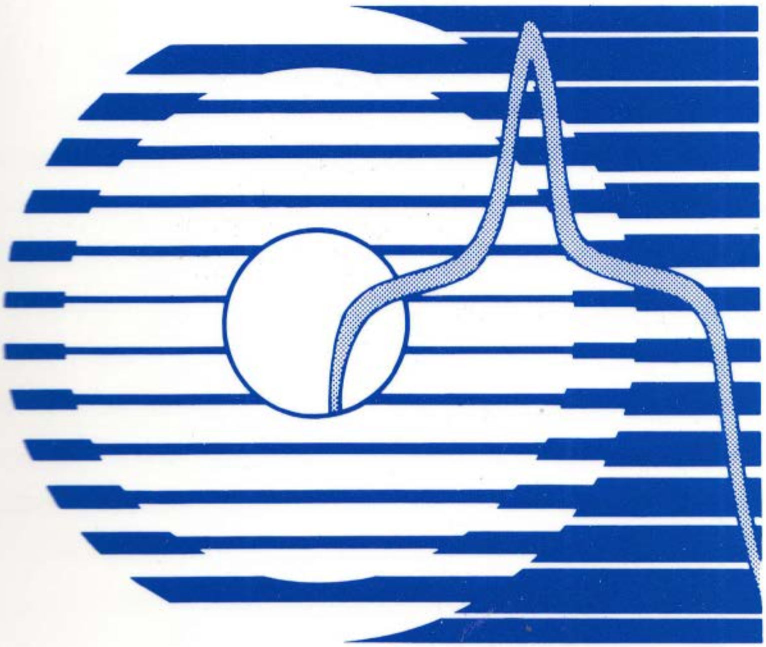
The SCSI Bench Reference



ENDL
PUBLICATIONS

Guidelines

Those of you who are familiar with the way the standards committee, X3T10, restructured SCSI-3 into multiple documents will find this edition of the SCSI Bench Reference retains ready access to all the information you really need to work with the Small Computer System Interface.

The biggest change you will find in these pages is the use of the new terms which were introduced by SCSI-3. SCSI-2 has dominated shipments for the past several years, but the future belongs to a new kind of SCSI, one that not only operates on the familiar parallel bus, but on serial interfaces.

The biggest technical change made in the SCSI-3 parallel standards has been the dramatic improvements made to the physical interface. These advances have been made under pressure from the performance and convenience promised by serial interfaces.

Should you happen to come across any discrepancies between the standards and the SCSI Bench Reference, be sure to drop us a line so we can make a correction. If you discover a major boo-boo, you will receive a free copy of the next edition.

SCSI Bench Reference assumes you have a working knowledge of both SCSI and the standard documents. If you find the standards overwhelming, then you should check out the SCSI Encyclopedia. This multi-copy reference work describes the parallel protocol and the disk commands in two Volumes:

Volume I: SCSI Phases and Protocol A-M
SCSI Phases and Protocol N-Z
Volume II: SCSI Disk Operations A-L
SCSI Disk Operations M-Z

Each volume contains detailed information on all topics, with many examples to assist understanding. Unlike the standard, the SCSI Encyclopedia has been written to assist comprehension. Lavish use of figures, diagrams, and even pseudo code for complicated subjects such as queueing.

Each entry includes cross-references to relevant subjects so that learning is by inquiry rather than painful searching of the standards. Information from all over the standards is gathered together under a single heading.

If you are interested in serial SCSI, be sure to check out the Fibre Channel Bench Reference. It is to Fibre Channel what this book is to parallel SCSI. For anybody planning to implement Fibre Channel, the Fibre Channel Bench Reference is an invaluable tool.

The SCSI Bench Reference

Jeffrey D. Stai

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Saratoga, California

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Dedicated to all those who have trouble finding things in 42 different standards documents!

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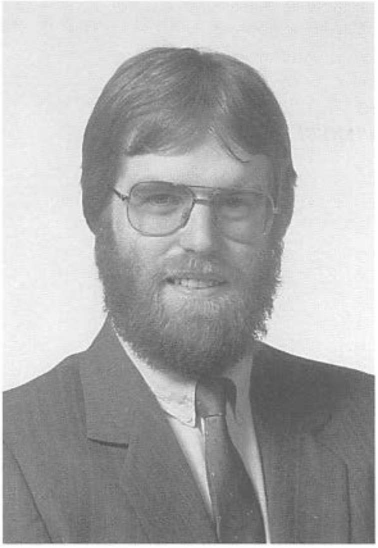
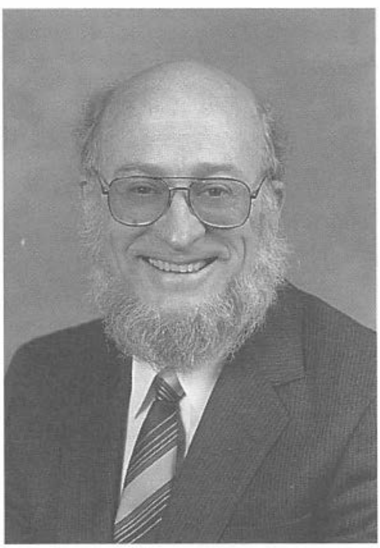
About the Author



Jeffrey Stai has been doing standards (and real work, mind you!) longer than anyone should be forced to do so. He has designed boards, firmware, and/or chips for SCSI, Fibre Channel, ATA, ISA, PCI, IEEE 1394, ESDI, MCA, and even SSA. He has been a principal representative to X3T10, X3T11, and IEEE P1394. He is currently employed by Brocade Communications Systems.

About the Publisher



Dal Allan has been working with computers a long time (back when they were built with vacuum tubes yet), and specializes in the issues of peripheral interfaces, especially storage. He claims to have had a lot of hair before he became connected (bad SCSI pun) with interface standards. He has been and continues to be active in the development of industry standards, including SCSI, ATA, ATAPI, and Fibre Channel.

About the SCSI Series

You are holding one member of a family of books known as the SCSI Series from ENDL Publications.

The SCSI Bench Reference re-packages the SCSI-1, SCSI-2 and SCSI-3 standards into a form which makes things easy-to-find. You also find things that are not found in any of the standards, like detailed timing charts, examples, easy references and vastly improved table structures.

The SCSI Encyclopedia is designed to explain the complexities of SCSI for neophyte and expert alike, in a format that was chosen so you can easily access information by subject. There are no chapters, you simply look up the name you are interested in to find the material you care about.

Volume I comes in two hard cover books, covering A-M and N-Z, and deals with the phases and protocols of the physical interface and the message system. If it has anything to do with cables, connectors, drivers and receivers, signals and phases, messages and nexuses you'll find it in Volume I. SCSI's message system includes upper-level principles like command queueing as well, so you find these principles covered in great detail.

Volume II deals with the most popular SCSI peripheral, the magnetic disk drive. Disks are not simple devices, and once again two hard cover books are needed, covering A-L and M-Z. It takes much more than coverage of the Direct Access Device commands to explain how disk drives are supported by SCSI. You also need to be aware of how the commands common to all devices operate, so these are covered from a disk drive point of view.

The following pages provide you a listing of titles on the subjects covered in the SCSI Encyclopedia. A quick perusal will provide you with an overview of what is included.

What was SCSI is SCSI no longer. SCSI-3 incorporated some radical changes in language as the primary task of the standards committee was to 'packetize' the interface in a form which could easily migrate to serial interfaces.

The Fibre Channel Bench Reference is the first in the SCSI Series which covers progress towards a serial world. Early implementations of serial interfaces will be led by the need for higher performance and connectivity for disk drives. Therefore, the Fibre Channel Bench Reference concentrates on the Arbitrated Loop and includes coverage of the SCSI-3 Fibre Channel Protocol.

The following subjects are covered in Volume I (A-M) of the SCSI Encyclopedia:

A Cable.
ABORT Message.
ABORT TAG message.
ACK Signal.
ACKB Signal.
Active I/O Process.
Active Pointers.
Active Pull-Up.
Arbitration Delay.
ARBITRATION Phase.
Assertion Period.
Assert Signal.
Asynchronous Data Transfer.
Asynchronous Event Notification (AEN).
ATN Signal.
Attention Condition.
B Cable.
Between Phases.
BSY Signal.
Bus Clear Delay.
BUS DEVICE RESET Message.
Bus Free Delay.
BUS FREE Phase.
Bus ID.
Bus Phases.
Bus Phase Signals.
Bus Set Delay.
Bus Settle Delay.
Bus Timing.
C/D Signal.
Cables.
Cable Skew Delay.
CAM (Common Access Method).
Chips.
CLEAR QUEUE Message.
COMMAND COMPLETE Message.
Command Descriptor Block.
COMMAND Phase.
Command Pointer.
COMMAND TERMINATED Status.
Condition.
Connect.
Connected I/O Process.
Connection.
Connection Phases.
Connectors.
Contingent Allegiance.
Control Byte.
Controller.
Control Signals.
Current I/O Process.
Data Bus Signals.
DATA IN Phase.
DATA OUT Phase.
DATA Phase.
Data Pointer.
Data Release Delay.
Deassert.
Deskew Delay.
Device.
Differential Interface.
DIFFSENS.
Disconnect.
Disconnection Delay.
DISCONNECT Message.
ECA.
Error Recovery.
Etiquette.
Extended Contingent Allegiance (ECA) Condition
Extended Messages.
False.
Fast Assertion Period.
Fast Cable Skew Delay.
Fast Data Transfer.
Fast Deskew Delay.
Fast Hold Time.
Fast Negation Period.
Forced Perfect Termination (FPT).
Hard Reset.
HEAD OF QUEUE TAG Message.
Hold Time.
Host Adapter.
I/O Process.
I/O Signal.
IDENTIFY Message.
IGNORE WIDE RESIDUE Message.
Information Transfer Phases.
Initial Connection.
Initialization.
INITIATE RECOVERY Message.
Initiator.
INITIATOR DETECTED ERROR Message.
LINKED COMMAND COMPLETE Messages.
Linked Commands.
Logical Block.
Logical Block Address (LBA).
Logical Unit.
Logical Unit Number (LUN).
Message.
MESSAGE IN Phase.
MESSAGE OUT Phase.
MESSAGE PARITY ERROR Message.
MESSAGE REJECT Message.
Message System.
MODIFY DATA POINTER Message.
MSG Signal.

The following subjects are covered in Volume I (N-Z) of the SCSI Encyclopedia:

Negate Signal.
Negation Period.
Nexus.
NO OPERATION Message.
ORDERED QUEUE TAG Message.
P Cable.
Parity.
Path Control.
Peripheral Device.
Phase.
Pointers.
Power-On to Selection Time.
Protocol Chips.
Pull-Up.
Queue.
Queue Tag.
Queue Tag Messages.
Reconnect.
Reconnection.
RELEASE RECOVERY Message.
Release Signal.
REQ/ACK Offset.
REQ Signal.
REQB Signal.
RESELECTION Phase.
Reselection Timeout.
Reserved.
Reset Condition.
Reset Hold Time.
Reset to Selection Time.
RESTORE POINTERS Message.
RST Signal.
SASI.
SAVE DATA POINTER Message.
Saved Pointers.
SCSI, SCSI-1, and SCSI-2.
SCSI-3?!
SCSI Address.
SCSI Bus.
SCSI Bus ID.
SCSI Commands.
SCSI Device.
SCSI ID.
Selection Abort Time.
SELECTION Phase.
Selection Time-out.
Selection Time-out Delay.
SEL Signal.
Signal Levels.
SIMPLE QUEUE TAG Message.
Single-Ended Interface.
Soft Reset.
Status.
STATUS Phase.
Status Pointer.
Synchronous Data Transfer.
Synchronous Data Transfer Negotiation.
SYNCHRONOUS DATA TRANSFER REQUEST Message.
Synchronous Offset.
Synchronous Transfer Period.
Tagged Queuing.
Target.
Target Routine.
Target Routine Number (TRN).
TERMINATE I/O PROCESS Message.
Termination.
Terminator Power (TERMPWR).
Timing.
Transfer Period.
True.
Unexpected BUS FREE Phase.
Unit Attention Condition.
Untagged Queuing.
Vendor Specific or Unique.
Wide Data Transfer.
Wide Data Transfer Negotiation.
WIDE DATA TRANSFER REQUEST Message.
Wire-OR Glitch.
X3T9.2 Committee.

The following subjects are covered in Volume II (A-L) of the SCSI Encyclopedia:

Aborting an I/O Process.
Additional Sense Code.
Additional Sense Code Qualifier.
Allegiance.
Allocation Length.
Alternate Media.
ASCII Fields.
Asynchronous Event Notification (AEN).
Automatic Reallocation.
BUFFER Commands.
Block Descriptor.
Cache.
Caching MODE Page.
CHANGE DEFINITION Command.
Command.
Command Descriptor Block.
Contingent Allegiance.
Control Mode Page.
COPY Commands.
Data Encoding.
Defect Lists.
Defect Management.
Deferred Errors.
Device Type.
Diagnostics.
Diagnostic Parameters and Pages.
Direct Access Device.
Disable Page Out (DPO) Bit.
Disconnect Reconnect MODE Page.
Disk Drive.
Download Microcode.
Error Code.
Error Correcting Codes.
Error Recovery.
Error Reporting.
Etiquette.
Extended Contingent Allegiance (ECA) Condition.
Extent Reservation.
Field Pointer.
Flexible Disk MODE Page.
Format Device MODE Page.
FORMAT UNIT Command.
Force Unit Access (FUA) Bit.
I/O Process.
Immediate Commands.
Initialization.
Initiator.
INQUIRY Command.
Linked Commands.
LOCK UNLOCK CACHE Command.
Logical Block.
Logical Block Address (LBA).
Logical Unit.
Logical Unit Number (LUN).
LOG Commands.
LOG Parameters and Pages.
LONG Commands.

The following subjects are covered in Volume II (M-Z) of the SCSI Encyclopedia:

Medium Type.
Medium Types Supported MODE Page.
Message.
MODE Commands.
MODE Parameters and Pages.
MODE SELECT Command.
MODE SENSE Command.
MODE SENSE and MODE SELECT Examples.
Notches.
Notch MODE Page.
Page.
Parameter List Length.
Peripheral Device MODE Page.
Power-On to Selection Time.
PRE-FETCH Command.
PREVENT/ALLOW MEDIUM REMOVAL Command.
Queue.
RAID.
RAID Advisory Board.
READ CAPACITY Command.
READ Command and WRITE Commands.
READ DEFECT DATA Command.
Ready.
Read-Write Error Recovery MODE Page.
REASSIGN BLOCKS Command.
Reassignment.
RECEIVE DIAGNOSTIC RESULTS Command.
RelAdr Bit.
Relative Addressing.
RELEASE Command.
Removable Media.
REQUEST SENSE Command.
Reservations.
RESERVE Command.
Reserved.
REZERO UNIT Command.
Rigid Disk Geometry MODE Page.
SCSI, SASI, SCSI-1, and SCSI-2.
SCSI-3?!
SCSI-4.
SEARCH DATA Commands.
SEEK Command.
SEND Command.
SEND DIAGNOSTIC Command.
Sense Data.
Sense Key.
Sense Keys.
START STOP UNIT Command.
Status.
Supported Diagnostics Page.
SYNCHRONIZE CACHE Command.
Tagged Queuing.
Target.
Target Routine.
Terminating an I/O Process.
TEST UNIT READY Command.
Third Party Reservation.
Transfer Length.
Translate Address Diagnostic Page.
Untagged Queuing.
Vendor Specific or Unique.
VERIFY Command.
Verify Error Recovery MODE Page.
WRITE AND VERIFY Command.
WRITE BUFFER Command.
WRITE Command.
WRITE LONG Command.
WRITE SAME Command.
X3T9.2 Committee.

