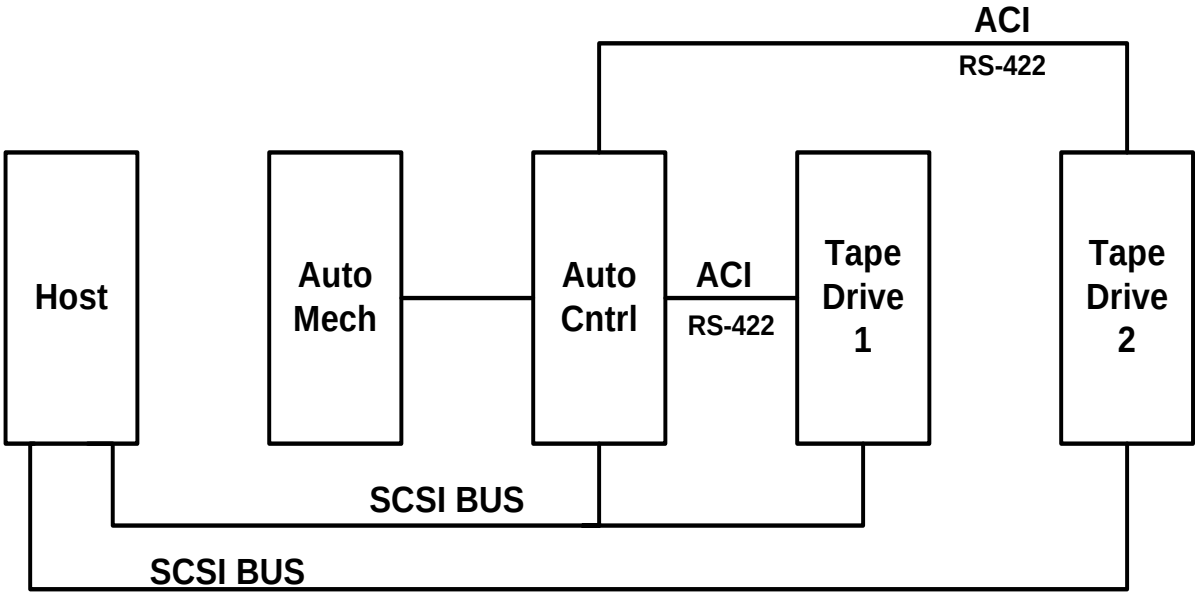
References to other documents appear in the form [xxx, yyy] with xxx being a descriptive acronym for the title of the document and yyy the section of interest within the document. Section 7 provides a bibliography of these documents.

2 System Configurations

The figure below shows a sample system configuration that this Automation Controller Interface supports. The Host connects to the tape drive and the automation controller via the SCSI Parallel Interface or SCSI Fibre Channel Interface.

The tape library manufacturer supplies the automation controller. It communicates to each tape drive via a separate Automation Controller Interface. The automation controller must support a separate ACI bus for each tape drive within the library system.

Example Library System Configuration

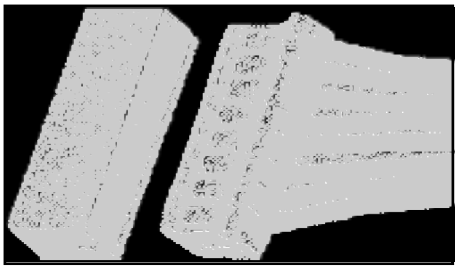


3 Hardware

Each tape drive supports a single Automation Controller Interface. The communication protocol does not provide a serial addressing scheme, so each tape drive within a library requires a dedicated interface on the automation controller.

3.1 ACI Connector (SCSI)

The Automation Controller Interface connector is a nine-pin JST PH surface mount right angle connector (JST P/N S 9B-PH-SM3-TB). This connector is small enough to mount alongside the SCSI connector. It can be surface mounted in a rugged manner. It also can be mated with either crimped or insulation displacement connectors.



See
http://www.jst-mfg.com/ProductGuideE/EPH.html
for details of the crimped connector and
http://www.jst-mfg.com/ProductGuideE/EKR.html
for details of the insulation displacement connector.

Manufacturer: JST

Crimp:

- Housing: PHR-9
- Contacts: SPH-002T-P0.5S (for AWG# 30-24 wire)
  SPH-004T-P0.5S (for AWG# 32-28 wire)

Insulation displacement:

09KR-8M for AWG# 28 wire

09KR-6S for AWG# 26 wire

3.2 Electrical Specification

The data lines of the Automation Controller Interface have the same electrical specifications as an RS-422 interface. All other lines use digital logic levels with 0 to 0.8 Volts representing a logic low and 2.8 to either 3.3 or 5 Volts representing a logic high.

3.3 Connector Pin-Out

Pin	ID	Function
1	ACI_RX+	RS-422 Receive (+ side of differential RS-422 line)
2	ACI_RX-	RS-422 Receive (- side of differential RS-422 line)
3	GND	Ground
4	ACI_TX-	RS-422 Transmit (- side of differential RS-422 line)
5	ACI_TX+	RS-422 Transmit (+ side of differential RS-422 line)
6	ACI_DRV_SEN_L	Drive Sense: tied low in tape drive so that the automation controller can sense tape drive presence, the automation controller should have a pull up resister on this line. LOW: Tape drive Present. HIGH: Tape drive Not Present (3.3 or 5 Volts).
7	ACI_LIB_SEN_L	Library Sense: Tape drive will not appear on SCSI/FC until commanded when low. Pulled up to 5V in the tape drive. Automation controller should tie LOW. LOW: Tape drive connected to an automation controller. HIGH: Tape drive is standalone (3.3 or 5 Volts).
8	ACI_RST_L	Tape drive Reset. Pulled up to 5 V in the tape drive. The tape drive will perform a Drive Reset when this line is pulled low (see section 5.8).
9	SCSI_ATN_L	The tape drive will set this pin low after it receives a SCSI CDB destined for the automation controller during Surrogate SCSI operation. The automation controller can receive the CDB using a Get SCSI CDB command. The tape drive will reset this pin high when it ACKs the Get SCSI CDB command packet.

4 Transfer Protocol

4.1 Introduction

This interface provides a client-server relationship where the automation controller acts as the client and the tape drive acts as the server. The automation controller sends commands and the tape drive responds to those commands.

The automation controller is not required to poll the tape drive to determine when a command has finished or to obtain the results. The tape drive returns status and possibly data as the response to every command sent.

The Automation Controller Interface supports two communication protocols: a primitive protocol and a packet-based protocol.

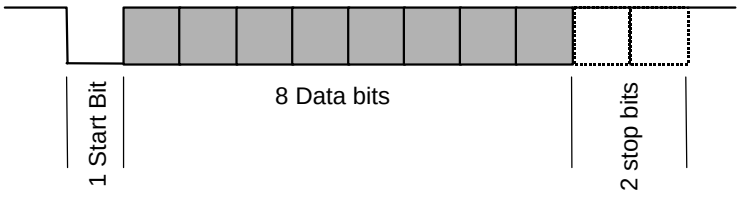
The following sections describe the framing, flow control, and common definitions used by both protocols and each transfer protocol in detail.

4.2 Baud Rate and Framing

The baud rate and byte framing specification appear below:

- Default baud rate equals 9600 baud. The automation controller and tape drive will always return to the default baud rate after power-on, a tape drive reset, or an ACI reset. The automation controller can configure the tape drive to use other baud rates using the Set Baud Rate command (see section 5.9).
- 1 start bit
- 8 data bits per character
- 2 stop bits
- No Parity

Framing Diagram



4.3 Flow Control (XOFF/XON)

4.3.1 Introduction

The Automation Controller Interface supports flow control using the XOFF and XON control characters to prevent the receive buffer from overflowing. This handshaking method allows the receiving device to halt data transmission in order to process the data that it has received.

If the receive buffer gets close to overflowing, the receiver sends the XOFF character to the sender while still receiving data (full duplex). Receipt of the XOFF character tells the sender to stop sending after finishing transmission of the current character. Once the receiver has emptied its buffer, it sends an XON character. Receipt of the XON tells the sender to continue sending additional characters. The XOFF/XON characters are used as a low-level flow control, only when the receiver needs to pause/resume data from the sender.

4.3.2 Control Characters

The Automation Control Interface uses the ASCII character **<DC3>** for **XOFF** and **<DC1>** for **XON.** Both the automation controller and the tape drive must support XOFF/XON flow control when sending and receiving. The receiver acts as the master of XOFF/XON flow control.

4.4 Common Time Definitions

4.4.1 Introduction

The protocols specified in sections 4.5 and 4.6 require that certain actions occur within specified periods. Likewise, they require that certain actions may not occur during specified periods. In some instances, both protocols use identical periods. This section defines those shared periods.

To provide a consistent nomenclature, this section also designates time intervals, one time interval for each specified period. The intervals simply name the actual amount of time taken by a specific automation controller or tape drive to perform the action required by the corresponding period.

4.4.2 Period Definitions

4.4.2.1 Wait Period between Commands

The automation controller shall insert a wait period of **100 milliseconds** or greater between conclusion of a command-response transaction and the beginning of the transmission of the next command.

Note: This period allows the tape drive to prepare for reception of the next command.

4.4.2.2 Wait Period after Baud Rate Change

When altering the baud rate of the ACI, the automation controller shall insert a wait period of **1 second** or greater between the conclusion of the command-response transaction that alters the baud rate and the beginning of the transmission of the next command.

Note: This period allows the tape drive to reconfigure for reception of the next command at the new baud rate.

4.4.2.3 Transmission Suspension Period

The receiver of an XOFF flow control character will cease transmission within the **Transmission Suspension Period**. The value of the Transmission Suspension Period depends on the current baud rate. The formula below yields the value of the Transmission Suspension Period.

Period (in seconds) =(11 / Baud Rate) * 2

4.4.2.4 Transmission Resumption Period

The receiver of an XON flow control character will begin transmission within the **Transmission Resumption Period** of **200 milliseconds**.

4.4.3 Interval Definitions

4.4.3.1 Wait Interval between Commands

The **Wait Interval between Commands** designates the actual time the automation controller waits between conclusion of a command-response transaction and the beginning of the transmission of the next command. This interval corresponds to the Wait Period between Commands defined in 4.4.2.1.

4.4.3.2 Wait Interval after Baud Rate Change

The **Wait Interval after Baud Rate Change** designates the actual time the automation controller waits between conclusion of a command-response transaction that alters the baud rate and the beginning of the transmission of the next command. This interval corresponds to the Wait Period after Baud Rate Change defined in 4.4.3.2.

4.4.3.3 Transmission Suspension Interval

The **Transmission Suspension Interval** designates the actual time the receiver of an XOFF flow control character takes to cease transmission. This interval corresponds to the Transmission Suspension Period defined in 4.4.2.3.

4.4.3.4 Transmission Resumption Interval

The **Transmission Resumption Interval** designates the actual time the receiver of an XON flow control character takes to begin transmission. This interval corresponds to the Transmission Resumption Period defined in 4.4.2.4.

4.5 Primitive Protocol

4.5.1 Command and Response Format

In this protocol, the automation controller sends a command to the tape drive as a single byte of data. The tape drive responds with one or more bytes of response data. The command sent from the automation controller cannot contain any data other than the command code. The length of the response data depends on the command code sent.

This protocol does not use any packet headers or footers to protect the command and response transmissions. No mechanism exists to detect data corruption or verify successful reception of commands or data.

4.5.2 Control Characters

With the exception of XOFF/XON flow control, described in section 4.3, this protocol does not use control characters.

4.5.3 Protocol Timing

This protocol includes all of the Period Definitions specified in section 4.4.2. It also includes the period defined below.

4.5.3.1 Command Qualification Period

A valid command consists of the transmission of the command byte followed by a quiet period, called the **Command Qualification Period**. During the Command Qualification Period, both the automation controller and the tape drive must refrain from transmission.

The value of the Command Qualification Period depends on the current baud rate (see section 4.2). The table below provides the value(s) for the baud rate(s) defined by this specification.

Baud Rate	Command Qualification Period (in milliseconds)
9600	200

Notes:

The Command Qualification Period reduces the likelihood of the tape drive, upon reception of a partial packet, interpreting one or more bytes of that partial packet as a primitive command. Reception of a partial packet can occur when certain time-out conditions arise when using the Packet Protocol (see section 4.6).

The HP LTO tape drive supports baud rates in addition to the ones defined by this specification (see section 5.9.3). The table below provides the Command Qualification Period values for these additional baud rates.

