dpANS

Project T10/1557-D

Revision 4
30 April 2003

Information technology - Automation/Drive Interface - Transport Protocol (ADT)

T10 Technical Editor:

Paul Entzel
Quantum Corporation
4001 Discovery Drive
Boulder, CO 80303
USA

Telephone: 720-406-5782
Facsimile: 720-406-5762
Email: paul.entzel@quantum.com

Reference number
ISO/IEC XXXXX-XXX : 200x
ANSI NCITS.*:200x**

Printed April 30, 2003

Points of Contact:

T10 Chair
John B. Lohmeyer
LSI Logic
4420 Arrows West Drive
Colorado Springs, CO 80907-3444
Tel: (719) 533-7560
Fax: (719) 533-7183
Email: lohmeyer@t10.org

T10 Vice-Chair
George O. Penokie
IBM/Tivoli
3605 Highway 52 N
MS: 2C6
Rochester, MN 55901
Tel: (507) 253-5208
Fax: (507) 253-2880
Email: gpenokie@tivoli.com

IINCITS Secretariat
IINCITS Secretariat
1250 Eye Street, NW Suite 200
Washington, DC 20005
Telephone: 202-737-8888
Facsimile: 202-638-4922
Email: iINCITS@itic.org

T10 Web Site www.t10.org

T10 Reflector To subscribe send e-mail to majordomo@T10.org with ‘subscribe’ in message body
To unsubscribe send e-mail to majordomo@T10.org with ‘unsubscribe’ in message body
Internet address for distribution via T10 reflector: T10@T10.org

Document Distribution
Global Engineering
15 Inverness Way East
Englewood, CO 80112-5704
Telephone: 303-792-2181 or
800-854-7179
Facsimile: 303-792-2192

Revision Information

1 Revision History

1.1 Revision 0 (05 April 2002)

- Began this revision from T10 Template

1.2 Revision 1 (3 December 2002)

- Updated Scope clause to change from multiple connections to a point-to-point connection. Updated the description of the port types for the automation and the data transport device. Changed Figure 1 to match the figure from SAS.
- Changed the clauses to match the flow used in SAS.
- Incorporated proposal 02-329r2
- Incorporated proposal 02-270r0 changing the SOF, EOF, and Escape character definitions to TBD.

1.3 Revision 2 (19 February 2003)

Editorial changes discussed via email:

- Fix Figure 3 missing terms.
- Spell out ULP.
- Standardize use of the terms “frame type” and “payload type”.
- Reworded the FRAME NUMBER field description in the NAK IU sub clause.

Changes agreed to at the working group meeting in Portland. See 03-041r0:

- Changed SCSI Command Frame to SCSI Request IU.
- Changed SOF, EOF, and EXC characters from TBD to values agreed to at the meeting.
- Changed encoding action of ESC character from OR to XOR.
- Changed from using the term “frame” to “information unit” or IU when describing specific frame types.
- Added an editors note to the Checksum sub clause.
- Add wording to sub clause 6.5.7 clarifying Port Login negotiations use a single exchange ID and X_Origin.
- Replaced SPECIAL field in Port Login IU with 2 bit VENDOR UNIQUE field.
- Removed PC field from Port Login IU.
- Remove “Disable surrogate mode” bullet from actions of a port logout.
- Added sentence to NOP IU sub clause indicating there is no payload.
- In sub clause 6.6.1.3, clarify FRAME NUMBER field.
- Specify FRAME NUMBER field for a new port login exchange start at 0.
- Changed 00h TASK MANAGEMENT FUNCTION field value to match SPI-5 and SAS.
- Add sentence to AER Control IU sub clause stating the AER control field are set to 0 at the start of a port login exchange.

Proposals approved by ADI working group at the 29 January 2003 conference call. See 03-069r0.

- 03-078r1.
- 03-079r0.
- 03-082r0.
- email from Erik Oetting changing the SOF, EOF, and ESC characters.

1.4 Revision 3 (25 March 2003)

Proposals approved by the ADI working group at the 29 January 2003 conference call. See 03-069:

- 02-358r4.

Proposals approved by the ADI working group at the 12 February 2003 conference call. See 03-086:

- 03-080r2.

Editorial changes suggested by the following emails:

- From Susan Gray, dated 26 February 2003.
- Paul Entzel's reply to message from Michael Banter, dated 28 February 2003.
- Paul Suhler's reply to message from Paul Entzel, dated 28 February 2003.
- From Lee Jesionowski, dated 11 March 2003.
- From Kevin Butt, dated 10 March 2003, except the definition changes and several of the questions.

Updated the documents listed in clause 1 and the reference documents per the list in SPC-3 revision 11.

Proposals approved by the ADI working group at the 10-11 March 2003 meeting in Dallas, TX. See 03-117:

- 03-101r1.

Other changes without formal proposals approved by the ADI working group at the 10-11 March 2003 meeting in Dallas, TX. See 03-117:

- Modified sub clause 6.5.4 state 1 text regarding frames to ignore and NAK per Kevin Butt's email.
- Added a statement to the definition of the MAXIMUM ACK OFFSET field that all ports shall be capable of supporting a value of 1.
- Add list entry in sub clause 6.5.5 stating port parameters revert to default after a port logout.
- Changed the definition of NAK status code 84h and add a range of values in each group of NAK status code for vendor specific status codes.
- Add text in sub clause 6.5.2.1 that a port shall discard frames that do not contain an SOF and EOF.
- Add editors note that a frame numbering section is required in clause 4.
- Change text in Pause IU sub clause such that is can only be generated by an automation device port.
- Add CLEAR TASK SET and CLEAR ACA task management functions.

1.5 Revision 4 (30 April 2003)

Proposals approved by the ADI working group at the 8 April 2003 conference call. See 03-159:

- 03-152r0, accepted as editorial.
- 03-153r1.
- Change connector standard to SFF-8054.

Proposals approved by the ADI working group at the 23 April 2003 conference call. See 03-161:

- 03-141r1.

Updates to subclause 5 based on ommitions from 02-358r4 that were approved by the working group and listed in Michael Banther's email of 28 April 2003.

ANSI (r)
NCITS.*:200x**

Draft

American National Standards
for Information Systems -

Automation/Drive Interface - Transport Protocol (ADT)

Secretariat
National Committee for Information Technology Standards

Approved mm dd yy

American National Standards Institute, Inc.

Abstract

This standard specifies the transport requirements for the SCSI automation drive interface device type. This standards permits the SCSI automation drive interface device type to attach to application clients and provides the definitions for their use.

This standard does not contain material related to any command or transport structure for automation drive interface devices, which is used in conjunction with this standard. For reference to command structure and transports, refer to automation drive interface command and transport documents.

Draft

American National Standard

Approval of an American National Standard requires verification by ANSI that the requirements for due process, consensus, and other criteria for approval have been met by the standards developer. Consensus is established when, in the judgment of the ANSI Board of Standards Review, substantial agreement has been reached by directly and materially affected interests. Substantial agreement means much more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered and that effort be made toward their resolution.

The use of American National Standards is completely voluntary; their existence does not in any respect preclude anyone, whether he or she has approved the standards or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not confirming to the standards.

The American National Standards Institute does not develop standards and will in no circumstances give interpretation on any American National Standard in the name of the American National Standards Institute. Requests for interpretations should be addressed to the secretariat or sponsor whose name appears on the title page of this standard.

CAUTION NOTICE: This American National Standard may be revised or withdrawn at any time. The procedures of the American National Standards Institute require that action be taken periodically to reaffirm, revise, or withdraw this standard. Purchasers of American National Standards may receive current information on all standards by calling or writing the American National Standards Institute.

CAUTION: The developers of this standard have requested that holders of patents that may be required for the implementation of the standard, disclose such patents to the publisher. However, neither the developers nor the publisher have undertaken a patent search in order to identify which, if any, patents may apply to this standard.

As of the date of publication of this standard, following calls for the identification of patents that may be required for the implementation of the standard, notice of one or more claims has been received. By publication of this standard, no position is taken with respect to the validity of this claim or of any rights in connection therewith. The patent holders have, however, filed a statement of willingness to grant a license under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license. Details may be obtained from the publisher.

No further patent search is conducted by the developer or the publisher in respect to any standard it processes. No representation is made or implied that licenses are not required to avoid infringement in the use of this standard.

Published by
American National Standards Institute
11 West 42nd Street, New York, NY 10036

Printed in the United States of America

Contents

Tables

Figures

Foreword

This foreword is not part of American National Standard NCITS.***:200x.

This draft specification covers the Automation Drive Interface - Transport Protocol. The ADI working group address the interface between removable media library controllers and the physical drives resident in those libraries. This specific document covers the transport mechanisms of that interface, specifically the encapsulation, logical transmission, and end-point delivery and reception of the commands associated with the ADI effort.

With any technical document there may arise questions of interpretation as new products are implemented. INCITS has established procedures to issue technical opinions concerning the standards developed by INCITS. These procedures may result in SCSI Technical Information Bulletins being published by INCITS.

These Bulletins, while reflecting the opinion of the Technical Committee that developed the standard, are intended solely as supplementary information to other users of the standard. This standard, ANSI NCITS.***:200x, as approved through the publication and voting procedures of the American National Standards Institute, is not altered by these bulletins. Any subsequent revision to this standard may or may not reflect the contents of these Technical Information Bulletins.

Current IINCITS practice is to make Technical Information Bulletins available through:

IINCITS Online Store	http://www.techstreet.com/IINCITS.html
managed by Techstreet	Telephone: 1-734-302-7801 or
1327 Jones Drive	1-800-699-9277
Ann Arbor, MI 48105 Facsimile:	1-734-302-7811

or

Global Engineering	http://global.ihs.com/
15 Inverness Way East	Telephone: 1-303-792-2181 or
Englewood, CO 80112-5704	1-800-854-7179
	Facsimile: 1-303-792-2192

Requests for interpretation, suggestions for improvement and addenda, or defect reports are welcome. They should be sent to the INCITS Secretariat, National Committee for Information Technology Standards, Information Technology Institute, 1250 Eye Street, NW, Suite 200, Washington, DC 20005-3922.