The following subjects are covered in the Fibre Channel Bench Reference:

Sources for Additional Information
Fibre Channel Logical Layers
Fibre Channel Roadmap
Fibre Channel Topologies
Fibre Channel Optical Physical Links
Fibre Channel Electrical Physical Links
Gigabaud Link Module (GLM) Interface
10-bit Gigabit Interface
FC-1 8B/10B Transmission Code Encode and Decode Tables
Ordered Sets
Exchanges, Sequences, Frames, Words, Bytes, and Bits
Link Protocols
Fibre Channel Classes of Service
Fibre Channel Flow Control
Fibre Channel General Frame Format
Link Control Frame Formats
Basic Link Service Frame Formats
Extended Link Service Frame Formats
Fabric and N_Port Login Procedures and Parameters
Arbitrated Loop (FC-AL)
Ordered Sets for the Arbitrated Loop
Arbitrated Loop Physical Addresses (AL_PA) and Loop IDs
Arbitrated Loop Port State Machine
Arbitrated Loop Bypass Circuit
Loop Initialization Procedure
Loop Initialization Sequence (Frame) Formats
SCSI-3 Fibre Channel Protocol (FCP) Information Units
FCP Command (FCP_CMND) Information Unit
FCP Transfer Ready (FCP_XFER_RDY) Information Unit
FCP Data (FCP_DATA) Information Unit
FCP Response (FCP_RSP) Information Unit
FCP Process Login (PRLI) Extended Link Service Request
FCP Process Login Accept (PRLI ACC) Extended Link Service Reply
Internet Protocol (IP) over Fibre Channel

TABLE OF CONTENTS

Sources for Additional References on SCSI

Copies of SCSI Standards: Copies of the SCSI-2 and SCSI-3 standards may be ordered from:

Global Engineering Documents
15 Inverness Way East
Englewood, CO 80112-5704
(800) 854-7179 or (303) 792-2181 voice; (303) 792-2192 facsimile

The following is a list of all relevant SCSI-3 standards and technical reports in the known universe, and their current document numbers as of April 1996, for ordering purposes:

Document Name	Acronym	Document Number
SCSI-3 Architecture Model	SAM	X3.270-1996
Small Computer System Interface - 2	SCSI-2	X3.131-1994
SCSI-3 Parallel Interface	SPI	X3.253-1996
SCSI-3 Fast-20 Parallel Interface	Fast-20	X3.277-1996
SCSI Parallel Interface - 2	SPI-2	X3T10/1142D rev 6
SCSI Enhanced Parallel Interface	EPI	X3T10/1143DT rev 5
SCSI-3 Interlocked Protocol	SIP	X3T10/0856D rev 9a
Fibre Channel Protocol	FCP	X3.269-1996
Serial Bus Protocol	SBP	X3.268-199x rev 22
SCSI-3 Primary Commands	SPC	X3T10/0995D rev 10
SCSI-3 Block Commands	SBC	X3T10/0996D rev 3
SCSI-3 Stream Commands	SSC	X3T10/0997D rev 7
SCSI-3 Controller Commands	SCC	X3.276-199x rev 6
SCSI-3 Multimedia Commands	MMC	X3T10/1048D rev 4
SCSI-3 Medium Changer Commands	SMC	X3T10/0999D rev 5
SCSI Enclosure Services	SES	not available
SCSI-3 Graphics Commands	SGC	X3T10/0998D rev 0

Technical Committee X3T10: The original SCSI-1 standard, the SCSI-2 standard, and the new SCSI-3 standards were produced by Technical Committee X3T10 (formerly X3T9.2) of the Accredited Standards Committee X3. The SCSI-3 standards are continuously evolving, and as such are subject to being revised or changed. For the latest information on the progress of the standards and for information on joining X3T10, contact:

John B. Lohmeyer, X3T10 Chairman
Symbios Logic Inc.
4420 Arrowswest Drive
Colorado Springs, CO 80907-3444
(719) 533-7000 voice; (719) 533-7036 facsimile
john.lohmeyer@symbios.com

There are fees associated with joining X3T10 as an observer and receiving the bi-monthly committee mailings (which are now available on CD-ROM! yay!). Contact the X3 Secretariat at (202) 626-5741 for exact prices. To become a voting member of X3T10, you must attend the committee meetings. Check the SCSI BBS or X3T10 web site (below), or call John Lohmeyer for more information.

Latest, Up to the Minute Electronic Information: For the serious user, there is an electronic Bulletin Board System (BBS) operated by Symbios Logic. The latest electronic versions of SCSI-3 and related working documents are available for download from the BBS.

SCSI BBS: (719) 533-7950 (300 baud - 28.8 Kbaud)

There is also an e-mail reflector on the Internet. The traffic on the reflector is mostly related to current topics and upcoming meetings. To join the reflector, just send a message to majordomo@symbios.com, and include "subscribe scsi" in the message body.

Draft standards are available from an ftp site maintained by Symbios Logic. To access the site, ftp to the following URL:

ftp://ftp.symbios.com/pub/standards/io/

This information is also accessible from the World Wide Web site:

http://www.symbios.com/x3t10/.

A SCSI newsgroup exists on Usenet called comp.periphs.scsi. Most of the traffic on this group is related to user issues (e.g., how to set up a particular disk drive), but general technical questions are often answered as well. Discussions on SCSI have also been seen on the comp.arch.storage newsgroup.

The SCSI Trade Association has been established to promote the understanding and use of parallel SCSI. For more information call (507) 931-0967; e-mail tforums@ic.mankato.mn.us. There is also a web page at:

http://www.scsita.com/

Be sure to check FaxAccess at 408-741-1600 menu #5 for the latest set of information on what ENDL Publications has to offer. It is always possible you will find additional reference material on SCSI which can assist you.

SFF **Committee Industry Group**: The SFF is an ad hoc industry group which crafts specifications for various interconnects, particularly for the disk drive industry. The SFF SCA (Single Connector Attach) is used by many SCSI disk drives, as described in SFF-8015 and SFF-8046.

Copies of published SFF Specifications may be ordered from Global Engineering Documents, as described on page 1. The SFF Committee only provides copies of Specifications via a Documentation Service. Individual copies of SFF Specifications under development are not sold, although they are available over FaxAccess.

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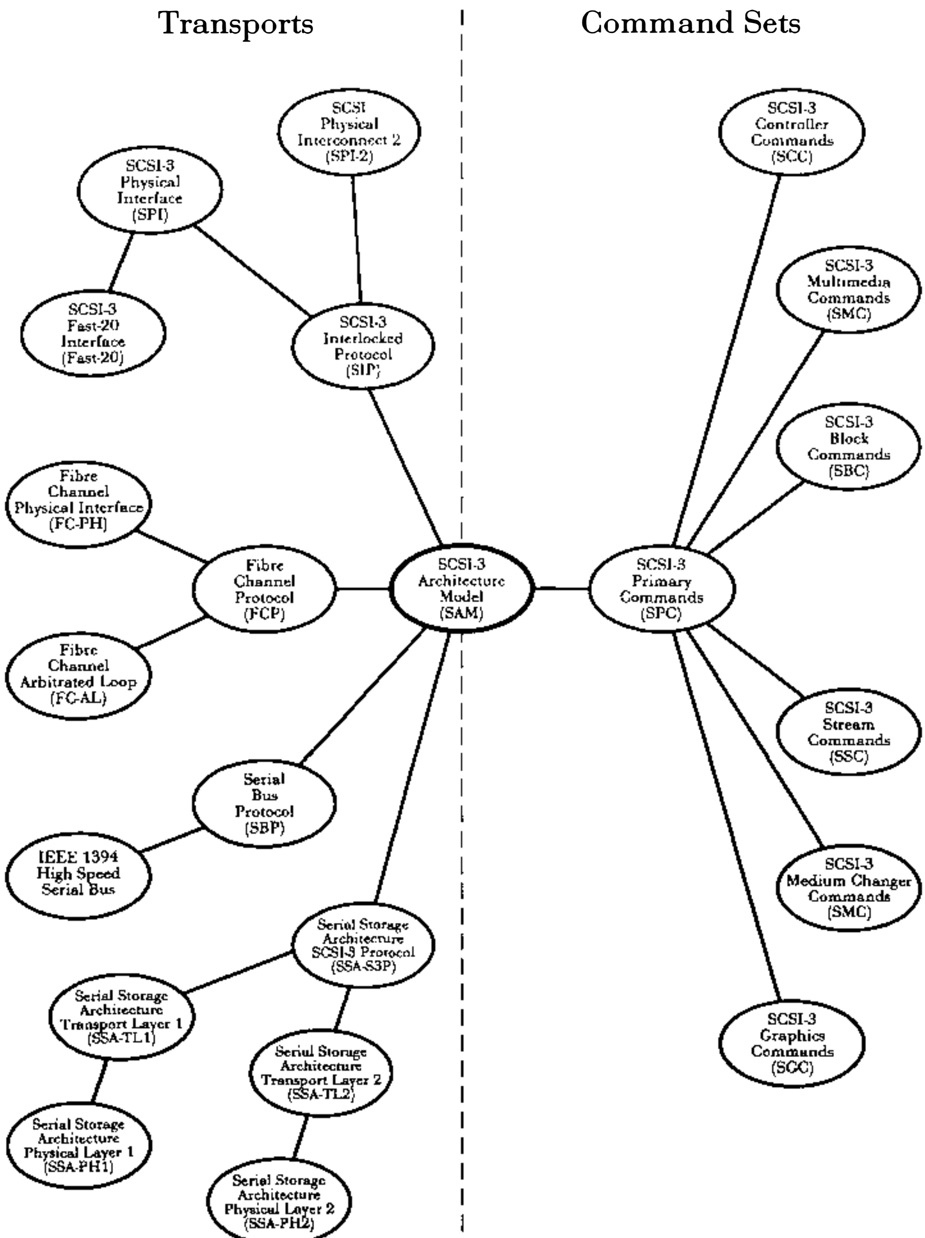
SCSI–3 Roadmap



SCSI-3 Document Summary

For those of you (and us!) who grew up with SCSI-2 and want to make sense out of the mass of SCSI-3 documents, we feature a brief summary:

- **SAM: SCSI-3 Architecture Model.** This document attempts to describe SCSI via a formal model (didn't think it could be done, did you?). It also contains the CDB formats, Auto Contingent Allegiance rules, and command queuing rules (now called "Task Set Management"). In essence, SAM ties all of the various SCSI-3 standards into one (hopefully) cohesive whole.

- **SPI: SCSI-3 Parallel Interface.** This document includes the single cable 16-bit "Wide" SCSI definition, and also improved single-ended electrical and cable specs. Also, buried in an Annex, is SCAM (SCSI Configured Auto-Magically); SCAM does not appear in a separate document. (Yes, we know that SPI says "Auto-Matically", but we like the original non-stuffy name better!)

- **Fast-20: SCSI-3 Fast-20 Parallel Interface.** This document is an "add-on" to SPI that includes the electrical, cable, and timing specs for running the SCSI bus at 20 megatransfers per second.

- **SPI-2: SCSI Parallel Interconnect 2.** This document will define a new type of differential interface that can be integrated into a single package. Also will contain Fast-40 and possibly Fast-80 timing. SPI-2 will replace SPI, and also contains several corrections to SCAM.

- **SIP: SCSI-3 Interlocked Protocol.** This document contains the rules for use of the SPI transfer modes and for the message system. Really nothing new here, SIP mostly exists to hold the layer between the parallel interconnect and the commands.

- **SPC: SCSI-3 Primary Commands.** This document is a compendium of all the commands that are common to all device types.

- **SBC: SCSI-3 Block Commands.** This document contains commands used by block devices: Direct-Access devices (you know, "hard disk drives"), Optical, and Write-Once Read-multiple disks.

- **SSC: SCSI-3 Stream Commands.** This document contains commands used by stream devices: Sequential Access devices (tapes), printers, and communication ports.

- **SCC: SCSI-3 Controller Commands.** This document contains commands used by array controllers, such as RAID controllers.

- **MMC: SCSI-3 Multimedia Commands.** This document contains commands used by CD-ROM and CD-Recordable devices.

- **SMC: SCSI-3 Medium Changer Commands.** This document contains commands used by medium changer devices.

Other standards are used to connect transport layers other than parallel SCSI. A popular example is Fibre Channel; the FCP document describes how to use Fibre Channel instead of parallel SCSI. If you want to know more, this would be a good time to buy a copy of **The Fibre Channel Bench Reference**!

So, how do you tie all of these together? A couple of examples:

- To make a Fast-20 parallel wide SCSI disk drive, you need: SAM, SPI, Fast-20, SIP, SPC, and SBC.

- To make a Fibre Channel Arbitrated Loop tape drive, you need: SAM, FC-PH, FC-AL, FCP, SPC, and SSC.

SCSI–3 Features Not Included

- Auto Contingent Allegiance (ACA)
- SCSI-3 Secondary Bus pinout
- Commands for All Devices:
  - CHANGE DEFINITION
  - COPY, COMPARE, COPY AND VERIFY
  - INQUIRY: VPD Data Format
  - MOVE MEDIUM and READ ELEMENT STATUS
- Disk Commands:
  - SEARCH DATA
  - SET LIMITS
  - XOR Commands (not ready at press time)
- Printer Commands
- Write Once Device Commands
- CD ROM Commands
- Optical Memory Device Commands
- Medium Changer Commands
- Communication Device Commands
- Array Controller (RAID) Commands
- Enclosure Services Commands

Style Notes

- Command tables have been expanded: In the SCSI standards, multiple byte fields are compressed to look like a two byte field. In this reference, these fields are expanded to full size. This is done to eliminate errors; the eye can see relative field sizes directly.

- Certain fields are self-explanatory. In these cases, the fields are not described in the text.

- Various tables in this reference include a pointer to the SCSI-3 document and section in which the table item is defined; for example, "SPC 7.1" refers to the SCSI-3 Primary Commands, section 7.1.

- In SCSI-3, the "Logical Unit Number" fields are no longer used, and have been reclaimed. We have maintained them in our CDB tables, but have put braces { } around them to remind you they are reserved in SCSI-3.

- When a name or term has changed from SCSI-2 to SCSI-3, the SCSI-3 term is shown in brackets [].

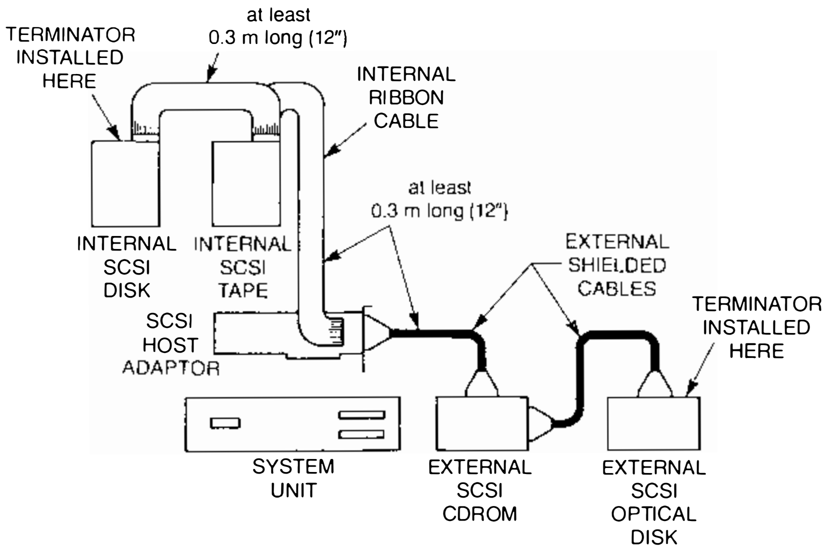
- This reference is accurate as of the document versions indicated on page 1. The section on SCAM is accurate as of the March 14, 1996 amendment.

- This is the Third (!) Edition.

LAYOUT

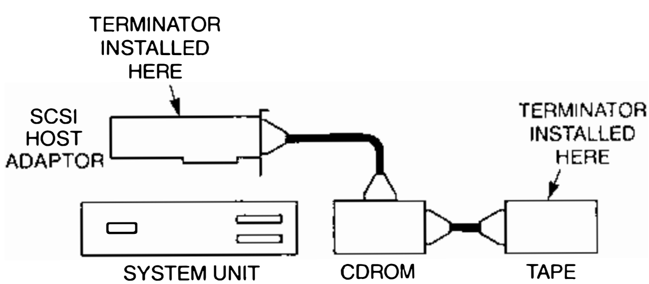
System Layout Examples

Typical Desktop Configuration



1. Every cable segment should be at least 0.3m (12 in.) long.
2. Total length of all cables is less than 6m (20 ft) for single ended, 25m (85 ft) for differential.
3. Avoid running flat ribbon or other unshielded cables close to metal chassis because it will lower cable impedance.

Typical "Add On" Configuration



LAYOUT

Connector Pin Numbers

SCSI–2 Single Ended 50–pin "A" Cable Connector Pinouts

Low Density (0.1" Spacing) Unshielded Header

Signal Name	Pin Number		Signal Name
Ground	1	2	-DB(0)
Ground	3	4	-DB(1)
Ground	5	6	-DB(2)
Ground	7	8	-DB(3)
Ground	9	10	-DB(4)
Ground	11	12	-DB(5)
Ground	13	14	-DB(6)
Ground	15	16	-DB(7)
Ground	17	18	-DB(P)
Ground	19	20	Ground
Ground	21	22	Ground
Reserved (*)	23	24	Reserved (*)
Open	25	26	TERMPWR
Reserved (*)	27	28	Reserved (*)
Ground	29	30	Ground
Ground	31	32	-ATN
Ground	33	34	Ground
Ground	35	36	-BSY
Ground	37	38	-ACK
Ground	39	40	-RST
Ground	41	42	-MSG
Ground	43	44	-SEL
Ground	45	46	-C/D
Ground	47	48	-REQ
Ground	49	50	-I/O

(*) "Reserved": SCSI-3 requires that the "Reserved" pins be left open. They may be grounded in earlier SCSI-1 and SCSI-2 designs. New designs should leave these open.