Baud Rate	Command Qualification Period (in milliseconds)
19200	100
38400	50
57600	34
115200	17

4.6 Packet Protocol

In this protocol, the automation controller and tape drive communicate with one another using command and response packets. Two packet formats exist:

- The automation controller sends a command and data to the tape drive using the **Command Packet** format.
- The tape drives responds to valid Command packets from the automation controller with data and a status value using the **Response Packet** format.

This protocol provides robust communication in case of lost or corrupted packets. Each packet includes a checksum value to ensure data integrity. Control characters provide immediate acknowledgement of the success or failure of each packet transmission. The protocol includes packet sequence numbering and time-outs to recover from lost packets or control characters.

Note: This protocol does not support connection to a “Dumb Terminal”.

4.6.1 Command Packet Format

<STX> SEQ LENGTH CMD_OPCODE CMD_DATA CHKSUM <ETX>

Where:

Field	Description	Size
<STX>	Start of text, value 0x02.	One byte.
SEQ	Packet sequence number. Incremented for each new Command packet sent. Not incremented when re-sending the same packet due to a <NAK> or time-out.	One byte
LENGTH	Length of this command packet. This field equals the number of all bytes in the packet, including the STX, SEQ, LENGTH, CMD_OPCODE, CMD_DATA, CHKSUM, and ETX fields.	Two bytes.
CMD_OPCODE	Automation Controller Command.	One byte
CMD_DATA	Command Parameters.	1 to N Bytes (command dependent)
CHKSUM	Sum of CMD_OPCODE + CMD_DATA bytes modulo 65536.	Two Bytes
<ETX>	End of text, value 0x03.	One Byte

Note:

The Command packet length cannot exceed the Receive Packet Buffer Size reported by the tape drive in the Get Buffer Size response (see section 5.21).

Example:

In the example below, the automation controller sends a Get Drive Status command (see section 5.5). The automation controller has set the SEQ field equal to 0x04 and the other fields as required by the command.

Byte	Meaning	Value
0	STX	0x02
1	SEQ	0x04
2	LENGTH	0x00
3	LENGTH	0x09
4	CMD_OPCODE	0x03
5	CMD_DATA	0x00
6	CHKSUM	0x00
7	CHKSUM	0x03
8	ETX	0x03

4.6.2 Response Packet Format

<STX> SEQ LENGTH RDATA STATUS CHKSUM <ETX>

Where:

Field	Description	Size
<STX>	Start of text, value 0x02.	One byte
SEQ	Packet sequence number. Matches the SEQ field for the corresponding Command packet.	One byte
LENGTH	Length of this response packet. This field equals the number of all bytes in the packet, including the STX, SEQ, LENGTH, RDATA, STATUS, CHKSUM, and ETX fields.	Two bytes
RDATA	Return data.	0 to N bytes (command dependent)
STATUS	Status of command execution: 0x01 = Good. 0x02 = Check Condition – the tape drive has additional information for the automation controller, see the Get Error Info command (section 5.11). 0x08 = Busy – The drive cannot execute the command at this time. The automation controller should retry the command later.	One Byte
CHKSUM	Sum of RDATA + STATUS bytes modulo 65536.	Two bytes
<ETX>	End of text, value 0x03.	One byte

Note:

The tape drive will not send a Response packet whose length exceeds the Transmit Packet Buffer Size reported by the tape drive in the Get Buffer Size response (see section 5.21).

Example:

In the example below, the tape drive responds to a Get Drive Status command in the previous example with a Response packet. The tape drive reports that a cartridge is present, loaded and ready for access. The tape drive is otherwise idle and no errors or cleaning conditions have been detected.

Byte	Meaning	Value
0	STX	0x02
1	SEQ	0x04
2	LENGTH	0x00
3	LENGTH	0x0B
4	RDATA	0x07
5	RDATA	0x00
6	RDATA	0x00
7	STATUS	0x01
8	CHKSUM	0x00
9	CHKSUM	0x08
10	ETX	0x03

4.6.3 Control Characters

The Packet protocol includes a set of Control characters. These characters have a special meaning when received outside of a packet. This section describes the purpose and use of each Control character.

4.6.3.1 Flow Control

The Packet protocol includes the XOFF/XON Flow Control characters described in Section 4.3.1 as Control characters.

4.6.3.2 Packet Acknowledgement

This protocol requires that the receiver of a packet must acknowledge receipt to the sender. This feature allows feedback from the receiver to the sender regarding the validity of packet transmission.

The receiver provides the acknowledgement by sending either the ASCII **<ACK>** or ASCII **<NAK>** control character. The character **<ACK> acknowledges receipt of a valid packet** whilst the character **<NAK> acknowledges receipt of an invalid packet**.

Section 4.6.5 discusses packet validation and expected behavior when receiving an invalid packet.

The receiver of a Control character should not acknowledge receipt; that is, it should not send an<ACK> or <NAK>, to the sender.

Notes:

An <ACK> does not indicate the success of a command. It only indicates receipt of a packet with a valid format. Likewise, a <NAK> does not indicate failure of a command. It only indicates receipt of a packet with an invalid format.

4.6.4 Protocol Timing

4.6.4.1 Introduction

The protocol requires automation controllers and tape drives to transmit each packet and packet acknowledgement within a limited period. These defined **Periods** establish **the maximum amount of time** the automation controller or tape drive can take to perform specific actions without causing a protocol error (see section 4.6.5 for a discussion of protocol error handling). Likewise, this protocol requires periods during which transmission cannot take place. These defined **Periods** establish **the minimum amount of time** the automation controller or tape drive must wait before performing specific actions without causing a protocol error.

To provide a consistent nomenclature, the protocol also defines time **Intervals**, one time interval for each specified period. The intervals simply **name the actual amount of time** taken by a specific automation controller or tape drive to perform the action required by the corresponding period.

4.6.4.2 Period Definitions

4.6.4.2.1 Common Period Definitions

This protocol includes all of the Period Definitions specified in section 4.4.2.

4.6.4.2.2 Packet Transmission Period

When sending a packet, the sender will transmit the entire packet within the **Packet Transmission Period**.

The Packet Transmission Period begins when the packet sender transmits the first bit of the frame containing the packet <STX>. The Packet Transmission Period does not include time during which Flow Control has disabled communication. In effect, the Packet Transmission Period suspends when the packet sender receives the last bit of the frame containing an XOFF and resumes when the packet sender receives the last bit of the frame containing a subsequent XON.

For each packet transmitted, the Packet Transmission Period will have an initial value based on the current baud rate (see section 4.2). The table below provides the initial value(s) for the baud rate(s) defined by this specification.

Baud Rate	Initial Packet Transmission Period (in milliseconds)
9600	200

The value of the Packet Transmission Period may increase once during the transmission of the packet depending on the value of the packet's length field (see sections 4.6.1 and 4.6.2). If the formula below yields a value greater than the initial value, then the value of the Packet Transmission Period will increase to the value given by the formula.

Period (in seconds) = Value of Length Field * (11 / Baud Rate) * 10

The increased Packet Transmission Period will come into effect when the packet sender completes transmission of the least significant byte of the Length field.

Note:

The HP LTO tape drive supports baud rates in addition to the ones defined by this specification (see section 5.9.3). The table below provides the initial Packet Transmission Period values for these additional baud rates.

Baud Rate	Initial Packet Transmission Period (in milliseconds)
19200	100
38400	50
57600	34
115200	17

4.6.4.2.3 Packet Acknowledgement Period

The receiver of a packet shall send a packet acknowledgement within the **Packet Acknowledgement Period** of **200 milliseconds**. The Packet Acknowledgement Period begins when the packet receiver receives the last bit of the frame containing the packet <ETX>.

4.6.4.2.4 Response Period

The **Response Period** specifies the maximum amount of time a tape drive will take to process a command from the time the tape drive sends the Command Packet Acknowledgement until it begins to transmit the Response Packet. This specification leaves the **value** of the Response Period **undefined**.

Note: *Response Period Estimation for HP LTO Tape Drives.*

In general, the time required for the tape drive to execute and respond to a command will depend on which command the automation controller sends. The equation below provides an estimate of the total time required by the HP LTO tape drive to receive, execute, and respond to certain commands. It applies to all Mandatory commands (see section 5.1.1.1), except for non-immediate mode Load and Unload:

Time (in seconds) = (Command Packet bytes + Response Packet bytes + 2) * 11 / Baud Rate * (1 + Drive Firmware Overhead)

The additional two bytes in the byte count account for the Command Packet and Response Packet acknowledgement bytes respectively. The figure 11 in "11 / Baud Rate" includes the Start and Stop bits plus the eight Data bits for each frame (see section 4.2). The equation assumes the tape drive firmware overhead measured as a percentage of command-response time.

Load and Unload commands in non-immediate mode will not complete until the Tape has mechanically loaded or unloaded. For non-immediate mode Load and Unload commands, the formula above does not provide an accurate estimate of the time required.

For Mandatory commands, the HP LTO tape drive has a firmware overhead of 15%. For the Send Firmware Image command, the HP LTO tape drive has a firmware overhead of 30%. This higher overhead includes time to erase and program flash memory which regular commands do not require.

Example

Sending the command with the longest response packet ("Get Drive Info", 9 byte command packet, 61-byte response packet) at 19200 baud will have a maximum Command-Response time of 47.4 milliseconds:

$$(9 + 61 + 2) * 11 / 19200 * (1 + 0.15) = 0.0474$$

Example

Downloading drive firmware of size 428 Kbytes at 19200 baud will take 326 seconds (5 minutes, 26 seconds):

$$(14 + 428 * 1024 + 8) * 11 / 19200 * (1 + 0.30) = 326$$

4.6.4.2.5 Wait Period between Packet Retries

The sender of a packet shall insert a wait period of **25 milliseconds** or greater before re-sending a negatively acknowledged packet. This wait period begins when the packet sender receives the last bit of the frame containing the <NAK>.

Note: This period allows the receiver time to prepare for reception of the re-sent packet.

4.6.4.3 Interval Definitions

4.6.4.3.1 Common Interval Definitions

This protocol includes all of the Interval Definitions specified in section 4.4.3.

4.6.4.3.2 Packet Transmission Interval

The **Packet Transmission Interval** designates the actual time taken for the sender of a packet to transmit the entire packet. This interval corresponds to the Packet Transmission Period defined in 4.6.4.2.2. The interval begins when the packet sender transmits the first bit of the frame containing the packet <STX>, and it ends when the packet sender transmits the last bit of the frame containing the packet <ETX>.

4.6.4.3.3 Packet Acknowledgement Interval

The **Packet Acknowledgement Interval** designates the actual time taken for the receiver of a packet to transmit the packet acknowledgement. This interval corresponds to the Packet Acknowledgement Period defined in 4.6.4.2.3. The interval begins when the packet receiver receives the last bit of the frame containing the packet <ETX>, and it ends when the packet receiver transmits the first bit of the frame containing the packet acknowledgement – either <ACK> or <NAK>.

4.6.4.3.4 Response Interval

The **Response Interval** designates the actual time taken for the tape drive to respond to a command. This interval corresponds to the Response Period defined in 4.6.4.2.4. The interval begins when the tape drive transmits the last bit of the frame containing the Command packet <ACK>, and it ends when the tape drive transmits the first bit of the frame containing the Response packet <STX>.