This standard was processed and approved for submittal to ANSI by the National Committee for Information Technology Standards (INCITS). Committee approval of the standard does not necessarily imply that all committee members voted for approval. At the time of it approved this standard, INCITS had the following members:

(Editor's Note: Insert INCITS member list)

Technical Committee T10 on Lower Level Interfaces, which developed and reviewed this standard, had the following members:(Editor's Note: Update for current membership)

Introduction

The Automation/Drive Interface - Transport Protocol (ADT) standard is divided into eight clauses:

Clause 1 is the scope.
Clause 2 enumerates the normative references that apply to this standard.
Clause 3 describes the definitions, symbols, and abbreviations used in this standard.
Clause 4 describes the conceptual relationship between this document and the SCSI-3 Architecture Model.
Clause 5 describes the physical layer including connectors and signal levels.
Clause 6 describes the link layer including encoding, frame format, and link services functions.
Clause 7 describes the transport layer and include the method of encapsulating SCSI.
Clause 8 describes the mapping between SCSI protocol services defined in SAM-2 and the services provided by this protocol.

The annexes provide information to assist with implementation of this standard.

American National Standard **INCITS.***:200x**

American National Standard for Information Systems - Information Technology - Automation/Drive Interface - Transport Protocol (ADT)

1 Scope

This standard defines the protocol requirements of the Automation/Drive Interface - Transport Protocol to allow conforming ADI SCSI devices to inter-operate. The objectives of ADT are:

a) To provide a low cost interconnect method between a library controller and the data transport devices that reside within the medium changer's domain. To standardize this interface such that different disk drives, tape drives, optical media drives, and other SCSI devices may be added to conforming libraries without requiring modifications to generic system hardware.
b) Provision is made for the addition of special features and functions through the use of vendor-specific options. Reserved areas are provided for future standardization.

The interface protocol includes provision for the connection of two SCSI ports. One of these ports is intended to be attached to a medium changer device and may operate either as a SCSI initiator port or a SCSI initiator/target port. The other device is intended to be attached to a data transport type device (i.e. a disk drive, tape drive, or optical medium device) and may operate as either a SCSI target port or SCSI initiator/target port. No provision is made for connection of more than two ports.

This standard defines the transport attributes of an input/output Automation/Drive Interface for interconnecting a conforming medium changer device to a conforming data transport device.

The set of SCSI standards specifies the interfaces, functions, and operations necessary to ensure interoperability between conforming SCSI implementations. This standard is a functional description. Conforming implementations may employ any design technique that does not violate interoperability.

Figure 1 is intended to show the general structure of SCSI standards. The figure is not intended to imply a relationship such as a hierarchy, protocol stack, or system architecture.

At the time this standard was generated examples of the SCSI general structure included:

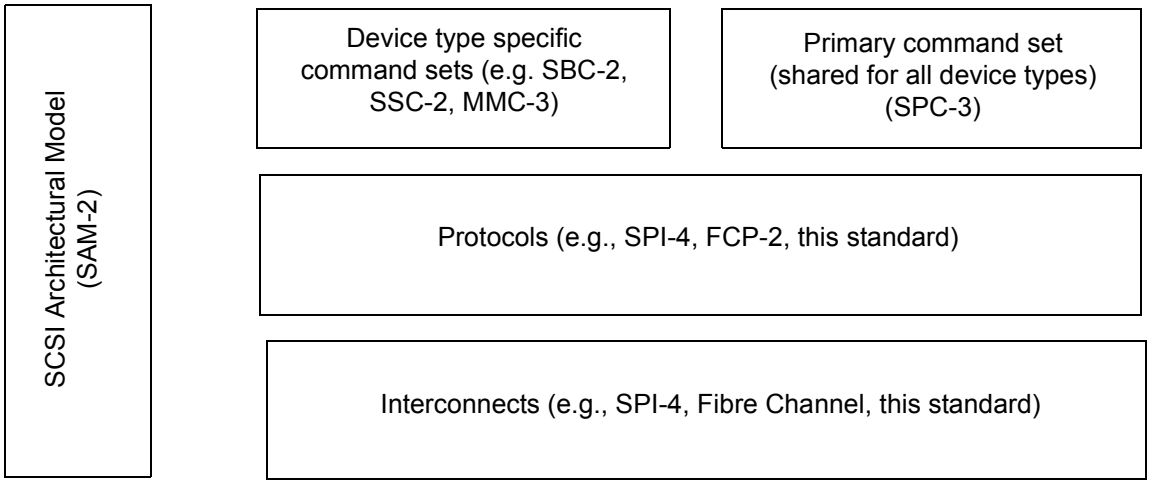


Figure 1 — General Document Structure of SCSI

Physical Interconnects:

Fibre Channel Arbitrated Loop - 2	FC-AL-2	[ISO/IEC 14165-122] [ANSI NCITS.332-1999] [ANSI NCITS.332-1999/AM1]
Fibre Channel Physical Interfaces	FC-PI	[ANSI INCITS.352-2002]
Fibre Channel Physical Interfaces - 2	FC-PI-2	[T11/1506-D]
Fibre Channel Framing and Signaling Interface	FC-FS	[T11/1331-D]
High Performance Serial Bus		[ANSI IEEE 1394-1995]
High Performance Serial Bus (supplement to ANSI/IEEE 1394-1995)		[ANSI IEEE 1394a-2000]
SCSI Parallel Interface - 2	SPI-2	[ISO/IEC 14776-112] [ANSI X3.302-1999]
SCSI Parallel Interface - 3	SPI-3	[ISO/IEC 14776-113] [ANSI NCITS.336-2000]
SCSI Parallel Interface - 4	SPI-4	[ISO/IEC 14776-114] [ANSI INCITS.362-2002]
SCSI Parallel Interface - 5	SPI-5	[ISO/IEC 14776-115] [ANSI INCITS.367:200x]
Serial Storage Architecture Physical Layer 1	SSA-PH	[ANSI X3.293-1996]
Serial Storage Architecture Physical Layer 2	SSA-PH-2	[ANSI NCITS.307-1998]
Serial Attached SCSI	SAS	[T10/1562-D]
Serial Attached SCSI - 2	SAS-2	[T10/1601-D]

Transport Protocols:

Automation/Drive Interface - Transport Protocol	ADT	[T10/1557-D]
Serial Storage Architecture Transport Layer 1	SSA-TL-1	[ANSI X3.295-1996]
Serial Storage Architecture Transport Layer 2	SSA-TL-2	[ANSI NCITS.308-1998]
SCSI-3 Fibre Channel Protocol	FCP	[ISO/IEC 14776-221] [ANSI X3.269-1996]

SCSI Fibre Channel Protocol - 2	FCP-2	[ISO/IEC 14776-222] [ANSI NCITS.350-2003]
SCSI Fibre Channel Protocol - 3	FCP-3	[ISO/IEC 14776-223] [T10/1560-D]
Serial Bus Protocol - 2	SBP-2	[ISO/IEC 14776-232] [ANSI NCITS.325-1999]
Serial Bus Protocol - 3	SBP-3	[ISO/IEC 14776-233] [T10/1467-D]
Serial Storage Architecture SCSI-3 Protocol	SSA-S3P	[ANSI NCITS.309-1998]
SCSI RDMA Protocol	SRP	[T10/1415-D]

Shared Command Set:

SCSI-3 Primary Commands	SPC	[ISO/IEC 14776-311] [ANSI X3.301-1997]
SCSI Primary Commands - 2	SPC-2	[ISO/IEC 14776-312] [ANSI NCITS.351-2001]
SCSI Primary Commands - 3	SPC-3	[ISO/IEC 14776-313] [T10/1416-D]

Device-Type Specific Commands Sets:

SCSI-3 Block Commands	SBC	[ISO/IEC 14776-321] [ANSI NCITS.306-1998]
SCSI Block Commands - 2	SBC-2	[ISO/IEC 14776-322] [T10/1417-D]
SCSI-3 Stream Commands	SSC	[ISO/IEC 14776-331] [ANSI NCITS.335-2000]
SCSI Stream Commands - 2	SSC-2	[ISO/IEC 14776-332] [T10/1434-D]
SCSI Stream Commands - 3	SSC-3	[ISO/IEC 14776-333] [T10/?1611-D]
SCSI-3 Medium Changer Commands	SMC	[ISO/IEC 14776-351] [ANSI NCITS.314-1998]
SCSI Media Changer Commands - 2	SMC-2	[ISO/IEC 14776-352] [T10/1383-D]
SCSI-3 Multimedia Command Set	MMC	[ANSI X3.304-1997]
SCSI Multimedia Command Set - 2	MMC-2	[ISO/IEC 14776-362] [ANSI NCITS.333-2000]
SCSI Multimedia Command Set - 3	MMC-3	[ISO/IEC 14776-363] [ANSI INCITS.360-2002]
SCSI Multimedia Command Set - 4	MMC-4	[ISO/IEC 14776-364] [T10/1545-D]
SCSI Controller Commands - 2	SCC-2	[ISO/IEC 14776-342] [ANSI NCITS.318-1998]
SCSI Reduced Block Commands	RBC	[ISO/IEC 14776-326] [ANSI NCITS.330-2000]
SCSI-3 Enclosure Services Commands	SES	[ISO/IEC 14776-371] [ANSI NCITS.305-1998]

SCSI Enclosure Services Commands - 2	SES-2	[ISO/IEC 14776-372] [T10/1559-D]
SCSI Specification for Optical Card Reader/Writer	OCRW	[ISO/IEC 14776-381]
Object-based Storage Devices Commands	OSD	[T10/1355-D]
SCSI Management Server Commands	MSC	[T10/1528-D]

Architecture Model:

SCSI-3 Architecture Model	SAM	[ISO/IEC 14776-411] [ANSI X3.270-1996]
SCSI Architecture Model - 2	SAM-2	[ISO/IEC 14776-412] [ANSI INCITS.366-2003]
SCSI Architecture Model - 3	SAM-3	[ISO/IEC 14776-413] [T10/1561-D]

The term SCSI is used to refer to the family of standards described in this clause.

