ISO/IEC 14776-263

Edition 1.0 2018-10

INTERNATIONAL STANDARD

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Information technology – Small Computer System Interface (SCSI) – Part 263: SAS Protocol Layer – 3 (SPL-3)



ISO/IEC 14776-263:2018-10(en)



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ISO/IEC 14776-263

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Information technology – Small Computer System Interface (SCSI) – Part 263: SAS Protocol Layer – 3 (SPL-3)

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 35.200

ISBN 978-2-8322-6190-3

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ISO/IEC 14776-263:2018

Information technology - Small Computer System Interface (SCSI) - Part 263:SAS Protocol Layer - 3 (SPL-3)

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ISO/IEC 14775-263

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INFORMATION TECHNOLOGY – SMALL COMPUTER SYSTEM INTERFACE (SCSI) –

Part 263: SAS Protocol Layer - 3 (SPL-3)

FOREWORD

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International Standard ISO/IEC 14776-263 was prepared by subcommittee 25: Interconnection of information technology equipment, of ISO/IEC joint technical committee 1: Information technology.

The list of all currently available parts of the ISO/IEC 14776 series, under the general title *Information technology – Small computer system interface (SCSI)*, can be found on the IEC web site.

This International Standard has been approved by vote of the member bodies and the voting results may be obtained from the address given on the second title page.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2 except as described in 3.4 and 3.5.

A bilingual version of this publication may be issued at a later date.

IMPORTANT - The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

The SCSI family of standards provides for many different transport protocols that define the rules for exchanging information between different SCSI devices. This document defines the rules for exchanging information between SCSI devices using a serial interconnect. Other SCSI transport protocol standards define the rules for exchanging information between SCSI devices using other interconnects.

Figure 1 shows the organization of the layers of this document.

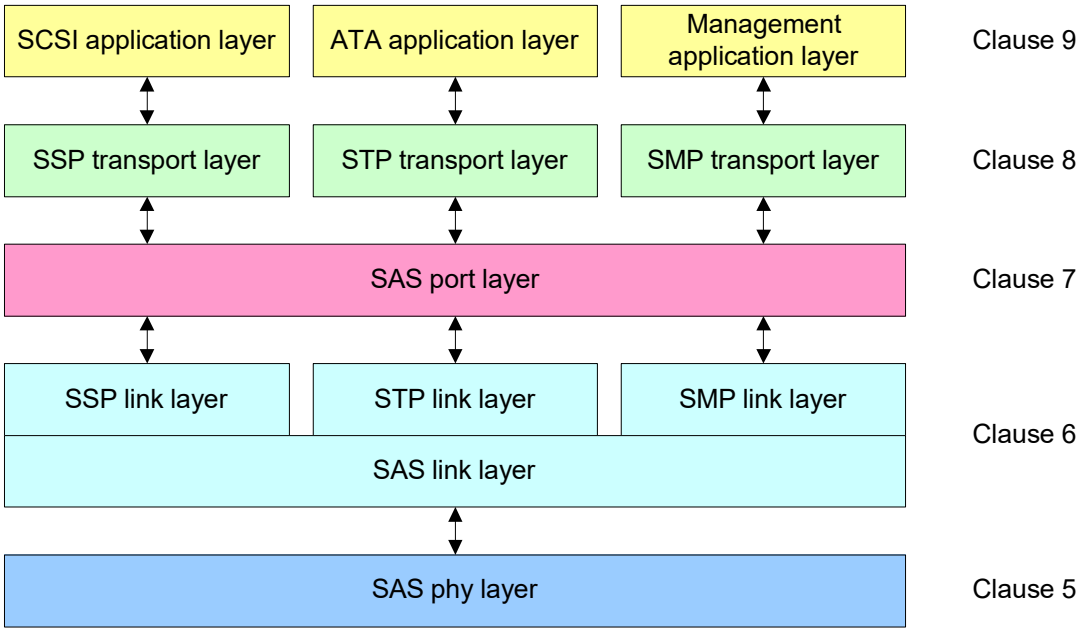


Figure 1 — Organization of this document

SCSI standards family

Figure 2 shows the relationship of this document to the other standards and related projects in the SCSI family of standards.

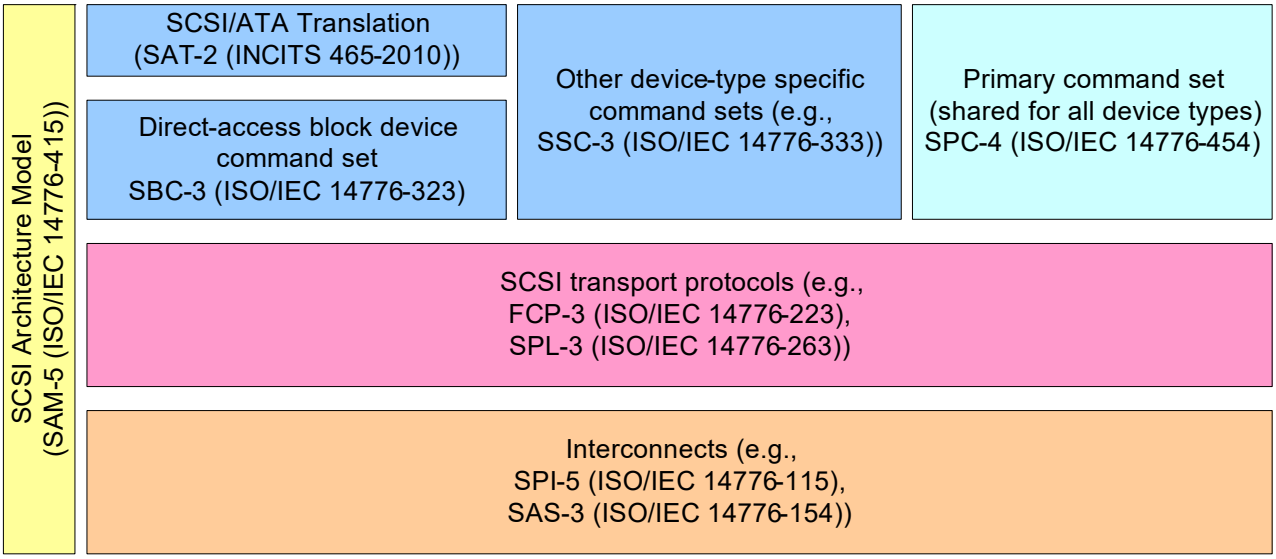


Figure 2 — SCSI document relationships

This document also defines the rules for exchanging information between ATA hosts and ATA devices using the same serial interconnect. Other ATA transport protocol standards define the rules for exchanging information between ATA hosts and ATA devices using other interconnects.

Figure 3 shows the relationship of this document to other standards and related projects in the ATA family of standards.

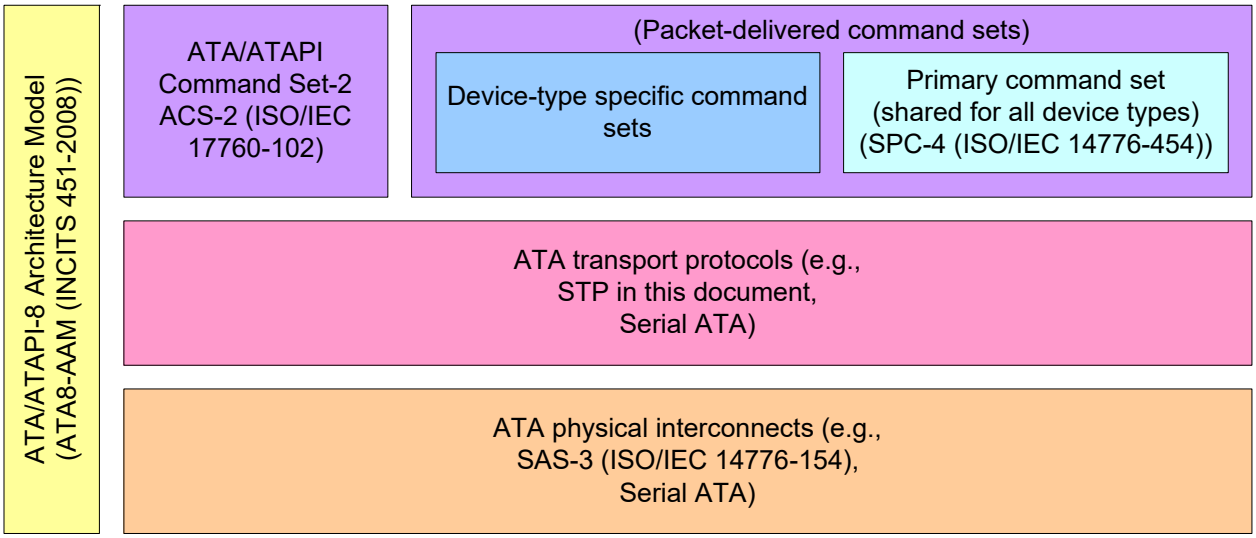


Figure 3 — ATA document relationships

Figure 2 and figure 3 show the general relationship of the documents to one another, and do not imply any hierarchy, protocol stack, or system architecture relationship.

These standards specify the interfaces, functions and operations necessary to ensure interoperability between conforming implementations. This document is a functional description. Conforming implementations may employ any design technique that does not violate interoperability.

INFORMATION TECHNOLOGY – SMALL COMPUTER SYSTEM INTERFACE (SCSI) –

Part 263: SAS Protocol Layer - 3 (SPL-3)

1 Scope

This document defines the protocol layer of the Serial Attached SCSI (SAS) interconnect and three transport protocols that use the SAS interconnect:

a) Serial SCSI Protocol (SSP): a mapping of SCSI supporting multiple initiators and targets;
b) Serial ATA Tunneled Protocol (STP): a mapping of Serial ATA expanded to support multiple initiators and targets; and
c) Serial Management Protocol (SMP): a management protocol.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Additional availability contact information is provided in Annex L.

ISO/IEC 17760-102, *Information technology - AT Attachment - Part 102: ATA/ATAPI Command Set - 2 (ACS-2)*

ISO/IEC 14776-151, *Information technology - Small Computer System Interface (SCSI) - Part 151: Serial Attached SCSI - 1.1 (SAS-1.1)*

ISO/IEC 14776-323, *Information technology - Small Computer System Interface (SCSI) - Part 323: SCSI Block Commands - 3 (SBC-3)*

ISO/IEC 14776-154, *Information technology - Small Computer System Interface (SCSI) - Part 154: Serial Attached SCSI - 3 (SAS-3)*

ISO/IEC 14776-454, *Information technology - Small Computer System Interface (SCSI) - Part 454: SCSI Primary Commands - 4 (SPC-4)*

INCITS 451-2008, *AT Attachment - 8 ATA/ATAPI Architecture Model (ATA8-AAM)*

INCITS 515, *Information technology - SCSI Architecture Model - 5 (SAM-5)* (planned as ISO/IEC 14776-415)

INCITS 518, *Information technology - SCSI Enclosure Services - 3 (SES-3)* (planned as ISO/IEC 14776-373)

For information on the current status of the listed documents, or regarding availability, contact the indicated organization.

Serial ATA Revision 3.1 (SATA). 18-July-2011 [1]

SFF-8485, *Serial GPIO (SGPIO) Bus* [2]

1. Serial ATA specifications are available from the Serial ATA International Organization (see http://www.sata-io.org)
2. SFF specifications are available from the SNIA SFF Technology Affiliate (see http://www.snia.org/sff).

3 Terms, definitions, symbols, abbreviations, keywords, and conventions

3.1 Terms and definitions

For the purposes of this document the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
8b10b coding
coding scheme that represents an 8-bit byte (i.e., a control byte or data byte) as a 10-bit character (i.e., a control character or data character)

Note 1 to entry: See 5.2.