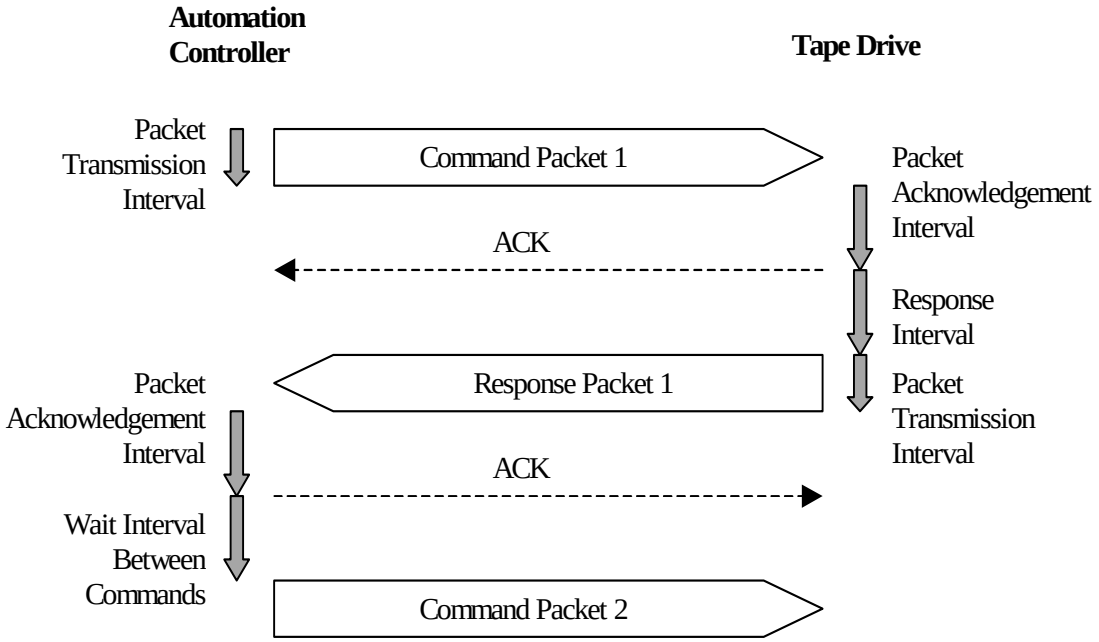
Note: The response Interval does not define the end-to-end Command-Response transaction time.

4.6.4.3.5 Wait Interval between Packet Retries

The **Wait Interval between Packet Retries** designates the actual time that the sender of a packet waits before re-sending the packet after receiving a negative acknowledgement. This interval corresponds to the Wait Period between Packet Retries defined in 4.6.4.2.5. The interval begins when the packet sender receives the last bit of the frame containing the <NAK>, and it ends when the packet sender re-transmits the first bit of the frame containing the packet <STX>.

4.6.4.4 Interval Relationships

The diagram below shows the relationship between some of the defined time intervals.



4.6.5 Protocol Error Handling

4.6.5.1 Recovery Algorithm

When the sender of a packet enters the Recovery Algorithm, it may retry the packet transmission or terminate the Command-Response transaction early.

To retry the packet transmission, the sender:

1) Stops transmission of the remainder of the packet if any remains unsent.
2) Waits until the Wait Period between Packet Retries has elapsed (see section 4.6.4.2.5).
3) Re-sends the entire packet.

To terminate the Command-Response transaction early:

1) The packet sender stops transmission of the remainder of the packet if any remains unsent.
2) The automation controller waits until the Wait Period between Commands has elapsed (see section 4.6.4.2.4). During this time, both the automation controller and the tape drive prepare to handle the next ACI command.

The automation controller may send the next Command Packet anytime after the Wait Period between Commands has completed. The Command Packet may invoke any supported command.

Note:

The HP LTO tape drive will re-send a Response Packet a maximum of three times. If it does not receive a Packet Acknowledgement after four retries, it will discard the Response Packet and wait for a new command from the automation controller.

4.6.5.2 Packet Validation

Upon receiving a packet, the receiver must validate the packet using the rules provided below. If the packet conforms to the rules, the packet receiver sends an <ACK> to the packet sender. If the packet does not conform to the rules, the packet receiver sends a <NAK> to the packet sender.

A valid packet:

- Begins with an <STX> character and ends with an <ETX> character.
- Consists of *n* bytes where *n* equals the value of the LENGTH field.
- Has a CHECKSUM field value equal to
    - The sum of the CMD_OPCODE and CMD_DATA fields modulo 65536 for a Command packet.

- The sum of the RDATA and STATUS fields modulo 65536 for a Response packet.

If the sender of a packet receives a <NAK> in response, it should invoke the Recovery Algorithm.

4.6.5.3 Framing Error

If the receiver detects a framing error (invalid stop bit) within a packet, it will send a <NAK> to the sender indicating bad command transmission. The sender, upon receiving the <NAK>, should invoke the Recovery Algorithm.

Note:

The HP LTO tape drive, upon detecting a Framing Error, will continue to accept characters from the automation controller until the automation controller ceases transmission for an interval of time. After this interval, the HP LTO tape drive will send the <NAK> character. The interval value equals the greater of 2 milliseconds or (11 / Baud Rate) * 10 milliseconds.

4.6.5.4 Data Overrun

If a packet overruns the receiver's data buffer, the receiver shall send a <NAK> to the sender indicating bad transmission. The sender, upon receiving the <NAK>, should invoke the Recovery Algorithm.

Note:

The HP LTO tape drive, upon detecting a Data Overrun, will continue to accept characters from the automation controller until the automation controller ceases transmission for an interval of time. After this interval, the HP LTO tape drive will send the <NAK> character. The interval value equals the greater of 2 milliseconds or (11 / Baud Rate) * 10 milliseconds.

4.6.5.5 Packet Timeout

After receiving the <STX> for the beginning of a packet, if the receiver does not receive the number of bytes indicated by packet's Length field within the Packet Transmission Period (see section 4.6.4.2.2), it shall send a <NAK> to the packet sender. The packet sender, upon receiving the <NAK>, should invoke the Recovery Algorithm.

4.6.5.6 Acknowledgement Timeout

After sending the <ETX> that ends a packet, if the sender does not receive a Packet Acknowledgement, either <ACK> or <NAK>, within the Packet Acknowledgement Period (see section 4.6.4.2.3), it should invoke the Recovery Algorithm.

Notes:

After sending a Response Packet, the HP LTO tape drive treats any byte received except for <ACK>, <NAK>, XOFF, or XON as a though it had received a <NAK>. The HP

LTO tape drive assumes corruption of a <NAK> has occurred, so it re-sends the Response Packet.

If the HP LTO tape drive fails to acknowledge multiple Command Packets, HP recommend that the automation controller reset the tape drive's ACI port using the Reset command with Reset Control equal to ACI Reset (see section 5.8). If the HP LTO tape drive fails to acknowledge the Reset command with Reset Control equal to ACI Reset, HP recommend that the automation controller reset the entire tape drive using the Reset command with Reset Control equal to Drive Reset.

4.6.5.7 Transmission Resumption Timeout

After sending an XON to resume data transmission, if the packet receiver does not receive data within the Transmission Resumption Period (see Section 4.4.2.4), it will re-send the XON.

Note: Under certain timing conditions, a packet sender may receive two XONs from a packet receiver without an intervening XOFF. If this situation occurs, HP recommends that the packet sender re-start data transmission if it hasn't already done so and otherwise ignore the additional XON.

4.6.5.8 Control Character Errors

If the receiver of a Control Character (see Section 4.3.2) detects an error in the Control Character, the receiver will ignore the Control Character; that is, the receiver will treat the situation as though no Control Character had been received. Errors covered by this clause include receive buffer overruns, framing errors, and receipt of unexpected Control Characters.

4.7 ACI Initialization

After power on, drive reset, ACI reset, or completion of a firmware upgrade, the tape drive establishes communication with the automation controller at the default baud rate (see section 4.2) by periodically sending an <ENQ> character. The tape drive will send this character at 10-second intervals until it receives a valid transmission from the automation controller. This character indicates to the automation controller that the tape drive has completed its initialization sequence and can receive a command over the ACI.

Notes:

The HP LTO tape drive supports a two-step initialization sequence. The first step behaves as described above; the tape drive will go through the first step of the initialization sequence and then begin to send the <ENQ> character at 10-second intervals.

Once the tape drive sends the first <ENQ> character, it will begin the second step of initialization. This second step may take several minutes to complete as it includes the rewinding of media, and optionally the unthreading of media, if the drive contains a seated cartridge with threaded media.

During the second step of initialization, the HP LTO tape drive will respond to all ACI commands, except Get Drive Info (see section 5.2) and Get Error Info (see section 5.11), with Busy status (see section 4.6.2). The HP LTO tape drive will respond normally to the Get Error Info command. It will respond normally to the get Drive Info command with the exception that every byte of the Manufacturing Data Code and Serial Number fields will contain the value 0xFF.

Once the HP LTO tape drive completes the second step of initialization, it will respond normally to all supported commands, and it will report the correct Manufacturing Date Code and Serial Number in the corresponding fields of the Get Drive Info RDATA.

HP recommend that automation controllers use the Get Drive Status command (see section 5.5) to detect the completion of the second step of tape drive initialization. After the HP LTO tape drive sends the first <ENQ> character and until it completes the second step of initialization, it will respond to a Get Drive Status command with Busy status. Once the HP LTO tape drive completes the second step of initialization, it will respond normally to the Get Drive Status command.

5 Command Set

5.1 Introduction

5.1.1 Command Subsets

To support the varying levels of functionality available on tape drives, the ACI command set falls into three subsets: Mandatory commands, Optional commands, and Vendor Unique commands.

5.1.1.1 Mandatory Commands (0x00 - 0x3F)

The Mandatory commands provide all of the basic information and control necessary for the correct operation of the interface.

Hex Value	Op-code
0x00	Get Drive Info
0x01	Load
0x02	Unload
0x03	Get Drive Status
0x04	Set Drive Configuration
0x05	Get Drive Configuration
0x06	Reset
0x07	Set Baud Rate
0x08	No Op
0x09	Get Error Info

5.1.1.2 Optional Commands (0x40 - 0x7F)

The Optional commands allow tape drives to provide enhanced functionality. Specifically, they provide for:

- Upload and download of firmware images.
- Access to Media Auxiliary Memory contents.
- A protocol for passing SCSI commands from an automation controller to a tape drive over the interface (Send SCSI).
- A protocol for passing SCSI commands from a host computer to an automation controller via a tape drive (Surrogate SCSI).

Hex Value	Op-code
0x40	Send SCSI Command
0x41	Get MAM Information
0x42	Send Firmware Image
0x43	Get Firmware Segment
0x44	Get SCSI CDB
0x45	Send SCSI Data
0x46	Get SCSI Data
0x47	Send SCSI Status
0x48	Configure SCSI Surrogate
0x49	Get Buffer Size
0x4A	Send Firmware Segment

5.1.1.3 Vendor Unique Commands (0x80 - 0xBF)

The ACI Specification sets these op-codes aside for vendor-specific use.

5.1.2 Command Format

For each command definition the following format applies:

- All multiple **bit** fields are specified with the least significant bit of the field value in the least significant bit of the defined field in the command or response.
- All multiple **byte** fields are specified with the most significant byte of the field value in the first (lowest byte number) byte of the defined field in the command or response.
- All fields defined as **Reserved** should contain zeroes.
- The order of transmission begins with byte zero and progresses through byte *n*.

Example: Get Drive Configuration Response Data

Bit => Byte:	7	6	5	4	3	2	1	0
0	On Bus		Packet Seq.		Upgrade Protect	Auto-Thread	Auto-Eject	Auto-Load
1	Auto-Load Point							
2	Drive Address							
3 : 10	Drive Name							

5.1.3 Status and Error Information handling

5.1.3.1 Native ACI

If the tape drive returns Good status for a command, it will return any RDATA associated with the command. This status indicates that the tape drive has processed the command successfully.

If the tape drive returns Check Condition status for a command, it will not return any RDATA. This status indicates that the tape drive encountered an exception whilst processing the command. The tape drive will preserve for a limited time **Error Information**; that is, **additional information describing the condition that prohibited the command from completing normally**. The tape drive will preserve the Error Information until it processes the next command received over the ACI.

Note: HP recommend that the automation controller retrieve the Error Information using the Get Error Info command (see section 5.11).

If the tape drive returns Busy status for a command, it will not return any RDATA. This status indicates that the tape drive could not process the command due to a resource conflict within the tape drive.

Note: HP recommend that, upon receipt of Busy status, the automation controller retry the command after waiting for an interval of time.

5.1.3.2 Send SCSI Command

The tape drive returns two status parameters for each Send SCSI Command command: the SCSI Status parameter in the RDATA (see section 5.12.2) and the ACI Status field that follows the RDATA in the Response packet (see section 4.6.2).

The tape drive will report exceptions from the processing of the embedded SCSI command in the SCSI Status parameter rather than the ACI Status. In this case, the tape drive will maintain SCSI Sense data which the automation controller can retrieve using a subsequent Send SCSI Command with an embedded Request Sense SCSI command.

The tape drive will report exceptions from the Send SCSI Command that do not involve the processing of the embedded SCSI command in the ACI Status field. In this case, the tape drive will maintain the Error Information as described in 5.1.3.1.