LAYOUT

Low Density (0.085” Spacing) ”D”Style Shielded
High Density (0.05” Spacing) ”D”Style Shielded and Unshielded

Signal Name	Pin Number		Signal Name
Ground	1	26	-DB(0)
Ground	2	27	-DB(1)
Ground	3	28	-DB(2)
Ground	4	29	-DB(3)
Ground	5	30	-DB(4)
Ground	6	31	-DB(5)
Ground	7	32	-DB(6)
Ground	8	33	-DB(7)
Ground	9	34	-DB(P)
Ground	10	35	Ground
Ground	11	36	Ground
Reserved (*)	12	37	Reserved (*)
Open	13	38	TERMPWR
Reserved (*)	14	39	Reserved (*)
Ground	15	40	Ground
Ground	16	41	-ATN
Ground	17	42	Ground
Ground	18	43	-BSY
Ground	19	44	-ACK
Ground	20	45	-RST
Ground	21	46	-MSG
Ground	22	47	-SEL
Ground	23	48	-C/D
Ground	24	49	-REQ
Ground	25	50	-I/O

(*) "Reserved": SCSI-3 requires that the "Reserved" pins be left open. They may be grounded in earlier SCSI-1 and SCSI-2 designs. New designs should leave these open.

LAYOUT

SCSI–2 Differential 50–pin "A" Cable Connector Pinouts

Low Density (0.1" Spacing) Unshielded Header

Signal Name	Pin Number		Signal Name
Shield Ground	1	2	Ground
+DB(0)	3	4	-DB(0)
+DB(1)	5	6	-DB(1)
+DB(2)	7	8	-DB(2)
+DB(3)	9	10	-DB(3)
+DB(4)	11	12	-DB(4)
+DB(5)	13	14	-DB(5)
+DB(6)	15	16	-DB(6)
+DB(7)	17	18	-DB(7)
+DB(P)	19	20	-DB(P)
DIFFSENS	21	22	Ground
Reserved (*)	23	24	Reserved (*)
TERMPWR	25	26	TERMPWR
Reserved (*)	27	28	Reserved (*)
+ATN	29	30	-ATN
Ground	31	32	Ground
+BSY	33	34	-BSY
+ACK	35	36	-ACK
+RST	37	38	-RST
+MSG	39	40	-MSG
+SEL	41	42	-SEL
+C/D	43	44	-C/D
+REQ	45	46	-REQ
+I/O	47	48	-I/O
Ground	49	50	Ground

(*) "Reserved": SCSI-3 requires that the "Reserved" pins be left open. They may be grounded in earlier SCSI-1 and SCSI-2 designs. New designs should leave these open.

Low Density (0.085” Spacing) ”D”Style Shielded
High Density (0.05” Spacing) ”D”Style Shielded and Unshielded

Signal Name	Pin Number		Signal Name
Shield Ground	1	26	Ground
+DB(0)	2	27	-DB(0)
+DB(1)	3	28	-DB(1)
+DB(2)	4	29	-DB(2)
+DB(3)	5	30	-DB(3)
+DB(4)	6	31	-DB(4)
+DB(5)	7	32	-DB(5)
+DB(6)	8	33	-DB(6)
+DB(7)	9	34	-DB(7)
+DB(P)	10	35	-DB(P)
DIFFSENS	11	36	Ground
Reserved (*)	12	37	Reserved (*)
TERMPWR	13	38	TERMPWR
Reserved (*)	14	39	Reserved (*)
+ATN	15	40	-ATN
Ground	16	41	Ground
+BSY	17	42	-BSY
+ACK	18	43	-ACK
+RST	19	44	-RST
+MSG	20	45	-MSG
+SEL	21	46	-SEL
+C/D	22	47	-C/D
+REQ	23	48	-REQ
+I/O	24	49	-I/O
Ground	25	50	Ground

(*) "Reserved": SCSI-3 requires that the "Reserved" pins be left open. They may be grounded in earlier SCSI-1 and SCSI-2 designs. New designs should leave these open.

LAYOUT

SCSI-3 Single Ended 68-pin Primary Bus ("P Cable") Connector Pinouts

High Density (0.05" Spacing) "D"Style Shielded and Unshielded

Signal Name	Pin Number		Signal Name
Ground	1	35	-DB(12)
Ground	2	36	-DB(13)
Ground	3	37	-DB(14)
Ground	4	38	-DB(15)
Ground	5	39	-DB(P1)
Ground	6	40	-DB(0)
Ground	7	41	-DB(1)
Ground	8	42	-DB(2)
Ground	9	43	-DB(3)
Ground	10	44	-DB(4)
Ground	11	45	-DB(5)
Ground	12	46	-DB(6)
Ground	13	47	-DB(7)
Ground	14	48	-DB(P)
Ground	15	49	Ground
Ground	16	50	Ground
TERMPWR	17	51	TERMPWR
TERMPWR	18	52	TERMPWR
Reserved (*)	19	53	Reserved (*)
Ground	20	54	Ground
Ground	21	55	-ATN
Ground	22	56	Ground
Ground	23	57	-BSY
Ground	24	58	-ACK
Ground	25	59	-RST
Ground	26	60	-MSG
Ground	27	61	-SEL
Ground	28	62	-C/D
Ground	29	63	-REQ
Ground	30	64	-I/O
Ground	31	65	-DB(8)
Ground	32	66	-DB(9)
Ground	33	67	-DB(10)
Ground	34	68	-DB(11)

(*) "Reserved": SCSI-3 requires that the "Reserved" pins be left open. They may be grounded in earlier designs. New designs should leave these open.

SCSI-3 Differential 68-pin Primary Bus ("P Cable") Connector Pinouts

High Density (0.05" Spacing) "D" Style Shielded and Unshielded

Signal Name	Pin Number		Signal Name
+DB(12)	1	35	-DB(12)
+DB(13)	2	36	-DB(13)
+DB(14)	3	37	-DB(14)
+DB(15)	4	38	-DB(15)
+DB(P1)	5	39	-DB(P1)
Ground	6	40	Ground
+DB(0)	7	41	-DB(0)
+DB(1)	8	42	-DB(1)
+DB(2)	9	43	-DB(2)
+DB(3)	10	44	-DB(3)
+DB(4)	11	45	-DB(4)
+DB(5)	12	46	-DB(5)
+DB(6)	13	47	-DB(6)
+DB(7)	14	48	-DB(7)
+DB(P)	15	49	-DB(P)
DIFFSENS	16	50	Ground
TERMPWR	17	51	TERMPWR
TERMPWR	18	52	TERMPWR
Reserved (*)	19	53	Reserved (*)
+ATN	20	54	-ATN
Ground	21	55	Ground
+BSY	22	56	-BSY
+ACK	23	57	-ACK
+RST	24	58	-RST
+MSG	25	59	-MSG
+SEL	26	60	-SEL
+C/D	27	61	-C/D
+REQ	28	62	-REQ
+I/O	29	63	-I/O
Ground	30	64	Ground
+DB(8)	31	65	-DB(8)
+DB(9)	32	66	-DB(9)
+DB(10)	33	67	-DB(10)
+DB(11)	34	68	-DB(11)

(*) "Reserved": SCSI-3 requires that the "Reserved" pins be left open. They may be grounded in earlier designs. New designs should leave these open.

LAYOUT

SFF-8015 Single Ended 80-pin SCA Connector Pinout

NC = No Connect

Signal Name	Pin Number		Signal Name
12V	1	41	Ground for 12V
12V	2	42	Ground for 12V
12V	3	43	Ground for 12V
12V	4	44	Ground for 12V
Reserved/NC	5	45	Reserved/NC
Reserved/NC	6	46	Ground
-DB(11)	7	47	Ground
-DB(10)	8	48	Ground
-DB(9)	9	49	Ground
-DB(8)	10	50	Ground
-I/O	11	51	Ground
-REQ	12	52	Ground
-C/D	13	53	Ground
-SEL	14	54	Ground
-MSG	15	55	Ground
-RST	16	56	Ground
-ACK	17	57	Ground
-BSY	18	58	Ground
-ATN	19	59	Ground
-DB(P)	20	60	Ground
-DB(7)	21	61	Ground
-DB(6)	22	62	Ground
-DB(5)	23	63	Ground
-DB(4)	24	64	Ground
-DB(3)	25	65	Ground
-DB(2)	26	66	Ground
-DB(1)	27	67	Ground
-DB(0)	28	68	Ground
-DB(P1)	29	69	Ground
-DB(15)	30	70	Ground
-DB(14)	31	71	Ground
-DB(13)	32	72	Ground
-DB(12)	33	73	Ground
5V	34	74	Ground for 5V
5V	35	75	Ground for 5V
5V	36	76	Ground for 5V
SPINDLE SYNC	37	77	ACTIVE LED OUT
RMT_START	38	78	DLYD_START
SCSI_ID(0)	39	79	SCSI_ID(1)
SCSI_ID(2)	40	80	SCSI_ID(3)

Note: Termination Power is not supplied. Terminators are powered on the platform backplane only.

SFF-8015 Differential 80-pin SCA Connector Pinout

NC = No Connect

Signal Name	Pin Number		Signal Name
12V	1	41	Ground for 12V
12V	2	42	Ground for 12V
12V	3	43	Ground for 12V
12V	4	44	Ground for 12V
Reserved/NC	5	45	Reserved/NC
Reserved/NC	6	46	DIFFSENS
-DB(11)	7	47	+DB(11)
-DB(10)	8	48	+DB(10)
-DB(9)	9	49	+DB(9)
-DB(8)	10	50	+DB(8)
-I/O	11	51	+I/O
-REQ	12	52	+REQ
-C/D	13	53	+C/D
-SEL	14	54	+SEL
-MSG	15	55	+MSG
-RST	16	56	+RST
-ACK	17	57	+ACK
-BSY	18	58	+BSY
-ATN	19	59	+ATN
-DB(P)	20	60	+DB(P)
-DB(7)	21	61	+DB(7)
-DB(6)	22	62	+DB(6)
-DB(5)	23	63	+DB(5)
-DB(4)	24	64	+DB(4)
-DB(3)	25	65	+DB(3)
-DB(2)	26	66	+DB(2)
-DB(1)	27	67	+DB(1)
-DB(0)	28	68	+DB(0)
-DB(P1)	29	69	+DB(P1)
-DB(15)	30	70	+DB(15)
-DB(14)	31	71	+DB(14)
-DB(13)	32	72	+DB(13)
-DB(12)	33	73	+DB(12)
5V	34	74	Ground for 5V
5V	35	75	Ground for 5V
5V	36	76	Ground for 5V
SPINDLE SYNC	37	77	ACTIVE LED OUT
RMT_START	38	78	DLYD_START
SCSI_ID(0)	39	79	SCSI_ID(1)
SCSI_ID(2)	40	80	SCSI_ID(3)

Note: Termination Power is not supplied. Terminators are powered on the platform backplane only.

LAYOUT

SFF-8046 Single Ended 80-pin SCA Connector Pinout

NC = No Connect
L = Long Host Receptacle Contact; blank means Short Host Receptacle Contact

Signal Name	Pin Number				Signal Name
12V CHARGE	1	L	L	41	Ground for 12V
12V	2		L	42	Ground for 12V
12V	3		L	43	Ground for 12V
12V	4			44	MATED 1
OPT 3.3V	5		L	45	OPT 3.3V CHARGE
OPT 3.3V	6		L	46	Ground
-DB(11)	7			47	Ground
-DB(10)	8			48	Ground
-DB(9)	9			49	Ground
-DB(8)	10			50	Ground
-I/O	11			51	Ground
-REQ	12			52	Ground
-C/D	13			53	Ground
-SEL	14			54	Ground
-MSG	15			55	Ground
-RST	16			56	Ground
-ACK	17			57	Ground
-BSY	18			58	Ground
-ATN	19			59	Ground
-DB(P)	20			60	Ground
-DB(7)	21			61	Ground
-DB(6)	22			62	Ground
-DB(5)	23			63	Ground
-DB(4)	24			64	Ground
-DB(3)	25			65	Ground
-DB(2)	26			66	Ground
-DB(1)	27			67	Ground
-DB(0)	28			68	Ground
-DB(P1)	29			69	Ground
-DB(15)	30			70	Ground
-DB(14)	31			71	Ground
-DB(13)	32			72	Ground
-DB(12)	33			73	Ground
5V	34			74	MATED 2
5V	35		L	75	Ground for 5V
5V CHARGE	36	L	L	76	Ground for 5V
SPINDLE SYNC	37	L	L	77	ACTIVE LED OUT
RMT_START	38	L	L	78	DLYD_START
SCSI_ID(0)	39	L	L	79	SCSI_ID(1)
SCSI_ID(2)	40	L	L	80	SCSI_ID(3)

Note: Termination Power is not supplied. Terminators are powered on the platform backplane only.

SFF-8046 Differential 80-pin SCA Connector Pinout

NC = No Connect

Signal Name	Pin Number		Signal Name
12V	1	41	Ground for 12V
12V	2	42	Ground for 12V
12V	3	43	Ground for 12V
12V	4	44	Ground for 12V
Reserved/NC	5	45	Reserved/NC
Reserved/NC	6	46	DIFFSENS
-DB(11)	7	47	+DB(11)
-DB(10)	8	48	+DB(10)
-DB(9)	9	49	+DB(9)
-DB(8)	10	50	+DB(8)
-I/O	11	51	+I/O
-REQ	12	52	+REQ
-C/D	13	53	+C/D
-SEL	14	54	+SEL
-MSG	15	55	+MSG
-RST	16	56	+RST
-ACK	17	57	+ACK
-BSY	18	58	+BSY
-ATN	19	59	+ATN
-DB(P)	20	60	+DB(P)
-DB(7)	21	61	+DB(7)
-DB(6)	22	62	+DB(6)
-DB(5)	23	63	+DB(5)
-DB(4)	24	64	+DB(4)
-DB(3)	25	65	+DB(3)
-DB(2)	26	66	+DB(2)
-DB(1)	27	67	+DB(1)
-DB(0)	28	68	+DB(0)
-DB(P1)	29	69	+DB(P1)
-DB(15)	30	70	+DB(15)
-DB(14)	31	71	+DB(14)
-DB(13)	32	72	+DB(13)
-DB(12)	33	73	+DB(12)
5V	34	74	Ground for 5V
5V	35	75	Ground for 5V
5V	36	76	Ground for 5V
SPINDLE SYNC	37	77	ACTIVE LED OUT
RMT_START	38	78	DLYD_START
SCSI_ID(0)	39	79	SCSI_ID(1)
SCSI_ID(2)	40	80	SCSI_ID(3)

Note: Termination Power is not supplied. Terminators are powered on the platform backplane only.

SCSI–3 Cabling Status

The SCSI-2 standard contains a solution for 16-bit and 32-bit bus "wide" extensions, known as the "A/B Cable" solution. This method adds a second 68-conductor "B Cable" to the SCSI-1 50-conductor "A Cable" set. This second cable is used whether the bus size is 16-bits or 32-bits.

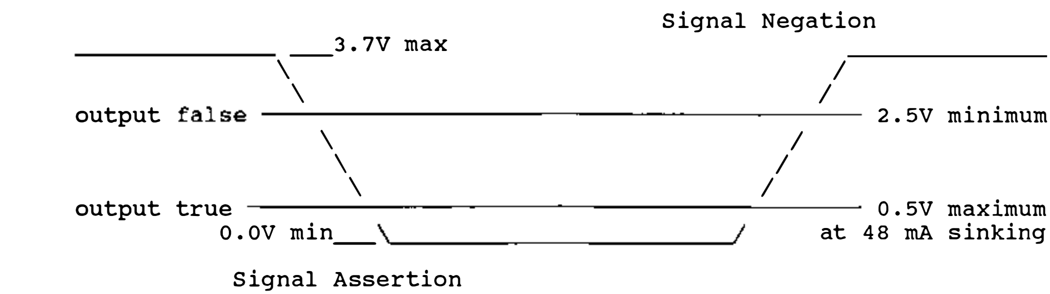
This solution fell out of favor with the SCSI-3 committee (and indeed the industry!), which then developed the SCSI-3 Primary Bus (formerly called the "P Cable") which is well on its way to becoming a published standard. To get to 32-bits, you add the SCSI-3 Secondary Bus, which adds the extra data bits and a second REQ/ACK pair (called REQQ and ACKQ).