3.1.2
8b10b encoding
method of encoding an 8-bit byte (i.e., a control byte or data byte) into a 10-bit character (i.e., a control character or data character)

Note 1 to entry: See 5.2.

3.1.3
10b8b decoding
method for decoding a 10-bit character (i.e., a control character or data character) into an 8-bit byte (i.e., a control byte or data byte)

Note 1 to entry: See 5.2.

3.1.4
active cable assembly
cable assembly (see SAS-3) that requires power for internal circuitry used in the transmission of the signal through the cable assembly

Note 1 to entry: See SAS-3.

3.1.5
active phy power condition
normal power condition for a SAS phy or expander phy

Note 1 to entry: See 4.10.1.2.

3.1.6
active zone manager
zone manager (see 3.1.258) that locks a zoning expander device (see 3.1.262)

Note 1 to entry: See 4.8.6.

3.1.7
affiliation
STP target port (see 3.1.229) state of limiting acceptance of connection requests to those from one or more STP initiator ports (see 3.1.224)

Note 1 to entry: See 6.19.4.

3.1.8
affiliation context
set of registers maintained by an STP target port for an STP initiator port holding an affiliation

Note 1 to entry: See 6.19.4.

3.1.9
aggregation
form of association that defines a whole-part relationship between the whole (i.e., aggregate) class and its parts

Note 1 to entry: This definition only applies when used in relation to UML.

Note 2 to entry: See 3.6.

3.1.10
application client
object that is the source of SCSI commands and task management function requests (see SAM-5), ATA commands (see ATA8-AAM), or SMP function requests

Note 1 to entry: See 4.1.5.

3.1.11
association
relationship between two or more classes that specifies connections among their objects

Note 1 to entry: This definition only applies when used in relation to UML.

Note 2 to entry: An association is a relationship that specifies that objects of one class are connected to objects of another class.

Note 3 to entry: See 3.6.

3.1.12
attached
attribute of a class used when an instance of that class is only accessible over a service delivery subsystem

3.1.13
attached SAS address
SAS address (see 3.1.169) of the attached phy or the SAS address of the STP target port in an STP SATA bridge (see 4.5.2)

Note 1 to entry: For example, the SAS address of an attached phy may be received in the incoming IDENTIFY address frame during the initialization sequence (see 4.1.2).

3.1.14
attribute
named property of a class that describes a range of values that its objects may hold

Note 1 to entry: This definition only applies when used in relation to UML.

Note 2 to entry: See 3.6.

3.1.15
AT Attachment
ATA
standard for the internal attachment of storage devices to hosts

Note 1 to entry: See ATA8-AAM.

3.1.16
ATA device
storage peripheral that processes ATA commands and device management functions

Note 1 to entry: Analogous to a SCSI target device (see 3.1.195).

Note 2 to entry: See ATA8-AAM.

3.1.17
ATA domain
I/O system consisting of an ATA host and one or more ATA devices that communicate with one another by means of a service delivery subsystem (see 3.1.203)

Note 1 to entry: Analogous to a SCSI domain (see 3.1.191).

Note 2 to entry: See ATA8-AAM.

3.1.18
ATA host
host device that originates requests to be processed by an ATA device

Note 1 to entry: Analogous to a SCSI initiator device (see 3.1.192).

Note 2 to entry: See ATA8-AAM.

3.1.19
big-endian
format for storage or transmission of binary data in which the most significant byte appears first

Note 1 to entry: In a multi-byte value, the byte containing the most significant bit is stored in the lowest memory address and transmitted first, and the byte containing the least significant bit is stored in the highest memory address and transmitted last (e.g., for the value 0080h, the byte containing 00h is stored in the lowest memory address, and the byte containing 80h is stored in the highest memory address).

3.1.20
bi-phase mark code
BMC
encoding in which a transition occurs at the beginning of each TTIU bit cell (see 3.1.247), a one is represented by a transition in the middle of the TTIU bit cell, and a zero is represented by no transition within the TTIU bit cell

Note 1 to entry: See 5.8.

3.1.21
Broadcast
information about an event in the SAS domain, communicated between phys with the BROADCAST primitive sequence (see 6.2.6.4) and/or the SMP ZONED BROADCAST function (see 9.4.3.20)

Note 1 to entry: See 4.1.15.

3.1.22
Broadcast propagation processor
BPP
object within an expander function (see 3.1.69) that manages Broadcasts (see 3.1.21)

Note 1 to entry: See 4.5.5.

3.1.23
burst time
part of an OOB signal where the OOB burst is transmitted

Note 1 to entry: See SAS-3.

3.1.24
byte
sequence of eight contiguous bits considered as a unit

3.1.25
cable assembly
bulk cable with a separable connector at each end plus any retention, backshell, shielding features, or circuitry used for cable management or signal transmission

Note 1 to entry: See SAS-3.

3.1.26
character
sequence of ten contiguous bits considered as a unit

Note 1 to entry: A byte is encoded as a character using 8b10b coding (see 5.2).

3.1.27
class
description of a set of objects that share the same attributes, operations relationships, and semantics

Note 1 to entry: Classes may have attributes and may support operations.

3.1.28
class diagram
diagram that shows a collection of classes and their contents and relationships

Note 1 to entry: See 3.6.

3.1.29
command descriptor block
CDB
structure used to communicate a command from a SCSI application client to a SCSI device server

Note 1 to entry: See SAM-5.

3.1.30
commonly supported setting
supported settings bit (see table 53) with a value set to one by both the phy and the attached phy as transmitted during the most recent SNW-3

3.1.31
compliant jitter tolerance pattern
CJTPAT
test pattern for jitter testing

Note 1 to entry: See A.2 and SAS-3.

3.1.32
configuration subprocess
subprocess invoked from the discover process (see 3.1.58) to configure an externally configurable expander device (see 3.1.76)

Note 1 to entry: See 4.7.

3.1.33
confirmation
information passed from a lower layer state machine to a higher layer state machine, usually responding to a request from that higher layer state machine

Note 1 to entry: For an example of a response from a peer layer state machine see figure 41 in 4.5.6.2.

Note 2 to entry: See 3.7.

3.1.34
connection
temporary association between a SAS initiator port and a SAS target port using a pathway (see 3.1.140)

Note 1 to entry: See 4.1.12 and 6.14.

3.1.35
connection rate
effective rate of dwords through the pathway (see 3.1.140) between a SAS initiator phy and a SAS target phy, established through the connection request

3.1.36
connection request
request to establish a connection originated by a SAS phy (see 3.1.175) using an OPEN address frame (see 6.8.3)

Note 1 to entry: See 6.14.2.1.

3.1.37
connector
electro-mechanical components consisting of a receptacle and a plug that provide a separable interface between two transmission segments

Note 1 to entry: See SAS-3.

3.1.38
constraint
mechanism for specifying semantics or conditions that are maintained as true between entities

Note 1 to entry: This definition only applies when used in relation to UML.

Note 2 to entry: An example of a constraint is a required condition between associations.

Note 3 to entry: See 3.6.

3.1.39
control byte
byte containing control information defined in table 50

Note 1 to entry: See 5.3.7.

3.1.40
control character
Kxx.y
character containing control information defined in table 50

Note 1 to entry: See 5.3.7.

3.1.41
credit advance
SSP phy feature that increments a transmit SSP frame credit on receipt of an OPEN address frame without waiting for an RRDY

Note 1 to entry: See 4.1.14.

3.1.42
cyclic redundancy check
CRC
error checking mechanism that checks data integrity by computing a polynomial algorithm based checksum

Note 1 to entry: See 6.5.

3.1.43
D.C. idle
differential signal level that is nominally 0 V peak-to-peak

Note 1 to entry: See SAS-3.

3.1.44
D.C. mode
mode in which D.C. idle is used, during the idle time and negation time of an OOB signal (see SAS-3), and during the RCDT time of speed negotiation windows (see 5.10.4.2.2)

3.1.45
data byte
byte containing data information defined in table 49

Note 1 to entry: See 5.3.6.

3.1.46
data character
Dxx.y
character containing data information defined in table 49 (see 5.2)

Note 1 to entry: See 5.3.6.

3.1.47
data dword
dword containing four data bytes or four data characters with correct disparity

3.1.48
deadlock
condition in which two or more processes (e.g., connection requests) are waiting on the others to complete, resulting in none of the processes completing

3.1.49
deletable primitive
primitive which may be deleted by a receiver instead of being placed into its elasticity buffer (see 6.3)

Note 1 to entry: See 6.2.5.

3.1.50
dependency
relationship between two classes where a change to one class (i.e., the independent class) may cause a change in the other class (i.e., the dependent class)

Note 1 to entry: This definition only applies when used in relation to UML.

Note 2 to entry: See 3.6.

3.1.51
device name
worldwide unique name for a device within a transport protocol

Note 1 to entry: See 4.2.6.

3.1.52
device server
object that processes SCSI commands (see SAM-5), ATA commands (see ATA8-AAM), or SMP functions

Note 1 to entry: See 4.1.5.

3.1.53
differential high signal level
signal level that exists when the Tx+ signal of a transmitter circuit (see SAS-3) is higher than the voltage measured on the Tx- signal of a transmitter circuit

3.1.54
differential low signal level
signal level that exists when the Tx+ signal of a transmitter circuit (see SAS-3) is lower than the voltage measured on the Tx- signal of a transmitter circuit

3.1.55
direct current
D.C.
non-alternating current component (see SAS-3) of a signal

Note 1 to entry: See SAS-3.

3.1.56
direct routing attribute
attribute of an expander phy that indicates that the expander phy may be used by the ECM (see 3.1.66) to route a connection request to an end device

Note 1 to entry: See 4.5.7.1.

3.1.57
direct routing method
method the ECM (see 3.1.66) uses to route connection requests to an attached end device or an attached expander device

Note 1 to entry: See 4.5.7.1.

3.1.58
discover process
process performed by a management application client to discover all the SAS devices and expander devices in the SAS domain

Note 1 to entry: The discover process invokes the configuration subprocess (see 3.1.32) as needed

Note 2 to entry: See 4.6.

3.1.59
disparity
difference between the number of ones and zeros in a character (see 5.2)

3.1.60
domain
I/O system consisting of devices that communicate with one another by means of a service delivery subsystem

Note 1 to entry: Examples of domains are a SAS domain (see 3.1.171), a SCSI domain (see 3.1.191), or an ATA domain (see 3.1.17).

Note 2 to entry: See 4.1.9.

3.1.61
dword
sequence of four contiguous bytes or four contiguous characters considered as a unit

Note 1 to entry: The meaning depends on the context (e.g., when discussing the bits being transmitted over a physical link, dword represents four characters (i.e., 40 bits) and when discussing the contents of a frame before 8b10b encoding (see 3.1.2) or after 10b8b decoding (see 3.1.3), dword represents four bytes (i.e., 32 bits)).

3.1.62
dword synchronization
detection of an incoming stream of dwords from a physical link by a phy

Note 1 to entry: See 5.13.

3.1.63
enclosure
box, rack, or set of boxes providing the powering, cooling, mechanical protection, EMI protection, and external electronic interfaces for one or more end device(s) (see 3.1.64) and/or expander device(s) (see 3.1.68)

Note 1 to entry: The enclosure provides the outermost electromagnetic boundary and acts as an EMI barrier; an enclosure is not a class in this document.

3.1.64
end device
SAS device (see 3.1.170) or SATA device (see 3.1.181) that is not contained within an expander device (see 3.1.68)

3.1.65
event notification
information passed from the SSP transport layer to the SCSI application layer notifying the SCSI application layer that a SCSI event has occurred

Note 1 to entry: See SAM-5.

3.1.66
expander connection manager
ECM
object within an expander function (see 3.1.69) that manages routing

Note 1 to entry: See 4.5.3.

3.1.67
expander connection router
ECR
portion of an expander function (see 3.1.69) that routes messages between expander phys

Note 1 to entry: See 4.5.4.