Examples:

If the automation controller sends a Send SCSI Command with a reserved field in the SCSI CDB set to an invalid value, the tape drive will return Good status in the ACI Status field but Check Condition in the SCSI Status parameter of the RDATA. This failure pertains to the embedded SCSI command. The tape drive will indicate the cause of the exception in its SCSI Sense data.

If an automation controller sends a Send SCSI Command with a Command packet Length field in excess of the Receive Packet Buffer Size (see sections 4.6.1 and 5.21), the tape drive will return check Condition status in the ACI Status field. This failure does not pertain to the processing of the embedded SCSI command but rather to the processing of the Send SCSI Command command itself. The tape drive will indicate the cause of the exception in the Error Information.

5.1.4 SCSI Reservation

If an initiator using the FC/SCSI bus reserves a tape drive, and the tape drive then receives a command, such as Unload, over the ACI, the tape drive will ignore the reservation and perform the requested action.

5.2 Get Drive Info (0x00)

This command returns information describing the tape drive.

5.2.1 Get Drive Info CMD_OPCODE & CMD_DATA

Bit => Byte:	7	6	5	4	3	2	1	0
0	Op-code = 0x00							
1	Vendor Unique		Reserved					

5.2.2 Get Drive Info RDATA

Bit => Byte:	7	6	5	4	3	2	1	0
0 7	Vendor ID							
8 23	Product ID							
24 27	Product Revision Level							
28 31	Manufacturing Date Code							
32 41	Serial Number							
42 45	ACI Version							
46 52	Firmware Version							

Parameters

All of the fields except ACI Version come directly from the tape drive's SCSI Inquiry data and follow the format defined there.

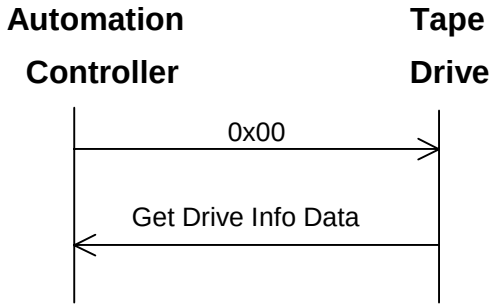
ACI Version:

Contains four ASCII encoded bytes that indicate the version of the ACI Specification to which the tape drive conforms.

5.2.3 Primitive Get Drive Info (0x00)

This command has the same purpose and function as the Get Drive Info command. However, it uses the Primitive protocol (see section 4.4) instead of the Packet protocol.

The automation controller sends the op-code, 0x00, to the tape drive and the tape drive responds with the Get Drive Info Response data. The tape drive will return the Get Drive Info response data anytime it detects the value 0x00 on the ACI bus outside of a Command packet.



5.2.4 Notes

The Primitive protocol does not use command or response packets. The command should contain nothing except the single byte 0x00. The tape drive's response will not include an STX, Sequence field, Length field, Status field, Checksum field, or ETX.

Automation controllers should limit the use of the Primitive Get Drive Info command to the first command issued after:

- Tape drive power-on, or
- Reset of the entire tape drive, or
- Reset of the tape drive's ACI port.

Future versions of this specification may enforce the limitation described above rather than simply recommending it.

5.3 Load (0x01)

This command instructs the tape drive to load and optionally thread a tape. See Section 6 for additional information on different load and unload scenarios.

5.3.1 Load CMD_OPCODE & CMD_DATA

Bit => Byte:	7	6	5	4	3	2	1	0
0	Op-code = 0x01							
1	Vendor Unique		Reserved		Clean	Up-grade	Immed Resp	Thread

Parameters

Thread:

With this bit set, the tape drive will thread the tape as part of a successful load sequence.

With this bit clear, a successful load sequence will cause the cartridge to seat into the tape drive, but the tape will not thread. The tape drive can access the Media Auxiliary Memory (MAM) with the cartridge in this position.

Immed Resp (Immediate Response):

With this bit set, the tape drive will send a Response packet to the automation controller without waiting for the loading operations to mechanically complete. A Response packet with Status equal to Good indicates only that the commands pre-execution checks succeeded. The automation controller may continue with its internal operations whilst the tape drive finishes loading.

While the tape drive completes the mechanical loading operations, the automation controller can monitor the progress of the tape drive using the Get Drive Status command (see Section 5.5).

With this bit clear, the tape drive will not send a Response packet to the automation controller until all of the loading operations mechanically complete.

Upgrade:

With this bit set, the tape drive will upgrade its micro-code, provided the automation controller has placed a firmware upgrade cartridge in the jaws of the tape drive and the automation controller has also set the Thread bit in the command parameters. If the command passes its pre-execution checks and the cartridge contains a valid firmware image, the tape drive will return a Response packet with Status equal to Good. If the command does not pass its pre-execution checks or the cartridge does not contain a valid firmware image, the tape drive will return a Response packet with Status equal to Check Condition.

If the automation controller presents a non-firmware upgrade cartridge to the tape drive and sends this command with the Upgrade bit set, the tape drive will return a Response packet with Status equal to Check Condition. If the automation controller presents a

firmware upgrade cartridge to the tape drive and sends this command with the Upgrade bit set but the Thread bit clear, then provided the command passes its pre-execution checks the tape drive will seat the cartridge and return a Response packet with Status equal Good. The tape drive will not thread the tape, and the upgrade of the micro-code will not take place.

With this bit clear, the upgrade behavior of the tape drive will depend on the Upgrade Protect configuration setting (see Section 5.6.1).

Clean:

With this bit set, the tape drive will clean the heads, provided the automation controller has placed a Cleaning cartridge in the jaws of the tape drive and the automation controller has also set the Thread bit in the command parameters. If the command passes its pre-execution checks and the Cleaning cartridge has not expired its usage count, the tape drive will return a Response packet with Status equal to Good. If the command does not pass its pre-execution checks or the Cleaning cartridge has expired its usage count, the tape drive will return a Response packet with Status equal to Check Condition.

If the automation controller presents a non-Cleaning cartridge to the tape drive and sends this command with the Clean bit set, the tape drive will return a Response packet with Status equal to Check Condition. If the automation controller presents a Cleaning cartridge to the tape drive and sends this command with the Clean bit set but the Thread bit clear, then provided the command passes its pre-execution checks the tape drive will seat the cartridge and return a Response packet with Status equal Good. The tape drive will not thread the tape, and cleaning of the heads will not take place.

With this bit clear, the cleaning behavior of the tape drive will depend on the Cleaning Protect configuration setting (see Section 5.6.1).

5.3.2 Unload RDATA

The Response packet for this command contains zero bytes of RDATA.

5.3.3 Notes

The table below provides a quick reference guide to drive behavior with various configuration settings and Load parameter values.

Drive Configuration			ACI Load Command				Tape	Drive	
Clean Protect[1]	Upgrade Protect[2]	Auto Eject	Clean	Up-grade	Immed Resp	Thread	Type	Action	Response
*[3]	*	*	*	*	Off	*	*	Load attempted	Sent when command execution completes.
*	*	*	*	*	On	*	*	Load attempted	Sent after pre-execution checks and before execution starts.
*	*	Off	*	*	*	*	*	Failed Load	Check Condition status. Media unthreaded. Cartridge at Hold Point.
*	*	On	*	*	*	*	*	Failed Load	Check Condition status. Cartridge ejected.
*	*	*	Off	Off	*	Off	Data	Successful Load	Good status. Media unthreaded. Cartridge at Hold Point.
*	*	*	Off	Off	*	On	Data	Successful Load	Good status. Cartridge seated. Media threaded, ready for access.
Off	*	*	*	Off	*	On	Cleaning	Successful Load	Good status. Heads cleaned. After cleaning: Media unthreaded, Cartridge position depends on Auto-Eject.
On	*	*	Off	*	Off	*	Cleaning	Load Attempted	Check Condition status. No cleaning. Media unthreaded. Cartridge position depends on Auto-Eject.
On	*	*	Off	*	On	*	Cleaning	Load Attempted	Good status. No cleaning. Media unthreaded, Cartridge position depends on Auto-Eject.
On	*	*	On	*	*	Off	Cleaning	Load attempted	Good status. No cleaning. Media unthreaded. Cartridge at Hold Point.
*	*	*	On	*	*	On	Cleaning	Successful Load	Good Status. Heads cleaned. Media unthreaded. Cartridge position depends on Auto-Eject.
*	*	*	On	*	*	*	Data/ Upgrade	Load attempted	Check Condition status. Media unthreaded. Cartridge position depends on Auto-Eject.
*	Off	*	Off	*	*	On	Upgrade	Successful	Good Status. Micro-code

[1] With Clean Protect configured On, the drive will reject any attempt to use the SCSI Load command or the Auto-Load feature to load a Cleaning cartridge.

[2] With Upgrade Protect configured On, the drive will reject any attempt to use the SCSI Load command or the Auto-Load feature to load an Upgrade cartridge.

[3] * means “don’t care”.

Drive Configuration			ACI Load Command				Tape	Drive	
Clean Protect[1]	Upgrade Protect[2]	Auto Eject	Clean	Up-grade	Immed Resp	Thread	Type	Action	Response
								Load	upgraded. Media unthreaded. Cartridge position depends on Auto-Eject.
*	On	*	*	Off	Off	*	Upgrade	Load Attempted	Check Condition status. No upgrade. Media unthreaded. Cartridge position depends on Auto-Eject.
*	On	*	*	Off	On	*	Upgrade	Load attempted	Good status. No upgrade. Media unthreaded. Cartridge position depends on Auto-Eject.
*	On	*	*	On	*	Off	Upgrade	Load attempted	Good status. No upgrade. Media unthreaded. Cartridge at Hold Point.
*	*	*	*	On	*	On	Upgrade	Successful Load	Good Status. Micro-code upgraded. Media unthreaded. Cartridge position depends on Auto-Eject.
*	*	*	*	On	*	*	Data/ Cleaning	Load attempted	Check Condition status. Media unthreaded. Cartridge position depends on Auto-Eject.

At present, the HP LTO tape drive does not support the Clean parameter for this command. Automation controllers should treat this bit as reserved. HP expects to support this command parameter in its LTO products in a future release. At present HP have this feature under investigation.

5.4 Unload (0x02)

This command instructs the tape drive to rewind and unthread the tape and optionally to eject the cartridge. See Section 6 for additional information on different load and unload scenarios.

5.4.1 Unload CMD_OPCODE & CMD_DATA

Bit => Byte:	7	6	5	4	3	2	1	0
0	Op-code = 0x02							
1	Vendor Unique		Reserved				Immed Resp	Eject

Parameters

Eject:

With this bit set, the tape drive will eject the cartridge to the Eject Point (see section 6.1).

With this bit clear, the tape drive will leave the cartridge unthreaded at the Cartridge Hold Point (see section 6.1). If the tape drive receives this command with a cartridge unthreaded and already at the Cartridge Hold Point, it will return a Response packet with Status equal to Good and leave the cartridge at the Cartridge Hold Point.

Immed Resp (Immediate Response):

With this bit set, the tape drive will send a Response packet to the automation controller without waiting for the unloading operations to mechanically complete. A Response packet with Status equal to Good indicates only that the command's pre-execution checks succeeded. The automation controller may continue with its internal operations whilst the tape drive finishes unloading.

While the tape drive completes the mechanical unloading operations, the automation controller can monitor the progress of the tape drive using the Get Drive Status command (see Section 5.5).

With this bit clear, the tape drive will not send a Response packet to the automation controller until all of the unloading operations mechanically complete.

5.4.2 Unload RDATA

The Response packet for this command contains zero bytes of RDATA.

5.4.3 Notes

If a host over the SCSI bus or the automation controller over the ACI bus has issued the SCSI Prevent Media Removal command, the Unload command will have no effect. The tape drive will respond with Status equal Check Condition. It will set the Error Information Sense Key equal to Illegal Request (0x5) and the Additional Sense Code and Qualifier equal to Medium Removal Prevented (0x5302).

In the HP LTO tape drive the mechanical operations required for an Unload operation can require up to three minutes to complete.

5.5 Get Drive Status (0x03)

This command returns information indicating overall status of the tape drive. Execution of the Get Drive Status command does not effect the drive status information.