2 Normative References

Editors Note 1 - pge: This clause will contain a list of other standards whose requirements are incorporated in this standard by reference. This may include approved references, references in the development process, or others. Edit this section as appropriate.

2.1 Normative references

The following standards contain provisions that, by reference in the text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below.

Copies of the following documents may be obtained from ANSI: approved ANSI standards, approved and draft international and regional standards (ISO, IEC, CEN/CENELEC, ITUT), and approved and draft foreign standards (including BSI, JIS, and DIN). For further information, contact ANSI Customer Service Department at 212-642-4900 (phone), 212-302-1286 (fax) or via the World Wide Web at http://www.ansi.org.

Additional availability contact information is provided below as needed.

2.2 Approved references

ISO/IEC 14776-412, SCSI Architecture Model - 2 (SAM-2) [ANSI INCITS.366-2003]

ISO/IEC 14776-113, SCSI Parallel Interface - 3 (SPI-3) [ANSI NCITS.336-2000]

ISO/IEC 14776-222, SCSI Fibre Channel Protocol - 2 (FCP-2) [ANSI INCITS.350:2003]

ISO/IEC 14776-351, SCSI-3 Medium Changer Commands (SMC) [ANSI NCITS.314:1998]

ISO/IEC 14766-332, SCSI-3 Stream Commands (SSC) [ANSI NCITS.335-2000]

2.3 References under development

At the time of publication, the following referenced standards were still under development. For information on the current status of the document, or regarding availability, contact the relevant standards body or other organization as indicated.

ISO/IEC 14776-413, SCSI Architecture Model - 3 (SAM-3) [T10/1561-D]

ISO/IEC 14776-xxx, SCSI Primary Commands-3 (SPC-3) [T10/1416-D]

ISO/IEC 14766-xxx, SCSI Stream Commands-2 (SSC-2) [T10/1434-D]

ISO/IEC 1476-xxx, SCSI Medium Changer Commands-2 (SMC-2) [T10/1383-D]

ISO/IEC 1476-xxx, Fibre Channel Protocol for SCSI, Second Version (FCP-2) [T10/1144-D]

NOTE 1 For more information on the current status of the document, contact the IINCITS Secretariat at 202-737-8888 (phone), 202-638-4922 (fax) or via Email at iINCITS@itic.org. To obtain copies of this document, contact Global Engineering at 15 Inverness Way, East Englewood, CO 80112-5704 at 303-792-2181 (phone), 800-854-7179 (phone), or 303-792-2192 (fax).

2.4 Other references

For information on the current status of the listed document(s), or regarding availability, contact the indicated organization.

SFF-8054, Automation Drive Interface *Connector*

NOTE 2 For more information on the current status of the document, contact the SFF committee at 408-867-6630 (phone), or 408-867-2115 (fax). To obtain copies of this document, contact the SFF committee at 14426 Black Walnut Court, Saratoga, CA 95070 at 408-867-6630 (phone) or 408-741-1600 (fax).

ASTM D-4566, *Standard Test Methods for Electrical Performance Properties of Insulations and Jackets for Telecommunications Wire and Cable*

ANSI/TIA/EIA-422-B-1994 Electrical Characteristics of Balanced Voltage Digital Interface Circuits. (RS-422)

3 Definitions, symbols, abbreviations, and conventions

3.1 Definitions

3.1.1 acknowledgement IU: An ACK information unit (IU) or NAK IU. See 6.5.3.

3.1.2 application client: An object that is the source of SCSI commands. Further definition of an application client is found in SCSI Architecture Model-2 standard

3.1.3 auto-contingent allegiance: An optional condition of a task set following the return of a CHECK CONDITION status. See SCSI Architecture Model-2 standard for a detailed definition of auto-contingent allegiance.

3.1.4 byte: Indicates an 8-bit construct.

3.1.5 device server: An object within a logical unit that processes SCSI tasks according to the rules for task management as described in SCSI Architecture Model-2 standard.

3.1.6 data transfer device: A component within an automation system capable of accessing the data stored on a removable medium.

3.1.7 exchange: The basic mechanism which transfers information consisting of one or more related information units which may flow in the same or opposite directions. An exchange is identified by its X_Origin and Exchange ID. See 6.3.

3.1.8 expected frame number: The value in the FRAME NUMBER field that a receiver port expects in the next frame. See 6.3.

3.1.9 field: A group of one or more contiguous bits.

3.1.10 hard reset: A response to a power on or reset condition in which the SCSI device performs the operations described .

3.1.11 I_T nexus: A nexus that exists between a SCSI initiator port and a SCSI target port.

3.1.12 I_T_L nexus: A nexus that exists between a SCSI initiator port, a SCSI target port, and a logical unit. This relationship replaces the prior I_T nexus.

3.1.13 I_T_L_Q nexus: A nexus between a SCSI initiator port, a SCSI target port, a logical unit, and a queue tag following the successful receipt of a queue tag. This relationship replaces the prior I_T nexus or I_T_L nexus.

3.1.14 logical unit: A SCSI target device object, containing a device server and task manager, that implements a device model and manages tasks to process SCSI commands sent by an application client.

3.1.15 logical unit number: An identifier for a logical unit.

3.1.16 logical unit reset: A logical unit action in response to a logical unit reset event in which the logical unit performs the operations described in SAM–2.

3.1.17 logical unit reset event: An event that triggers a logical unit reset from a logical unit as described in SAM-2.

3.1.18 nexus: A relationship between two SCSI devices, and the SCSI initiator port and SCSI target port objects within those SCSI devices.

3.1.19 object: A container that encapsulates data types, services, or other objects that are related in some way.

3.1.20 port: Synonymous with SCSI port

3.1.21 queue: The arrangement of tasks within a task set usually according to the temporal order that they were created.

3.1.22 SCSI device: A device that contains one or more SCSI ports that are connected to a service delivery subsystem and supports a SCSI application protocol.

3.1.23 SCSI initiator device: A SCSI device containing application clients and SCSI initiator ports that originates device service and task management requests to be processed by a SCSI target device and receives device service and task management responses from SCSI target devices. When used this term refers to SCSI initiator devices or SCSI target/initiator devices that are using the SCSI target/initiator port as a SCSI initiator port.

3.1.24 SCSI initiator port: A SCSI initiator device object that acts as the connection between application clients and the service delivery subsystem through which requests and confirmations are routed. In all cases when this term is used it refers to an initiator port or a SCSI target/initiator port operating as a SCSI initiator port

3.1.25 SCSI port: A SCSI device resident object that connects the application client, device server or task manager to the service delivery subsystem through which requests and responses are routed. SCSI port is synonymous with port. A SCSI port is either a SCSI initiator port (see 3.1.24) or a SCSI target port (see 3.1.27).

3.1.26 SCSI target device: A SCSI device containing logical units and SCSI target ports that receives device service and task management requests for processing and sends device service and task management responses to SCSI initiator devices. When used this term refers to SCSI target devices or SCSI target/initiator devices that are using the SCSI target/initiator port as a SCSI target port.

3.1.27 SCSI target port: A SCSI target device object that contains a task router and acts as the connection between device servers and task managers and the service delivery subsystem through which indications and responses are routed. When this term is used it refers to a SCSI target port or a SCSI target/initiator port operating as a SCSI target port.

3.1.28 task: An object within the logical unit representing the work associated with a command or group of linked commands.

3.1.29 task manager: A server within a logical unit that controls the sequencing of one or more tasks and processes task management functions.

3.1.30 task management function: A task manager service that may be invoked by sending a SCSI Request IU with the requested task management function to affect the processing of one or more tasks.

3.1.31 task set: A group of tasks within a logical unit, whose interaction is dependent on the task management (e.g., queuing) and ACA requirements.

3.1.32 vendor-specific: Something (e.g., a bit, field, code value) that is not defined by this standard and may be used differently in various implementations.

3.1.33 zero: A false signal value or a false condition of a variable.

3.2 Symbols and abbreviations

≠ or NE	not equal
≤ or LE	less than or equal to
±	plus or minus
≈	approximately
x	multiply
+	add
-	subtract
< or LT	less than
= or EQ	equal
> or GT	greater than
≥ or GE	greater than or equal to
ACA	auto-contingent allegiance
AWG	American wire gauge
FCP-2	Fibre Channel Protocol for SCSI, Second Version
LSB	Least significant bit

LUN	Logical unit number
MSB	Most significant bit
SCSI	Small Computer System Interface
SAM-2	SCSI Architecture Model-2
SAM-3	SCSI Architecture Model-3
SCSI-3	Small Computer System Interface - 3
SMC	SCSI-3 Medium Changer Commands
SMC-2	SCSI Medium Changer Commands-2
SPC-2	SCSI Primary Commands-2
SPC-3	SCSI Primary Commands-3
SPI-5	SCSI Parallel Interface-5
SSC	SCSI-3 Stream Commands
SSC-2	SCSI_Stream Commands-2

3.3 Keywords

3.3.1 expected: A keyword used to describe the behavior of the hardware or software in the design models assumed by this standard. Other hardware and software design models may also be implemented.

3.3.2 invalid: A keyword used to describe an illegal or unsupported bit, byte, word, field or code value. Receipt of an invalid bit, byte, word, field or code value shall be reported as an error.

3.3.3 mandatory: A keyword indicating an item that is required to be implemented as defined in this standard.