3.1.68
expander device
device that is part of a service delivery subsystem (see 3.1.203), facilitates communication between SAS devices (see 3.1.170) and SATA devices (see 3.1.181), and is either an externally configurable expander device (see 3.1.76) or a self-configuring expander device (see 3.1.197)

Note 1 to entry: See 4.1.7.

3.1.69
expander function
object within an expander device (see 3.1.68) that contains an expander connection manager (see 3.1.66), expander connection router (see 3.1.67), and Broadcast propagation processor (see 3.1.22)

Note 1 to entry: See 4.5.1.

3.1.70
expander logical phy
expander phy (see 3.1.71) or a multiplexed portion of an expander phy

Note 1 to entry: See 4.1.2.

3.1.71
expander phy
phy in an expander device (see 3.1.68) that interfaces to a service delivery subsystem (see 3.1.203)

3.1.72
expander port
expander device object that interfaces to a service delivery subsystem (see 3.1.203) and to SAS ports in other devices

Note 1 to entry: See 4.5.2.

3.1.73
expander route entry
SAS address and an enable/disable bit in an expander route table (see 3.1.75)

3.1.74
expander route index
value used in combination with a phy identifier to select an expander route entry in an expander route table (see 3.1.75) in an externally configurable expander device (see 3.1.76)

Note 1 to entry: See 4.5.7.4.

3.1.75
expander route table
table of expander route entries (see 3.1.73) within an expander device (see 3.1.68)

Note 1 to entry: The table is used by the expander function (see 3.1.69) to resolve connection requests.

Note 2 to entry: See 4.5.7.4.

3.1.76
externally configurable expander device
non-self-configuring expander device (see 3.1.68) that contains an expander route table (see 3.1.75)

Note 1 to entry: An externally configurable expander device that is configurable with the SMP CONFIGURE ROUTE INFORMATION function (see 9.4.3.27).

Note 2 to entry: See 4.1.7.

3.1.77
field
group of one or more contiguous bits

3.1.78
Final-SNW
final speed negotiation window for 1.5 Gbit/s or 3 Gbit/s without training (see 5.10.4.2.3.2)

3.1.79
frame
sequence of data dwords between a start of frame primitive and an end of frame primitive

Note 1 to entry: Start of frame primitives are SOF, SOAF, and SATA_SOF.

Note 2 to entry: End of frame primitives are EOF, EOAF, and SATA_EOF.

3.1.80
frame information structure
FIS
SATA frame format

Note 1 to entry: See SATA.

3.1.81
generalization
relationship among classes where one class (i.e., the superclass) shares the attributes and operations of one or more other classes (i.e., the subclasses)

Note 1 to entry: This definition only applies when used in relation to UML.

Note 2 to entry: See 3.6.

3.1.82
hard reset
SAS device or expander device action in response to a reset event in which the device performs the operations described in 4.4.2

3.1.83
hard reset sequence
sequence that causes a hard reset (see 3.1.82)

Note 1 to entry: See 4.4 and 6.9.

3.1.84
hardware maximum physical link rate
maximum physical link rate capability of a phy

3.1.85
hardware minimum physical link rate
minimum physical link rate capability of a phy

3.1.86
hash
mathematical function that maps values from a larger set of values into a smaller set of values, reducing a long value into a shorter hashed value

3.1.87
highest priority commonly supported setting
commonly supported setting based on the priority defined in table 56

3.1.88
I_T nexus
nexus between a SAS initiator port and a SAS target port or a nexus between a SCSI initiator port and a SCSI target port

Note 1 to entry: When referring to SAS ports, a nexus between a SAS initiator port and a SAS target port.

Note 2 to entry: When referring to SCSI ports, a nexus between a SCSI initiator port and a SCSI target port.

Note 3 to entry: See SAM-5.

3.1.89
I_T nexus loss
condition where a SAS port determines that another SAS port is no longer available or an I_T nexus loss operation occurs in a SCSI port

Note 1 to entry: When referring to SAS ports (see 3.1.177), a condition where a SAS port determines that another SAS port is no longer available.

Note 2 to entry: When referring to SCSI ports (see 3.1.194) (e.g., SSP ports), a condition resulting from the events defined by SAM-5 in which the SCSI device performs the I_T nexus loss operations described in SAM-5, SPC-4, and the appropriate command standards.

Note 3 to entry: See 4.4.3 and SAM-5.

3.1.90
I_T nexus loss event
event that results in an I_T nexus loss condition (see SAM-5)

Note 1 to entry: See 4.4.3 and SAM-5.

3.1.91
I_T nexus loss timer event
event that starts an I_T nexus loss timer (see 7.2.2.1)

Note 1 to entry: See 4.4.3.

3.1.92
I_T_L nexus
nexus between a SCSI initiator port, a SCSI target port, and a logical unit

Note 1 to entry: See SAM-5.

3.1.93
I_T_L_Q nexus
nexus between a SCSI initiator port, a SCSI target port, a logical unit, and a command or task management function

Note 1 to entry: See SAM-5.

3.1.94
IDENTIFY (PACKET) DEVICE data
IDENTIFY DEVICE data from an ATA device, or IDENTIFY PACKET DEVICE data from an ATAPI device

Note 1 to entry: See ACS-2.

3.1.95
identification sequence
sequence where phys exchange IDENTIFY address frames

Note 1 to entry: See 4.4 and 6.9.

3.1.96
idle dword
vendor specific data dword that is scrambled and is transmitted outside a frame

Note 1 to entry: See 6.4.

3.1.97
idle time
part of an OOB signal (see 3.1.135) where OOB idle (see 3.1.133) is being transmitted

Note 1 to entry: See 5.6.

3.1.98
indication
information passed from a lower layer state machine to a higher layer state machine, usually responding to a request from that higher layer state machine (e.g., see figure 40)

Note 1 to entry: See 3.7.

3.1.99
information unit
portion of an SSP frame that carries command, task management function, data, response, or transfer ready information

Note 1 to entry: See 8.2.2.

3.1.100
initiator connection tag
value in the OPEN address frame used for SSP and STP connection requests to provide a SAS initiator port an alternative to using the SAS target port's SAS address for context lookup when the SAS target port originates a connection request

Note 1 to entry: See 6.8.3.

3.1.101
initiator port transfer tag
value that allows an SSP initiator port to establish a context for commands and task management functions

Note 1 to entry: See 8.2.1.

3.1.102
invalid character
character that is not a control character (see 3.1.40) or a data character (see 3.1.46)

3.1.103
invalid dword
dword that is not a data dword (see 3.1.47) or a primitive (see 3.1.155)

Note 1 to entry: In the character context, a dword that contains an invalid character, a control character in other than the first character position, a control character other than K28.3 or K28.5 in the first character position, or one or more characters with a running disparity error.

3.1.104
jitter tolerance pattern
JTPAT
test pattern for jitter testing

Note 1 to entry: See SAS-3.

3.1.105
least significant bit
LSB
bit or bit position with the smallest numerical weighting in a group of bits that, when taken as a whole, represent a numerical value

Note 1 to entry: This definition only applies when used in relation to binary codes.

Note 2 to entry: For example in the number 0001b, the LSB bit is the bit that is set to one.

3.1.106
left-aligned
type of field containing ASCII data in which unused bytes are placed at the end of the field (highest offset) and are filled with ASCII space (20h) characters

Note 1 to entry: See SPC-4.

3.1.107
link reset sequence
phy reset sequence

Note 1 to entry: For a SATA a link reset sequence is only a phy reset sequence (see 3.1.146).

Note 2 to entry: For SAS a link reset sequence is a phy reset sequence followed by an identification sequence (see 3.1.95), or a phy reset sequence followed by a hard reset sequence (see 3.1.83), another phy reset sequence, and an identification sequence.

Note 3 to entry: See 4.4 and 6.9.

3.1.108
little-endian
format for storage or transmission of binary data in which the least significant byte appears first

Note 1 to entry: In a multi-byte value, the byte containing the least significant bit is stored in the lowest memory address and transmitted first, and the byte containing the most significant bit is stored in the highest memory address and transmitted last (e.g., for the value 0080h, the byte containing 80h is stored in the lowest memory address, and the byte containing 00h is stored in the highest memory address)

3.1.109
livelock
condition where two or more processes (e.g., connection requests) repeatedly change their state in response to changes in other processes, resulting in none of the processes completing

3.1.110
local
attribute of a class used when an instance of that class is accessible without having to access any service delivery subsystem

3.1.111
locked zoning expander device
zoning expander device (see 3.1.262) that has been locked by a zone manager (see 3.1.258)

Note 1 to entry: See 4.8.6.2.

3.1.112
logical link
physical link or a multiplexed portion of a physical link

Note 1 to entry: See 4.1.3.

3.1.113
logical link rate
link rate between two logical phys established as a result of speed negotiation and multiplexing negotiation between the physical phys containing those logical phys

3.1.114
logical phy
phy (see 3.1.143) or a multiplexed portion of a phy

Note 1 to entry: See 4.1.2.

3.1.115
logical unit
object that implements a device model and manages and processes commands sent by a SCSI application client

Note 1 to entry: See SAM-5.

3.1.116
logical unit number
LUN
identifier for a logical unit (see 3.1.115)

Note 1 to entry: See SAM-5.

3.1.117
low phy power condition
partial phy power condition or the slumber phy power condition

Note 1 to entry: See 4.10.1.

3.1.118
medium
material on which data is stored

Note 1 to entry: The plural of medium is media.

Note 2 to entry: An example of a medium on which data is stored is a magnetic disk.

3.1.119
message
information sent between state machines

Note 1 to entry: See 3.7.

3.1.120
most significant bit
MSB
bit or bit position with the largest numerical weighting in a group of bits that, when taken as a whole, represent a numerical value

Note 1 to entry: This definition only applies when used in relation to binary codes.

Note 2 to entry: For example in the number 1000b the MSB bit is the bit that is set to one.

3.1.121
multiplexing
interleaving of dwords

Note 1 to entry: Multiplexing divides a single physical link into two logical links by creating two logical phys from a single physical phy.

Note 2 to entry: See 5.15.

3.1.122
multiplicity
indication of the range of allowable instances of an object or an attribute

Note 1 to entry: This definition only applies when used in relation to UML.

Note 2 to entry: See 3.6.

3.1.123
narrow link
physical link that attaches a narrow port to another narrow port

Note 1 to entry: See 4.1.4.

3.1.124
narrow port
port that contains exactly one phy

Note 1 to entry: See 4.1.4.

3.1.125
negation time
part of an OOB signal (see 3.1.135) during which OOB idle (see 3.1.133) is transmitted after the last OOB burst (see 3.1.132)

Note 1 to entry: See 5.6.

3.1.126
negotiation idle
transmission of OOB idle (see 3.1.133)

Note 1 to entry: See 5.12.4.2.

3.1.127
negotiated logical link rate
current operational logical link rate (see 3.1.113)

3.1.128
negotiated physical link rate
current operational physical link rate (see 3.1.148)

3.1.129
nexus
relationship between two SAS devices or two SCSI devices

Note 1 to entry: When referring to SAS devices (see 3.1.170), a relationship between two SAS devices, and the SAS initiator port and the SAS target port objects within those SAS devices.

Note 2 to entry: When referring to SCSI devices (see 3.1.190), a relationship between two SCSI devices, and the SCSI initiator port and the SCSI target port objects within those SCSI devices.

Note 3 to entry: See SAM-5.

3.1.130
object
entity with a well-defined boundary and identity that encapsulates state and behavior

Note 1 to entry: All objects are instances of classes (i.e., a concrete manifestation of a class is an object).

3.1.131
object diagram
diagram that encompasses objects and their relationships at a point in time

Note 1 to entry: See 3.6.

3.1.132
OOB burst
transmission of signal transitions for a burst time

Note 1 to entry: See SAS-3.