5.5.1 Get Drive Status CMD_OPCODE & CMD_DATA

Bit => Byte:	7	6	5	4	3	2	1	0
0	Op-code = 0x03							
1	Vendor Unique		Reserved					

5.5.2 Get Drive Status RDATA

Bit => Byte:	7	6	5	4	3	2	1	0
0	Reserved		Prevent Media Removal	Write Protect	Ready Eject	Ready Access	Cartridge Load	Cartridge Present
1	Reserved			Com-pression	Tape Activity			
2	Drive Error	Media Error	Reserved		Clean Expired	Cleaning	Clean Required	Clean Needed

Parameters

Cartridge Present:

When set this bit indicates that the tape drive has detected a cartridge inserted with the trailing (labeled) edge at or beyond Load Point 1 (see section 6.1). When clear this bit indicates that the trailing edge of the cartridge lies in between the Eject Point and Load Point 1 or that no cartridge is present in the tape drive.

Cartridge Load (Cartridge Loading/Loaded)**:**

When set this bit indicates that the tape drive has begun a load operation. This bit remains set after a successful load operation as long as the media remains threaded. When clear this bit indicates that either no cartridge is present in the tape drive or that the tape drive has placed the cartridge with the media unthreaded at the Hold Point (see section 6.1).

Ready Access (Ready for Access)**:**

When set this bit indicates that the tape drive contains a seated cartridge with threaded media. When clear this bit indicates that either no cartridge is present in the tape drive or that the tape drive has placed the cartridge with the media unthreaded at the Hold Point (see section 6.1).

Ready Eject (Ready to Eject)**:**

When set this bit indicates that the tape drive has placed the cartridge with the media unthreaded at the Hold Point (see section 6.1). When clear this bit indicates that either no cartridge is present in the tape drive or that the tape drive contains a seated cartridge with threaded media.

Write Protect:

When set this bit indicates that the tape drive has detected a Write Protected cartridge present in the drive. When clear this bit indicates that either no cartridge is present in the tape drive or that the tape drive has detected a cartridge present without Write Protection.

Prevent Media Removal:

When set this bit indicates that the tape drive will not allow removal of a loaded cartridge. When clear this bit indicates that the tape drive will allow removal of a loaded cartridge. The tape drive will set this bit on execution of a SCSI Prevent/Allow Medium Removal command with the Prevent bit set. The tape drive will clear this bit on execution of a SCSI Prevent/Allow Medium Removal command with the Prevent bit clear, at power-on initialization, and after a drive reset.

Tape Activity:

These bits indicate the tape activity from a host's perspective. For example, the tape drive will indicate a Tape Activity of Writing (0x04) even when repositioning or re-reading as part of executing a write command.

Value	Meaning
0x00 – Idle	There is currently no tape motion with the loaded cartridge or no cartridge is loaded.
0x01 – Rewinding	The tape drive is currently rewinding the loaded cartridge.
0x02 – Seeking	The tape drive is currently positioning on the loaded cartridge.
0x03 – Reading	The tape drive is currently reading data from the loaded cartridge.
0x04 – Writing	The tape drive is currently writing data on the loaded cartridge.
0x05 – Erasing	The tape drive is currently erasing the data from the loaded cartridge.
0x06 – Loading	The tape drive is currently loading a cartridge or threading the media.
0x07 – Unloading	The tape drive is currently unloading a cartridge or unthreading the media.
0x08 – Calibrating	The tape drive is currently calibrating.
0x09 – Code Update in Progress	The tape drive is currently updating its micro-code.
0x0A – Cleaning	The tape drive is currently in a head-cleaning mode.

Compression:

This bit set indicates that the tape drive will compress data when writing. This bit clear indicates that the tape drive will not compress data when writing. The value of this bit equals the value of the DCE bit in the SCSI Data Compression Mode Page [SPC, 5.4.3.1].

Cleaning Needed:

This bit indicates that the tape drive's heads need cleaning with a Cleaning cartridge. The tape drive can continue to operate. The automation controller should load a Cleaning cartridge at the next available opportunity. The tape drive will clear this bit upon completion of the head cleaning operation.

Cleaning Required:

When set this bit indicates to the automation controller that the tape drive will **not** read or write until head cleaning using a Cleaning cartridge has occurred. The tape drive will clear this bit upon completion of the head cleaning operation.

Cleaning:

When set this bit indicates to the automation controller that head cleaning is in progress in the tape drive. The tape drive will clear this bit upon completion of the head cleaning operation.

Clean Expired:

When set this bit indicates to the automation controller that a loaded cleaning cartridge has exceeded its use count. The tape drive will clear this bit after the next load.

Media Error:

When set this bit indicates to the automation controller that the tape drive has detected a cartridge or tape fault.

Drive Error:

When set this bit indicates to the automation controller that the tape drive has experienced a hardware fault.

5.5.3 Notes

Once the tape drive sets the Cartridge Present bit, a Load command from the automation controller will cause the tape drive to attempt a cartridge load. The tape drive will return Check Condition status to a Load command sent whilst the Cartridge Present bit is clear.

In addition to the conditions listed above, the HP LTO tape drive will clear the Prevent Media Removal bit after completion of a successful firmware upgrade.

The HP LTO tape drive will set the Cartridge Load bit as a consequence of any Load operation. In addition to the ACI Load command, the HP LTO tape drive supports loads using the SCSI Load/Unload command and the Auto-Load feature.

The HP LTO tape drive includes a mechanical head cleaning brush. The tape drive uses this brush at selected times to wipe debris from the heads. The tape drive will set the Cleaning bit when using this cleaning brush as well as when cleaning the heads with a Cleaning cartridge.

In the HP LTO tape drive, the status bits in the Response packet represent the underlying condition of the tape drive at the time the command execution occurs. During transient conditions, these bits may show conflicting information. To receive a consistent set of status information, HP recommend that automation controllers use the condition Tape Activity equal Idle to qualify decisions based on the Cartridge Present, Cartridge Load, Ready Access, and Ready Eject status bits.

5.6 Set Drive Configuration (0x04)

This command controls the configuration settings of the tape drive.

5.6.1 Set Drive Configuration CMD_OPCODE & CMD_DATA

Bit => Byte:	7	6	5	4	3	2	1	0
0	Op-code = 0x04							
1	On Bus	Reserved	Packet Seq.	Cleaning Protect	Upgrade Protect	Auto-Thread	Auto-Eject	Auto-Load
2	Auto-Load Point							
3	Drive Address							
4 : 11	Drive Name							

Parameters

Auto-Load:

This bit allows the automation controller to control the automatic loading of a cartridge. With this bit set, the tape drive will automatically load a cartridge once the cartridge reaches the configured Auto-Load Point (see section 6.1). With this bit clear, the tape drive will only load a cartridge on receipt of an ACI Load command or a SCSI Load/Unload command with the Load bit set.

Auto-Eject:

This bit allows the automation controller to control the automatic ejection of a cartridge during a non-ACI Unload operation. With this bit set, the tape drive will eject a cartridge as part of any non-ACI Unload operation. With this bit clear, the tape drive will not eject the cartridge as part of any non-ACI Unload operation.

Regardless of the value of this bit, the Eject bit in the ACI Unload command will determine the tape drive's eject behavior for Unload operations initiated by that command (see section 5.4).

Auto-Thread:

This bit allows the automation controller to control the automatic threading of the tape during a Load operation. With this bit set, the tape drive will thread the tape as part of any Load operation. With this bit clear, the tape drive will thread the tape only for an ACI Load command with the Thread bit set (see section 5.3). The tape drive will not thread the tape as part of any other Load operation including auto-loads (if enabled) and SCSI Load/Unload commands with the Load bit set.

Upgrade Protect:

This bit allows the automation controller to protect the drive's micro-code from accidental upgrade. With this bit set, a Firmware Upgrade cartridge will fail to load unless the ACI Load command has the Upgrade bit set (see section 5.3). With this bit

clear, any load and thread of a Firmware Upgrade tape will result in an upgrade to the drive's micro-code.

Cleaning Protect:

This bit allows the automation controller to protect the drive's heads from accidental cleaning. With this bit set, a Cleaning cartridge will fail to load unless the ACI Load command has the Clean bit set (see section 5.3). With this bit clear, any load and thread of a Cleaning cartridge will result in cleaning of the drive's heads.

Packet Seq.

This bit allows the automation controller to control the use of the SEQ field in the Command and Response packets. With this bit set, the tape drive will treat byte one of each packet as specified in section 4.6.1 for Command packets and in section 4.6.2 for Response packets, i.e., the tape drive will expect this field to contain a packet sequence number. With this bit clear, the tape drive will treat the contents of byte one of each packet as reserved.

On Bus:

This bit allows the automation controller to control whether or not the tape drive responds over the Host Interface (e.g., SCSI) bus. With this bit set, the tape drive will respond on the Host Interface bus at the address specified in the Drive Address parameter. With this bit clear, the tape drive will not respond over the Host Interface.

Auto-Load Point:

For tape drives that support a configurable Auto-Load Point, this parameter specifies the location at which the tape drive begins an Auto-Load operation (see section 6.1). For tape drives that do not support a configurable Auto-Load Point, the value of this parameter has no effect. This specification does not define units or values for this field.

Drive Address:

For tape drives that support a run-time configurable SCSI address, this parameter specifies the address that the tape drive will use. For Parallel SCSI tape drives, this parameter specifies the SCSI bus address of the tape drive. For Fibre Channel tape drives, this parameter specifies the default address used in AL_PA Assignment.

Drive Name:

For Fibre Channel tape drives, this field allows an automation controller to assign a FC World Wide Name to the tape drive. For parallel SCSI tape drives, this field is reserved.

5.6.2 Set Drive Configuration RDATA

The Response packet for this command contains zero bytes of RDATA.

5.6.3 Notes

When the tape drive powers up with the ACI_LIB_SEN_L hardware line low, it will not respond on the Host Interface bus until the automation controller sends this command with the On Bus bit set. When the tape drive receives this command it will start

responding on the Host Interface bus using the address sent in the Drive Address parameter instead of the address indicated by the Address jumpers. Each time the automation controller clears the On Bus bit and then sets the On Bus bit back on, the tape drive's Host Interface port will behave as though the tape drive has just powered up.

In order for the automation controller to change the tape drive's Host Interface address, the automation controller must either:

1. Power-cycle the tape drive and then, after the tape drive completes its power-on sequence, send this command with the On Bus bit set and the Drive Address parameter set to the desired value, or
2. Send this command with the On Bus bit cleared and then send this command again with the On Bus bit set and the Drive Address parameter set to the desired value.

Section 6.1 provides a specific definition for the units used in the Auto-Load Point parameter.

The HP LTO tape drive supports one or two non-ACI Unload operations depending on the configuration of the tape drive. All HP LTO tape drives support the SCSI Load/Unload command with the Load bit clear. In addition, HP LTO tape drives that have a front panel support unloading the cartridge by pressing the Eject button on the front panel.

HP LTO tape drives with a front panel support a Forced Unload feature. Pressing and holding the Eject button on the front panel for a period of several seconds will cause the tape drive to unthread the tape and eject the cartridge regardless of the value of the Auto-Eject bit.

At present, the HP LTO tape drive does not support the Auto-Load Point parameter for this command. The HP LTO tape drive has the Auto-Load Point fixed at Load Point 1 (see section 6.1). HP expects to support this command parameter in its LTO products in a future release. At present HP have this feature under investigation.

At present, the HP LTO tape drive does not support the Cleaning Protect parameter for this command. Automation controllers should treat this bit as reserved. HP expects to support this command parameter in its LTO products in a future release. At present HP have this feature under investigation.

At power-on, the HP LTO tape drive sets various tape drive configurations. The table below shows the power-on configuration values for the standard automation HP LTO tape drive firmware. Special variants may have different power-on settings.

Configuration	Power-on Value	Configuration	Power-on Value
Auto Eject	OFF	Drive Address	Not Configured[1]
Auto Load	OFF	Drive Name	Not Configured[2]
Auto Load Point	0	On Bus	OFF
Auto Thread	ON	Packet Seq.	ON
Cleaning Protect	Reserved	Upgrade Protect	ON

[1] This configuration is invalid until set by the Set Drive Configuration command.

[2] Fibre Channel only. This field is not used in parallel SCSI.

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5.7 Get Drive Configuration (0x05)

This command returns tape drive configuration information.

5.7.1 Get Drive Configuration CMD_OPCODE & CMD_DATA

Bit => Byte:	7	6	5	4	3	2	1	0
0	Op-code = 0x05							
1	Vendor Unique		Reserved					

5.7.2 Get Drive Configuration RDATA

Bit => Byte:	7	6	5	4	3	2	1	0
0	On Bus	Reserved	Packet Seq.	Cleaning Protect	Upgrade Protect	Auto-Thread	Auto-Eject	Auto-Load
1	Auto-Load Point							
2	Drive Address							
3 : 10	Drive Name							
11	SCSI LUN			SCSI Peripheral Device Type				

Parameters

With the exception of the SCSI LUN and SCSI Peripheral Device Type, the parameters in this RDATA have the same definition as those used in the Set Drive Configuration's CMD_DATA. See section 5.6.1 for the definitions.