The industry standard today is the SCSI-3 Primary Bus, which is used for all "wide SCSI" applications. In fact, the A Cable and P Cable (with its SCA variations) account for virtually all cabling today.

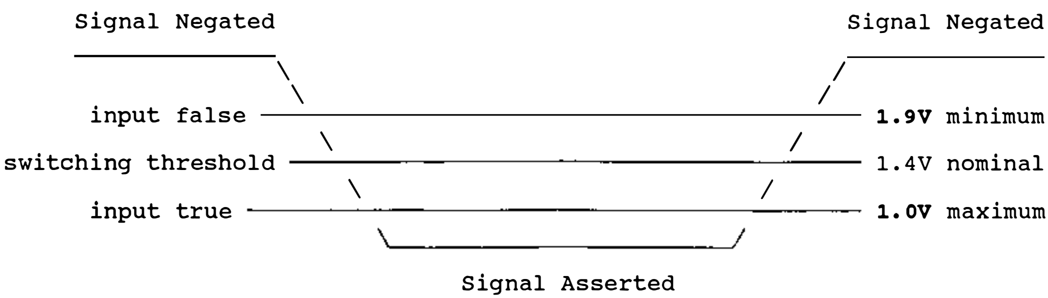
Electrical Characteristics

SCSI–3 Single Ended Interface

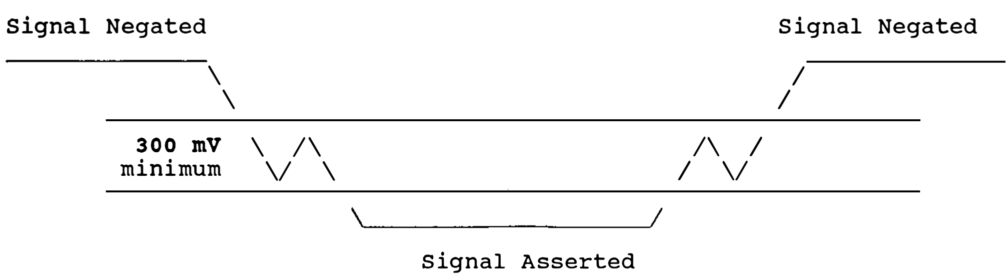
SIGNAL OUT



SIGNAL IN



SIGNAL IN - HYSTERESIS



Other Single Ended electrical characteristics:

(1) Input low current is ±20 μA when Vin = 0.5V.

(2) Input high current is ±20 μA when Vin = 2.7V.

(3) Input peak current 10 ns after hot plugging is +1.5 mA when Vin = 2.7V. Maximum transient duration to 10% of peak current value is 20 μs.

(4) Devices should meet notes (1) and (2) even when powered down, except during hot plugging.

(5) An actively-negated output driver loaded at 7.0 mA has an output voltage between 2.0V and 3.24V. Loaded at 20mA or more, it has an output voltage less than 3.0V. (This does not mean the driver has to source 20mA, but if it can, this spec keeps it from being too powerful to burn a terminator!) Actively-negated drivers should not source current above 3.7V.

(6) The Fast-20 rise **rate** of a SCSI-3 output driver going between 0.7V and 2.3V is 520 mV/ns or less; the fall **rate** going between 2.3V and 0.7V is also 520 mV/ns or less. The SPI rise **time** is 5 ns minimum between 10% and 90% of the full amplitude; the fall **time** between 90% and 10% of full amplitude is also 5 ns minimum.

(7) Terminators each supply up to 24 mA (48 mA total) to any driver when signal line is pulled below 2.5V by the driver. Note that the old 220/330 Ohm terminators are no longer allowed on a SCSI-3 Fast-20 bus.

(8) Terminators source no current when the signal is above 3.24V. Minimum release voltage is 2.5V,

(9) Input capacitance is 25 pF maximum per input or terminator, measured at the connector, including any PCB or stub effects. For Fast-20, getting below 15 pF is a good idea.

(10) Devices provide 1.5A of Terminator Power (TERMPWR) at 4.25V to 5.25V. Current limiting should be 2.0A (via fuse, etc.). If no internal terminator is installed, then a device may not sink more than 1.0mA from the TERMPWR line. TERMPWR should be decoupled at each terminator with 2.2 μF and 0.01 μF capacitors.

Single Ended Cable Characteristics

(1) SPI Cable impedance is 72 to 96 ohms, measured with one conductor of each pair grounded. Maximum impedance difference between any two signals is 12 ohms. Best results have been found when the cable impedance is between 75% and 100% of the termination impedance. The exact percentage is affected by cable attenuation, type of terminator, TERMPWR voltage level, cable insulation and routing, the low voltage level of the single ended driver, and whether the cable is round or flat. The phase of the moon has no effect known at this time. In other words, 75% to 100% is a guideline only. Results of testing by members of X3T10 has shown that a cable impedance of 84 ohms works well with active termination.

(2) Fast-20 cable impedance is 80 to 100 ohms for all signals except REQ and ACK, which must be between 84 and 96 ohms.

(3) The maximum propagation delay of any conductor is 5.4 ns/m. The maximum propagation skew between any two signals is 0.15 ns/m.

(4) Terminator Power conductor size must be at least 28AWG (0.08098 mm^2) in 50 conductor cables, and must be at least 30AWG (0.05092 mm^2) in 68 conductor cables.

(5) Cable must be spaced at least 0.050 inches (1.25 mm) from itself, other cables, or any other conductor (for example, a metal computer enclosure).

(6) Stubs must be no longer than 4 inches (0.1 m). Stubs must be spaced at least 12 inches (0.3 m) apart. In other words, use at least a one foot cable between each device. Avoid stub clustering.

(7) The "nominal" maximum cable length for 5 megatransfer/second (5 MT/s) systems is 6m. For 10 MT/s systems, it is 3m. For 20 MT/s systems (Fast-20), it is 1.5m. Some demonstrations have shown that longer cables are possible at the higher rates. Proceed with caution, because what can be acheived is a function of many interacting parameters. It pays to do your homework welll

(8) The conductors for REQ and ACK should be in the cable core of a round cable, and if there are more than 3 pairs in the core, should not be adjacent. The data bus (DB) signals should be in the outer layer.

A complete writeup on cabling and termination can be found in Volume I of The SCSI Encyclopedia.

Active Single Ended Termination Products

These products are included here as a guide only. We have not tried them and do not endorse them. We include them because we recognize that having a few part numbers as a starting place can be very helpful when dealing with any vendor. Note that some of the following part numbers may be better suited to a particular interface (e.g., Fast-20), and may come in 9-pin, 18-pin, and/or 27-pin versions. As always, you should contact the vendor for the latest specifications.

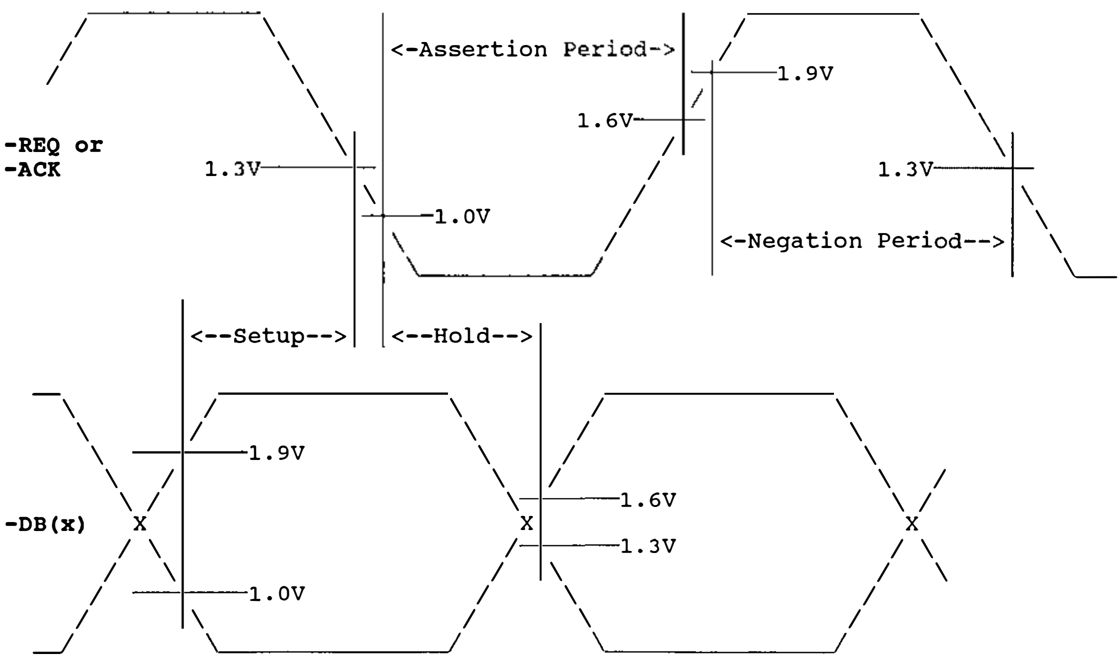
Unitrode: UCC5606/14, UCC5610/11/17/18, UCC5619/20/21/22

Dallas: DS2114Z, DS2109

Linfinity: LX5207, LX5208, LX512/513

ELECTRICAL

Fast–20 Single Ended Timing Measurement Points



Data Setup: Measured from the 1.3V point of the falling (assertion) edge of REQ/ACK to the 1.0V point (data is asserted) or 1.9V point (data is negated) of the data signal.

Data Hold: Measured from the 1.0V point of the falling (assertion) edge of REQ/ACK to the 1.6V point (data was asserted) or 1.3V point (data was negated) of the data signal.

Assertion Period: Measured from the 1.0V point of the falling (assertion) edge of REQ/ACK to the 1.6V point of the rising (negation) edge of REQ/ACK.

Negation Period: Measured from the 1.9V point of the rising (negation) edge of REQ/ACK to the 1.3V point of the falling (assertion) edge of REQ/ACK.

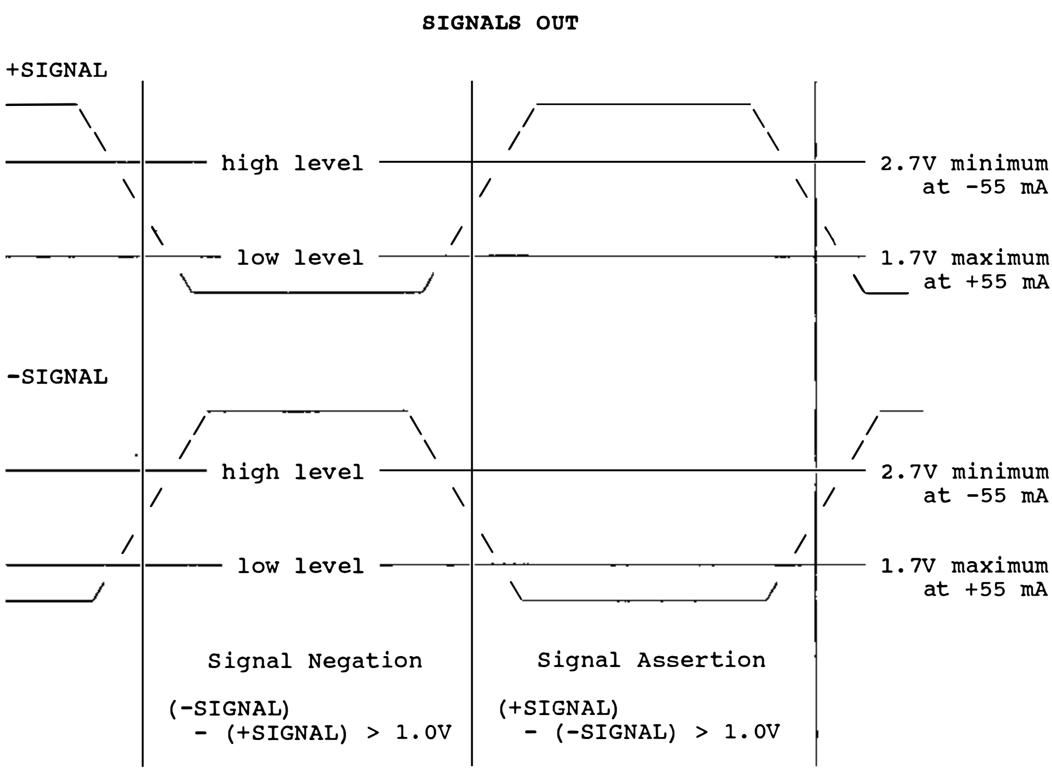
Future SCSI–3 Parallel Physical Interface Development

The current state of parallel interface development is focused in two areas: a new kind of differential interface, and a new method for expanding parallel busses.

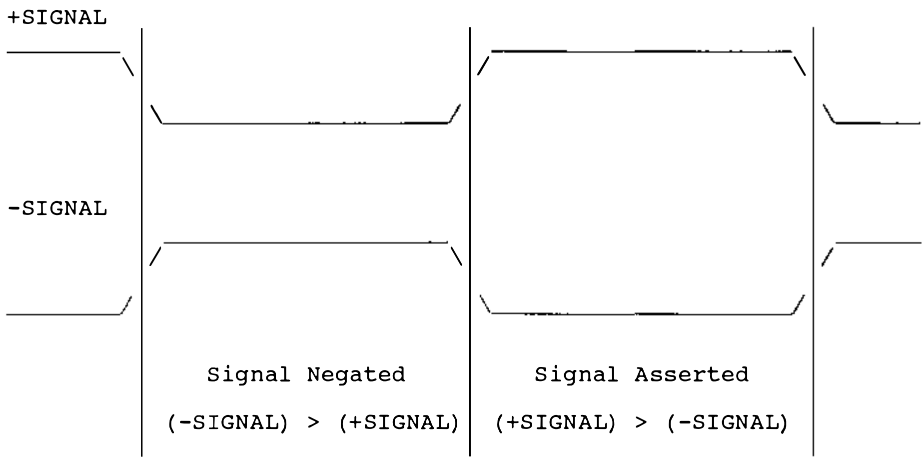
SPI-2 (SCSI Parallel Interconnect 2) contains a parallel low voltage differential (LVD) interface that uses a low voltage swing which allows lower cost, more highly integrated devices to be produced. This LVD interface should be able to operate at higher transfer rates and longer distances than single-ended interfaces.

EPI (Enhanced Parallel Interface) introduces the concept of 'bus segments', where each bus segment has its own TERMPWR distribution, and they are separated from one another by active components. EPI is also expected to further define "hot-plugging", and to describe ways of extending SPI and Fast-20 beyond the limits defined in those standards.

Differential Interface



SIGNALS IN



Other Differential electrical characteristics:

(1) Input low or high current is ±2.0 mA when Vin is between -7.0V and +12.0V.

(2) Terminators supply a total of 36.2 mA to the driver of the +SIGNAL line when pulled asserted.

(3) Terminators supply a total of 29.6 mA to the driver of the -SIGNAL line when pulled asserted.

(4) Input capacitance is 25 pF maximum per input, measured at the connector, including any PCB or stub effects.

(5) Devices should meet note (1) even when powered down.

(6) Differential output voltage (absolute value of (+SIGNAL) minus (-SIGNAL)) is 1.0V minimum with common mode voltage ranges from -7.0V to +12.0V.

(7) Hysteresis of inputs is 35mV minimum.

(8) When a signal is released, the -SIGNAL is between 3.5V and 2.1V, and the +SIGNAL is between 2.4V and 1.4V. Note that the voltages tend to track so that the proper difference is maintained.

(9) Devices provide 1.0A of Terminator Power (TERMPWR) at 4.00V to 5.25V. Current limiting should be 2.0A (via fuse, etc.). If no internal terminator is installed, then a device may not sink more than 1.0mA from the TERMPWR line.