3.1.133
OOB idle
transmission of D.C. idle when D.C mode (see 3.1.44) is enabled, or a defined sequence of dwords when optical mode (see 3.1.137) is enabled

Note 1 to entry: See SAS-3.

3.1.134
OOB sequence
sequence where two phys exchange OOB signals (see 3.1.135)

Note 1 to entry: See 5.10.2.1 and 5.10.4.1.

3.1.135
OOB signal
pattern of idle time (see 3.1.97), burst time, and negation time (see 3.1.125) used during the link reset sequence

Note 1 to entry: See 5.6.

3.1.136
operation
service that may be requested from any object of the class in order to affect behavior

Note 1 to entry: This definition only applies when used in relation to UML

Note 2 to entry: Operations describe what a class is allowed to do and may be a request or a query.

Note 3 to entry: An operation that is a request may change the state of the object but an operation that is a query should not.

Note 4 to entry: See 3.6.

3.1.137
optical mode
mode in which a defined sequence of dwords is used during the idle time and negation time of an OOB signal (see SAS-3) and during the RCDT time of speed negotiation windows (see 5.10.4.2.2)

3.1.138
partial pathway
set of logical links participating in a connection request that have not yet conveyed a connection response

Note 1 to entry: See 4.1.11.

3.1.139
partial phy power condition
low phy power condition for a SAS phy or expander phy

Note 1 to entry: See 4.10.1.3.

3.1.140
pathway
set of logical links between a SAS initiator phy and a SAS target phy being used by a connection (see 3.1.34)

Note 1 to entry: See 4.1.11.

3.1.141
pathway blocked count
number of times the port has retried this connection request due to receiving OPEN_REJECT (PATHWAY BLOCKED), OPEN_REJECT (RESERVED STOP 0), or OPEN_REJECT (RESERVED STOP 1)

3.1.142
persistent connection
connection that may be extended indefinitely

3.1.143
phy
object in a device that is used to interface to other devices (e.g., an expander phy (see 3.1.71) or a SAS phy (see 3.1.175))

Note 1 to entry: See 4.1.2 and SAS-3.

3.1.144
phy identifier
value by which a phy is identified within a device

Note 1 to entry: See 4.2.10.

3.1.145
phy ready state
condition of a phy when its SP state machine is in the SP15:SAS_PHY_Ready state (see 5.12.4.10)

3.1.146
phy reset sequence
OOB sequence (see 3.1.134) followed by a speed negotiation sequence (see 3.1.213)

Note 1 to entry: See 4.4 and 5.10.

3.1.147
physical link
two differential signal pairs, one pair in each direction, that connect two physical phys

Note 1 to entry: See 4.1.2 and SAS-3.

3.1.148
physical link rate
link rate between two physical phys established as a result of speed negotiation between those phys

3.1.149
physical phy
phy that contains a transceiver and electrically interfaces to a physical link to communicate with another physical phy

Note 1 to entry: See 4.1.2 and SAS-3.

3.1.150
port
SAS port (see 3.1.177) or an expander port (see 3.1.72)

Note 1 to entry: Each port contains one or more phys (see 3.1.143).

Note 2 to entry: See 4.1.4.

3.1.151
port identifier
value by which a port is identified within a domain

Note 1 to entry: See 4.2.9.

3.1.152
port name
worldwide unique name for a port within a transport protocol

Note 1 to entry: See 4.2.8.

3.1.153
potential pathway
set of logical links between a SAS initiator phy and a SAS target phy

Note 1 to entry: See 4.1.11.

3.1.154
power on
power being applied

3.1.155
primitive
8b10b coded dword in which the first byte is a control byte (i.e., 7Ch or BCh) or a control character (i.e., K28.3 or K28.5)

Note 1 to entry: For a phy that supports being attached to SATA phy, an 8b10b coded dword containing a 7Ch or BCh control byte followed by three data bytes, or a K28.3 or K28.5 control character with correct disparity followed by three data characters with correct disparity.

Note 2 to entry: For a phy that does not support being attached to SATA phy, an 8b10b coded dword containing a BCh control byte followed by three data bytes, or a K28.5 control character with correct disparity followed by three data characters with correct disparity.

Note 3 to entry: See 6.2.

3.1.156
primitive sequence
set of primitives treated as a single entity

Note 1 to entry: See 6.2.4.

3.1.157
programmed maximum physical link rate
maximum operational physical link rate of a phy

Note 1 to entry: The programmed maximum physical link rate may be programmed via the SMP PHY CONTROL function (see 9.4.3.28) or the Phy Control and Discover mode page (see 9.2.7.5).

3.1.158
programmed minimum physical link rate
minimum operational physical link rate of a phy

Note 1 to entry: The programmed minimum physical link rate may be as programmed via the SMP PHY CONTROL function (see 9.4.3.28) or the Phy Control and Discover mode page (see 9.2.7.5))

3.1.159
rate
data transfer rate of a physical or logical link

Note 1 to entry: Rate examples are 1.5 Gbit/s, 3 Gbit/s, 6 Gbit/s, and 12 Gbit/s.

3.1.160
read data
data transferred to the SCSI application client's data-in buffer from the SCSI device server, as requested by the Send Data-In transport protocol service (see 9.2.1.6)

3.1.161
receiver device
Rx
device downstream from a receiver device compliance point containing a portion of the physical link and a receiver circuit

Note 1 to entry: See SAS-3.

3.1.162
request
information passed from a higher layer state machine to a lower layer state machine, usually to initiate some action

Note 1 to entry: See 3.7.

3.1.163
reset event
event that triggers a hard reset (see 4.4.2) in a SAS device

3.1.164
response
information passed from a higher layer state machine to a lower layer state machine, usually in response to an indication (see 3.1.98)

Note 1 to entry: See 3.7.

3.1.165
role
label at the end of an association (see 3.1.11) or aggregation (see 3.1.9) that defines a relationship to the class on the other side of the association or aggregation

Note 1 to entry: This definition only applies when used in relation to UML.

Note 2 to entry: See 3.6.

3.1.166
route table optimization
configuration subprocess (see 3.1.32) algorithm that reduces the number of entries required in an expander route table (see 3.1.75) in an externally configurable expander device (see 3.1.76)

Note 1 to entry: See 4.7.3.

3.1.167
run length
number of consecutive identical bits in the transmitted signal

Note 1 to entry: For example the pattern 00 11111010b includes the following run lengths of five 1s, one 0, one 1, and indeterminate run lengths of 0s at the start and end.

3.1.168
running disparity
RD
binary parameter with a negative (-) or positive (+) value indicating the cumulative encoded signal imbalance between the one and zero signal state of all characters since dword synchronization has been achieved

Note 1 to entry: See 5.3.5.

3.1.169
SAS address
identifier assigned to a SAS port (see 3.1.177) or expander device (see 3.1.68)

Note 1 to entry: See 4.2.4.

3.1.170
SAS device
SAS initiator device and/or a SAS target device

Note 1 to entry: See 4.1.6.

3.1.171
SAS domain
I/O system defined by this document that may serve as a SCSI domain

Note 1 to entry: See 4.1.9.

3.1.172
SAS initiator device
device containing SSP, STP, and/or SMP initiator ports in a SAS domain

Note 1 to entry: See 4.1.6.

3.1.173
SAS initiator phy
logical phy (see 3.1.114) in a SAS initiator device

3.1.174
SAS initiator port
SSP initiator port (see 3.1.217), STP initiator port (see 3.1.224), and/or SMP initiator port (see 3.1.206) in a SAS domain

3.1.175
SAS phy
phy in a SAS device that interfaces to a service delivery subsystem (see 3.1.203)

3.1.176
SAS logical phy
SAS phy (see 3.1.175) or a multiplexed portion of a SAS phy

Note 1 to entry: See 4.1.2.

3.1.177
SAS port
SAS initiator port (see 3.1.174) and/or a SAS target port (see 3.1.180)

3.1.178
SAS target device
device containing SSP, STP, and/or SMP target ports in a SAS domain

Note 1 to entry: See 4.1.6.

3.1.179
SAS target phy
logical phy (see 3.1.114) in a SAS target device

3.1.180
SAS target port
SSP target port (see 3.1.221), STP target port (see 3.1.229), and/or SMP target port (see 3.1.210) in a SAS domain

3.1.181
SATA device
ATA device that contains a SATA device port in an ATA domain; analogous to a SAS target device (see 3.1.178)

3.1.182
SATA device port
ATA device object that interfaces to a service delivery subsystem (see 3.1.203) with SATA

Note 1 to entry: Analogous to a SAS target port (see 3.1.180).

3.1.183
SATA host
ATA host that contains a SATA host port in an ATA domain

Note 1 to entry: Analogous to a SAS initiator device (see 3.1.172).

3.1.184
SATA host port
ATA host object that interfaces to a service delivery subsystem (see 3.1.203) with SATA

Note 1 to entry: Analogous to a SAS initiator port (see 3.1.174).

3.1.185
SATA phy
phy in a SATA device or SATA port selector that interfaces to a service delivery subsystem (see 3.1.203)

Note 1 to entry: Analogous to a SAS phy (see 3.1.175).

3.1.186
SATA port selector
device that attaches to two SATA host ports (i.e., two ATA domains) and one SATA device port, and provides the means for one SATA host to access the device at any given time (see SATA)

3.1.187
SATA spinup hold
state entered by an expander phy attached to a SATA device in which it halts the automatic phy reset sequence to delay temporary consumption of additional power

Note 1 to entry: An example when a SATA device consumes additional power is during spin up of rotating media.

Note 2 to entry: See 5.16.

3.1.188
saturating counter
counter that remains at its maximum value after reaching its maximum value

3.1.189
scrambling
modifying data by XORing each bit with a pattern generated by a linear feedback shift register to minimize repetitive character patterns

Note 1 to entry: See 6.6.

3.1.190
SCSI device
device that contains one or more SCSI ports that are connected to a service delivery subsystem (see 3.1.203) and supports a SCSI application protocol

Note 1 to entry: See SAM-5.

3.1.191
SCSI domain
I/O system consisting of a set of SCSI devices that communicate with one another by means of a service delivery subsystem (see 3.1.203)

Note 1 to entry: See SAM-5.

3.1.192
SCSI initiator device
SCSI device containing SCSI 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

Note 1 to entry: See SAM-5.

3.1.193
SCSI initiator port
SCSI initiator device object that acts as the connection between SCSI application clients and a service delivery subsystem (see 3.1.203) through which requests and confirmations are routed

Note 1 to entry: See SAM-5.

3.1.194
SCSI port
SCSI initiator port and/or a SCSI target port

Note 1 to entry: See SAM-5.

3.1.195
SCSI target device
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

Note 1 to entry: See SAM-5.

3.1.196
SCSI target port
SCSI target device object that contains a task router and acts as the connection between SCSI device servers and task managers and a service delivery subsystem (see 3.1.203) through which requests, indications, responses, and confirmations are routed

Note 1 to entry: See SAM-5.

3.1.197
self-configuring expander device
expander device (see 3.1.68) containing an SMP initiator port and a management application client to perform the discover process (see 3.1.58) to configure its own expander route table (see 3.1.75)

Note 1 to entry: See 4.6.4.

3.1.198
Serial ATA
SATA
protocol defined in SATA (see clause 2)

3.1.199
Serial ATA Tunneled Protocol
STP
protocol defined in this document used by STP initiator ports (see 3.1.224) to communicate with STP target ports (see 3.1.229) in a SAS domain

Note 1 to entry: See 6.19 and 8.3.

3.1.200
Serial Attached SCSI
SAS
set of protocols defined by this document and the interconnects defined in SAS-3

3.1.201
Serial Management Protocol
SMP
protocol defined in this document used by SMP initiator ports (see 3.1.206) to communicate with SMP target ports (see 3.1.210) in a SAS domain

Note 1 to entry: See 6.20 and 8.4

3.1.202
Serial SCSI Protocol
SSP
protocol defined in this document used by SSP initiator ports (see 3.1.217) to communicate with SSP target ports (see 3.1.221) in a SAS domain

Note 1 to entry: See 6.18 and 8.2.