SCSI LUN:

This field contains the Logical Unit Number that hosts must use when communicating with the tape drive on the SCSI bus to access the tape drive's Stream Command set.

SCSI Peripheral Device Type:

This field contains the SCSI Peripheral Device Type of the tape drive for the Logical Unit Number reported in the SCSI LUN field. It always has the value 0x01 indicating a Sequential Access device.

5.7.3 Notes

At present, the HP LTO tape drive does not support the Auto-Load parameter for this command. HP expects to support this command parameter in its LTO products in a future release. At present HP have this feature under investigation.

At present, the HP LTO tape drive does not support the Cleaning Protect parameter for this command. Automation controllers should treat this bit as reserved. HP expects to support this command parameter in its LTO products in a future release. At present HP have this feature under investigation.

5.8 Reset (0x06)

This command resets either the tape drive's ACI port or the entire tape drive.

5.8.1 Reset CMD_OPCODE & CMD_DATA

Bit => Byte:	7	6	5	4	3	2	1	0
0	Op-code = 0x06							
1	Vendor Unique		Reserved		Reset Control			

Parameters

Reset Control: This field controls the type of reset the tape drive will perform.

0x01 – ACI Reset: Resets the tape drive's Automation Control Interface port and SCSI port. The reset includes the following functions in order:

- The tape drive flushes all buffered write data to tape and writes EOD.
- The tape drive disables its SCSI port.
- The tape drive resets its ACI port configuration to the power-on values (see section 4.7).

If the tape drive receives a Reset command with Reset Control equal to ACI Reset whilst executing another command received over the SCSI port, it will not disable the SCSI port or reset the ACI port configuration until the currently executing command has completed.

The tape drive may execute the Reset command with Reset Control equal to ACI Reset when executing another ACI command, or it may refuse to reset the ACI port under this condition and send a Response packet with Status equal to Check Condition.

0x0F – Drive Reset: Equivalent to a power-on reset. The tape drive must accept and execute the Reset command with Reset Control equal to Drive Reset even when executing other ACI commands.

5.8.2 Reset RDATA

The Response packet for this command contains zero bytes of RDATA.

5.8.3 Notes

In order for the tape drive to accept the Reset command, the automation controller must follow the normal ACI protocol. As a counter-example, the automation controller stops transmission in the middle of a Command packet and then sends a Reset command without waiting for the Wait Period between Commands to expire. The tape drive cannot differentiate the Reset Command packet from the previous incomplete Command packet. In this case, the tape drive will not execute the Reset command.

After the tape drive receives an <ACK> from the automation controller indicating a good response packet, the automation controller cannot send any more commands until after reset completion and receiving an XON character via Automation Controller Interface. See ACI Initialization (section 4.6).

Because a Reset command returns the tape drive's ACI port configuration to the power-on value, the tape drive will cease to respond on the Host Interface bus until the tape drive receives a Set Configuration command with the On Bus bit set (see section 5.6).

With regards to buffered write data and the writing of EOD, this specification does not define the drive's behavior upon receiving a Reset command with Reset Control equal to Drive Reset.

The ACI bus provides an ACI_RST_L line (see section 3.3). Pulling this line Low resets the tape drive in the same manner as a Reset command with Reset Control equal to Drive Reset.

If the HP LTO tape drive receives a Reset command with Reset Control equal to ACI Reset whilst executing another ACI command, it will refuse to execute the reset under this condition and send a Response packet with Status equal to Check Condition.

When processing a Reset command with Reset Control equal to ACI Reset, the HP LTO tape drive will not return a Response packet to the automation controller until any previously executing command received over the SCSI port has finished and the tape drive has flushed all buffered write data to tape and written EOD.

The HP LTO tape drive does not flush buffered write data or write an EOD to tape upon receiving a Reset command with Reset Control equal to Drive Reset. For this reason, HP recommend that automation controllers limit their use of this option.

The HP LTO tape drive requires a minimum of two seconds to reset after processing a Reset command with Reset Control equal to Drive Reset. This two second period begins when the HP LTO tape drive receives the ACK from the automation controller indicating successful reception of the Reset Response packet.

When processing a Reset command received during the Wait Period after Baud Rate Change (see section 4.4.2.2) with Reset Control parameter equal to Drive Reset, the HP LTO tape drive will require an additional one second period to reset itself. In this circumstance the HP LTO tape drive requires a total of three seconds to perform the reset after receiving the Response packet ACK from the automation controller.

5.9 Set Baud Rate (0x07)

This command sets a new baud rate for communication between automation controller and tape drive.

5.9.1 Set Baud Rate CMD_OPCODE & CMD_DATA

Bit => Byte:	7	6	5	4	3	2	1	0
0	Op-code = 0x07							
1	Vendor Unique		Baud Rate					

Parameters

Baud Rate: These bits indicate the new baud rate for ACI communication between the automation controller and the tape drive. The table below defines the meaning of the different values for this parameter:

Parameter Value	Baud Rate
0x00	9600 baud
0x01 through 0x3f	Vendor Unique

5.9.2 Set Baud Rate RDATA

The Response packet for this command contains zero bytes of RDATA.

5.9.3 Notes

The tape drive starts using the new baud rate after sending the Response Packet and receiving a positive acknowledgement <ACK> from the automation controller. The automation controller must delay transmission of the next Command packet until the **Wait Period after Baud Rate Change** has expired (see section 4.4.2.2).

Section 4.2 defines the tape drive's power-on baud rate.

The HP LTO tape drive supports four baud rates in addition to the one defined above:

Parameter Value	Baud Rate
0x01	19200 baud
0x02	38400 baud
0x03	57600 baud
0x04	115200 baud

Example:

The automation controller sends the Set Baud Rate command. The tape drive receives the Command packet and responds with an <ACK>. After the tape drive verifies the command, it returns a Response packet with GOOD status to the automation controller. The automation controller receives the Response packet and returns an <ACK> indicating good transmission. The tape drive receives the <ACK> indicating completion of the command transaction. The tape drive then changes to the **new** baud rate within the **Wait Period after Baud Rate Change**. The automation controller confirms the new baud rate by sending the Get Drive Info command and checking the tape drive response.

5.10 No Op (0x08)

This command tests transmission between the automation controller and the tape drive.

5.10.1 No Op CMD_OPCODE & CMD_DATA

Bit => Byte:	7	6	5	4	3	2	1	0
0	Op-code = 0x08							
1	Length N							
2 : N+2	Data							

Parameters

Length:

The length in bytes of the following data. This value does not include Length byte itself.

Data:

Any hexadecimal values.

5.10.2 No Op RDATA

Bit => Byte:	7	6	5	4	3	2	1	0
0	Length N							
1 : N+1	Data							

Parameters

Length:

The length in bytes of the following data. This value does not include Length byte itself.

Data:

The data bytes sent in the No Op CMD_DATA.

5.11 Get Error Info (0x09)

This command returns error information saved by the tape drive when an ACI command returns non-Good status (see section 5.1.3). The tape drive returns a subset of the information returned by a SCSI Request Sense command [SAM, 5.6.4; SPC, 7.20].

5.11.1 Get Error Info CMD_OPCODE & CMD_DATA

Bit => Byte:	7	6	5	4	3	2	1	0
0	Op-code = 0x09							
1	Vendor Unique		Reserved					

5.11.2 Get Error Info RDATA

Bit => Byte:	7	6	5	4	3	2	1	0
0	Reserved				Sense Key			
1	Additional Sense Code							
2	Additional Sense Code Qualifier							
3, 4	Drive Error Code							

Parameters

Sense Key:

Generic information describing an error or exception condition (see table 65 in [SPC, 7.20.4] for definition of values).

Additional Sense Code:

Further information related to the error or exception condition reported in the Sense Key field (see table 66 in [SPC, 7.20.4] for definition of values).

Additional Sense Code Qualifier:

Detailed information related to the Additional Sense Code field (see table 66 in [SPC, 7.20.4] for definition of values).

Drive Error Code:

An error code unique to the error or exceptional condition.

5.11.3 Notes

For any ACI error that cannot be mapped into SCSI Sense data, the tape drive reports the Sense Key as ‘No Sense’, and the Additional Sense Code and Additional Sense Code

Qualifier as ‘No Additional Sense Information’. In this case, the Drive Error Code field contains all of the information associated with the error or exceptional condition.

The Drive Error Code is provided for informational purposes only. LTO tape drive vendors use them to assist in product integration and fault diagnosis. The automation controller should not rely upon the values reported in the Drive Error Code field since these values may change between products and product revisions.

The HP LTO tape drive returns two pieces of information in the Drive Error Code field. Bits 7 through 2 of byte 3 report the firmware module that detected the error condition. Bits 1 and 0 of byte 3 plus all of byte 4 forms a 10-bit field that reports an error code unique to the error condition. In HP LTO tape drives, the format of the Drive Error Code field matches the format of bytes 16 and 17 returned by the SCSI Request Sense command when the SKSV bit equals zero.

5.12 Send SCSI Command (0x40) – Optional

This command provides a mechanism for the automation controller to send a command in SCSI format, possibly including data, to the tape drive via the Automation Controller Interface. The tape drive returns any resulting data and the status of the SCSI command.

5.12.1 Send SCSI Command CMD_OPCODE & CMD_DATA

Bit => Byte:	7	6	5	4	3	2	1	0
0	Op-code = 0x40							
1	CDB Length							
2 : N	SCSI CDB							
N+1 : M	Data Out							

Parameters

CDB Length:

Length of the SCSI Command Descriptor Block (CDB) [SAM, 5.1; SPC 4.2] in bytes (N-2 in above diagram).

SCSI CDB:

The CDB for the SCSI command ordered from least significant byte to most significant byte, e.g., byte 0 of the CDB occupies byte 2 of the CMD_DATA; byte 1 of the CDB occupies byte 3 of the CMD_DATA, etc.

Data Out:

All data that the automation controller sends with the SCSI command, ordered from least significant byte to most significant byte, e.g., byte 0 of the Data Out occupies byte N+1 of the CMD_DATA, byte 1 of the Data Out occupies byte N+2 of the CMD_DATA, etc.

5.12.2 Send SCSI Command RDATA

Byte/Bit	7	6	5	4	3	2	1	0
0 : N-2	Data In							
N-1	SCSI Status							

Parameters

Data In:

All data returned for the SCSI command, ordered from least significant byte to most significant byte, e.g., byte 0 of the Data In occupies byte 0 of the RDATA; byte 1 of the Data In occupies byte 1 of the RDATA, etc.

SCSI Status:

The SCSI Status returned for the command [SAM, 5.2].

5.12.3 Notes

If the tape drive is busy and can't service a SCSI command received from the automation controller via the Send SCSI Command, it will return GOOD status with RDATA containing the SCSI status byte of BUSY.

Use of this mechanism may require coordination between the automation controller and software running on the host computer(s) when changing the tape drive's configuration, for instance when sending a Mode Select command.

Upon receiving a SCSI command via the ACI Send SCSI command, an HP LTO tape drive will enter a simple task into the SCSI Task Set to process the command [SAM, 7]. Since at the time of reception, the tape drive may have another task current, the automation controller may notice a delay in the processing of the SCSI command. Likewise, hosts sending SCSI commands to the tape drive over the SCSI bus may notice delays in processing those commands once the task for the SCSI command sent by the automation controller becomes current.

At present, the HP LTO tape drive supports a limited set of SCSI commands using the ACI Send SCSI command. The commands supported include:

- Inquiry
- Log Select
- Log Sense
- Mode Sense
- Test Unit Ready

HP expects to support some additional SCSI commands using the ACI Send SCSI command in its LTO products in a future release. At present HP have these SCSI commands under investigation.:

- Receive Diagnostic Results
- Request Sense
- Read Buffer (limited Buffer Ids)
- Send Diagnostic

5.13 Get MAM Information (0x41) – Optional

This command returns Media Auxiliary Memory data for the currently loaded cartridge. The command will return Check Condition status if no cartridge is present in the tape drive.