Differential Cable Characteristics

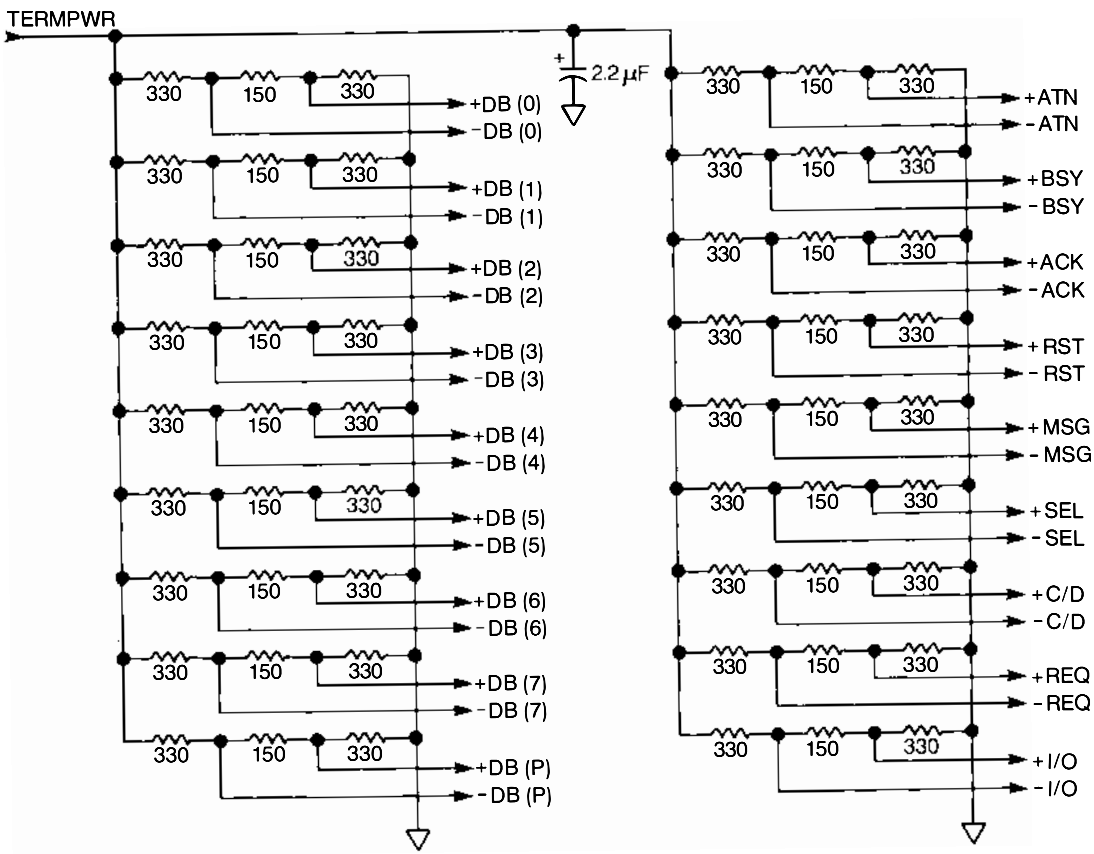
(1) Cable impedance is 115 to 160 ohms (nominal 122 ohms). Maximum impedance difference between any two signals is 20 ohms.

(2) Terminator Power conductor size must be at least 28AWG (0.08042 mm^2).

(3) Cable must be spaced at least 0.050 inches (1.25 mm) from itself, other cables, or any other conductor (for example, a metal computer enclosure).

(4) Stubs must be no longer than 8 inches (0.2 m). Total cable length is 25m or less.

Differential Termination



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Bus Signals and Phases

Signal Names and Definitions

ACK (ACKNOWLEDGE): Driven by the Initiator to acknowledge an Information Transfer.

ACKB (ACKNOWLEDGE for "Q Cable"): Used for SCSI-3 Secondary Bus wide data handshake.

ATN (ATTENTION): Driven by the Initiator when connected to get the Target's attention so that it may send it a MESSAGE OUT (see page 61). **WARNING**: A SCSI-1 Target responds to the Initiator pretty much at its own convenience, though there are some requirements for SCSI-2 targets (see page 94).

BSY (BUS BUSY): Indicates that the SCSI Bus is in use. Also used to gain control of the bus (see ARBITRATION Phase, page 43). (OR-tied: BSY is not actively driven false)

C/D (COMMAND OR DATA): Driven by the Target to indicate the Bus Phase (see tables on pages 28 and 29). In general, indicates whether data is being transfered or "other information" (COMMAND, STATUS, or MESSAGE)."True/Asserted" indicates other information is being transferred.

DB(7–0) (DATA BUS): Driven by either device, as determined by the state of the I/O signal. Contains the data that is sent from one device to the other during an 8-bit Information Transfer.

DB(15–8) (DATA BUS): Extends data bus for 16-bit wide data transfers.

DB(31–16) (DATA BUS): Extends data bus for 32-bit wide data transfers.

DB(P) (DATA BUS PARITY): Driven by either device. Contains the parity bit for the data that is sent on DB(0-7) from one device to the other during an Information Transfer. The parity is odd parity: when DB(0-7) are all zero, DB(P) is set to one.

DB(P1), DB(P2), DB(P3) (DATA BUS PARITY): Bus parity for DB(15-8), DB(23-16), and DB(31-24), respectively.

DIFFSENS (DIFFERENTIAL SENSE): When high, enables the Differential Interface. The new SPI-2 definition is (these are the values chosen at publication time and may very well change):
- less than 0.6V = the bus is Single Ended;
- 0.7V to 1.9V = the bus is the new Low Voltage Differential;
- greater than 2.2V = the bus is the old (High Voltage) Differential.

I/O (INPUT OR OUTPUT): Driven by the Target to indicate the Bus Phase (see tables on pages 28 and 29). In general, I/O indicates the bus information transfer direction. I/O also determines SELECTION and RESELECTION phases. "True/Asserted" indicates the direction is from the Target to the Initiator.

MSG (MESSAGE PHASE): Driven by the Target to indicate the Bus Phase (see tables on pages 28 and 29). In general, indicates whether the "other" information alluded to under C/D is MESSAGE IN, MESSAGE OUT, COMMAND, or STATUS information.

REQ (REQUEST): Driven by the Target to request an Information Transfer.

REQQ (REQUEST for "Q Cable"): Used for SCSI-3 Secondary Bus wide data handshake.

RST (BUS RESET): Driven by any device to clear all devices from the bus. May cause "power on reset" type condition on many devices (see page 42). (OR-tied: RST is not actively driven false)

SEL (SELECT DEVICE): Driven by: (1) an Initiator to select a Target; (2) a Target to reselect an Initiator. (OR-tied: SEL is not actively driven false)

Bus ID Priority Levels

Bus ID Number	Bus ID Bit Image (DB31 -> DB0)	Priority Level
7	.... 1.......	highest
6	.... .1......	2
5	....1.....	3
4	....1....	4
3	....1...	5
2	....1..	6
1	....1.	7
0	1	8
15	.... 1.......	9
14	.... .1......	10
13	....1.....	11
12	....1....	12
11	....1...	13
10	....1..	14
9	....1.	15
8	....1	16
23	.... 1.......	17
22	.... .1......	18
21	....1.....	19
20	....1....	20
19	....1...	21
18	....1..	22
17	....1.	23
16	....1	24
31	1.......	25
30	.1......	26
29	..1.....	27
28	...1....	28
27	....1...	29
26	.....1..	30
25	......1.	31
24	.......1	lowest

NOTE: "1" means "asserted"
"." means "released"

Bus Phases: Connections

BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	RST		Bus Phase or Condition
0	0	X	X	X	X	X	X	0		BUS FREE (*3)
0	0	X	X	X	X	X	X	1		RESET CONDITION (*3)
1	0	0	0	0	0	0	0	0		ARBITRATION
1	1	X	0	X	0	0	X	0	(*1)	bus winner takes bus
0	1	0	0	0	0	0	1	0		SELECTION
1	1	0	0	0	0	0	1	0	(*1)	Target responds to Selection
1	0	0	0	0	0	0	1	0	(*2)	Initiator responds to Target
0	1	0	0	1	0	0	0	0		RESELECTION
1	1	0	0	1	0	0	0	0	(*1)	Initiator responds to Reselection
1	0	0	0	1	0	0	0	0	(*2)	Target responds to Initiator (*4)
0	1	1	0	0	0	0	0	0		SCAM SELECTION (see page 38)
1	0	X	X	X	0	0	X	0	(*2)	between Information Transfer Phases
1	0	X	X	X	X	X	1	0	(*2)	ATTENTION CONDITION

BSY SEL MSG C/D I/O REQ ACK ATN RST Bus Phase or Condition

NOTE: Signal states are "generic":

0 = Negated or Released; False
1 = Asserted; True
X = Can be either state

(*1): These states are essentially identical to each other. These states must be evaluated in the context of the previous state. See Bus Phase State Diagram on page 30.

(*2): These states are essentially identical to each other. These states must be evaluated in the context of the previous state. See Bus Phase State Diagram on page 30.

(*3): The signals that are don't care ("X") during the BUS FREE Phase and the RESET Condition are either false or are transitioning to a false state.

(*4): Initiator then releases BSY; does not change Bus Phase since Target is asserting BSY.

BY THE WAY (regarding Phases): The SCSI-3 standards have done away with the term "phase". They are still there, just named something else. This was done to facilitate the use of non-parallel ways of delivering SCSI commands, but the new terminology (in our humble opinion) will not necessarily catch on any time soon. Therefore, we have opted to continue with the "old" terms for now.

Bus Phases: Information Transfer

BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	RST	Bus Phase or Condition
1	0	X	X	X	0	0	X	0	between Information Transfer Phases
1	0	0	0	0	1	0	X	0	beginning of DATA OUT Phase
1	0	0	0	0	1	1	X	0	state during DATA OUT Phase (*5)
1	0	0	0	0	0	1	X	0	state during DATA OUT Phase (*5)
1	0	0	0	0	0	0	X	0	state during DATA OUT Phase (*6)
1	0	0	0	1	1	0	X	0	beginning of DATA IN Phase
1	0	0	0	1	1	1	X	0	state during DATA IN Phase (*5)
1	0	0	0	1	0	1	X	0	state during DATA IN Phase (*5)
1	0	0	0	1	0	0	X	0	state during DATA IN Phase (*6)
1	0	0	1	0	1	0	X	0	beginning of COMMAND Phase
1	0	0	1	0	1	1	X	0	state during COMMAND Phase
1	0	0	1	0	0	1	X	0	state during COMMAND Phase
1	0	0	1	1	1	0	X	0	beginning of STATUS Phase
1	0	0	1	1	1	1	X	0	state during STATUS Phase
1	0	0	1	1	0	1	X	0	state during STATUS Phase
1	0	1	1	0	1	0	X	0	beginning of MESSAGE OUT Phase
1	0	1	1	0	1	1	X	0	state during MESSAGE OUT Phase
1	0	1	1	0	0	1	X	0	state during MESSAGE OUT Phase
1	0	1	1	1	1	0	X	0	beginning of MESSAGE IN Phase
1	0	1	1	1	1	1	X	0	state during MESSAGE IN Phase
1	0	1	1	1	0	1	X	0	state during MESSAGE IN Phase
1	0	1	0	0	1	0	X	0	reserved phase
1	0	1	0	1	1	0	X	0	reserved phase
1	0	X	X	X	X	X	1	0	ATTENTION CONDITION
BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	RST	Bus Phase or Condition

(*5): These states during DATA IN and DATA OUT Phases are true for both Asynchronous and Synchronous data transfers.

(*6): These states can occur during Synchronous DATA IN and DATA OUT phases when the number of REQs issued is greater than the number of ACKs issued.

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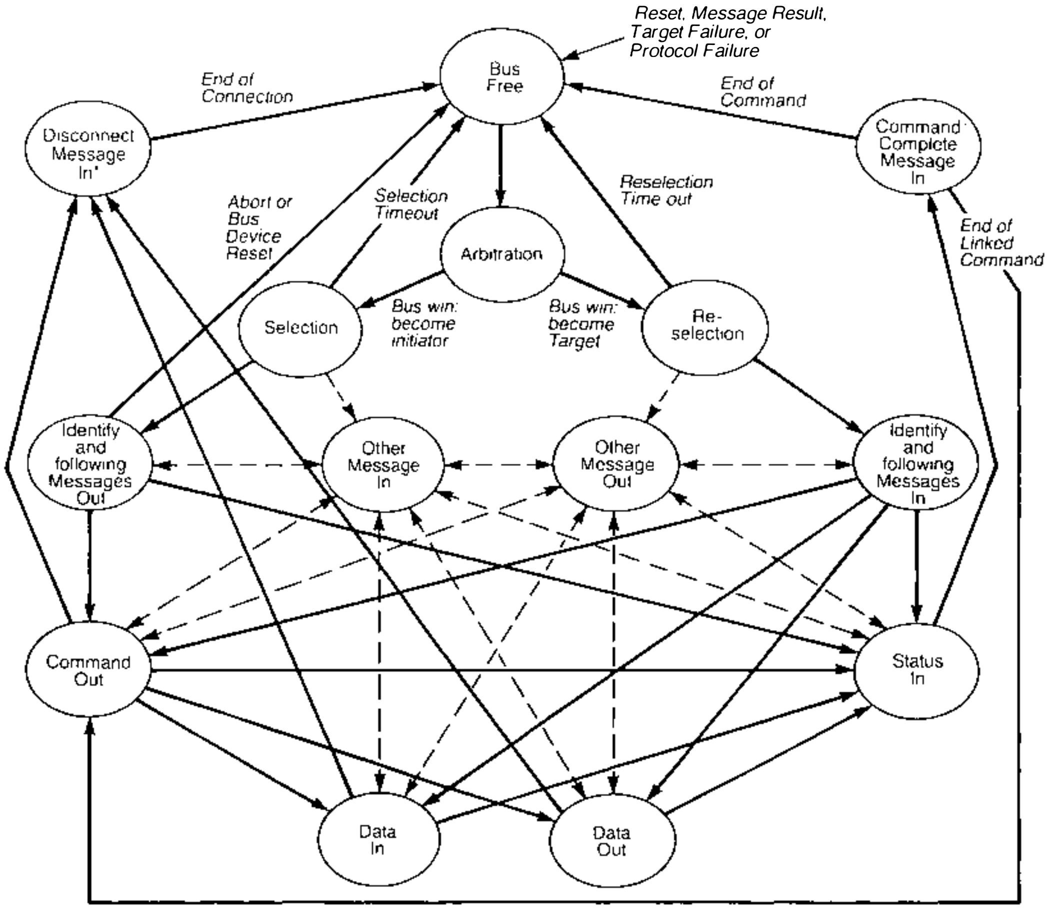
SCSI Bus Phase State Diagram

SCSI PHASE SEQUENCES



A word of explanation: First, Don't Be Frightened! Take a minute to examine the diagram and it will become a little clearer. The solid arrow lines represent "typical" phase sequences that occur during normal command transfer and execution. The dashed arrow lines represent "exceptional" transitions to the MESSAGE IN and MESSAGE OUT phases that would occur to send SYNCHRONOUS DATA TRANSFER REQUEST messages, or any error recovery procedure (e.g., RESTORE POINTERS).

(*): Disconnect Message In may be preceeded by a Save Data Pointer Message In.

SCSI Configured Auto–Magically (SCAM)

SCAM is a new protocol in SCSI-3 that allows bus IDs to be assigned over the bus. A summary of the protocol:

- A "SCAM Initiator" is a SCSI Initiator that can initiate the SCAM protocol and assign bus IDs to SCAM Targets.
- A "SCAM Target" is a SCSI Device that can recognize the SCAM protocol and receive an ID assignment from a SCAM Initiator.
- Even if all devices do not implement SCAM, they can peacefully exist with devices that do, provided they are "SCAM tolerant" (see below).
- Any SCAM device can initiate the SCAM protocol by arbitrating for the bus, winning, and entering the SCAM selection "phase": BSY, SEL, and MSG asserted. All participating SCAM devices then complete the Initiation protocol.
- After the SCAM protocol has been initiated, SCAM transfer cycles are used to issue function codes, action codes, and to isolate devices by comparing 'world wide ID' strings.
- After SCAM protocol initiation, all SCAM Initiators compete to be the Dominant SCAM Initiator through an isolation process. The Dominant SCAM Initiator then controls future SCAM transfer cycles and assigns IDs to SCAM Targets and to the now "Subordinate" SCAM Initiators.
- The Dominant SCAM Initiator then isolates SCAM Targets and assign bus IDs to them.
- Once all devices have received a bus ID assignment, the SCAM protocol is complete and the bus is released for normal operation.

NOTE: Several, um, "editorial errors" have been found in the original definition of SCAM in SPI. These errors are being fixed in SPI-2. Refer to SPI-2 for all new SCAM development.

See pages 63-65 for detailed SCAM timing.

SCAM Tolerance

A SCAM Tolerant-Target:

- Enables its response to SELECTION phase within 5 seconds after power-on.
- Enables its response to SELECTION phase within 250 ms after a reset.
- Recognizes a valid selection whether or not the data bus includes the Initiator's ID bit (single bit selection).
- Responds to a valid selection within 1.0 ms of the beginning of the SELECTION phase.

See page 34 for the other SCAM requirement levels.

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SCAM Identification String Format

Byte \ Bit	7	6	5	4	3	2	1	0
0	Priority Code		Maximum ID Code		Reserved	ID Valid		SNA
1	Reserved			ID				
2	(MSB) Vendor Identification							
3								
4								
5								
6								
7								
8								
9								(LSB)
10	(MSB) Vendor Specific Code							
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								(LSB)
31	Reserved, sorta							

The SCAM ID String is used during any isolation process to select a single SCAM Initiator or Target for the next action, either Dominant SCAM Initiator Contention or SCAM Target isolation prior to bus ID assignment. Bit 7 of each byte is sent first. The first two bytes are referred to as the "Type Code".