3.1.203
service delivery subsystem
part of a SCSI I/O system that transmits information between a SCSI initiator port and a SCSI target port, or the part of an ATA I/O system that transmits information between an ATA host and an ATA device, or the part of a SAS I/O system that transmits information between a SAS initiator port and a SAS target port

Note 1 to entry: See 4.1.8.

3.1.204
slumber phy power condition
low phy power condition for a SAS phy or expander phy

Note 1 to entry: See 4.10.1.4.

3.1.205
SMP initiator phy
SAS initiator phy (see 3.1.173) in an SMP initiator port (see 3.1.206)

3.1.206
SMP initiator port
SAS initiator device object in a SAS domain that interfaces to a service delivery subsystem with SMP

3.1.207
SMP phy
SAS logical phy (see 3.1.176) in an SMP port

3.1.208
SMP port
SMP initiator port (see 3.1.206) and/or an SMP target port (see 3.1.210)

3.1.209
SMP target phy
SAS target phy (see 3.1.179) in an SMP target port (see 3.1.210)

3.1.210
SMP target port
SAS target device object in a SAS domain that interfaces to a service delivery subsystem (see 3.1.203) with SMP

3.1.211
SMP zone configuration function
SMP function that configures zoning expander shadow values (see 3.1.264) and is only accepted by a locked zoning expander device

Note 1 to entry: See 4.8.6.3.

3.1.212
SNW-3 bit cell time
time for transmitting a phy capabilities bit during SNW-3 (see 5.10.4.2.3.3)

3.1.213
speed negotiation sequence
sequence in which two phys negotiate the operational physical link rate

Note 1 to entry: See 5.10.2.2 and 5.10.4.2.

3.1.214
speed negotiation window
SNW
portion of the SAS speed negotiation sequence

Note 1 to entry: See 5.10.4.2.3.

3.1.215
spread spectrum clocking
SSC
technique of modulating the operating frequency of a transmitted signal (i.e., the physical link rate) to reduce the measured peak amplitude of radiated emissions

Note 1 to entry: See SAS-3.

3.1.216
SSP initiator phy
SAS initiator phy (see 3.1.173) in an SSP initiator port (see 3.1.217)

3.1.217
SSP initiator port
SCSI initiator port in a SAS domain that implements SSP

3.1.218
SSP phy
SAS logical phy (see 3.1.176) in an SSP port

3.1.219
SSP port
SSP initiator port (see 3.1.217) and/or an SSP target port (see 3.1.221)

3.1.220
SSP target phy
SAS target phy (see 3.1.179) in an SSP target port (see 3.1.221)

3.1.221
SSP target port
SCSI target port in a SAS domain that implements SSP

3.1.222
state machine variable
variable that exists within the context of a state machine

Note 1 to entry: A state machine variable may contain status from one state that is used in another state of the same state machine.

Note 2 to entry: The value contained in a state machine variable may affect subsequent state transitions or state machine outputs.

3.1.223
STP initiator phy
SAS initiator phy (see 3.1.173) in an STP initiator port (see 3.1.224)

3.1.224
STP initiator port
SAS initiator device object in a SAS domain that interfaces to a service delivery subsystem (see 3.1.203) with STP

3.1.225
STP phy
SAS logical phy (see 3.1.176) in an STP port

3.1.226
STP port
STP initiator port (see 3.1.224) and/or an STP target port (see 3.1.229)

3.1.227
STP primitive
primitive used only inside STP connections and on SATA physical links

Note 1 to entry: See 6.2.2.

3.1.228
STP target phy
SAS target phy (see 3.1.179) in an STP target port (see 3.1.229)

3.1.229
STP target port
SAS target device object in a SAS domain that interfaces to a service delivery subsystem (see 3.1.203) with STP

3.1.230
STP SATA bridge
expander device object containing an STP target port, a SATA host port, and the functions required to forward information between the STP target port and SATA host port to enable STP initiator ports in a SAS domain to communicate with SATA devices in an ATA domain

3.1.231
subtractive routing attribute
attribute of an expander phy that indicates that the expander phy may be used by the ECM (see 3.1.66) to route connection requests to an attached expander device that were not resolved using the direct routing method or table routing method

Note 1 to entry: See 4.5.7.1.

3.1.232
subtractive routing method
method the ECM (see 3.1.66) uses to route connection requests not resolved using the direct routing method or table routing method to an attached expander device (see 3.1.68)

Note 1 to entry: See 4.5.7.1.

3.1.233
table routing attribute
attribute of an expander phy that indicates that the expander phy may be used by the ECM (see 3.1.66) to route connection requests using an expander route table (see 3.1.75)

Note 1 to entry: See 4.5.7.1.

3.1.234
table routing method
method the ECM (see 3.1.66) uses to route connection requests to an attached expander device (see 3.1.68) using an expander route table (see 3.1.75)

Note 1 to entry: See 4.5.7.1.

3.1.235
target port transfer tag
optional value that allows an SSP target port to establish the write data context when receiving a write DATA frame

Note 1 to entry: See 8.2.1.

3.1.236
task management function
task manager service capable of being requested by a SCSI application client to affect the processing of one or more commands

Note 1 to entry: See SAM-5.

3.1.237
task manager
object that controls the sequencing of SCSI commands and processes SCSI task management functions

Note 1 to entry: See SAM-5.

3.1.238
Train_Rx-SNW
speed negotiation window with receiver training

Note 1 to entry: See 5.10.4.2.3.5.

3.1.239
Train_Rx-SNW window time
actual duration of Train_Rx-SNW

3.1.240
Train_Tx-SNW
speed negotiation window with transmitter training

Note 1 to entry: See 5.10.4.2.3.4.

3.1.241
transmitter device
Tx
device upstream from a transmitter device compliance point containing a portion of the physical link and a transmitter circuit (see SAS-3)

3.1.242
transport protocol service confirmation
information passed from the SSP transport layer to the SCSI application layer (e.g., from the SSP initiator port to the SCSI application client) that notifies the SCSI application layer that a SCSI transport protocol service has completed

3.1.243
transport protocol service indication
information passed from the SSP transport layer to the SCSI application layer notifying the SCSI application layer (e.g., from the SSP target port to the SCSI device server) to begin a SCSI transport protocol service

3.1.244
transport protocol service request
information passed from the SCSI application layer to the SSP transport layer (e.g., from the SCSI application client to the SCSI initiator port) to begin a SCSI transport protocol service

3.1.245
transport protocol service response
information passed from the SCSI application layer to the SSP transport layer (e.g., from the SCSI device server to the SSP target port) that completes the SCSI transport protocol service

3.1.246
transmitter training information unit
TTIU
32 TTIU bit cells that follow a pattern marker transmitted during Train_Tx-SNW (see 5.10.4.2.3.4)

Note 1 to entry: See 5.10.4.2.3.5.

3.1.247
TTIU bit cell
group of ten UIs that encode a single bit of BMC (see 3.1.20) information

3.1.248
unit interval
UI
time period that has the normalized, dimensionless, nominal duration of a symbol (see SAS-3)

EXAMPLE - Examples of unit intervals are: 666.$\overline{6}$ ps at 1.5 Gbit/s, 333.$\overline{3}$ ps at 3 Gbit/s, 166.$\overline{6}$ ps at 6 Gbit/s, and 83.$\overline{3}$ ps at 12 Gbit/s.

Note 1 to entry: See SAS-3.

3.1.249
valid character
character that is a control character (see 3.1.40) or a data character (see 3.1.46)

3.1.250
valid dword
dword that is a data dword (see 3.1.47) or a primitive (see 3.1.155)

3.1.251
virtual phy
phy (see 3.1.143) that interfaces with a vendor specific interface to another virtual phy inside the same device

Note 1 to entry: See 4.1.2.

3.1.252
wide link
group of physical links that attaches a wide port to another wide port

Note 1 to entry: See 4.1.4.

3.1.253
wide port
port that contains more than one phy

Note 1 to entry: See 4.1.4.

3.1.254
word
sequence of 16 contiguous bits considered as an unit

3.1.255
wrapping counter
counter that wraps back to zero after reaching its maximum value

3.1.256
write data
data transferred from the SCSI application client's data-out buffer to the SCSI device server, as requested by the Request Data-Out transport protocol service (see 9.2.1.8)

3.1.257
zone group
set of phys in a ZPSDS (see 3.1.260) that all have the same access permission

Note 1 to entry: See 4.8.

3.1.258
zone manager
entity responsible for configuring a ZPSDS (see 3.1.260)

Note 1 to entry: See 4.8.1.

3.1.259
zone permission table
table that defines access permission between the zone group of a source phy and the zone group of the destination phy

Note 1 to entry: See 4.8.3.3.

3.1.260
zoned portion of a service delivery subsystem
ZPSDS
group of zoning expander devices (see 3.1.262) that cooperate to control access between phys; the ZPSDS may include all or part of a service delivery subsystem (see 3.1.203)

Note 1 to entry: See 4.8.

3.1.261
zoning expander current values
current zone permission table (see 3.1.259) and zone phy information in a zoning expander device (see 3.1.262)

Note 1 to entry: See 4.8.6.

3.1.262
zoning expander device
expander device (see 3.1.68) that supports zoning

Note 1 to entry: See 4.8.

3.1.263
zoning expander phy
expander phy in a zoning expander device (see 3.1.262)

3.1.264
zoning expander shadow values
shadow zone permission table (see 3.1.259) and zone phy information in a zoning expander device, which are changed by SMP zone configuration functions (see 3.1.211) but do not become active until the activate step (see 4.8.6.4) is performed

Note 1 to entry: See 4.8.6.

3.2 Symbols and abbreviations

3.2.1 Abbreviations

See Annex L for abbreviations of standards bodies (e.g., ISO).

Abbreviations used in this standard

Abbreviation	Meaning
ACA	auto contingent allegiance (see SAM-5)
ACK	acknowledge (see 6.2.7.1)
AIP	arbitration in progress (see 6.2.6.1)
ATA	AT attachment (see 3.1.15)
ATAPI	AT attachment packet interface
ATA8-AAM	AT Attachment - 8 ATA/ATAPI Architecture Model standard (see clause 2)
ACS-2	ATA/ATAPI Command Set-2 standard (see clause 2)
AWT	arbitration wait time
BCH	Bose, Chaudhuri and Hocquenghem code (see 4.2.5)
BIST	built in self test
BMC	bi-phase mark code (see 3.1.20)
BPP	Broadcast propagation processor (see 3.1.22)
CDB	command descriptor block (see 3.1.29)
CJTPAT	compliant jitter tolerance pattern (see 3.1.31)
CRC	cyclic redundancy check (see 3.1.42)
CRN	command reference number (see SAM-5)
D.C.	direct current (see 3.1.55)
ECM	expander connection manager (see 3.1.66)
ECR	expander connection router (see 3.1.67)
EMI	electromagnetic interference
EOAF	end of address frame (see 6.2.6.6)
EOF	end of frame (see 6.2.7.4)
FIS	frame information structure (see 3.1.80)
G1	generation 1 physical link rate (i.e., 1.5 Gbit/s)
G2	generation 2 physical link rate (i.e., 3 Gbit/s)
G3	generation 3 physical link rate (i.e., 6 Gbit/s)
G4	generation 4 physical link rate (i.e., 12 Gbit/s)
Gbit/s	gigabits per second (i.e., 10^9 bits per second)
ID	identifier
JTPAT	jitter tolerance pattern (see 3.1.104)
LED	light-emitting diode
LSB	least significant bit (see 3.1.105)
LUN	logical unit number (see 3.1.116)
MA	management application layer (see 9.4)
MRTT	maximum receiver training time (see table 70)