5.13.1 Get MAM Information CMD_OPCODE & CMD_DATA

Bit => Byte:	7	6	5	4	3	2	1	0
0	Op-code = 0x41							
1	Vendor Unique		Reserved					

5.13.2 Get MAM Information RDATA

Bit => Byte:	7	6	5	4	3	2	1	0
0 : N	MAM Data							

Parameters

MAM Data:

Media Auxiliary Memory data.

5.13.3 Notes

At present, the HP LTO tape drive does not support this command. HP expects to support this command in its LTO products in a future release. At present HP have this feature under investigation.

5.14 Send Firmware Image (0x42) – Optional

This command allows an automation controller to download a firmware image into the tape drive. Upon completion of the download, the tape drive will use the image to update its micro-code.

The command/response sequence for this command is slightly different due to the large amount of data associated with it. After the tape drive receives this command and sends the automation controller the <ACK> for command acknowledgement, it will send the automation controller an XON. The XON indicates that the tape drive has configured itself to receive the firmware image. The automation controller sends the image as a series of bursts **without a packet header or footer**. The tape drive uses the XOFF/XON flow control mechanism to pace the reception of data (see section 4.3).

Once the tape drive has received the full image, it checks the image for validity and then tape drive sends a response packet. For a valid firmware image, as soon as the tape drive receives the <ACK> for the response packet, it will start the firmware update process. The drive will store the firmware image in non-volatile storage and then perform a Drive Reset to start executing the new code (see section 4.7).

If the tape drive receives a <NAK> for the response packet, it assumes that the automation controller does not want to update the drive firmware. Consequently, the tape drive discards the firmware image data and prepares for a new ACI command.

5.14.1 Send Firmware Image CMD_OPCODE & CMD_DATA

Bit => Byte:	7	6	5	4	3	2	1	0
0	Op-code = 0x42							
1 2 3	Segment Offset							
4 5 6	Segment Length (N)							

Tape Drive sends XON

0 : N	Firmware Image Data

Parameters

Segment Offset:

The offset of this segment into the firmware image. If sending firmware image as one block, then this field must equal zero.

Segment Length:

The length of this segment of the firmware image in bytes. If sending firmware image as one block, then this field contains the length of the firmware image.

Firmware Image Data:

The firmware image being transferred.

5.14.2 Send Firmware Image RDATA

The Response packet for this command contains zero bytes of RDATA.

5.14.3 Notes

When calculating the checksum for the Command packet, the automation controller should not include the firmware image data in the calculation.

This specification does not define the format of the firmware image or the means used to validate it.

This specification also provides an enhanced method for sending a firmware image to the tape drive. See the Send Firmware Segment command in section 5.22.

The HP LTO tape drive does not support sending the firmware image in multiple segments.

5.15 Get Firmware Segment (0x43) – Optional

This command allows the automation controller to upload a segment of a firmware image from a tape in the tape drive.

5.15.1 Get Firmware Segment CMD_OPCODE & CMD_DATA

Bit => Byte:	7	6	5	4	3	2	1	0
0	Op-code = 0x43							
1	Vendor Unique		Reserved					
2 3 4	Segment Offset							
5 6 7	Requested Length							

Parameters

Segment Offset:

The offset of this segment into the firmware image. Provided the size of the image exceeds the Segment Offset plus one, the tape drive will return data starting at this offset in the firmware image. If the size of the image does not exceed the Segment Offset plus one, the tape drive will return Check Condition status.

Requested Length:

The length, in bytes of the data requested. Provided the size of the image exceeds the Segment Offset plus the Requested Length, the tape drive will return the number of bytes specified by this field. If the size of the image exceeds the Segment Offset plus one but does not exceed the Segment Offset plus the Requested Length, the tape drive will return data beginning at the Segment Offset up to the end of the image.

5.15.2 Get Firmware Segment RDATA

Bit => Byte:	7	6	5	4	3	2	1	0
0 1 2	Data Length (N)							
3 : N+2	Firmware Image Data							

Parameters

Data Length:

The length, in bytes, of the data that follows.

Firmware Image Data:

The firmware image segment.

5.15.3 Notes

This specification does not define the format of the firmware image or the means used to validate it.

This specification does not define the use of the firmware image retrieved from tape. Several possibilities exist. For example, the automation controller could use the image to update the tape drive supplying the image, other tape drives in the library, or the automation controller itself.

A sample process for using this command follows:

- The automation controller loads a tape into the tape drive.
- On receipt of the first Get Firmware Segment command, the tape drive fills its internal buffer from tape and returns the requested image data.
- The tape drive returns more image data in response to further Get Firmware Segment commands.
- If the amount of data requested (Segment Offset plus Requested Length) exceeds the available data, the tape drive returns the available data. The Data Length field in the RDATA always indicates the actual amount of data returned.
- The automation controller unloads the tape from the tape drive.

After the receipt of the first Get Firmware Segment command and automation controller unloads the tape, the HP LTO tape drive will respond to any SCSI command that accesses the media with Busy status or Check Condition status. If this case, the tape drive will set the Sense Key equal to Not Ready and the Additional Sense Code and Qualifier equal to Cause Not Reportable.

At present, the HP LTO tape drive does not support this command. HP expects to support this command in its LTO products in a future release. At present HP have this feature under investigation.

5.16 Get SCSI CDB (0x44) - Optional

If the automation controller has enabled the SCSI Surrogate interface (see section 5.20), this command starts a SCSI Surrogate command sequence.

The automation controller uses this command to receive the SCSI CDB from the tape drive when the tape drive has set the SCSI_ATN_L signal line low. The tape drive will return the SCSI_ATN_L line to a high level when it receives the <ACK> for this command's Response packet.

5.16.1 Get SCSI CDB CMD_OPCODE & CMD_DATA

Bit => Byte:	7	6	5	4	3	2	1	0
0	Op-code = 0x44							
1	Vendor Unique		Reserved					

5.16.2 Get SCSI CDB RDATA

Bit => Byte:	7	6	5	4	3	2	1	0
0	Reserved						Abort	Reset
1	Host Index							
2 : 9	Host Device Name/SCSI Address							
10	CDB Size							
11 : N	CDB							

Reset:

This bit reports whether the tape drive has received a reset for the automation controller. The reset could come from a bus signal, message, or command. The CDB Size field will equal zero when the Reset bit is set.

Abort:

This bit reports whether the tape drive has received an abort for the automation controller. The abort could come from a message or command. The CDB Size field will equal zero when the Abort bit is set.

Host Index:

The tape drive will set this field to reflect the address of the host sending the automation controller command. The automation controller should use this value to identify the sending host in subsequent SCSI Surrogate commands.

Host Device Name/SCSI Address:

On a Fibre Channel tape drive, this field will equal the World Wide Name of the host device.

On a parallel SCSI tape drive, this field will contain the SCSI address of the initiator in bits 0-3 of the first byte (byte 3 of the RDATA). Bit 3 will contain the most significant bit and bit 0 the least significant bit of the SCSI address.

CDB Size:

The length in bytes of the SCSI CDB that follows.

CDB:

The SCSI CDB [SAM, 5.1; SPC, 4.2] received by the tape drive on LUN 1 (the automation controller). The tape drive will order these bytes from least significant byte to most significant byte, i.e., byte 0 of the CDB will appear in byte 12 of the RDATA, byte 1 of the CDB will appear in byte 13 of the RDATA, etc.

5.16.3 Notes

After obtaining a CDB using this command, the automation controller may use either a Send or Receive SCSI Data command (depending on command) to obtain the Data Out and return the Data In for the command. The automation controller must use a Send SCSI Status command to complete the SCSI command with the host.

At present, the HP LTO tape drive does not support this command. HP expects to support this command in its LTO products in a future release. At present HP have this feature under investigation.

5.17 Send SCSI Data (0x45) - Optional

If the automation controller has enabled the SCSI Surrogate interface (see section 5.20), this command transmits data from the automation controller to a SCSI host.

The automation controller uses this command to send a burst of data to the host via the SCSI Surrogate LUN. While processing this command, the tape drive will connect to the host via SCSI, send the data, and then disconnect. The automation controller may use multiple Send SCSI Data commands for a single SCSI command.

5.17.1 Send SCSI Data CMD_OPCODE & CMD_DATA

Bit => Byte:	7	6	5	4	3	2	1	0
0	Op-code = 0x45							
1	Vendor Unique		Reserved					
2	Host Index							
3 4 5	Data Length (N bytes)							
6 : N+5	Data Bytes							

Parameters

Host Index:

The Host Index value from the corresponding Get SCSI CDB Response Packet (see section 5.16.2).

Data Length:

The length in bytes of the Data that follows.

Data Bytes:

The data to transmit to the SCSI host via LUN 1 (the automation controller). The automation controller will order these bytes to conform to the SCSI specification.

5.17.2 Send SCSI Data RDATA

The Response packet for this command contains zero bytes of RDATA.

5.17.3 Notes

At present, the HP LTO tape drive does not support this command. HP expects to support this command in its LTO products in a future release. At present HP have this feature under investigation.

5.18 Get SCSI Data (0x46) - Optional

If the automation controller has enabled the SCSI Surrogate interface (see section 5.20), this command receives data from a SCSI host for the automation controller.

The automation controller uses this command to receive a burst of data from a SCSI host via the Surrogate SCSI LUN. Upon receipt of this command, the tape drive will connect to the host via SCSI, receive the data, and then disconnect. The automation controller may issue multiple Get SCSI Data commands for a single SCSI command.

5.18.1 Get SCSI Data CMD_OPCODE & CMD_DATA

Bit => Byte:	7	6	5	4	3	2	1	0
0	Op-code = 0x46							
1	Vendor Unique	Reserved						
2	Host Index							
3 4 5	Data Length (N bytes)							

Parameters

Host Index:

The Host Index value from the corresponding Get SCSI CDB Response Packet (see section 5.16.2).

Data Length:

The length in bytes of the data to accept from the SCSI host and the length in bytes of data returned to the automation controller in the RDATA.

5.18.2 Get SCSI Data RDATA

Bit => Byte:	7	6	5	4	3	2	1	0
0 : N	Data Bytes							

Data Bytes:

The data received from the SCSI host via LUN 1 (the automation controller). The tape drive will order these bytes to conform to the SCSI specification.

5.18.3 Notes

At present, the HP LTO tape drive does not support this command. HP expects to support this command in its LTO products in a future release. At present HP have this feature under investigation.

5.19 Send SCSI Status (0x47) - Optional

If the automation controller has enabled the SCSI Surrogate interface (see section 5.20), this command transmits status from the automation controller to a SCSI host.

The automation controller uses this command to send SCSI Status to a SCSI host and Sense data to the tape drive.

5.19.1 Send SCSI Status CMD_OPCODE & CMD_DATA

Bit => Byte:	7	6	5	4	3	2	1	0
0	Op-code = 0x47							
1	Vendor Unique		Reserved					
2	Host Index							
3	Status							
4	Sense Data Length (N)							
5 : N+4	Sense Data							

Parameters

Host Index:

The Host Index value from the corresponding Get SCSI CDB Response Packet (see section 5.16.2).

Status:

The SCSI Status [SAM, 5.2] for return to the SCSI host.

Sense Data Length:

The length in bytes of the SCSI Sense Data that follows.

Sense Data:

SCSI Sense Data for the command [SAM, 5.6.4; SPC, 7.20].

5.19.2 Send SCSI Status RDATA

The Response packet for this command contains zero bytes of RDATA.

5.19.3 Notes

At present, the HP LTO tape drive does not support this command. HP expects to support this command in its LTO products in a future release. At present HP have this feature under investigation.

5.20 Configure SCSI Surrogate (0x48) - Optional

This command turns on Surrogate SCSI mode in the tape drive.

Once configured to act as a SCSI Surrogate, the tape drive will accept commands sent to LUN 1 for transmission to the automation controller via the ACI.

For performance reasons, the tape drive will cache the automation controller's normal inquiry data. The tape drive will respond to a SCSI Inquiry command sent to LUN 1 with the EVPD bit off without passing the Inquiry command on to the automation controller.

5.20.1 Configure SCSI Surrogate CMD_OPCODE & CMD_DATA

Bit => Byte:	7	6	5	4	3	2	1	0
0	Op-code = 0x48							
1	Vendor Unique		Reserved					
2	Inquiry Data Length (N)							
3 : N+2	Inquiry Data							

Parameters

Inquiry Data Length:

The length in bytes of the Inquiry Data that follows.

Inquiry Data:

The Inquiry Data that the tape drive will return in response to a SCSI Inquiry command to LUN 1 with the EVPD bit off.