Priority Code: If the current SCAM Function is "Dominant Initiator Contention", the codes are:
00 = Level 1 SCAM Initiator.
01 = Level 2 SCAM Initiator that does not want to be dominant.
10 = reserved
11 = Level 2 SCAM Initiator that wants to be dominant (was dominant last time, etc.)

If the current SCAM function is "Isolate" or "Isolate and Set Priority Flag", the codes are:
00 = Priority Flag cleared
10 = Priority Flag set
01, 11 = reserved

Maximum ID Code: largest bus ID assignment that the device can accept:
00 = SCSI bus ID may be up to 1Fh (range 0-31, 32-bit bus)
01 = SCSI bus ID may be up to 0Fh (range 0-15, 16-bit bus)
10 = SCSI bus ID may be up to 07h (range 0-7, 8-bit bus)
11 = reserved

ID Valid:
00 = ID field not valid
01 = ID contains current bus ID, but device has not been assigned an ID
10 = ID contains assigned ID
11 = reserved

SNA: 0 = the entire ID string is not available yet (e.g., reading it from disk).
1 = the entire ID string is available.

ID: SCSI bus ID, as defined by ID Valid field (above).

Vendor Identification Field: 8 byte ASCII field identifying product vendor, same as INQUIRY data (see page 100).

Vendor Specific Code: 21 byte ASCII field that is a unique (for the vendor) identification code for the device. The recommended method is to concatenate the model ID with the serial number.

Reserved, sorta: The current SCAM definition is for a 31 byte ID string; however, SCAM also states that the SCAM Initiator shall be capable of receiving 32 byte ID strings to permit future protocol extensions. Presumably (but not necessarily) the extra byte will be tacked onto the end of the string. Therefore, this reserved byte may or may not be sent during an isolation transfer cycle.

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SCAM Requirement Levels

(SCAM Tolerant Target is shown on page 31 to make it more obvious!)

A Level 1 SCAM Target:

- responds to SCAM Selection;
- does not initiate the SCAM Protocol.

A Level 2 SCAM Target:

- will initiate SCAM Protocol if it has no assigned ID;
- will initiate SCAM Protocol if a reset has occurred.

A Level 1 SCAM Initiator:

- is not required to recognize SCAM Selection;
- can detect Dominant Initiator Contention and participate in the Isolation Stage for Dominant Initiator;
- must have an assigned ID.

A Level 2 SCAM Initiator:

- must recognize SCAM Selection;
- must perform Dominant Initiator Contention each time the SCAM Protocol is initiated;
- must have an assigned ID or be able to arbitrate without an ID.

SCAM Transfer Cycle Conditions for Isolation Stage

The "Bit Value to Send" in the table below is the next bit of the SCAM Identification String to send in the current Isolation Stage. The value asserted on DB(4-0) is the encoded value of the bit to send.

Bit Value to Send	Assert on DB(4-0)	Then IF...	Value Received from DB(4-0) is	The Transfer Cycle Condition is...
0	00001		00001	Continue Isolation Stage
			00011	Defer Isolation Stage; Device has lost; Release DB(4-0) (send "none") Continue handshake until next Synchronization Function and ignore all other codes
			10001 OR 10011	Terminate Isolation Stage; Action Code may follow
			11111	Synchronization Function
			anything else	Bus error or reserved code
1	00010		00010 OR 00011	Continue Isolation Stage
			10010 OR 10011	Terminate Isolation Stage; Action Code may follow
			11111	Synchronization Function
			anything else	Bus error or reserved code
none	00000		00001 OR 00010 OR 00011	Continue handshake until next Synchronization Pattern
			00000 OR 10000	Terminate Isolation Stage; Action Code may follow
			11111	Synchronization Function
			anything else	Bus error or reserved code

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SCAM Function Codes

Function Codes are sent to begin a stage of the SCAM protocol. The Synchronization function is usually sent prior to one of the other Function Codes to ensure that all devices are starting at the same place.

Function Code DB(4-0)	Description
00000	Isolate SCAM Target(s) (perform Action Code after isolation terminates)
00001	Isolate SCAM Target(s) and Set Priority Flag (perform Action Code after isolation terminates)
00011	Configuration Process Complete (normal end of SCAM protocol)
01111	Dominant Initiator Contention (isolate Dominant SCAM Initiator)
11111	Synchronization Function (next function to perform follows in next transfer cycle)
all others	Reserved

SCAM Action Codes

Action Codes are sent after SCAM Target Isolation Termination, and are sent in two SCAM Transfer Cycles.

Action Code First	Second	Description
11000	11000	Assign SCSI bus ID 0
11000	10001	Assign SCSI bus ID 1
11000	10010	Assign SCSI bus ID 2
11000	01011	Assign SCSI bus ID 3
11000	10100	Assign SCSI bus ID 4
11000	01101	Assign SCSI bus ID 5
11000	01110	Assign SCSI bus ID 6
11000	00111	Assign SCSI bus ID 7
10001	11000	Assign SCSI bus ID 8
10001	10001	Assign SCSI bus ID 9
10001	10010	Assign SCSI bus ID 10
10001	01011	Assign SCSI bus ID 11
10001	10100	Assign SCSI bus ID 12
10001	01101	Assign SCSI bus ID 13
10001	01110	Assign SCSI bus ID 14
10001	00111	Assign SCSI bus ID 15
10010	11000	Assign SCSI bus ID 16
10010	10001	Assign SCSI bus ID 17
10010	10010	Assign SCSI bus ID 18
10010	01011	Assign SCSI bus ID 19
10010	10100	Assign SCSI bus ID 20
10010	01101	Assign SCSI bus ID 21
10010	01110	Assign SCSI bus ID 22
10010	00111	Assign SCSI bus ID 23
01011	11000	Assign SCSI bus ID 24
01011	10001	Assign SCSI bus ID 25
01011	10010	Assign SCSI bus ID 26
01011	01011	Assign SCSI bus ID 27
01011	10100	Assign SCSI bus ID 28
01011	01101	Assign SCSI bus ID 29
01011	01110	Assign SCSI bus ID 30
01011	00111	Assign SCSI bus ID 31
10100	11000	Clear Priority Flag
10100	10010	Locate On (turn on physical location indicator)
10100	01011	Locate Off (turn it off!)
all others		Reserved

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Bus Phases: SCSI Configured Auto-Magically(SCAM), Protocol Initiation

BSY	SEL	MSG	C/D	I/O	DB7	DB6	DB5	DB4-0	Bus Phase or Condition
0	0	X	X	X	X	X	X	XXXXX	BUS FREE (*1)
1	0	0	0	0	0	0	0	00000	ARBITRATION
1	1	X	0	0	0	0	0	00000	bus winner takes bus
0	1	1	0	0	0	0	0	00000	SCAM SELECTION
0	1	0	0	0	0	0	0	00000	MSG release (*2)
1	1	0	0	0	1	0	0	00000	assert BSY on MSG release detect
1	1	0	0	1	1	1	0	00000	SCAM Target response
1	1	0	1	1	1	1	0	00000	SCAM Initiator response
1	0	0	X	X	1	1	0	00000	SEL release (*3)
1	0	0	X	X	1	0	0	00000	DB6 release (*4)
1	0	0	0	1	1	0	0	00000	SCAM Initiator not present (*5)
1	0	0	1	1	1	0	0	00000	SCAM Initiator present
1	1	0	1	1	1	0	0	00000	SCAM Initiation complete
1	1	0	0	X	X	X	X	XXXXX	end of SCAM protocol
BSY	SEL	MSG	C/D	I/O	DB7	DB6	DB5	DB4-0	Bus Phase or Condition

NOTE: Signal states are "generic":

0 = Negated or Released; False
1 = Asserted; True
X = Can be either state

ANOTHER NOTE: REQ, ACK, RST, ATN, and DB(15-8,P,P1) are not used during the SCAM protocol and may be considered to be "don't care".

(*1): The signals that are don't care ("X") during the BUS FREE Phase are either false or are transitioning to a false state.

(*2): Perform wire-OR glitch filtering before detecting MSG false.

(*3): Perform wire-OR glitch filtering before detecting SEL false.

(*4): Perform wire-OR glitch filtering before detecting DB6 false.

(*5): If no SCAM Initiator is present, SCAM protocol cannot be continued and the SCAM targets release all signals.

See page 63 for detailed SCAM Initiation timing.

Bus Phases: SCSI Configured Auto-Magically(SCAM), Transfer Cycle

BSY	SEL	MSG	C/D	I/O	DB7	DB6	DB5	DB4-0	Bus Phase or Condition
1	1	0	1	1	1	0	0	XXXXX	between SCAM transfer cycles
1	1	0	1	1	1	0	0	ddddd	start of cycle; assert valid data
1	1	0	1	1	1	0	1	ddddd	all devices assert DB5
1	1	0	1	1	0	0	1	ddddd	all devices release DB7 (*1)
1	1	0	1	1	0	1	1	ddddd	all devices read and latch data from DB4-0 and then assert DB6
1	1	0	1	1	0	1	0	ddddd	all devices release DB5 (*2)
1	1	0	1	1	1	1	0	XXXXX	all devices assert DB7
1	1	0	1	1	1	0	0	XXXXX	all devices release DB6 (*3)

BSY SEL MSG C/D I/O DB7 DB6 DB5 DB4-0 Bus Phase or Condition

NOTE: Signal states are "generic":

0 = Negated or Released; False
1 = Asserted; True
X = Can be either state
d = Valid data

(*1): Perform wire-OR glitch filtering before detecting DB7 false and reading DB4-0.

(*2): Perform wire-OR glitch filtering before detecting DB5 false and changing DB4-0.

(*3): Perform wire-OR glitch filtering before detecting DB6 false.

See page 65 for detailed SCAM Transfer timing.

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SCSI Bus Timing

NOTE: In the timing figures, the basic SCSI timing values referred to in the standard are given in parentheses ( ). Some of the timing values are not named in the SCSI standard and are so indicated.

ANOTHER NOTE: Timing is shown as "generic" levels: a "high" level is true/asserted, and a low level is false/negated, as shown below:

```
                                   ________________signal true/asserted
   signal false/negated___________/
```

YET ANOTHER NOTE: The term "Data Bus" is used in the timing diagrams to refer to the set of data bus signals appropriate to the bus transaction:

- 8-bit Data Bus is DB0-7, DBP. (SCSI-2 A Cable or SPI Primary Bus)
- 16-bit Data Bus is DB0-15, DBP, DBP1. (SPI Primary Bus)
- 32-bit Data Bus is DB0-31, DBP, DBP1, DBP2, DBP3. (SPI Primary and Secondary Buses)

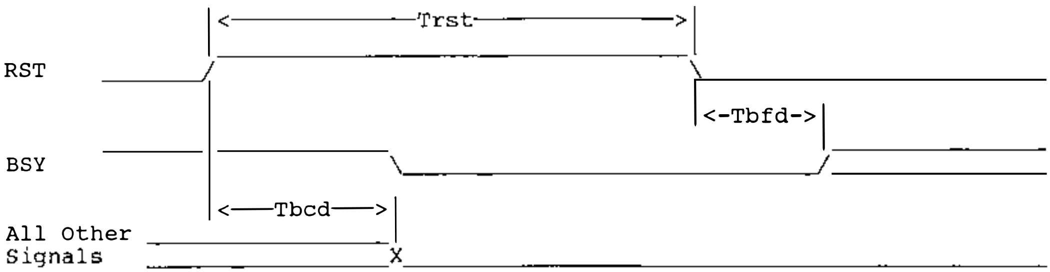
Note that "REQ" and "ACK" timing also applies to REQQ and ACKQ.

Basic SCSI Timing Values

Timing Value	async	slow	fast	fast-20	fast-40?
Arbitration Delay	2400 ns	2400 ns	2400 ns	2400 ns	2400 ns
Bus Clear Delay	800 ns	800 ns	800 ns	800 ns	800 ns
Bus Free Delay	800 ns	800 ns	800 ns	800 ns	800 ns
Bus Set Delay	1800 ns	1800 ns	1800 ns	1800 ns	1800 ns
Bus Settle Delay	400 ns	400 ns	400 ns	400 ns	400 ns
Data Release Delay	400 ns	400 ns	400 ns	400 ns	400 ns
Disconnection Delay	200 us	200 us	200 us	200 us	200 us
Reset Hold Time	25 us	25 us	25 us	25 us	25 us
Selection Abort Time	200 us	200 us	200 us	200 us	200 us
Selection Timeout (recomm.)	250 ms	250 ms	250 ms	250 ms	250 ms
Transfer Period	n/a	200 ns	100 ns	50 ns	25 ns
Cable Skew Delay	4 ns	4 ns	4 ns	3 ns	1.5 ns
System Deskew Delay	45 ns	45 ns	20 ns	15 ns	10 ns
Assertion Period - Transmit:	n/a	80 ns	30 ns	15.0 ns	9.00 ns
Receive:	n/a	70 ns	22 ns	11.0 ns	7.50 ns
Negation Period - Transmit:	n/a	80 ns	30 ns	15.0 ns	9.00 ns
Receive:	n/a	70 ns	22 ns	11.0 ns	7.50 ns
Setup Time - Transmit:	n/a	23 ns	23 ns	11.5 ns	8.25 ns
Receive:	n/a	15 ns	15 ns	6.5 ns	4.75 ns
Hold Time - Transmit:	n/a	53 ns	33 ns	16.5 ns	8.75 ns
Receive:	n/a	25 ns	25 ns	11.5 ns	5.25 ns

NOTE: Fast-40 Times shown above are EXTREMELY PRELIMINARY, have not been approved, and will likely change. Be sure to check the latest version of SPI that you can find!

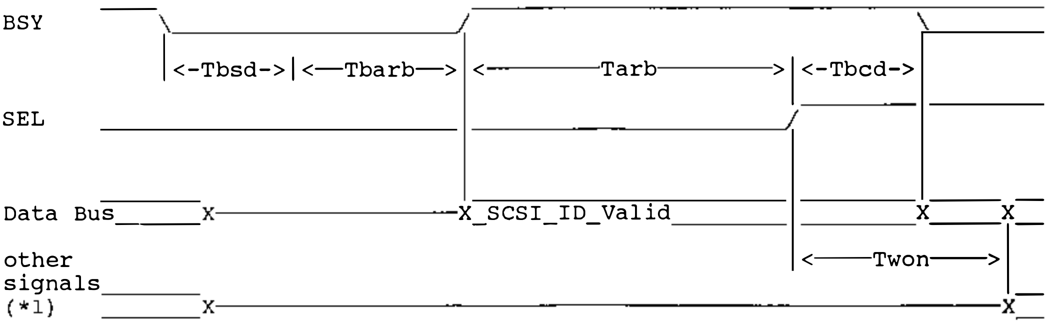
Bus Reset Condition



Time	Description	Min	Max	Units
Trst	RST assert by a device (Initiator or Target) to RST negated by the device (reset hold time)	25	—	µsec
Tbcd	RST true to all other bus signals released by all devices (bus clear delay)	—	800	nsec
Tbfd	RST false to BUS FREE validated (bus free delay)	800	—	nsec

TIMING

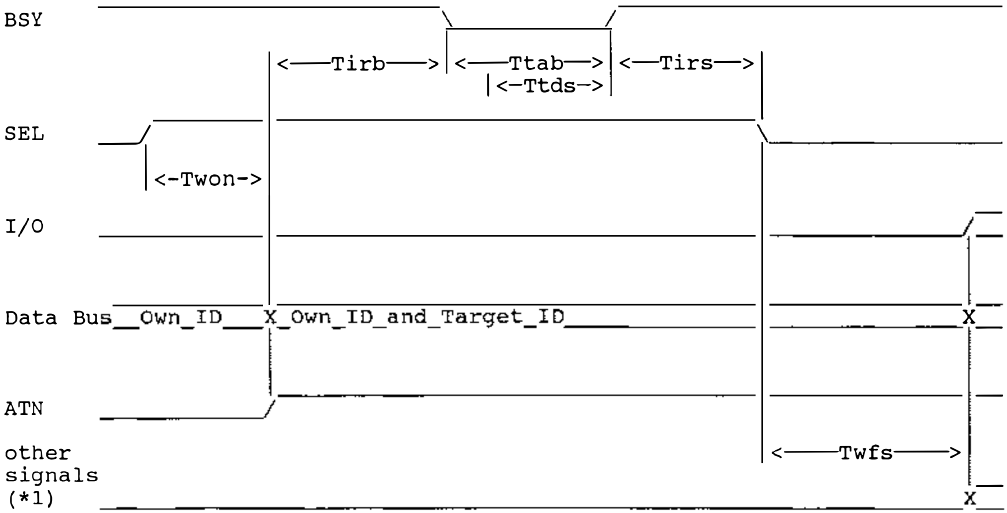
Arbitration Phase



(*1) Other signals = DBP, DBP1, DBP2, DBP3, C/D, I/O, REQ, ACK, and ATN. They are not asserted during arbitration phase.