Abbreviation	Meaning
MSB	most significant bit (see 3.1.120)
MT	SMP transport layer state machines (see 8.4.5)
MTTT	maximum transmitter training time (see table 70)
MTWT	maximum Train_Rx-SNW window time (see table 70)
MTXT	maximum Train_Tx-SNW window time (see table 70)
N/A	not applicable
NAA	network address authority (see 4.2)
NAK	negative acknowledge (see 6.2.7.6)
NVRAM	non-volatile random-access memory
OOB	out-of-band
OOBI	out-of-band interval
OUI	organizationally unique identifier (i.e., company identifier)
PL	port layer state machines (see 7.2)
PTT	phy layer transmitter training state machines (see 5.14)
RCDT	rate change delay time (see table 70)
RD	running disparity (see 3.1.168)
RRDY	receiver ready (see 6.2.7.7)
Rx	receiver device (see 3.1.161)
SA	SCSI application (see 9.2)
SAM-5	SCSI Architecture Model - 5 standard (see clause 2)
SA_PC	SCSI application layer power condition state machine (see 9.2.10.2)
SAS	Serial Attached SCSI (see 3.1.200)
SATA	Serial ATA (see 3.1.198) or the Serial ATA 3.1 specification (see clause 2)
SBC-3	SCSI Block Commands - 3 standard (see clause 2)
SCSI	Small Computer System Interface family of standards
SL	link layer for SAS phys state machines (see 6.16)
SL_IR	link layer identification and hard reset state machines (see 6.10)
SL_CC	connection control state machine (see 6.16.4)
SL_P	SL_P_C or SL_P_S
SL_P_C	link layer power consumer device state machine (see 6.12.5)
SL_P_S	link layer power source device state machine (see 6.12.4)
SL_RA	connection control state machine (see 6.16.3)
SMP	Serial Management Protocol (see 3.1.201), or link layer for SMP phys state machines (see 6.20.5)
SNLT	speed negotiation lock time (see table 70)
SNTT	speed negotiation transmit time (see table 70)
SNW	speed negotiation window (see 3.1.214)
SNW-1	speed negotiation window for 1.5 Gbit/s without training (see 5.10.4.2.3.2)
SNW-2	speed negotiation window for 3 Gbit/s without training (see 5.10.4.2.3.2)
SNW-3	speed negotiation window negotiating physical link rates with training (see 5.10.4.2.3.3)
SNWT	speed negotiation window time (see table 70)
SOAF	start of address frame (see 6.2.6.18)

Abbreviation	Meaning
SOF	start of frame (see 6.2.7.8)
SP	phy layer state machine (see 5.12)
SP_DWS	phy layer dword synchronization state machine (see 5.13)
SPC-4	SCSI Primary Commands - 4 standard (see clause 2)
SSP	Serial SCSI Protocol (see 3.1.202), or link layer for SSP phys state machines (see 6.18.9)
ST	SSP transport layer state machines (see 8.2.6)
STP	Serial ATA Tunneled Protocol (see 3.1.199), or link layer for STP phys state machines (see 6.19.8)
TLT	training lock time (see table 70)
TT	STP transport layer state machines (see 8.3.3)
TTIU	transmitter training information unit (see 3.1.246)
Tx	transmitter device (see 3.1.241)
UI	unit interval (see 3.1.248)
VPD	vital product data (see 9.2.11)
XL	link layer for expander phys state machine (see 6.17)
ZPSDS	zoned portion of a service delivery subsystem (see 3.1.260)

3.2.2 Units

Units used in this standard:

Units	Meaning
µs	microsecond (i.e., 10^{-6} seconds)
m	meter
ms	millisecond (i.e., 10^{-3} seconds)
ns	nanosecond (i.e., 10^{-9} seconds)
s	second (unit of time)
V	volt

3.2.3 Symbols

Symbols used in this standard:

Symbols	Meaning
Kxx.y	control character (see 3.1.40)
Dxx.y	data character (see 3.1.46)
ZP[s, d]	zone permission bit for a source zone group (i.e., s) and a destination zone group (i.e., d) in the zone permission table (see 4.8.3.3)
®	registered trademark

3.2.4 Mathematical operators

Mathematical operators used in this standard:

Mathematical Operators	Meaning
NE	not equal
XOR	exclusive logical OR
^	exclusive logical OR
<	less than
≤	less than or equal to
>	greater than
≥	greater than or equal to
+	plus
-	minus
±	plus or minus
×	multiplied by
/	divided by
|v|	the absolute value (i.e., magnitude) of v
~	approximately equal to
∈	set membership

3.3 Keywords

3.3.1
invalid
keyword used to describe an illegal or unsupported bit, byte, word, field or code value

Note 1 to entry: Receipt of an invalid bit, byte, word, field or code value shall be reported as an error.

3.3.2
mandatory
keyword indicating an item that is required to be implemented as defined in this standard

3.3.3
may
keyword that indicates flexibility of choice with no implied preference (equivalent to “may or may not”)

3.3.4
may not
keywords that indicate flexibility of choice with no implied preference (equivalent to “may or may not”)

3.3.5
obsolete
keyword indicating that an item was defined in prior standards but has been removed from this standard

3.3.6
optional
keyword that describes features that are not required to be implemented by this standard

Note 1 to entry: If any optional feature defined in this standard is implemented, then it shall be implemented as defined in this standard.

3.3.7
reserved
keyword referring to bits, bytes, words, fields, and code values that are set aside for future standardization

Note 1 to entry: A reserved bit, byte, word or field shall be set to zero, or in accordance with a future extension to this standard.

Note 2 to entry: 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.

3.3.8
restricted
keyword referring to bits, bytes, words, and fields that are set aside for other identified standardization purposes

Note 1 to entry: A restricted bit, byte, word, or field shall be treated as a reserved bit, byte, word or field in the context where the restricted designation appears.

3.3.9
shall
keyword indicating a mandatory requirement

Note 1 to entry: Designers are required to implement all such mandatory requirements to ensure interoperability with other products that conform to this standard.

3.3.10
should
keyword indicating flexibility of choice with a strongly preferred alternative (equivalent to “is strongly recommended”)

3.3.11
vendor specific
something (e.g., a bit, field, or code value) that is not defined by this standard

Note 1 to entry: Specification of the referenced item is determined by the SCSI device vendor and may be used differently in various implementations

3.4 Editorial conventions

Certain words and terms used in this 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, address frames, primitives and primitive sequences, SMP functions, state machines, SCSI and ATA commands, SCSI statuses, SCSI sense keys, and SCSI additional sense codes are in all uppercase (e.g., REQUEST SENSE command).

Names of messages, requests, confirmations, indications, responses, event notifications, timers, SCSI diagnostic pages, SCSI mode pages, and SCSI log pages are in mixed case (e.g., Disconnect-Reconnect mode page).

Names of fields are in small uppercase (e.g., DESTINATION SAS ADDRESS). Normal case is used when the contents of a field are being discussed. Fields containing only one bit are usually referred to as the NAME bit instead of the NAME field.

Names of procedure calls are identified by a name in bold type (e.g., **Execute Command**). For more information on procedure calls see 3.9.

Lists sequenced by lowercase or uppercase letters show no ordering relationship between the listed items.

EXAMPLE 1 -The following list shows no relationship between the named items:

a) red, specifically one of the following colors:
   A) crimson; or
   B) amber;
b) blue; or
c) green.

Lists sequenced by numbers show an ordering relationship between the listed items.

EXAMPLE 2 -The following list shows an ordered relationship between the named items:

1) top;
2) middle; and
3) bottom.

Lists are associated with an introductory paragraph or phrase, and are numbered relative to that paragraph or phrase (i.e., all lists begin with an a) or 1) entry).

If a conflict arises between text, tables, or figures, the order of precedence to resolve the conflicts is text, then tables, and finally figures. Not all tables or figures are fully described in the text. Tables show data format and values.

Notes and example do not constitute any requirements for implementers and notes are numbered consecutively throughout this standard.

3.5 Numeric and character conventions

3.5.1 Numeric conventions

A binary number is represented in this standard by any sequence of digits consisting of only the Arabic numerals 0 and 1 immediately followed by a lower-case b (e.g., 0101b). Underscores or spaces may be included between characters in binary number representations to increase readability or delineate field boundaries (e.g., 00010101 11001110b, 00010101_11001110b, 0 0101 1010b, or 0_0101_1010b).

A hexadecimal number is represented in this standard by any sequence of digits consisting of only the Arabic numerals 0 to 9 and/or the upper-case English letters A to F immediately followed by a lower-case h (e.g., FA23h). Underscores or spaces may be included between characters in hexadecimal number representations to increase readability or delineate field boundaries (e.g., B FD8C FA23h or B_FD8C_FA23h).

A decimal number is represented in this standard by any sequence of digits consisting of only the Arabic numerals 0 to 9 not immediately followed by a lower-case b or lower-case h (e.g., 25).

A range of numeric values is represented in this standard in the form “a to z”, where a is the first value included in the range, all values between a and z are included in the range, and z is the last value included in the range (e.g., the representation “0h to 3h” includes the values 0h, 1h, 2h, and 3h).

This standard uses the following conventions for representing decimal numbers:

a) the decimal separator (i.e., separating the integer and fractional portions of the number) is a period;
b) the thousands separator (i.e., separating groups of three digits in a portion of the number) is a space;
c) the thousands separator is used in both the integer portion and the fraction portion of a number; and
d) the decimal representation for a year is 1999 not 1 999.

Table 1 shows some examples of decimal numbers using various numbering conventions.

Table 1 — Numbering conventions

French	English	This standard
0,6	0.6	0.6
3,141 592 65	3.14159265	3.141 592 65
1 000	1,000	1 000
1 323 462,95	1,323,462.95	1 323 462.95

A decimal number represented in this standard with an overline over one or more digits following the decimal point is a number where the overlined digits are infinitely repeating (e.g., $666.\overline{6}$ means 666.666 666... or 666 2/3, and $12.\overline{142\ 857}$ means 12.142 857 142 857... or 12 1/7).

3.5.2 Units of measure

This standard represents values using both decimal units of measure and binary units of measure. Values are represented by the following formats:

a) for values based on decimal units of measure:
   1) numerical value (e.g., 100);
   2) space; and
   3) prefix symbol and unit:
      1) decimal prefix symbol (e.g., M) (see table 2); and
      2) unit abbreviation (e.g., B);

   and

b) for values based on binary units of measure:
   1) numerical value (e.g., 1 024);
   2) space; and
   3) prefix symbol and unit:
      1) binary prefix symbol (e.g., Gi) (see table 2); and
      2) unit abbreviation (e.g., b).

Table 2 compares the prefix, symbols, and power of the binary and decimal units.

Table 2 — Comparison of decimal prefixes and binary prefixes

Decimal			Binary		
Prefix name	**Prefix symbol**	**Power (base-10)**	**Prefix name**	**Prefix symbol**	**Power (base-2)**
kilo	k	10^3	kibi	Ki	2^{10}
mega	M	10^6	mebi	Mi	2^{20}
giga	G	10^9	gibi	Gi	2^{30}
tera	T	10^{12}	tebi	Ti	2^{40}
peta	P	10^{15}	pebi	Pi	2^{50}
exa	E	10^{18}	exbi	Ei	2^{60}
zetta	Z	10^{21}	zebi	Zi	2^{70}
yotta	Y	10^{24}	yobi	Yi	2^{80}

3.5.3 Byte encoded character strings conventions

When this standard requires one or more bytes to contain specific encoded characters, the specific characters are enclosed in single quotation marks. The single quotation marks identify the start and end of the characters that are required to be encoded but are not themselves to be encoded. The characters that are to be encoded are shown in the case that is to be encoded.

An ASCII space character (i.e., 20h) may be represented in a string by the character '¬' (e.g., 'SCSI¬device').