3.3.4 may: A keyword that indicates flexibility of choice with no implied preference (synonymous with "may or may not").

3.3.5 may not: A keyword that indicates flexibility of choice with no implied preference (synonymous with "may or may not").

3.3.6 obsolete : A keyword indicating that an item was defined in prior SCSI standards but has been removed from this standard.

3.3.7 optional: A keyword that describes features that are not required to be implemented by this standard. However, if any optional feature defined by this standards is implemented, it shall be implemented as defined in this standard.

3.3.8 reserved: A keyword referring to bits, bytes, words, fields and code values that are set aside for future standardization. Their use and interpretation may be specified by future extensions to this or other standards. A reserved bit, byte, word or field shall be set to zero, or in accordance with a future extension to this standard. Recipients are not required to check reserved bits, bytes, words or fields for zero values. Receipt of reserved code values in defined fields shall be reported as an error.

3.3.9 shall: A keyword indicating a mandatory requirement. Designers are required to implement all such requirements to ensure interoperability with other products that conform to this standard.

3.3.10 should: A keyword indicating flexibility of choice with a strongly preferred alternative; equivalent to the phrase "it is strongly recommended".

3.4 Conventions

Editors Note 2 - pge: Make sure that the conventions below are true for your project or edit as appropriate.

Certain words and terms used in this American National Standard have a specific meaning beyond the normal English meaning. These words and terms are defined either in clause 3 or in the text where they first appear. Names of signals, phases, messages, commands, statuses, sense keys, additional sense codes, and additional sense code qualifiers are in all uppercase (e.g., REQUEST SENSE), names of fields are in small uppercase (e.g., STATE OF SPARE), lower case is used for words having the normal English meaning.

Fields containing only one bit are usually referred to as the name bit instead of the name field.

Numbers that are not immediately followed by lower-case b or h are decimal values.

Numbers immediately followed by lower-case b (xxb) are binary values.

Numbers immediately followed by lower-case h (xxh) are hexadecimal values.

Decimals are indicated with a comma (e.g., two and one half is represented as 2,5).

Decimal numbers having a value exceeding 999 are represented with a space (e.g., 24 255).

An alphanumeric list (e.g., a,b,c or A,B,C) of items indicate the items in the list are unordered.

A numeric list (e.g., 1,2,3) of items indicate the items in the list are ordered (i.e., item 1 must occur or complete before item 2).

In the event of conflicting information the precedence for requirements defined in this standard is:

1) text,
2) tables, then
3) figures.

Editors Note 3 - pge: Is this the correct order of precedence for your draft?

3.5 Notation for Procedures and Functions

Procedure Name ([input:1a|input:1b|input:1c][,input:2a+input:2b]...[input:n]||
[output:1][,output:2]...[output:n])

Where

Procedure Name:	A descriptive name for the function to be performed.
"(...)":	Parentheses enclosing the lists of input and output arguments.
input:1a|input:1b|...	A number of arguments of which only one shall be used in any single procedure
input:1, input:2, ...:	A comma-separated list of names identifying caller-supplied input data objects.
output:1, output:2, ...:	A comma-separated list of names identifying output data objects to be returned by the procedure.
"||":	A separator providing the demarcation between inputs and outputs. Inputs are listed to the left of the separator; outputs, if any, are listed to the right.
"[...]":	Brackets enclosing optional or conditional parameters and arguments.
"|":	A separator providing the demarcation between a number of arguments of which only one shall be used in any single procedure.
"+":	A collection of objects presented to a single object. No ordering is implied.

4 General

4.1 Architecture

Figure 2 shows an example of an ADT interface within a medium changer containing 2 Data Transfer Devices. Other common components of a medium changer are alos shown for reference.

Figure 2 — Example Medium Changer application of ADT

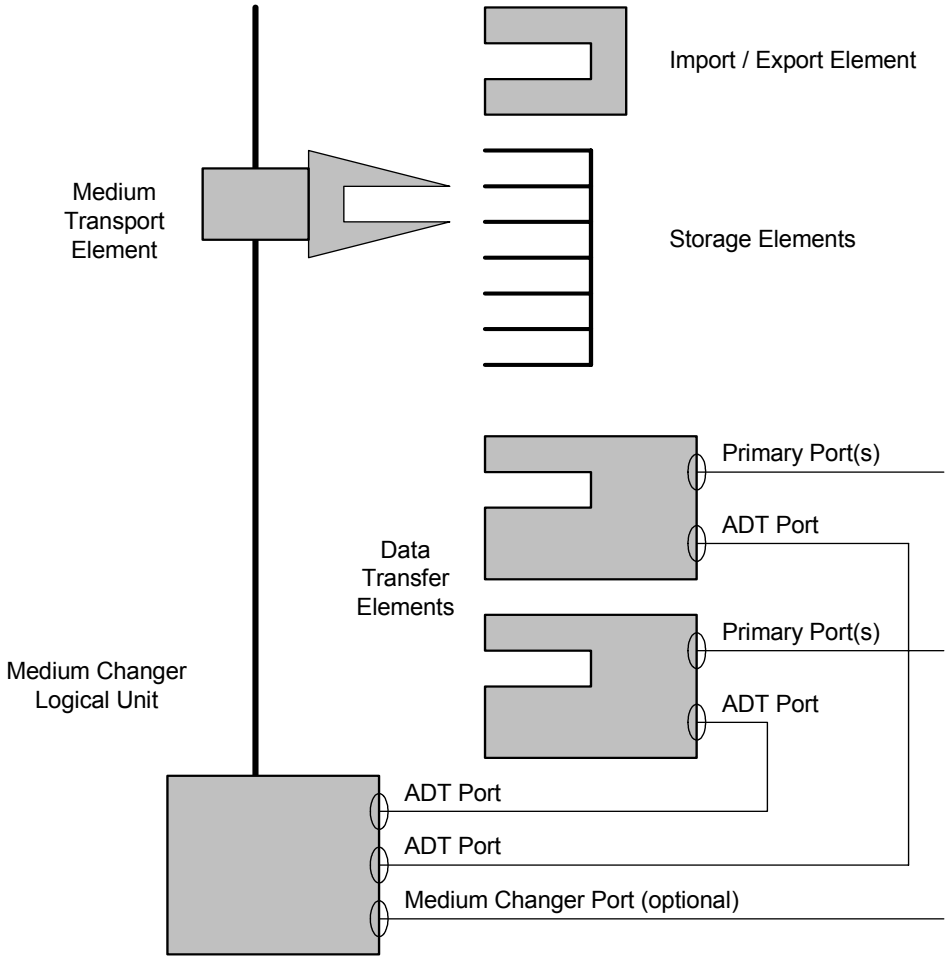
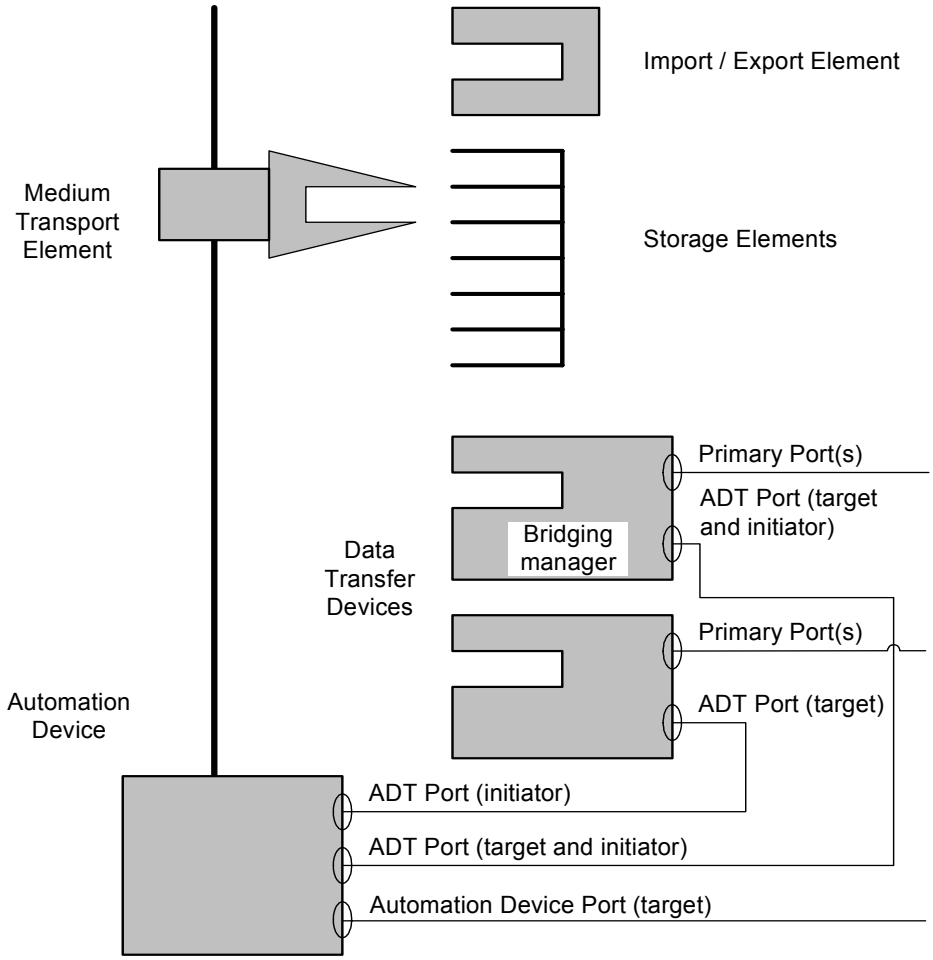


Figure 3 shows an example in which the automation device has only ADT ports and one of the data transfer devices is performing bridging. The upper data transfer device contains an active bridging manager. Its ADT port is operating both in initiator mode (to issue commands to the automation device) and in target mode (to receive commands initiated by the automation device). The corresponding ADT port on the automation device also operates in both modes.