Time	Description	Min	Max	Units
Tbsd	BSY false to validate BUS FREE (bus settle delay)	400	—	nsec
Tbarb	BUS FREE validated to assert BSY and Bus ID bit for Arbitration: (bus free delay)	800	—	nsec
	(bus set delay)	—	1800	nsec
Tarb	Assert BSY to examine bus for win (arbitration delay)	2400	—	nsec
Tbcd	Arbitration winner asserts SEL to Arbitration loser(s) release all signals (bus clear delay)	—	800	nsec
Twon	Arbitration winner asserts SEL to winner changing any bus signal (bus clear delay plus bus settle delay)	1200	—	nsec

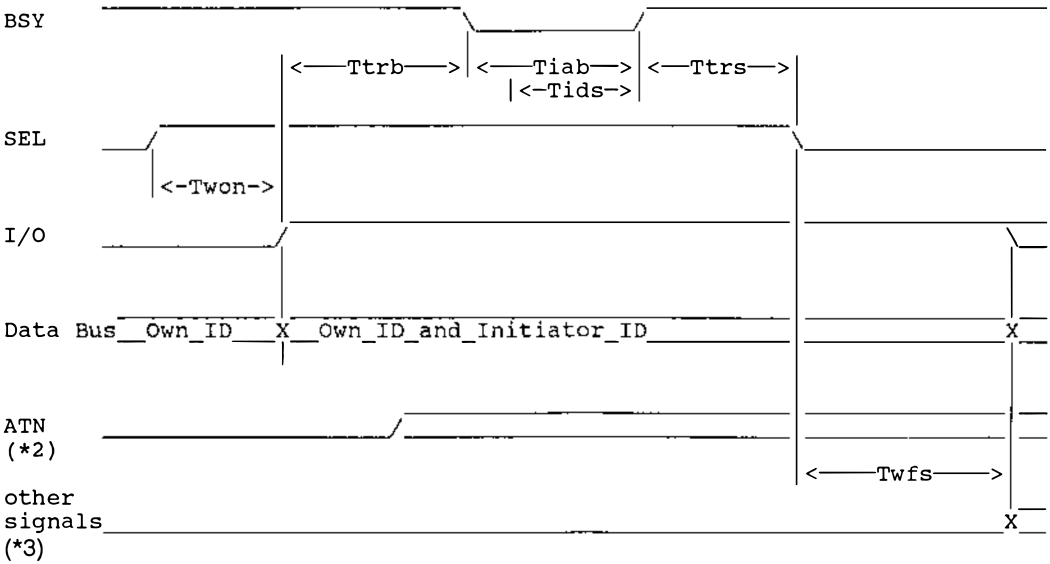
Selection Phase



(*1) Other signals = MSG, C/D, REQ, and ACK. They are not asserted during selection phase.

Time	Description	Min	Max	Units
Twon	Arbitration winner asserts SEL to winner changing any bus signal (bus clear delay plus bus settle delay)	1200	—	nsec
Tirb	Initiator asserts data bus and ATN to releasing BSY (two async system deskew delays)	90	—	nsec
Ttab	Initiator releases BSY at start of SELECTION Phase to Target asserts BSY:			
	(bus settle delay)	400	—	nsec
	(selection timeout)	—	250	msec
Ttds	Target last validates Selection Phase to Target asserts BSY (selection abort time)	—	200	μsec
Tirs	Target asserts BSY to Initiator releases SEL (two async system deskew delays)	90	—	nsec
Twfs	Initiator releases SEL to Target changes any other signal (timing not named)	0	—	nsec

Reselection Phase

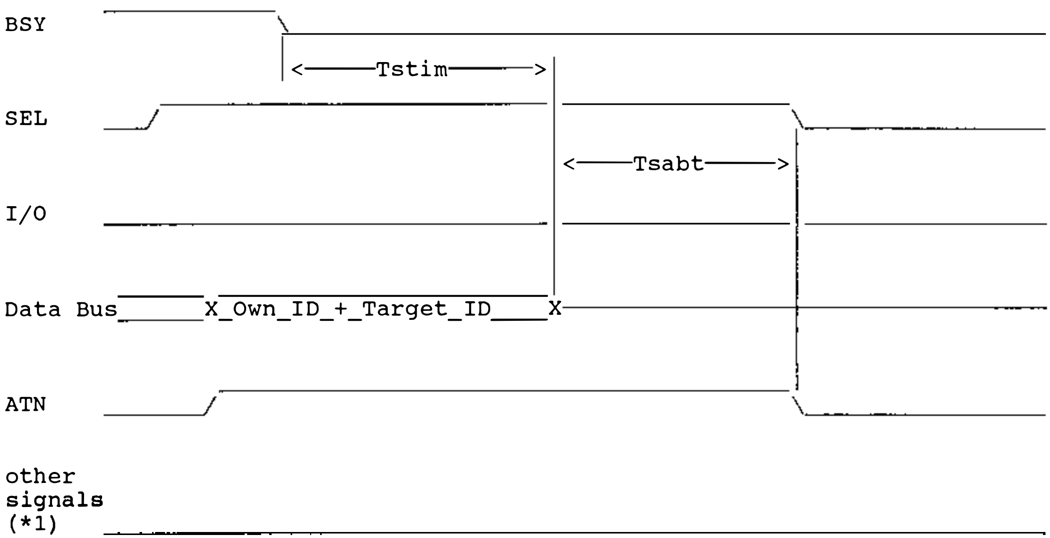


(*2) ATN may be asserted during reselection phase, but it is not part of the normal protocol. The Target does not respond to the ATN signal until after the first MESSAGE OUT phase (which includes IDENTIFY).

(*3) Other signals = MSG, C/D, REQ, and ACK.

Time	Description	Min	Max	Units
Twon	Arbitration winner asserts SEL to winner changing any bus signal (bus clear delay plus bus settle delay)	1200	—	nsec
Ttrb	Target asserts data bus and I/O to releasing BSY (two async system deskew delays)	90	—	nsec
Tiab	Target releases BSY at start of RESELECTION Phase to Initiator asserts BSY:			
	(bus settle delay)	400	—	nsec
	(selection timeout)	—	250	msec
Tids	Initiator last validates Reselection Phase to Initiator asserts BSY (selection abort time)	—	200	μsec
Ttrs	Initiator asserts BSY to Target releases SEL (two async system deskew delays)	90	—	nsec
Twfs	Target releases SEL to Target changes any other signal (timing not named)	0	—	nsec

Selection Timeout

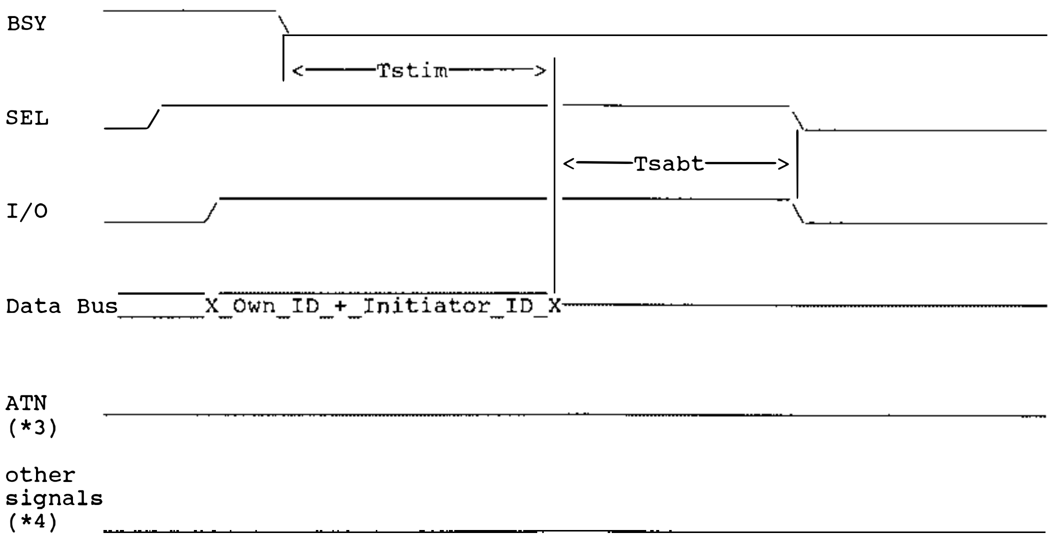


(*1) Other signals = MSG, C/D, REQ, and ACK. They are not asserted during selection phase.

Time	Description	Min	Max	Units
Tstim	Initiator releases BSY at start of SELECTION Phase to Initiator releases data bus for timeout (selection timeout)	250	——	msec
Tsabt	Initiator releases SEL and ATN to complete timeout (selection abort time plus two async system deskew delays) (*2)	200.09	——	μsec

(*2): Yes, this is correct. The extra 90 nsec is to allow a window between the maximum time for the Target to validate selection (Ttds, page 44, 63, 64, 65) and the minimum time for the Initiator to wait before giving up.

Reselection Timeout



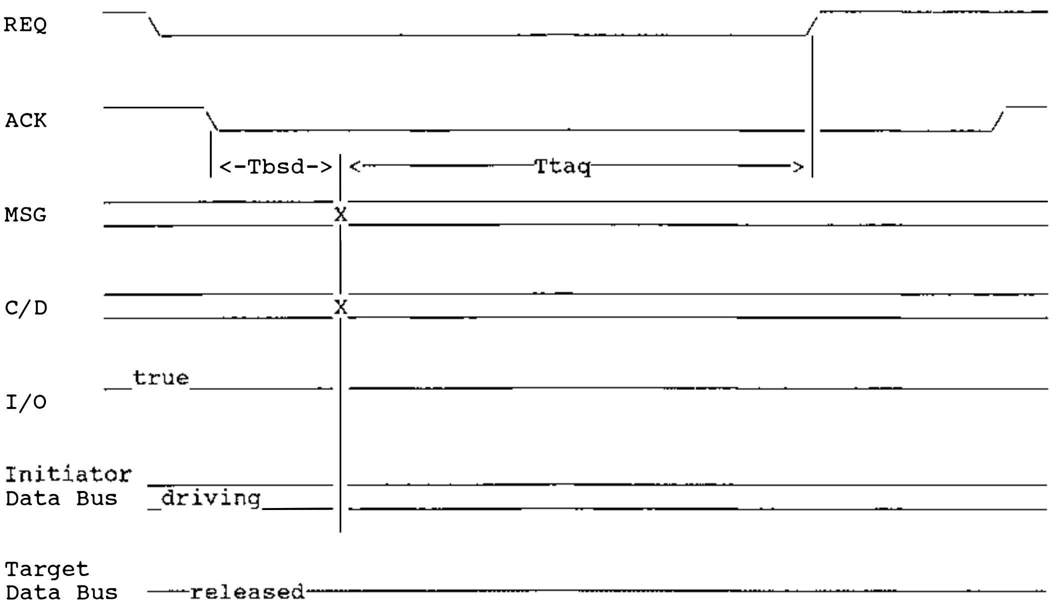
(*3) ATN may be asserted during reselection phase, but it is not part of the normal protocol.

(*4) Other signals = MSG, C/D, REQ, and ACK.

Time	Description	Min	Max	Units
Tstim	Target releases BSY at start of RESELECTION Phase to Target releases data bus for timeout (selection timeout)	250	—	msec
Tsabt	Target releases SEL to complete timeout (selection abort time plus async system two deskew delays) (*5)	200.09	—	μsec

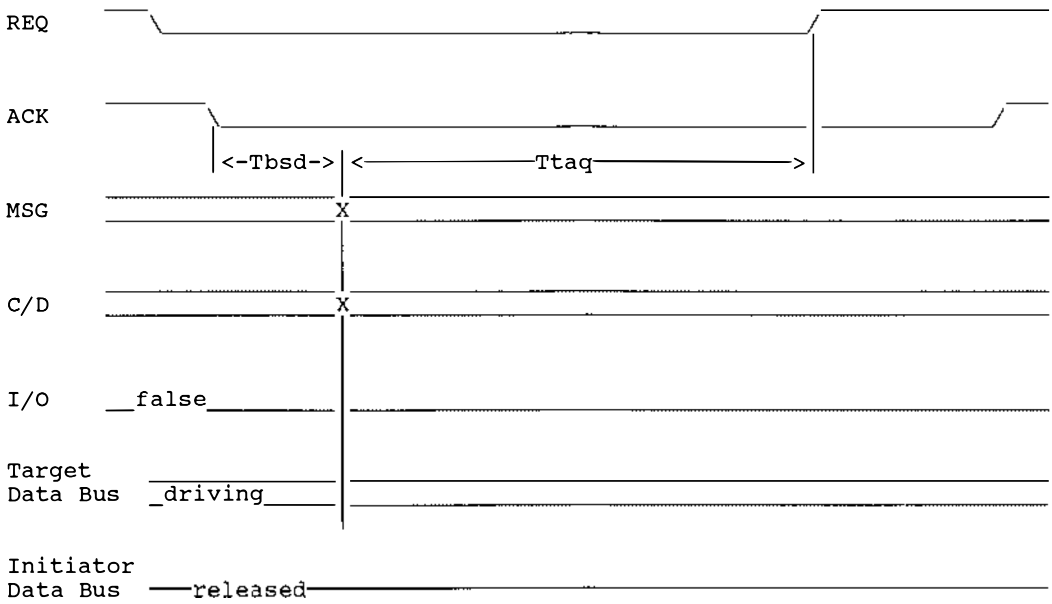
(*5): Yes, this is correct. The extra 90 nsec is to allow a window between the maximum time for the Initiator to validate reselection (Tids, page 45) and the minimum time for the Target to wait before giving up.

Info Transfer Out Phase Transition to Info Transfer Out Phase



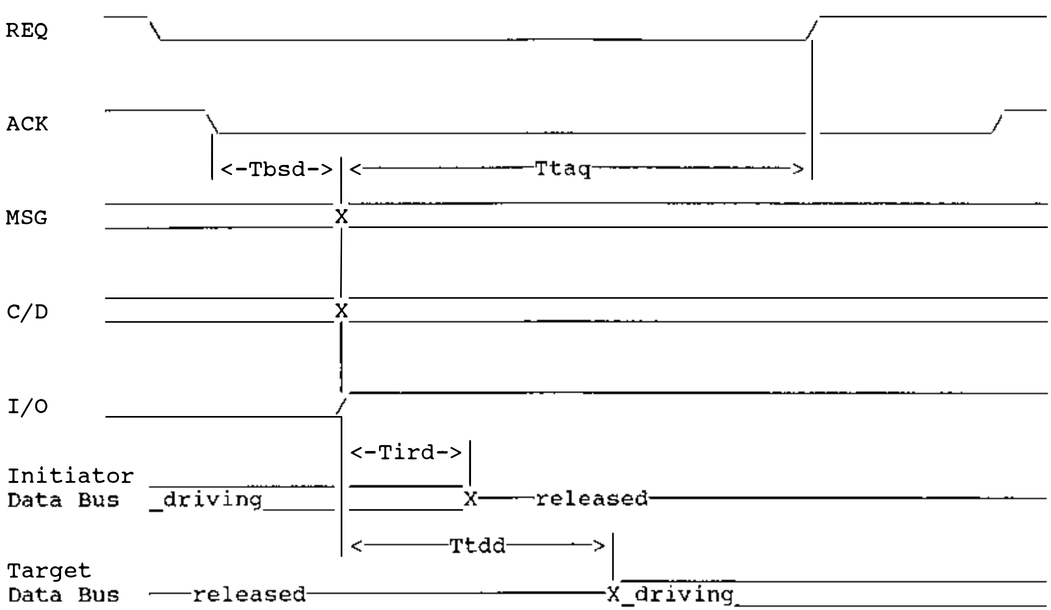
Time	Description	Min	Max	Units
Tbsd	Last ACK of phase false to Target change MSG, C/D, and I/O (timing not named)	0	—	nsec
Ttaq	Target changes MSG and/or C/D to Target asserts REQ (bus settle delay)	400	—	nsec

Info Transfer In Phase Transition to Info Transfer In Phase



Time	Description	Min	Max	Units
Tbsd	Last ACK of phase false to Target change MSG, C/D, and I/O (timing not named)	0	—	nsec
Ttaq	Target changes MSG and/or C/D to Target asserts REQ (bus settle delay)	400	—	nsec