The encoded characters and the single quotation marks that enclose them are preceded by text that specifies the character encoding methodology and the number of characters required to be encoded.

EXAMPLE - Using the notation described in this subclause, stating that eleven ASCII characters 'SCSI device' are to be encoded is the same as writing out the following sequence of byte values: 53h 43h 53h 49h 20h 64h 65h 76h 69h 63h 65h.

3.6 UML notation conventions

3.6.1 Notation conventions overview

This standard uses class diagrams and object diagrams with notation that is based on the Unified Modeling Language (UML).

See 3.6.3 for the conventions used for class diagrams.

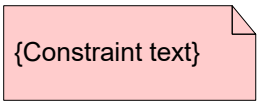
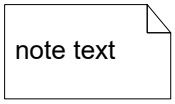
See 3.6.4 for the conventions used for object diagrams.

3.6.2 Constraint and note conventions

Class diagrams and object diagrams may include constraints, which specify requirements, and notes, which are informative.

Table 3 shows the notation used for constraints and notes.

Table 3 — Constraint and note notation

Notation	Description
	The presence of the curly brackets (i.e., {}) defines constraint that is a normative requirement. An example of a constraint is shown in figure 5.
	The absence of curly brackets defines a note that is informative. An example of a note is shown in figure 6.

3.6.3 Class diagram conventions

Table 4 shows the notation used for classes in class diagrams.

Table 4 — Class diagram notation for classes

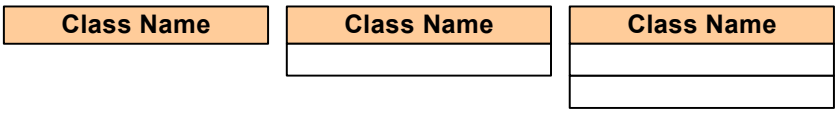
Notation	Description
	A class with no attributes or operations.

Table 4 — Class diagram notation for classes

Notation	Description
Class Name Attribute01[1] Attribute02[1] **Class Name** Attribute01[1] Attribute02[1]	A class with attributes and no operations.
Class Name Operation01() Operation02()	A class with operations and no attributes.
Class Name Attribute01[1] Attribute02[1] Operation01() Operation02()	A class with attributes and operations.
Class Name Attribute01[1..*] Attribute02[1] Operation01() Operation02()	A class with attributes that have a specified multiplicity (see table 5) and operations.

Table 5 shows the notation used to indicate multiplicity of classes and attributes in class diagrams.

Table 5 — Multiplicity notation

Notation [a]	Description
not specified	The number of instances of a class or attribute is not specified.
1	One instance of the class or attribute exists.
0..*	Zero or more instances of the class or attribute exist.
1..*	One or more instances of the class or attribute exist.
0..1	Zero or one instance of the class or attribute exists.
n..m	n to m instances of the class or attribute exist (e.g., 2..8).
x, n..m	Multiple disjoint instances of the class or attribute exist (e.g., 2, 8..15).

[a] See figure 4 and figure 5 for examples of multiplicity notation.

Table 6 shows the notation used to denote association (i.e., “knows about”) relationships between classes.

Unless the two classes in an association relationship also have an aggregation relationship, association relationships have multiplicity notation (see table 5) at each end of the relationship line.

Table 6 — Class diagram notation for associations

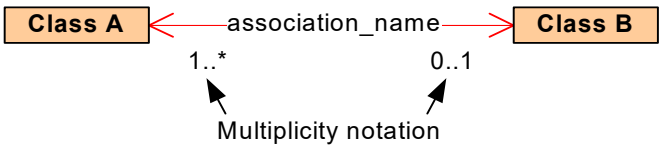
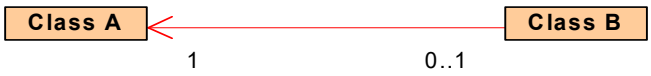
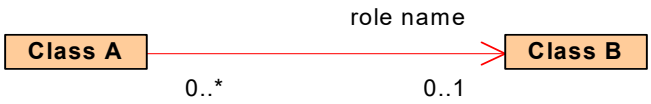
Notation	Description
	Class A knows about Class B (i.e., read as “Class A association_name Class B”) and Class B knows about Class A (i.e., read as “Class B association name Class A”).
	Class B knows about Class A (i.e., read as “Class B knows about Class A”) but Class A does not know about Class B.
	Class A knows about Class B (i.e., read as “Class A uses the role name attribute of Class B”) but Class B does not know about Class A.
Note - The use of role names and association names are optional.	

Figure 4 shows examples of association relationships between classes.

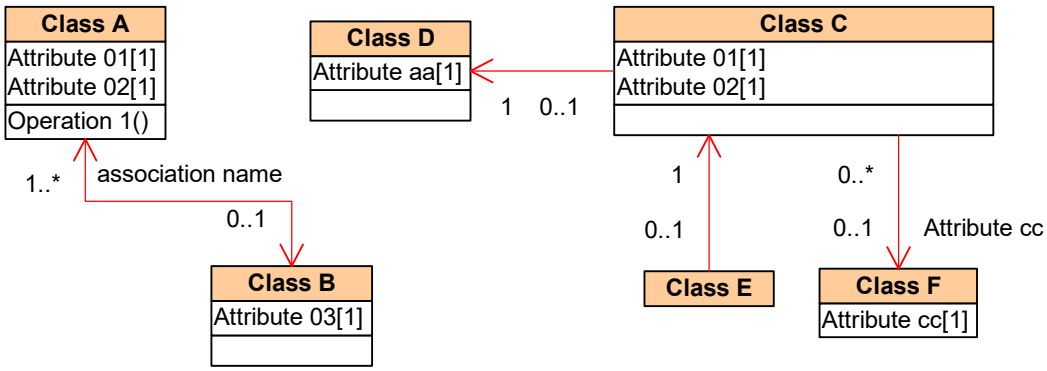


Figure 4 — Examples of association relationships in class diagrams

Table 7 shows the notation used to denote aggregation (i.e., “is a part of” or “contains”) relationships between classes. The aggregation relationship is a specific type of association (see table 6) and always include multiplicity notation (see table 5) at each end of the relationship line.

Table 7 — Class diagram notation for aggregations

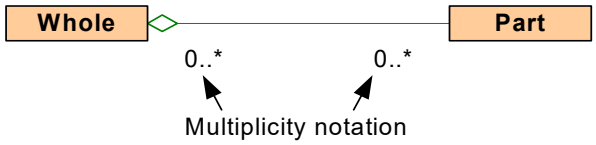
Notation	Description
	The Part class is part of the Whole class and may continue to exist even if the Whole class is removed (i.e, read as “the whole contains the part”).
	The Part class is part of the Whole class, shall only belong to one Whole class, and shall not continue to exist if the Whole class is removed (i.e., read as “the whole contains the part”).

Figure 5 shows examples of aggregation relationships between classes.

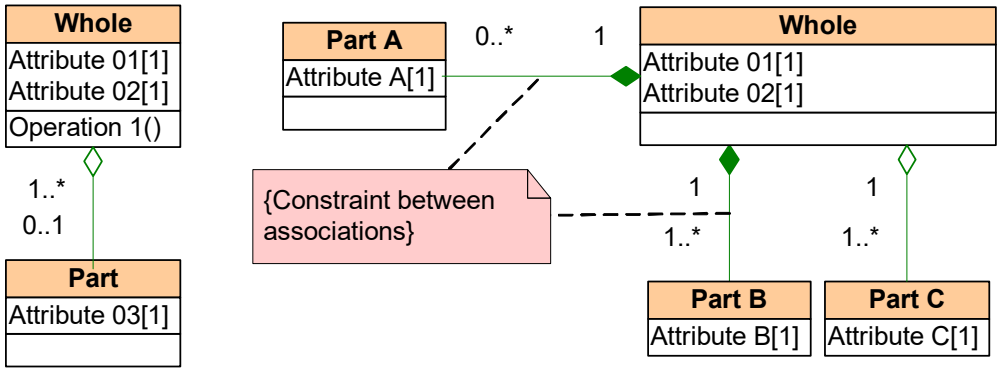


Figure 5 — Examples of aggregation relationships in class diagrams

Table 8 shows the notation used to denote generalization (i.e., “is a kind of”) relationships between classes.

Table 8 — Class diagram notation for generalizations

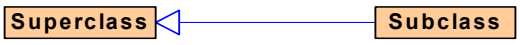
Notation	Description
	Subclass is a kind of superclass. A subclass shares all the attributes and operations of the superclass (i.e., the subclass inherits from the superclass).

Figure 6 shows examples of generalization relationships between classes.

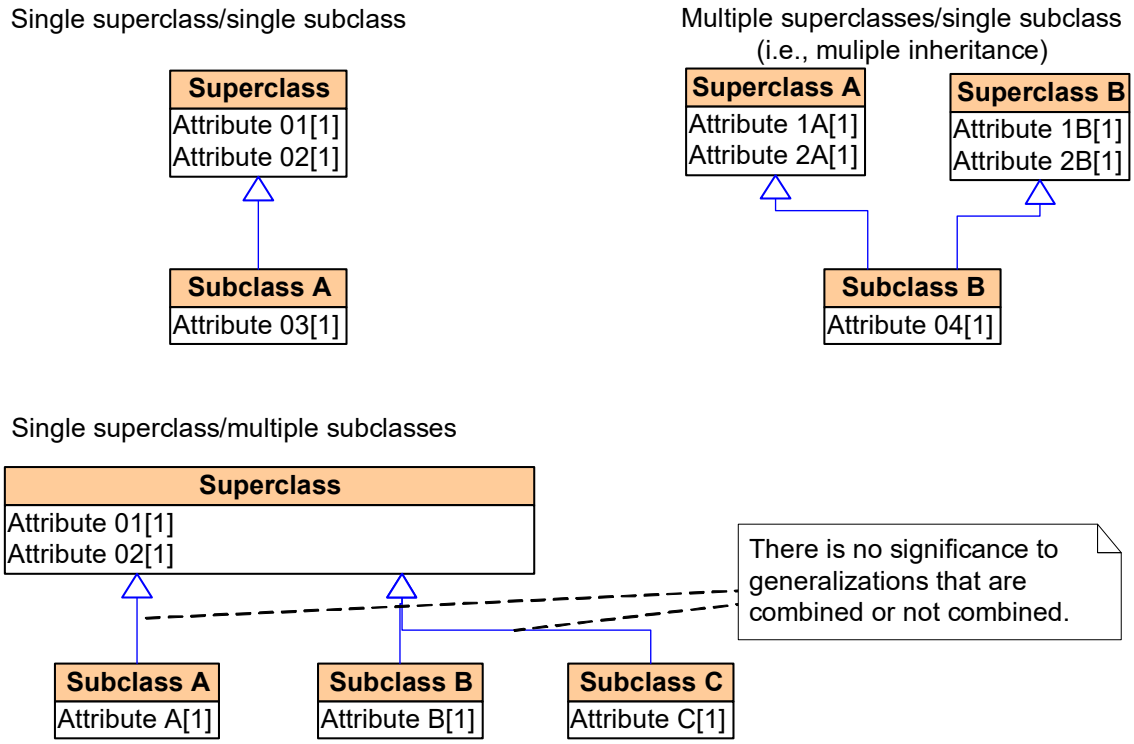


Figure 6 — Example of generalization relationships in class diagrams

Table 9 shows the notation used to denote dependency (i.e., “depends on”) relationships between classes.

Table 9 — Class diagram notation for dependency

Notation	Description
	Class A depends on class B. A change in class B may cause a change in class A.

Figure 7 shows an example of a dependency relationship between classes.



Figure 7 — Example of a dependency relationship in class diagrams

3.6.4 Object diagram conventions

Table 10 shows the notation used for objects in object diagrams.