The lower data transfer device is not performing bridging and its ADT port only operates in target mode. The corresponding ADT port on the automation device only operates in initiator mode.

Figure 3 — Automation and data transfer device relationship for bridging



Editors Note 4 - pge: The March 2003 working group meeting approved that the editor add a sub clause describing the “expected frame number”, how it is initialized, and how it is adjusted after each frame is received.

5 Physical layer

5.1 Electrical Characteristics

5.1.1 ADT compliance points

An ADT compliance point is a defined point in the ADT physical interconnection. At an ADT compliance point, a compliant device shall meet the ADT interoperability specifications. ADT compliance points always occur at separable connectors. Table 1 lists the ADT compliance points.

Table 1 — ADT Compliance Points

Compliance Point	Description
I_t	Initiator port connector; transmit serial port
I_r	Initiator port connector; receive serial port
T_t	Target port connector; transmit serial port
T_r	Target port connector; receive serial port

5.1.2 Cabling

All ADT connections shall have a length less than or equal to 25m.

NOTE 3 The connection specifications in subclauses 5.1.3 through 5.1.5 assume cable with a R < 400 ohms/km, Z_0 = 100 ohms (nominal), and C = 50 pF/m (nominal).

5.1.3 Sense connection

A Sense connection is a complete uni-directional signal path from one ADT port to a second ADT port. A Sense connection includes:

a) A current generator connected to the output compliance point of one ADT port,
b) A transmission medium from the output compliance point of one ADT port to the input compliance point of a second ADT port, and
c) A current detector connected to the input compliance point of the second ADT port.

Table 2 describes the electrical characteristics of a Sense connection at the output compliance point.

Table 2 — Sense connection output characteristics

Current	Voltage
$I_{OH} < 100\ \mu A$	$0{,}7V_{dd}{}^{a} < V_{OH} < 3{,}6\ V$
$-100\ \mu A < I_{OL}$	$V_{OL} < 0{,}4\ V;\ V_{OL} < 0{,}2V_{dd}{}^{a}$
[a] V_{dd} is the positive supply voltage at the receiving end.	

5.1.4 Signal connection

A Signal connection is a complete uni-directional signal path from one ADT port to a second ADT port. A Signal connection includes:

a) A signal generator connected to the output compliance point of one ADT port,
b) A transmission medium from the output compliance point of one ADT port to the input compliance point of a second ADT port, and
c) A signal receiver connected to the input compliance point of the second ADT port.

A signal connection shall use single ended signalling. An ADT port shall include termination for Signal connection inputs.

Single ended signals always exist in one of two states: true (i.e., asserted) or false (i.e., negated). The device that asserts a signal shall actively drive the signal to the true state. A device that negates a signal shall refrain from driving the signal to either state. A non-driven signal goes to the false state because the bias of the terminator pulls the signal false.

Table 3 describes the electrical characteristics of a Signal connection at the output compliance point.

Table 3 — Signal connection output characteristics

Signal State	Current	Voltage
Asserted	-12 mA < I_{OL}	$V_{OL} < 0,4$ V; $V_{OL} < 0,2\ V_{dd}$[a]
Negated		$V_{OH} <= 3,6$ V
[a] V_{dd} is the positive supply voltage at the receiving end.		

Table 4 describes the electrical characteristics of a Signal connection at the input compliance point.

Table 4 — Signal connection input characteristics

Signal State	Current	Voltage
Asserted	-12 mA < I_{IL} at 0 V	$V_{IL} < 0,3\ V_{dd}$[a]
Negated		$0,7\ V_{dd}$[a] < $V_{IH} <= 3,6$ V; 400 mV < $V_{hysteresis}$
[a] V_{dd} is the positive supply voltage at the receiving end.		

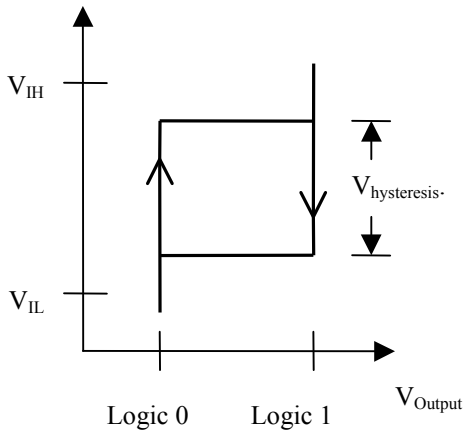
Table 5 describes the timing characteristics of a Signal connection.

Table 5 — Signal connection timing characteristics

Duration	1,5 µs < t_L	1,5 µs < t_H
Transition: 0,3 V_{dd}[a] to 0,7 V_{dd} with a connection capacitance of 1250 pF.	t_r < 500 ns	t_f < 500 ns
[a] V_{dd} is the positive supply voltage at the receiving end.		

Figure 4 defines $V_{hysteresis}$.

Figure 4 — $V_{hysteresis}$ definition



5.1.5 Transmit-receive connection

A Transmit-Receive (Tx-Rx) connection is a complete simplex signal path from one ADT port to a second ADT port. A Tx-Rx connection includes:

a) A signal generator connected to the output compliance point of one ADT port,
b) A pair of transmission media from the output compliance point of one ADT port to the input compliance point of a second ADT port, and
c) A signal receiver connected to the input compliance point of the second ADT port.

A Tx-Rx connection shall conform to TIA/EIA-422-B as measured at the associated compliance points.

A Tx-Rx connection shall support 9600 baud and may support the Modulation Rates listed in Table 6.

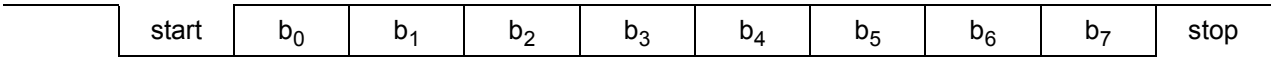
Table 6 — Optional Tx-Rx Modulation Rates

Modulation rate (baud)
19 200
38 400
57 600
76 800
115 200
153 600

A Tx-Rx connection shall use Non-return to Zero (NRZ) encoding of data bits to signaling elements. Hence, the data-signaling rate (in bps) equals the modulation rate (in baud).

A Tx-Rx connection shall transmit data bytes asynchronously adding one start bit, zero parity bits, and one stop bit to each data byte as depicted in figure 5.

Figure 5 — Asynchronous Transmission Format



5.2 Bus composition

5.2.1 Connection definition

Table 7 defines the connections that make up the ADT bus. With the exception of $Sense_a$ and $Sense_d$ this standard defines the behavior of these connections only when an initiator port asserts $Sense_a$ and a target port asserts $Sense_d$.

Table 7 — ADT bus connections

Connection Name	O/M	Connection Type	Driven By	Connection Definition
$Reset_a$	O	Signal	automation port	An automation device may use this connection to signal a reset request to a data transfer device. A data transfer device shall treat the receipt of a signal on this connection as a port logout (see 6.5.5).
$Sense_a$	M	Sense	automation port	A data transfer device shall use this connection to sense the presence or absence of an automation device on the ADT bus.
$Sense_{aux}$	O	Sense		A Vendor Unique sense connection. This standard does not define the use of this connection.
$Sense_d$	M	Sense	DTD port	An automation device shall use this connection to sense the presence or absence of a data transfer device on the ADT bus.
$Signal_{aux}$	O	Signal		A Vendor Unique signal connection. This standard does not define the use of this connection.
Tx_a - Rx_d	M	Tx-Rx	automation port	An automation device shall use this connection to send serialized data. A data transfer device shall receive serialized data on this connection.
Tx_d - Rx_a	M	Tx-Rx	DTD port	A data transfer device shall use this connection to send serialized data. An automation device shall receive serialized data on this connection.

6 Link layer

6.1 Basic frame format

The general layout of the ADT frame is shown in Figure 6. It consists of a Start of Frame (SOF) character, followed by a frame header, the frame payload, a checksum field, and concludes with an End of Frame (EOF) character

Figure 6 — Basic ADT frame format

6.2 Encoding

To guarantee that the Start of Frame (SOF) and End of Frame (EOF) characters are unique to the data stream, special characters are reserved to represent them. To ensure that these are unique to the data stream, a technique known as “byte stuffing” is utilized to encode any other occurrence of these values outside of indicating the start or end of a frame. This is accomplished by using an “escape” character to indicate that the very next byte in the stream has been modified from its original value.

Table 8 — Special characters

Character	Description
5Bh	Start of frame
5Dh	End of frame
7Fh	Escape

Occurrences of the Escape character value are also encoded. When a data byte having the value that matches the code assigned to SOF, EOF, or Escape is encountered in the data stream, an Escape character is inserted before it and the data byte itself is modified by an XOR operation with 80h.

Byte stuffing shall not affect the actual usable header or payload sizes, as the Escape encoding and decoding shall be performed as the data is being sent and received. The checksum shall be calculated before the encoding occurs and after the decoding occurs.

6.3 ADT frame header

An ADT frame header shall be included in every frame. The ADT frame header contains the information needed to validate and route the frame to the proper protocol handler. Table 9 defines the ADT Frame Header.

Table 9 — ADT frame header

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved	PROTOCOL			FRAME TYPE			
1	X_ORIGIN	EXCHANGE ID			Reserved	FRAME NUMBER		
2 - 3	PAYLOAD SIZE							

The FRAME TYPE field specifies the type of data contained in the frame. See the individual protocol sections for a description of the values in this field.

The PROTOCOL field indicates the protocol that is carried in the payload. Table 10 defines the values for the PROTOCOL field.