5.20.2 Configure SCSI Surrogate RDATA

The Response packet for this command contains zero bytes of RDATA.

5.20.3 Notes

An automation controller using Surrogate SCSI operation should send this command prior to any Set Drive Configuration command (see section 5.6). Failure to follow this order will result in Check Condition status returned for the Configure SCSI Surrogate command. The tape drive will set the Error Information to:

- Sense Key equals Illegal Request (0x5)
- Additional Sense Code and Qualifier equal Command Sequence Error (0x2C00).

At present, the HP LTO tape drive does not support this command. HP expects to support this command in its LTO products in a future release. At present HP have this feature under investigation.

5.21 Get Buffer Size (0x49) - Optional

The automation controller uses this command to retrieve the size of various ACI-related buffers within the tape drive.

5.21.1 Get Buffer Size CMD_OPCODE & CMD_DATA

Bit => Byte:	7	6	5	4	3	2	1	0
0	Op-code = 0x49							
1	Vendor Unique		Reserved					

5.21.2 Get Buffer Size RDATA

Bit => Byte:	7	6	5	4	3	2	1	0
0 1 2 3	Receive Burst Buffer Size							
4 5 6 7	Receive Packet Buffer Size							
8 9 10 11	Transmit Burst Buffer Size							
12 13 14 15	Transmit Packet Buffer Size							

Parameters

Receive Burst Buffer Size:

The size in bytes of the ACI receive burst buffer within the tape drive. When receiving packets larger than this size, the tape drive may use XOFF/XON flow control to regulate the automation controller's transmission.

Receive Packet Buffer Size:

The size in bytes of the ACI receive packet buffer within the tape drive. The tape drive cannot receive packets larger than this size.

Transmit Burst Buffer Size:

The size in bytes of the ACI transmission burst buffer within the tape drive.

Transmit Packet Buffer Size:

The size in bytes of the ACI transmission packet buffer within the tape drive. The tape drive cannot transmit packets larger than this size.

5.21.3 Notes

At present, the HP LTO tape drive does not support this command. HP expects to support this command in its LTO products in a future release. At present HP have this feature under investigation.

5.22 Send Firmware Segment (0x4A) - Optional

This command allows an automation controller to send a firmware image segment to the tape drive. After sending a complete firmware image using by using this command multiple times, the automation controller may instruct the tape drive to upgrade its micro-code using the firmware image.

This command provides an alternative to the Send Firmware Image command (see section 5.14) for upgrading the tape drive's micro-code. The automation controller must not intermix the use of the Send Firmware Image and Send Firmware Segment commands.

5.22.1 Send Firmware Segment CMD_OPCODE & CMD_DATA

Bit => Byte:	7	6	5	4	3	2	1	0
0	Op-code = 0x4A							
1	Vendor Unique		Reserved			Action		
2 3 4	Remaining Image Length							
5 6	Segment Length (N)							
7 : N+6	Firmware Image Data							

Parameters

Action:

This field allows the automation controller to control the use of the firmware image sent with this and previous Send Firmware Segment commands. The table below specifies the purpose of each field value.

Action	
Value	Purpose
0x0	Reserved
0x1	Abort
0x2	Reserved
0x3	Start Image
0x4	Extend Image
0x5	Extend Image and Upgrade
0x6 - 0x7	Reserved

If the tape drive detects a reserved value in the Action parameter or a value that does not conform to the sequence requirements specified below, it will send a Response packet with Status equal to Check Condition, and it will set the Error Information to:

- Sense Key equals Illegal Request (0x5)
- Additional Sense Code and Qualifier equal Invalid Field in CDB (0x2400).

Abort

With Action equal to Abort, the tape drive will discard all Firmware Image Data sent since the receipt of the last Send Firmware Segment command with Action equal to Start Image. The next Send Firmware Segment command sent by the automation controller must have Action equal to Start Image.

The automation controller may not send this command with Action equal to Abort without having previously sent, for this firmware image, a Send Firmware Segment command with Action equal to Start Image.

Start Image

Between the receipt of a Send Firmware Segment command with Action equal to Start Image and a subsequent Send Firmware Segment command with Action equal to either Abort or Extend Image and Upgrade, the tape drive will consider the segments received using multiple Send Firmware Segment commands as belonging to a single firmware image. The automation controller must set the Action parameter equal to Start Image for the first segment in the image.

The automation controller may not send this command with Action equal to Start Image after having previously sent, for this same firmware image, a Send Firmware Segment command with Action equal to Start Image without an intervening Send Firmware Segment command with Action equal to either Abort or Extend Image and Upgrade.

Extend Image

With Action equal to Extend Image, the tape drive will append the Firmware Image Data to previously received segments for the same firmware image.

The automation controller may not send this command with Action equal to Extend Image without having previously sent, for this firmware image, a Send Firmware Segment command with Action equal to Start Image.

Extend Image and Upgrade

With Action equal to Extend Image and Upgrade and Remaining Image Length equal to zero, the tape drive will append the Firmware Image Data to previously received segments of the same firmware image, and then the tape drive will check the firmware image for validity. If the tape drive detects a valid firmware image, it will send the Response packet with Good status, and after receiving the <ACK> from the automation controller the tape drive will upgrade its micro-code and perform a Drive Reset to start executing the new micro-code (see section 4.7). If the tape drive detects an invalid firmware image, it will send a Response packet with Check Condition status, and it will set the Error Information to:

- Sense Key equals Illegal Request (0x5)
- Additional Sense Code and Qualifier equal Bad Microcode Detected (0x8283).

The automation controller may not send this command with Action equal to Extend Image and Upgrade and with the Remaining Image Length not equal to zero.

The automation controller may not send this command with Action equal to Extend Image and Upgrade without having previously sent, for this firmware image, a Send Firmware Segment command with Action equal to Start Image.

Remaining Image Length:

The amount, in bytes, of firmware image data remaining after this segment to form a complete firmware image. This field must equal zero if Action equals Extend Image and Upgrade.

Segment Length:

The length of this segment of the firmware image in bytes. This parameter must have a value less than or equal to the Receive Packet Buffer Size reported by the Get Buffer Size command (see section 5.21) minus fourteen to ensure that the Command packet does not exceed the size of the Receive Packet buffer in the tape drive. If the tape drive detects a value in excess of this limit, it will send a Response packet with Status equal to Check Condition, and it will set the Error Information to:

- Sense Key equals Illegal Request (0x5)
- Additional Sense Code and Qualifier equal Invalid Field in CDB (0x2400).

Firmware Image Data:

The firmware image being transferred.

5.22.2 Send Firmware Segment RDATA

The Response packet for this command contains zero bytes of RDATA.

5.22.3 Notes

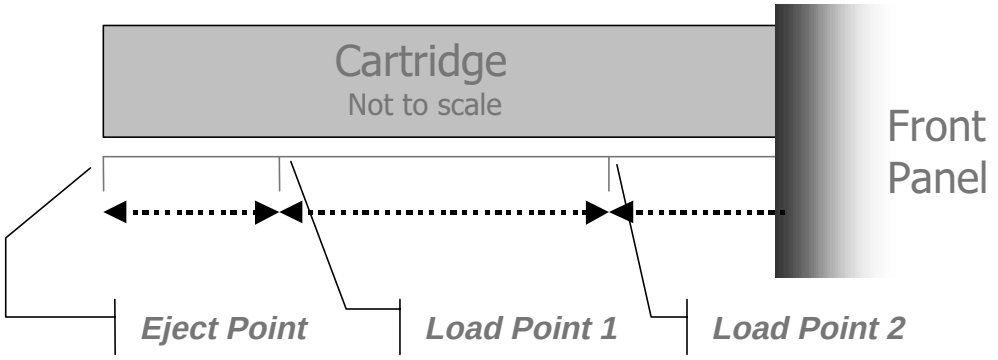
This specification does not define the format of the firmware image or the means used to validate it.

Depending of its state at the time it receives this command with Action equal to Start Image, the HP LTO tape drive may require several minutes to configure itself for receipt of further segments. The HP LTO tape drive will not send the Response packet for the command until the configuration has completed. To minimize the amount of time required, HP recommend that the automation controller unload any tape from the tape drive prior to issuing this command. In the unloaded state, the HP LTO tape drive will respond to this command within 1 second.

6 Load/Unload Operation

6.1 Definitions

This specification defines four cartridge positions that affect Load and Unload operations:



Eject Point The tape drive ejects a cartridge to this position. The automation controller cannot configure the location of this position.

Load Point 1 If Auto-Load is set then the tape drive will start to load the cartridge when it reaches this point.

If Auto-Load is not set, the automation controller must insert the cartridge into the tape drive to a position between Load Point 1 and Load Point 2. The automation controller may then issue a Load command over the ACI to instruct the tape drive to load and thread the cartridge.

Note:

In tape drives that support a configurable Auto-Load Point, the automation controller can use the Set Drive Configuration command to change the location of Load Point 1 (see section 5.6).

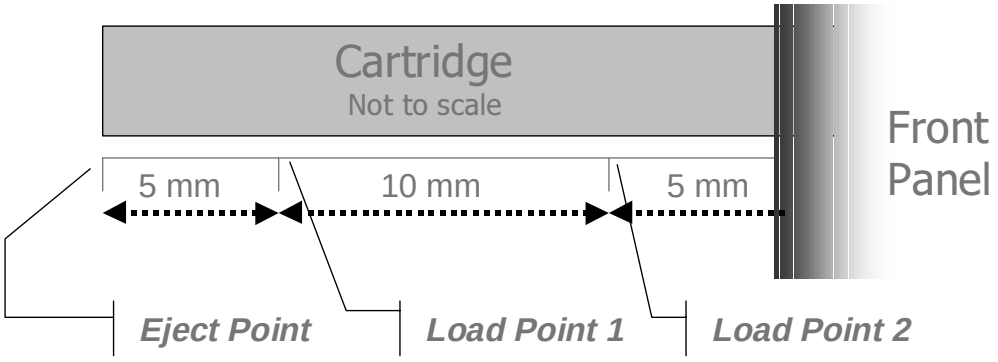
Load Point 2 This position is the furthest location that the automation controller can insert the cartridge into the tape drive without damaging the tape drive. The automation controller cannot configure the location of this position.

There is one other point of note.

Hold Point If the Auto-Eject configuration is not set then when the tape drive receives an unload command, it will rewind and unthread the media. The tape drive will leave the cartridge seated at the Hold Point. The automation controller cannot configure the location of this position.

Notes:

The diagram and paragraphs below provide cartridge position measurements for the HP LTO tape drive.



Eject Point 20mm beyond the Front Panel and 25mm beyond the front of the mechanism.

Load Point 1 At power-on and after a drive reset, 15mm beyond the Front Panel and 20mm beyond the front of the mechanism. At present, not configurable in the HP LTO tape drive.

Load Point 2 5mm beyond the Front Panel and 10mm beyond the front of the mechanism.

Examples:

Load Scenario 1: Auto-Load

1. The automation controller sends an ACI Set Configuration command to enable Auto-Load.
2. The Host sends a Move Medium command to robotics.
3. The Picker gets a cartridge from a storage slot.
4. Picker inserts the cartridge into tape drive aperture.
5. Picker pushes cartridge to Load Point 1 (default).
   Note exact point of Load Point 1 is configurable.
6. Tape drive automatically takes cartridge, loads and threads it.

Load Scenario 2: ACI Controlled

1. The Host sends a Move Medium command to robotics.
2. Picker gets a cartridge from a storage slot.
3. Picker inserts cartridge to between Load Point 1 and Load Point 2.
4. Picker lets go of cartridge.
5. Automation controller sends ACI Load command to tape drive.

6. Tape drive takes cartridge and loads/threads it.

Unload Scenario 1: Auto-Eject

1. The automation controller sends an ACI Set Configuration command to enable Auto-Eject.
2. Host sends SCSI unload command to tape drive.
3. Tape drive rewinds, unthreads, and ejects cartridge to Eject Point.
4. Host sends Move Medium command to robotics.
5. Picker takes cartridge from tape drive and places it in storage slot.

Unload Scenario 2: ACI Controlled

1. Host sends SCSI unload command to tape drive.
2. Tape drive rewinds and unthreads tape. It pauses with the cartridge at the Hold Point.
3. Automation controller sends ACI Unload command to eject cartridge.
4. Tape drive ejects tape to Eject Point.
5. Picker takes cartridge from tape drive and places it in storage slot.

7 Bibliography

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