Table 10 — Object diagram notation for objects

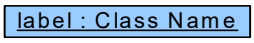
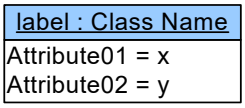
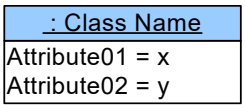
Notation	Description
	Notation for a named object with no attributes.
	Notation for a named object with attributes.
	Notation for a anonymous object with no attributes.
	Notation for a anonymous object with attributes.

Table 11 shows the notation used to denote link relationships between objects.

Table 11 — Object diagram notation for link

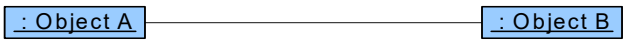
Notation	Description
	An instance of an association between object A and object B.

Figure 8 shows examples of a link relationships between objects.

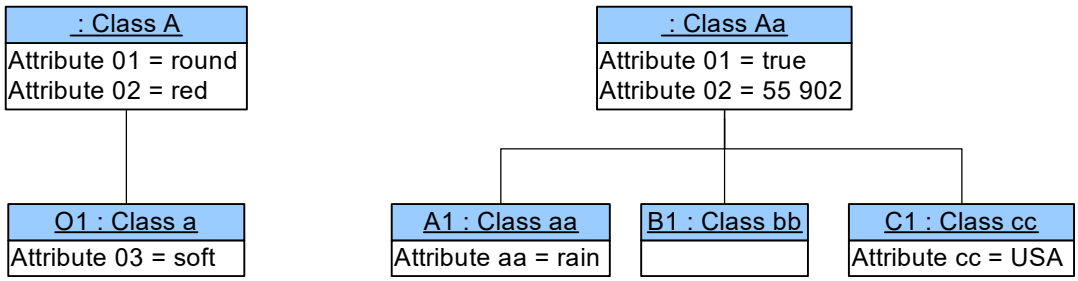


Figure 8 — Examples of link relationships for object diagrams

3.7 State machine conventions

3.7.1 State machine conventions overview

Figure 9 shows how state machines are described. See 4.3 for a summary of the state machines in this standard.

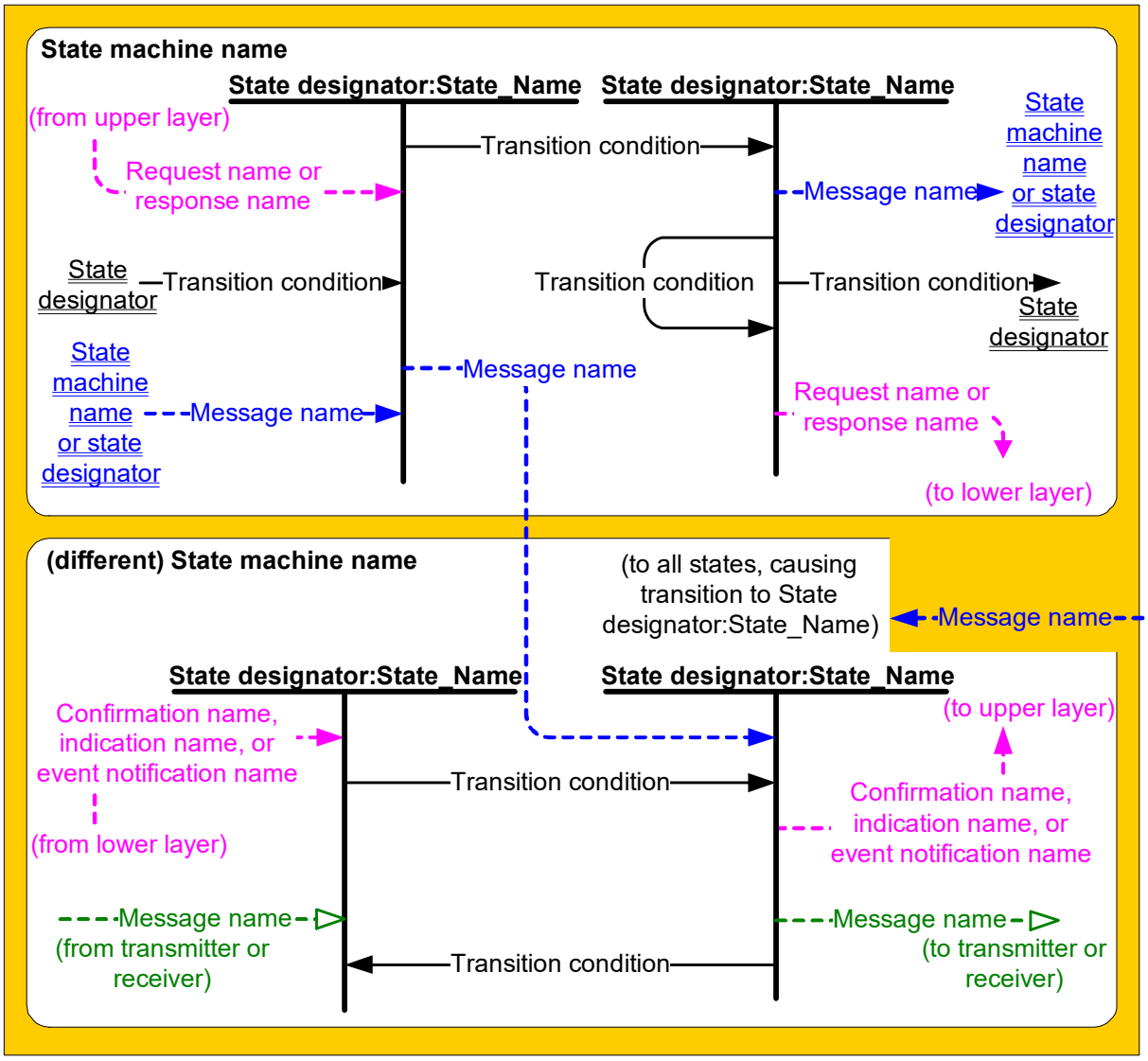


Figure 9 — State machine conventions

When multiple state machines are present in a figure, they are enclosed in boxes with rounded corners.

Each state machine is identified by a state machine name. In state machines with one state, the state machine is identified by a state designator. In state machines with multiple states, each state is identified by a state designator and a state name. The state designator (e.g., SL1) is unique among all state machines in this standard. The state name (e.g., Idle) is a brief description of the primary action taken during the state, and the same state name may be used by other state machines. Actions taken while in each state are described in the state description text.

3.7.2 Transitions

Transitions between states are shown with solid lines, with an arrow pointing to the destination state. A transition may be labeled with a transition condition label (i.e., a brief description of the event or condition that causes the transition to occur).

If the state transition in one figure goes to or comes from a state machine or state in a different figure, then the transition is shown going to or coming from a state machine name or a state designator label with double underlines.

The conditions and actions are described fully in the transition description text. In case of a conflict between a figure and the text, the text shall take precedence.

Upon entry into a state, all actions to be processed in that state are processed. If a state is re-entered from itself, all actions to be processed in the state are processed again. A state may be entered and exited in zero time if the conditions for exiting the state are valid upon entry into the state. Transitions between states are instantaneous.

3.7.3 Messages, requests, indications, confirmations, responses, and event notifications

Messages passed between state machines are shown with dashed lines labeled with a message name. When messages are passed between state machines within the same layer of the protocol, they are identified by either:

a) a dashed line to or from a state machine name label with double underlines and/or state name label with double underlines, if the destination is in a different figure from the source;
b) a dashed line to or from a state in another state machine in the same figure; or
c) a dashed line from a state machine name label with double underlines to a “(to all states)” label, if the destination is every state in the state machine.

The meaning of each message is described in the state description text.

Requests, indications, confirmations, responses, and event notifications are shown with curved dashed lines originating from or going toward the top or bottom of the figure. Each request, indication, confirmation, response, and event notification is labeled. The meaning of each request, indication, confirmation, response, and event notification is described in the state description text.

Messages with unfilled arrowheads are passed to or from the state machine’s transmitter or receiver, not shown in the state machine figures, and are directly related to data being transmitted on or received from the physical link.

The state machine description text for each state wholly defines the messages sent while the state machine is in that state. If a state is repeatedly sending a message transitions to another state, then that state stops sending that message before making the transition.

3.7.4 State machine counters, timers, and variables

State machines may contain counters, timers, and variables that affect the operation of the state machine. The following properties apply to counters, timers, and variables:

a) their scope is the state machine itself;
b) they are created and deleted within the state machines with which they are associated;
c) their initialization and modification is specified in the state descriptions and the transition descriptions; and
d) their current values may be used to determine the behavior of a state and select the transition out of a state.

State machine timers may continue to run while a state machine is in a given state, and a timer may cause a state transition upon reaching a defined threshold value (e.g., zero for a timer that counts down).

3.7.5 State machine arguments

State machines may contain one or more arguments received in a message or confirmation as state machine arguments. The following properties apply to state machine arguments:

a) the state machine that sends an argument owns that argument's value;
b) the state machine that receives an argument shall not modify that argument's value;
c) the state machine that sends an argument may resend that argument with a different value;
d) the scope of a state machine argument is the state machine itself; and
e) state machine argument usage is described in the state descriptions and the transition descriptions.

3.8 Bit and byte ordering

In a field in a table consisting of more than one bit that contains a single value (e.g., a number), the least significant bit (LSB) is shown on the right and the most significant bit (MSB) is shown on the left (e.g., in a byte, bit 7 is the MSB and is shown on the left and bit 0 is the LSB and is shown on the right). The MSB and LSB are not labeled if the field consists of 8 or fewer bits.

In a field in a table consisting of more than one byte that contains a single value (e.g., a number), the byte containing the MSB is stored at the lowest address and the byte containing the LSB is stored at the highest address (i.e., big-endian byte ordering). The MSB and LSB are labeled.

NOTE 1 - SATA numbers bits within fields the same as this standard, but uses little-endian byte ordering.

In a field in a table consisting of more than one byte that contains multiple fields each with their own values (e.g., a descriptor), there is no MSB and LSB of the field itself and thus there are no MSB and LSB labels. Each individual field has an MSB and LSB, but they are not labeled.

In a field containing a text string (e.g., ASCII or UTF-8), the MSB label is the MSB of the first character, and the LSB label is the LSB of the last character.

Multiple byte fields are represented by only two rows, where a non-sequentially increasing byte number indicates the presence of additional bytes.

A data dword consists of 32 bits. Table 12 shows a data dword containing a single value, where the MSB is on the left in bit 31, and the LSB is on the right in bit 0.

Table 12 — Data dword containing a value

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MSB															Value																LSB

Table 13 shows a data dword containing four one-byte fields, where byte 0 (the first byte) is on the left and byte 3 (the fourth byte) is on the right. Each byte has an MSB on the left and an LSB on the right.

Table 13 — Data dword containing four one-byte fields

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MSB			Byte 0 (First byte)				LSB	MSB			Byte 1 (Second byte)				LSB	MSB			Byte 2 (Third byte)				LSB	MSB			Byte 3 (Fourth byte)				LSB

3.9 Notation for procedures and functions

In this standard, the model for functional interfaces between objects is the callable procedure. Such interfaces are specified using the following notation:

[Result =] Procedure Name (IN ([input-1] [,input-2] …), OUT ([output-1] [,output-2] …))

where:

Result	A single value representing the outcome of the procedure or function.
Procedure Name	A descriptive name for the function to be performed.
IN (Input-1, Input-2, ...)	A comma-separated list of names identifying caller-supplied input data objects.
OUT (Output-1, Output-2, ...)	A comma-separated list of names identifying output data objects to be returned by the procedure.
[...]	Brackets enclose optional or conditional parameters and arguments.

This notation allows data objects to be specified as inputs and outputs. An interface between entities may require only inputs. If a procedure call has no output arguments, the word OUT, preceding comma, and associated pair of balanced parentheses are omitted.