Table 10 — PROTOCOL **field values**

Value	Description
0	link service
1	Encapsulated SCSI
2	ADC fast access
3	Vendor specific
4 - 7	Reserved

The FRAME NUMBER field is a continuously incrementing number assigned by the transmitting port that uniquely identifies a frame from other frames sent by that port over a small period of time. It ranges from 0 to 7, and repeats. ACK IUs return the FRAME NUMBER field value of the frame that they are acknowledging. The FRAME NUMBER field of a NAK IU shall contain the frame number the port expected to receive (see 6.6.1.3). An Initiate Recovery IU shall contain the frame number of the frame with the detected error (see 6.6.2.3). A transmitting port shall assign all other types of frames the next frame number in sequence, independent of the traffic the port is receiving.

The EXCHANGE ID field contains the identifier used to distinguish frames that are part of the same exchange. Some exchanges require more than one frame to complete, often involving frames originating in both devices. All frames that are associated in these sequences shall have the same exchange ID and X_Origin values. An originator of an exchange may not re-use an exchange ID value until all frames associated with that exchange have been acknowledged, or until an Abort Exchange IU has been acknowledged.

The X_ORIGIN bit shall be set to zero if the Automation device originates the exchange. The X_ORIGIN bit shall be set to one if the Data Transfer Device originates the exchange. This bit shall remain constant for all frames associated with a given exchange.

The PAYLOAD SIZE field shall contain the number of bytes in the Payload area of the frame. The number of bytes does not include the SOF, EOF, ADT Frame Header, Checksum, or Escape bytes within the payload.

A receiving port shall NAK any frame, except an acknowledgement IU, containing a header reserved bit equal to one. The receiving port shall set the NAK status code value equal to Header Reserved Bit Set.

6.4 Checksum

The CHECKSUM field shall be one byte. The value of this field shall be the XOR of the following bytes:

a) all bytes in the ADT header field,
b) all bytes (if any) in the ADT payload field, and
c) one byte of value FFh.

The CHECKSUM value shall be calculated before the encoding operation specified in 6.2.

NOTE 4 When verifying the checksum of a received frame, the XOR of all data received after the SOF character and before the EOF character after decoding should be equal to FFh on a frame with good CRC.

6.5 Link service frames units

6.5.1 Link service frames overview

Either port may initiate link service frames. Link service frames are used to manage the transport layer. Table 11 defines the values for FRAME TYPE field in ADT frame header for link service protocol frames.

Table 11 — Link service information units

Frame Type	Description
0h	ACK (acknowledge)
1h	NAK (negative acknowledge)
2h	Port login
3h	Port logout
4h	Pause
5h	NOP (no operation)
6h	Initiate recovery
7h - Fh	Reserved

6.5.2 Payload size – type consistency

Unless otherwise specified in this standard, the receiver of a link service frame shall not consider it an error if the value of the PAYLOAD SIZE field does not match the specified size for those link service information units that have a specified size. If the size of the payload exceeds the specified size, the frame receiver shall ignore the excess payload bytes except with respect to the calculation of the Checksum field. If the size of the payload is less than the specified size, the frame receiver shall not change the current setting(s) of the parameter(s) controlled by any missing field(s).

6.5.3 Acknowledgement information units

6.5.3.1 Acknowledgement information units introduction

An acknowledgement IU is an ACK IU or a NAK IU. A port shall not send an acknowledgement IU in response to receiving a frame that does not contain a valid SOF and EOF character.

6.5.3.2 ACK information unit

An ACK IU is sent by the transport layer to indicate that the port has received a frame without error. Except for acknowledge IUs, a port shall send an ACK IU for every frame that it receives without error. An ACK IU shall contain 0 bytes of payload.

6.5.3.3 NAK information unit

A NAK IU is sent by the transport layer to indicate that the port has detected an error during the reception of a frame. Except for acknowledgement IUs, a port shall send a NAK IU for every frame that it receives in error. The Payload of a NAK IU shall contain 1 byte indicating the status. The FRAME NUMBER field in the ADT Header of the NAK IU shall be set to the frame number the port expected to receive. Table 12 lists the status values:

Table 12 — NAK frame status code value

Status	Description
00h	Reserved
01h	Bad checksum
02h	Over-length (more bytes received than PAYLOAD SIZE field indicates)
03h	Under-length (fewer bytes received than PAYLOAD SIZE field indicates)
04h	Framing error
05h	Hardware over-run
06h	Non-sequential frame numbers
07h	Awaiting Initiate Recovery IU
08h	Header reserved bit set (for the version of ADT the receiving device supports)
09h - 6Fh	Reserved
70h - 7Fh	Vendor specific transmission error.
80h	Unsupported protocol
81h	Out of resources, retry later. The receiving port has run out of buffers to store the frame.
82h	Login in progress
83h	Invalid or illegal Pause IU received
84h	Illegal operation for current operating parameters
85h	Rejected, port is logged out
86h	Maximum ACK offset exceeded
87h	Maximum frame size exceeded
88h	Unsupported frame type for selected protocol
89h - EFh	Reserved
F0h - FFh	Vendor specific protocol error

6.5.3.4 Interleaving acknowledgement and other frame types

A port shall not terminate transmission of a frame to send an acknowledgement IU except in the case of receiving a Port Login IU or Port Logout IU. A port that receives a Port Login IU or Port Logout IU may terminate transmission of a frame in progress, or it may complete the transmission. Once a port completes transmission of a frame, it shall acknowledge all frames that it has received before starting transmission of any other frame type, except Port Login, Port Logout, or Pause.

6.5.4 Port login information unit

Port Login IUs are used to establish or change link parameters. The login process is a negotiation between the ports that shall result in the determination of a set of operating parameters that are acceptable to both ports. Following power-up or a Port Logout condition, the Port Login IU shall be sent using default parameters (i.e Baud rate). If the port is already logged in, the Port Login IU may be sent using current operating parameters. A port shall NAK any frame containing a protocol other than link service until the login process has completed. The login process consists of the following states, all within a single exchange containing a series of Port Login IUs containing the same X-Origin and Exchange ID values:

1) One of the ports on the link sends a Port Login IU containing its default parameters. The ACCEPT field shall be zero. Any frames received by the port after it sends a Port Login IU shall be discarded and a NAK IU shall be sent containing a Status field of “Login in progress”.
2) After acknowledging a Port Login IU, transmission of frames for other exchanges shall either suspended or aborted based on the setting of the AOE bit in the Port Login IU. If the parameters in the Port Login IU are acceptable, the port shall send a Port Login IU with the accept bit set to one and transition to state 4. If one or more parameter is unacceptable, the port shall adjust these parameters down to values that are acceptable to the port, and respond with a Port Login IU that contains these values. The ACCEPT bit shall be set to zero.
3) Upon receiving a Port Login IU, the login exchange originator shall send an ACK IU. If the parameters in the Port Login IU are acceptable, the port shall send a Port Login IU with the ACCEPT bit set to one and transition to state 4. If one or more parameter is unacceptable, the port shall adjust these parameters down to values that are acceptable to the port, and respond with a Port Login IU that contains these values. The ACCEPT bit set to zero.
4) If a port receives a Port Login IU with acceptable parameters, it shall set the ACCEPT bit to one and send it back. Upon receiving a Port Login IU with the ACCEPT bit set to one, a port shall send an ACK IU. If the port has not yet sent a Port Login IU with the ACCEPT bit set to one, it shall do so in response to this IU. The login parameters shall take effect after a port has received an ACK IU for a Port Login IU it sent with the ACCEPT bit set to one and has acknowledged a Port Login IU from the other port with an ACCEPT bit set to one.

To avoid a deadlock condition when both ports in a link attempt to initiate a Port Login exchange at the same time, the following rules shall applied to Port Login exchanges. An automation device port that receives a Port Login IU with an exchange originated by the other port shall:

a) If the automation device port has initiated a Port Login Exchange that has not yet completed, it shall ACK and discard the Port Login IU from the other port.
b) If no other Port Login exchange is open, it shall either discard the Port Login IU and initiate a Port Login exchange, or it shall negotiate the Port Login using the exchange originated by the other port.

A Data Transfer Device that receives a Port Login IU in a new exchange shall abort all other Port Login exchanges.

Editors Note 5 - pge: Add a state transition table here so this stuff makes some sense.

A device that receives a Port Login IU whose payload contains fewer bytes than specified by this standard shall respond with a fully populated Port Login IU.

Table 13 defines the payload of the Port Login Frame.

Table 13 — Port login IU payload contents

Bit / Byte	7	6	5	4	3	2	1	0
0	ACCEPT	Reserved					VENDOR SPECIFIC	
1	MAJOR REVISION			MINOR REVISION				
2	Reserved							
3	AOE	Reserved				MAXIMUM ACK OFFSET		
4	(MSB)	MAXIMUM PAYLOAD SIZE						
5								(LSB)
6	(MSB)	BAUD RATE						
7								(LSB)

The ACCEPT bit shall be set to zero on the first Port Login IU of a negotiation exchange and all subsequent Port Login IUs sent by a port until the Port Login IU parameters it is sending matches the parameters of the last Port Login IU received. When the Port Login IU parameters sent by a port matches the parameters of the last Port Login IU it received, the ACCEPT bit shall be set to one.

Ports claiming compliance with this standard at draft revision shall set the MAJOR REVISION field to 0. Ports claiming compliance with this standard at INCITS approved version shall set the MAJOR REVISION field to 1.

Port claiming compliance with a draft version of this standard shall set the MINOR REVISION field to the revision of the draft standard. Ports claiming compliance with this standard at INCITS approved version shall set the MINOR REVISION field to 0. When initiating a Port Login exchange, a port shall set the MAJOR REVISION field to the highest value it can support and the MINOR REVISION field to the highest draft standard revision it can support for the reported major revision. A port that was designed to support this standard at INCITS approved version shall initiate a Port Login exchange with the MAJOR REVISION field set to 1 and the MINOR REVISION field set to 0. During the negotiation process, a port that can not support the revision in a Port Login IU that it receives shall reply with a reduced revision level. The revision level shall be reduced as follows:

a) If the port supports the major revision level in the received Port Login IU, but not the minor revision level in the IU, it shall respond with the same major revision level. The minor revision level shall be set to the highest it can support that is lower then the minor revision in the received Port Login IU. If the device does not support the major revision with a lower minor revision value, it shall respond as if it does not support the major revision level.
b) If the port does not support the major revision in the Port Login IU it receives, it shall respond with the highest major revision it does support that is lower than the major revision in the received Port Login IU. The minor revision shall be set to the highest level supported at that major revision level.

All fields in the Port Login IU sent by a port shall comply with the revision level specified by the MAJOR REVISION and MINOR REVISION fields. Once the Port Login process has completed, both ports shall operate as defined by the major revision and minor revision values in the accepted Port Login IU.

The Abort Other Exchanges (AOE) field shall be set in a Port Login IU sent by a port under the following conditions:

a) The port has experienced a hard reset condition.
b) The port has experienced an error condition that may have led to loss of data or state on one or more exchanges.
c) The port has received a Port Login IU with the AOE bit set to one.

The AOE bit shall not affect Port Login exchanges. See subclause 6.5.4 for Port Login exchange precedence.

A port that receives a valid Port Login IU with the AOE bit set to one shall abort all other exchanges, other than Port Login exchanges. No frames shall be sent for exchanges other than the Port Login exchange after a Port Login IU with the AOE bit set to one has been acknowledged.

A Port that receives a valid Port Login IU with the AOE bit set to zero shall suspend transmission of any frames not associated with the Port Login exchange after acknowledging the Port Login IU until the Port Login exchange is complete. Frames from exchanges other than Port Login exchanges shall not be transmitted until all port login exchanges are complete.

The MAXIMUM ACK OFFSET field indicates the number of frames that may be sent to the port without receiving an acknowledgement IU in response. The offset count is incremented for each frame sent by a port and decremented for each acknowledgement IU received. Link service IUs are not counted in the offset. A value of zero indicates the port is disabled for all but link service traffic. All ports shall be capable of supporting a Maximum Ack Offset value of 1

Editors Note 6 - pge: We need to add a description of how ACK Offset credit is reset (Port Login and Initiate Recovery).

The MAXIMUM PAYLOAD SIZE field indicates the maximum number of bytes in the payload of a frame that the port can accommodate. A port shall be capable of supporting a frame payload size of 270 bytes.

The BAUD RATE field indicates the speed that the port is negotiating the physical interface shall run. The BAUD RATE field contains the desired Baud rate divided by 100. All ports shall default to operating at 9600 Baud at power-up and following error conditions that require re-establishment of the link (see 6.6.2).

6.5.5 Port logout information unit

Only automation may send this IU. Upon receiving a Port Logout IU, the device shall:

a) Abort all open exchanges.
b) Disable Asynchronous Event Reporting.
c) Disable initiating Port Login exchanges.
d) Port operating parameters revert to default settings following receipt of the ACK IU for the Port Logout IU (see 6.6.2.2).

Knowledge of the logged out state may be volatile, so a power cycle or other hard reset condition in the logged out device may cause the port to become active again and attempt to log in to the automation port.

The Port Logout IU shall contain zero bytes of payload.

6.5.6 Pause information unit

A Pause IU may be sent by an automation device to temporarily stop traffic on the link. Data transfer device ports shall not initiate a Pause IU exchange. When a data transfer device port receives a Pause IU, it shall acknowledge the frame and then temporarily discontinue sending any more frames on the link. Once in the paused state, receipt of any valid frame other than an acknowledgement IU shall place the port back into active state. The paused state is volatile, so a power cycle or other hard reset condition in the paused device may cause the port to become active again. A Pause IU shall not be sent until the ports have successfully negotiated the link parameters with a Port Login exchange. The paused state only affects the sending of frames, a port must always be capable of receiving frames unless it has placed the opposite port into paused state.

The Pause IU shall contain zero bytes of payload.

Editors Note 7 - pge: We need to include link state definitions in the model section.

6.5.7 NOP information unit

A NOP IU may be sent by a port to re-activate the other device's port after it has been paused.

The NOP IU shall contain zero bytes of payload.

6.5.8 Initiate Recovery information unit

An initiate Recovery IU shall be sent by a port when it detects an error has occurred with a frame that it sent. The FRAME NUMBER field in the ADT Frame Header shall contain the frame number of the frame in error. The X_ORIGIN and EXCHANGE ID fields are undefined and shall be ignored. An Initiate Recovery IU shall contain zero bytes of payload. See clause 6.6 for a full explanation of the error recover process.

6.6 Link layer error recovery

6.6.1 Error detection

6.6.1.1 Error detection overview

Errors in the transport layer may be detected by either the sender of a frame, receiver of a frame, or by both.

6.6.1.2 Error detection by the frame sender

6.6.1.2.1 Acknowledgement IU time-out

The sender of a frame, other than an acknowledgement IU, shall time-out the resulting acknowledgement. It shall be considered an error condition if a corresponding acknowledgement IU is not received within the time-out period. The time-out period shall start after the EOF of the frame is sent. When operating with an ACK offset greater than 1, a port may start the time-out period for a frame that has completed transmission after the acknowledgement IU

for a previously sent frame has been received. The minimum acknowledgement IU time-out period shall be calculated using the formula in Figure 7.

$Timeout_{ACK}$ = (Period * $Size_{Max}$ * 2) + (Period * ($Offset_{Max}$ * $Size_{NAK}$ * 2)) + 0.1 seconds

Where:

$Timeout_{ACK}$ is the minimum time-out period in seconds.

Period is the time per byte calculated as (10 / Baud Rate) and is expressed in seconds per byte.

$Size_{Max}$ is the Maximum Payload Size negotiated with the Port Login process, plus SOF, EOF, ADT Header, and checksum bytes.

$Offset_{Max}$ is the maximum ACK offset negotiated with the Port Login process.

$Size_{NAK}$ is the size in bytes of the NAK IU including SOF, EOF, and checksum bytes.

For example, at 9600 Baud with a negotiated Maximum Payload Size of 1024 and Maximum ACK Offset of 2, the minimum timeout period would be approximately 2.28 seconds.

Figure 7 — Minimum acknowledgement time-out period

6.6.1.2.2 NAK acknowledgement

It shall also be considered an error condition if a port receives a NAK IU.

6.6.1.3 Error detection by the frame receiver

The port that receives a frame shall detect and report the following link level errors:

a) Checksum, over-length, under-length, or improperly formatted frames.
b) Unsupported PROTOCOL or FRAME TYPE values.
c) Frames with protocol other than link service when logged out.
d) Frames with non-sequential Frame Numbers.

When a port detects an error on a frame it receives it shall send a NAK IU to the other port with appropriate status so that the port that sent the frame in error can initiate recovery steps. The FRAME NUMBER field of the NAK IU shall be set to the frame number the port expected to receive when the error was detected.

6.6.2 Error recovery for transmission problems

6.6.2.1 Differentiating transmission problems

The status codes for NAK IUs are grouped into 2 categories:

a) Link level problems (01h through 7Fh)
b) Formatting or upper-layer protocol problems (80h through FFh)

Transmission problems are those that are reported with the link level status codes. A time-out on an acknowledgement IU also qualifies as a transmission problem. Some of the problems in the formatting or upper-layer protocol category may also be recovered using techniques from this clause, when a retry is called for.

6.6.2.2 Error recovery for Port login IUs

If a transmission error is detected on a Port Login IU, the recovery process is to restart the negotiation process. This is accomplished by initiating a Port Login IU with a frame number of zero and a new exchange ID value. Values in the payload of the frame should be set to the default values for the port.

If an error is detected in a Port Login IU, or if a Port Login exchange is initiated as part of the recovery process for error on other frames, the port's operating parameters shall be set to the default values. The default operating parameters for the port are as follows:

a) The baud rate shall be set to 9600.
b) The ACK offset shall be set to 1.
c) The Maximum Payload size shall be 16 bytes.

These values shall remain in effect until the negotiation process is complete, at which time the negotiated values shall take effect.

6.6.2.3 Error recovery for other protocols and frame types

After detecting a transmission error condition has occurred with a frame that it sent, a port shall initiate an error recovery process. A port that detects an error on a frame that it sent must retry sending the frame at least once and no more than 4 times. The frame retry sequence is:

1) The port that sent the frame in error sends an Initiate Recovery IU. The Initiate Recovery IU contains the frame number that was detected in error in the FRAME NUMBER field.
2) After sending the Initiate Recovery IU, the port in error waits for an ACK IU for that frame. No other frames shall be sent by that port except acknowledgement IUs for frames it receives until an acknowledgement IU is received for the Initiate Recovery IU, a time-out occurs on the ACK IU, or a Port Login IU is received.
3) If an ACK IU is received for the Initiate Recovery IU, the error port shall resume normal operation by re-sending the frame in error and all frames sent after it before the error was detected, with the exception of acknowledgement IUs. The FRAME NUMBER field values for re-transmitted frames shall not be changed from the values used when they were originally transmitted.
4) If no ACK IU is received for the Initiate Recovery IU before the ACK time-out, or an NAK IU is received indicating an error on the Initiate Recovery IU, and the Initiate Recovery IU has not been retried, the port in error shall re-send the Initiate Recovery IU.
5) If the Initiate Recovery IU has been sent twice with no ACK IU returned, or a NAK IU is received indicating an error on the Initiate Recovery IU, the port in error shall abort all exchanges, set the operating parameters of the interface to default settings, and initiate a Port Login exchange with the AOE bit set to one.

When a port receives an Initiate Recovery IU it is an indication that the other port is attempting to recover from a transmission error. The following steps shall be taken by the receiving port to accommodate the recovery process.

a) An ACK IU shall be sent to acknowledge receipt of the Initiate Recovery IU.
b) The FRAME NUMBER field in the Initiate Recovery IU shall be compared to the frame number the port expected in the next frame the port received. If the frame numbers match, the port shall proceed as normal.
c) If the frame number does not match, this is an indication that an ACK IU was lost in transmission. Frames that are received by the port shall be acknowledged and discarded until the frame that matches the value in the FRAME NUMBER field in the Initiate Recovery IU. Normal operation shall continue once the frame received matches the value in the FRAME NUMBER field in the Initiate Recovery IU.

7 Transport layer

7.1 SCSI Encapsulation

7.1.1 SCSI encapsulation overview

SCSI frames contain information required to implement the SCSI protocol. Each SCSI frame shall include a payload header at the start of the payload to carry other information that is required to perform the selected function. All SCSI commands use the simple queue model described in SAM-2. The X_ORIGIN bit in the ADT Frame Header implies the SCSI initiator port and SCSI target port identities. The EXCHANGE ID value from the ADT Frame Header takes on the roll of the Queue Tag from SAM-2. The LUN is included in the SCSI Request IU payload header.

SCSI frames support the Frame Type values defined in Table 14.

Table 14 — SCSI protocol information units

Frame Type	Description
0h	SCSI Request
1h	SCSI Response
2h	SCSI Transfer Ready
3h	SCSI Data
4h - Fh	Reserved

7.1.2 SCSI Request information unit

The SCSI Request IU payload shall contain information described in Table 15.

Table 15 — SCSI Request IU payload contents

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1				LUN				(LSB)
2	TASK MANAGEMENT FUNCTION							
3	Reserved							
4								
19				CDB				
20	(MSB)							
23				BUFFER ALLOCATION LENGTH				(LSB)

Editors Note 8 - pge: This IU does not carry enough information for true pass through of SCSI commands in surrogate mode. This is sufficient for a bridge implementation. When passing surrogate mode commands through, the data transport device must manage reservations and queue unit attentions and sense data since the automation device is unaware of the true initiator. I recommend a proposal be written to expand the capabilities of this IU to include either the initiator port name or a tag that can be associated with an initiator port name (the tag method would require a Process Login to register an initiator port name with a tag).

The LUN field indicates the Logical Unit Number that the command or task management function shall be routed to within the SCSI target device. If the logical unit does not exist within the device, the device shall return a CHECK CONDITION status with a Sense Key of ILLEGAL REQUEST and additional sense code of INVALID LOGICAL UNIT.

The TASK MANAGEMENT FUNCTION field indicates the type of action that is to be performed by the logical unit or SCSI target device. The values for this field are defined in Table 16.

Table 16 — TASK MANAGEMENT FUNCTION values

Value	Description
00h	Indicates no task management requests for the selected task or logical unit. The information unit contains a CDB.
01h	ABORT TASK
02h	ABORT TASK SET
03h	Reserved
04h	CLEAR TASK SET
05h - 07h	Reserved
08h	LOGICAL UNIT RESET
09h - 1Fh	Reserved
20h	TARGET RESET
21h - 3Fh	Reserved
40h	CLEAR ACA
41h - FFh	Reserved

Editors Note 9 - pge: LOGICAL UNIT RESET code matches SAS which is different than FCP-2. If SAS changes to match FCP-2, this standard should change also.

If the TASK MANAGEMENT FUNCTION field contains 00h, the CDB field contains a SCSI Command Descriptor Block. Otherwise, the logical unit shall ignore the CDB field, and the task management function indicated by the TASK MANAGEMENT FUNCTION field shall be processed. See SAM-2 for a definition of the task management functions provided.

The BUFFER ALLOCATION LENGTH field contains a count of the greatest number of data bytes to be transferred to or from the application client data buffer by the SCSI CDB. The BUFFER ALLOCATION LENGTH field is the data buffer size defined by SAM-2. A Buffer Allocation Length value of zero indicates that no data transfer is expected and that no SCSI Transfer Ready or SCSI Data IUs shall be transferred for this exchange.

7.1.3 SCSI Response information unit

A SCSI Response IU shall be returned to the Exchange Initiator for every SCSI Request IU that is sent. Table 17 defines the payload of a SCSI Response IU.

Table 17 — SCSI Response IU payload contents

Bit / Byte	7	6	5	4	3	2	1	0
0	RESPONSE CODE							
1	SCSI STATUS							
2	(MSB)			SENSE LENGTH				
3								(LSB)
4				SCSI AUTOSENSE DATA				
n								

The RESPONSE CODE field indicates the results of the operation as an extension to the SCSI Status. Table 18 defines the values for this field.

Table 18 — RESPONSE CODE **values**

Value	Description
00h	Command or task management function complete
01h	More data transferred than requested
02h	Invalid field in SCSI Request IU (excludes CDB)
03h	Incorrect RELATIVE OFFSET value in SCSI Data IU
04h	Task Management function not supported
05h	Task Management function failed
06h - FFh	Reserved

The SCSI STATUS field contains SCSI Status as defined in SAM-2. This is only valid if the RESPONSE CODE field is set to 00h and the SCSI Request IU for the exchange was a SCSI command containing a CDB.

The SENSE LENGTH field indicates how many bytes of sense data can be found in the IU. This field shall be set to 0 if the response code is not 00h, and no sense data shall be included in the IU. If the response code is 00h and the SCSI STATUS field contains Check Condition, autosense data shall be included in the IU as defined in SPC-2 and the SENSE LENGTH field shall be set to indicate how much sense data is included.

7.1.4 SCSI Transfer Ready information unit

A SCSI Transfer Ready IU shall be sent by a target of an exchange to inform the exchange initiator that it is ready to receive data associated with the command. The target port may request all of the data associated with a command with a single SCSI Transfer Ready, or it may use multiple SCSI Transfer Ready IUs within the exchange context to request the data a little bit at a time. The contents of the SCSI Transfer Ready IU payload are described in Table 19.

Table 19 — SCSI Transfer Ready IU payload contents

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
3				BUFFER OFFSET				(LSB)
4	(MSB)							
7				BURST LENGTH				(LSB)

The BUFFER OFFSET field indicates the offset from the beginning of the buffer associated with the first byte of data that shall be sent. Data shall not be requested out of order. This field can be used to recover from an error detected in transmission by allowing the SCSI target port to request re-transmission of the previous burst of data.

The BURST LENGTH field indicates the size of the buffer that has been allocated to receive data within the target device. The exchange initiator shall respond to the SCSI Transfer Ready IU by transmitting data using one or more SCSI Data IUs until Burst Length bytes of data have been sent.

7.1.5 SCSI Data information unit

The SCSI Data IU is used to send data associated with SCSI Data In and Data Out operations. Table 20 describes the contents of a SCSI Data IU.

Table 20 — SCSI Data IU payload contents

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
3				BUFFER OFFSET				(LSB)
4	(MSB)							
7				DATA LENGTH				(LSB
8								
n				DATA				

The BUFFER OFFSET field indicates the offset from the beginning of the buffer associated with the first byte sent shall be sent. Data shall not be sent out of order, however, a port may re-send a data burst should it detect an error in transmission.

The DATA LENGTH field indicates the number of bytes of data included in this frame.

The DATA field contains data.

7.2 ADC fast access

7.2.1 ADC fast access overview

This protocol is intended to provide a feature set beyond what is provided by SCSI to both take advantage of the features of the transport layer and work around the slower speed of it. The ADC Fast Access protocol provides:

a) A simple method for accessing the Very High Frequency Data defined in ADC,
b) a method for device to report asynchronous activity, and
c) a method to control these asynchronous reports.

ADC fast access frames support the Frame Type values listed in Table 21.

Table 21 — ADC Fast Access information units

Frame Type	Description
0h	Request for VHF Data IU
1h	VHF Data IU
2h	AER IU
3h	AER Control IU
4h - Fh	Reserved

7.2.2 Payload size – type consistency

Unless otherwise specified in this standard, the receiver of an ADC fast access frame shall not consider it an error if the value of the PAYLOAD SIZE field does not match the specified size for those ADC fast access information units that have a specified size. If the size of the payload exceeds the specified size, the frame receiver shall ignore the excess payload bytes except with respect to the calculation of the Checksum field. If the size of the payload is less than the specified size, the frame receiver shall not change the current setting(s) of the parameter(s) controlled by any missing field(s).

7.2.3 Request for VHF Data information unit

Only Automation devices may initiate a Request for VHF Data IU. This IU has no payload.

7.2.4 VHF Data information unit

A VHF Data IU shall be returned by a Data Transfer device in response to a Request for VHF Data IU. Only Data Transfer devices may initiate a VHF Data IU. The payload of this IU is described in ADC.

7.2.5 AER information unit

Asynchronous Event Report IUs may optionally be used to report that an event has occurred that may be of interest. Only a Data Transfer device may initiate AER IUs. The payload of an AER IU shall contain the VHF Data as defined in ADC.

7.2.6 AER Control information unit

The AER Control IU may optionally be sent by an Automation device to a Data Transfer device to enable or disable AER reporting. The payload of the AER Control IU shall contain a VHF Data structure, with the bits set to one for

each field that the device shall report a change. Multiple-bit fields shall have either all of the bits of the field set to 1 or all of the bits in the field set to 0.

Data Transfer devices that do not support AER shall send a NAK IU in response with the STATUS field set to Unsupported protocol or frame type.

Data Transfer devices that support AER shall respond to the receipt of a AER Control IU by sending an AER Control IU back to the Automation Device with the same X_origin and EXCHANGE ID values. The payload of the IU shall contain a VHF Data IU data structure. Each field that has been enabled for AER notification and is supported by the device shall contain all 1 bits. Each field that has been either disabled for AER notification or is not supported for AER notification by the device shall contain 0. The default setting for all AER events in a Data Transfer device shall be zero.

All AER control fields shall be set to zero by the Data Transfer device at the start of the port login process.

8 SCSI Application layer

Annex A
(Informational)