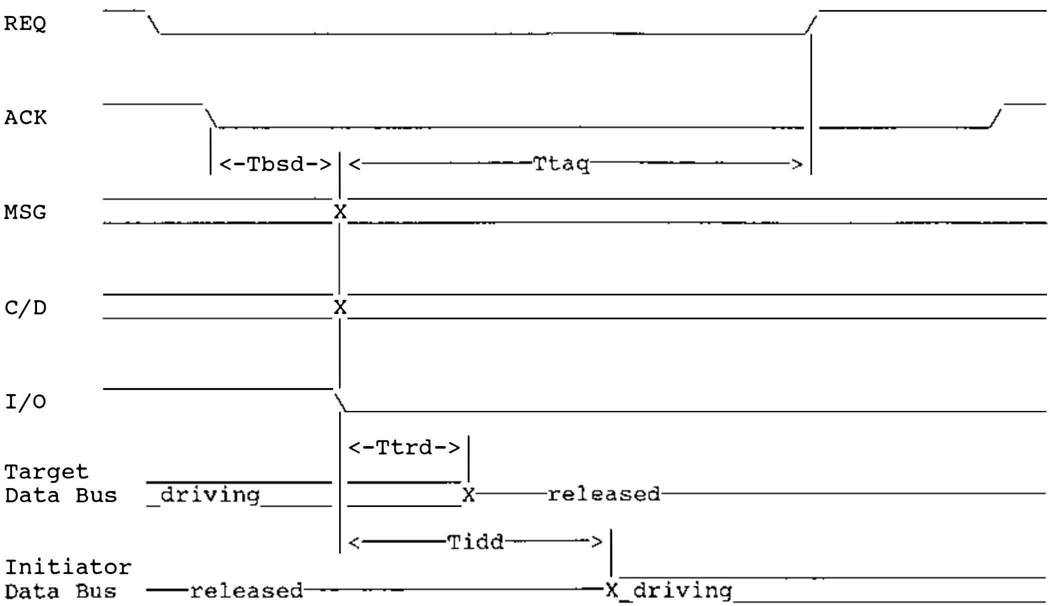
Info Transfer Out Phase Transition to Info Transfer In Phase



Time	Description	Min	Max	Units
Tbsd	Last ACK of phase false to Target change MSG, C/D, and I/O (timing not named)	0	—	nsec
Tird	Target assert I/O to Initiator releases data bus (data release delay)	—	400	nsec
Ttdd	Target assert I/O to Target drives data bus (data release delay plus bus settle delay)	800	—	nsec
Ttaq	Target changes MSG and/or C/D, and asserts I/O to Target asserts REQ (Ttdd plus async system deskew delay plus cable skew delay) (*1)	849	—	nsec

(*1): Even though the standard states 400 nsec for this value (bus settle delay), the data bus direction switch delay plus the data setup to REQ delay results in the larger value. If the bus phase is changing from an IN phase to another IN phase, then 400 nsec is the minimum value of Ttaq.

Info Transfer In Phase Transition to Info Transfer Out Phase



Time	Description	Min	Max	Units
Tbsd	Last ACK of phase false to Target change MSG, C/D, and I/O (timing not named)	0	—	nsec
Ttrd	Target assert I/O to Target releases data bus (async system deskew delay)	—	45	nsec
Tidd	Initiator detects I/O to Initiator drives data bus (async system deskew delay)	45	—	nsec
Ttaq	Target changes MSG and/or C/D, and negates I/O to Target asserts REQ (bus settle delay)	400	—	nsec

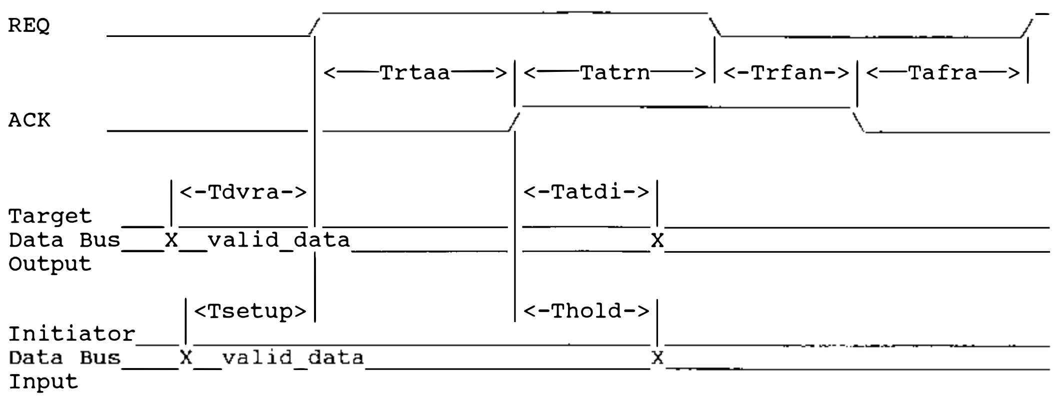
Asynchronous Transfer Out to Target

```
REQ       ________/‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾\____________________________/‾‾
                  |<——Trtaa——>|<————Tatrn————>|<-Trfan->|<—Tafra—>|

ACK       ____________________________/‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾\______________

                       |<-Tdvaa->|               <-Trtdi->|
Initiator_______________________________________________________________________
Data Bus_______________X__valid_data____________________________X_______________
Output
                        |<Tsetup>|               |<-Thold->|
Target  ________________________________________________________________________
Data Bus________________X__valid data___________________________X_______________
Input
```

Time	Description	Min	Max	Units
Trtaa	Target REQ true to Initiator assert ACK (timing not named)	0	—	nsec
Tatrn	Initiator ACK true to Target negate REQ (timing not named)	0	—	nsec
Trfan	Target REQ false to Initiator negate ACK (timing not named)	0	—	nsec
Tafra	Initiator ACK false to Target assert REQ (timing not named)	0	—	nsec
Tdvaa	Initiator data output valid to Initiator assert ACK (async system deskew delay plus cable skew delay)	49	—	nsec
Trtdi	Target negate REQ to Initiator data output invalid (timing not named)	0	—	nsec
Tsetup	Target receives data output valid to Target detects ACK asserted (timing not named)	0	—	nsec
Thold	Target negate REQ to received data invalid (timing not named)	0	—	nsec

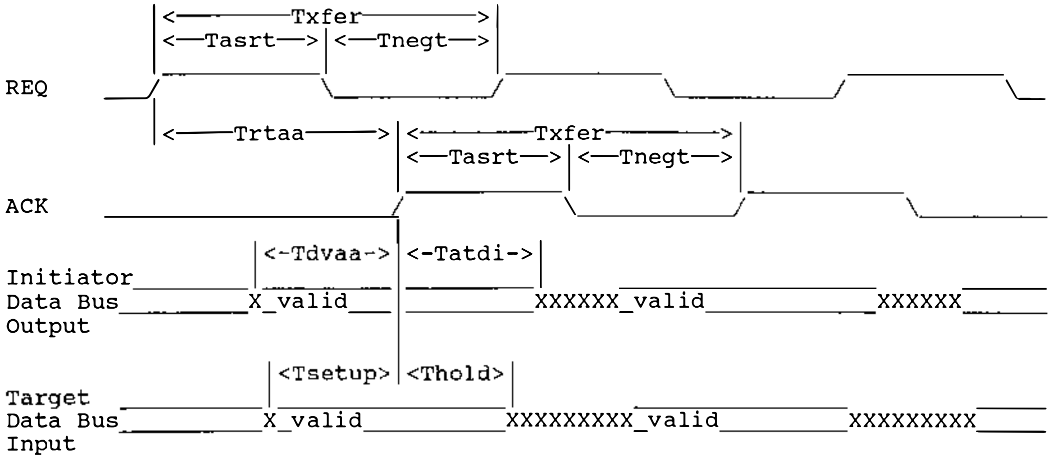
TIMING

Asynchronous Transfer In to Initiator



Time	Description	Min	Max	Units
Trtaa	Target REQ true to Initiator assert ACK (timing not named)	0	—	nsec
Tatrn	Initiator ACK true to Target negate REQ (timing not named)	0	—	nsec
Trfan	Target REQ false to Initiator negate ACK (timing not named)	0	—	nsec
Tafra	Initiator ACK false to Target assert REQ (timing not named)	0	—	nsec
Tdvra	Target drives data output valid to Target asserts REQ (async system deskew delay plus cable skew delay)	49	—	nsec
Tatdi	Initiator assert ACK to Target data output invalid (timing not named)	0	—	nsec
Tsetup	Initiator receives data output valid to Initiator detects REQ asserted (timing not named)	0	—	nsec
Thold	Initiator assert ACK to received data invalid (timing not named)	0	—	nsec

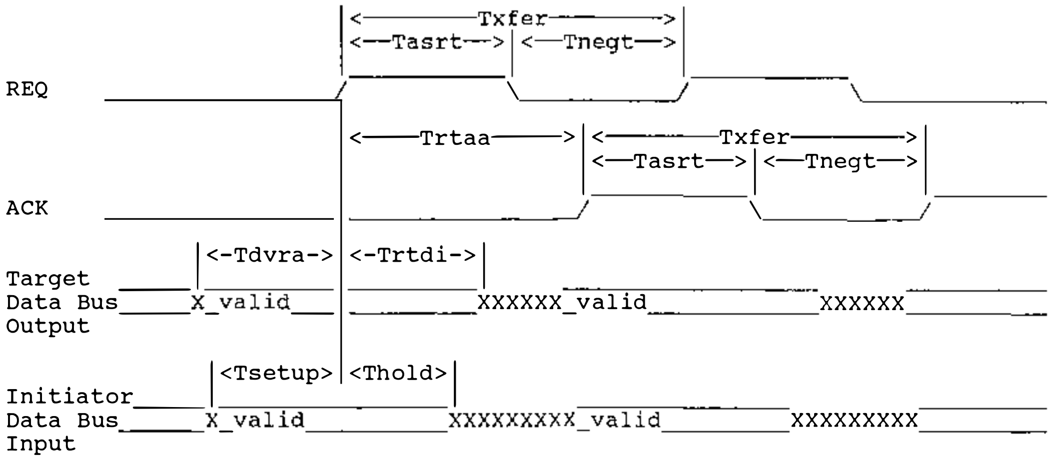
Slow Synchronous Transfer Out to Target



Time	Description	Min	Max	Units
Trtaa	Target REQ true to Initiator assert ACK (timing not named)	0	—	nsec
Tasrt	Target REQ true to Target negate REQ or Initiator ACK true to Initiator negate ACK (slow transmit assertion period)	80	—	nsec
Tnegt	Target REQ false to Target assert REQ or Initiator ACK false to Initiator assert ACK (slow transmit negation period)	80	—	nsec
Txfer	Target REQ true to Target assert REQ or Initiator ACK true to Initiator assert ACK (*1) (slow transfer period)	200	—	nsec
Tdvaa	Initiator data output valid to Initiator assert ACK (slow transmit setup time)	23	—	nsec
Tatdi	Initiator ACK true to data output invalid (slow transmit hold time)	53	—	nsec
Tsetup	Target receives data output valid to Target detects ACK asserted (slow receive setup time)	15	—	nsec
Thold	Target detects ACK true to received data invalid (slow receive hold time)	25	—	nsec

(*1) As set by the Synchronous Data Transfer Request (SDTR) message (see page 92, 93).

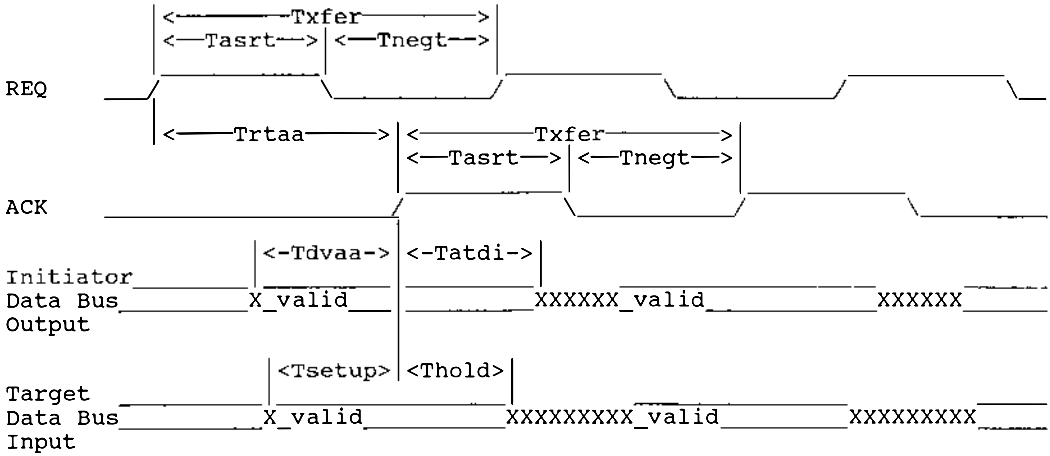
Slow Synchronous Transfer In to Initiator



Time	Description	Min	Max	Units
Trtaa	Target REQ true to Initiator assert ACK (timing not named)	0	—	nsec
Tasrt	Target REQ true to Target negate REQ or Initiator ACK true to Initiator negate ACK (slow transmit assertion period)	80	—	nsec
Tnegt	Target REQ false to Target assert REQ or Initiator ACK false to Initiator assert ACK (slow transmit negation period)	80	—	nsec
Txfer	Target REQ true to Target assert REQ or Initiator ACK true to Initiator assert ACK (*1) (slow transfer period)	200	—	nsec
Tdvra	Target data output valid to Target assert REQ (slow transmit setup time)	23	—	nsec
Trtdi	Target REQ true to data output invalid (slow transmit hold time)	53	—	nsec
Tsetup	Initiator receives data output valid to Initiator detects REQ asserted (slow receive setup time)	15	—	nsec
Thold	Initiator detects REQ true to received data invalid (slow receive hold time)	25	—	nsec

(*1) As set by the Synchronous Data Transfer Request (SDTR) message (see page 92, 93).

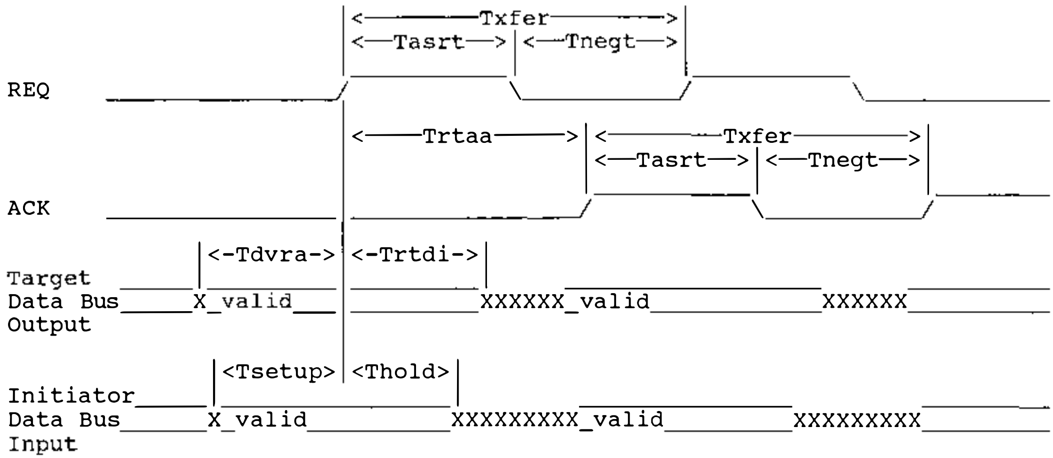
Fast (Fast–10) Synchronous Transfer Out to Target



Time	Description	Min	Max	Units
Trtaa	Target REQ true to Initiator assert ACK (timing not named)	0	—	nsec
Tasrt	Target REQ true to Target negate REQ or Initiator ACK true to Initiator negate ACK (fast transmit assertion period)	30	—	nsec
Tnegt	Target REQ false to Target assert REQ or Initiator ACK false to Initiator assert ACK (fast transmit negation period)	30	—	nsec
Txfer	Target REQ true to Target assert REQ or Initiator ACK true to Initiator assert ACK (*1) (fast transfer period)	100	—	nsec
Tdvaa	Initiator data output valid to Initiator assert ACK (fast transmit setup time)	23	—	nsec
Tatdi	Initiator ACK true to data output invalid (fast transmit hold time)	33	—	nsec
Tsetup	Target receives data output valid to Target detects ACK asserted (fast receive setup time)	15	—	nsec
Thold	Target detects ACK true to received data invalid (fast receive hold time)	25	—	nsec

(*1) As set by the Synchronous Data Transfer Request (SDTR) message (see page 92, 93).

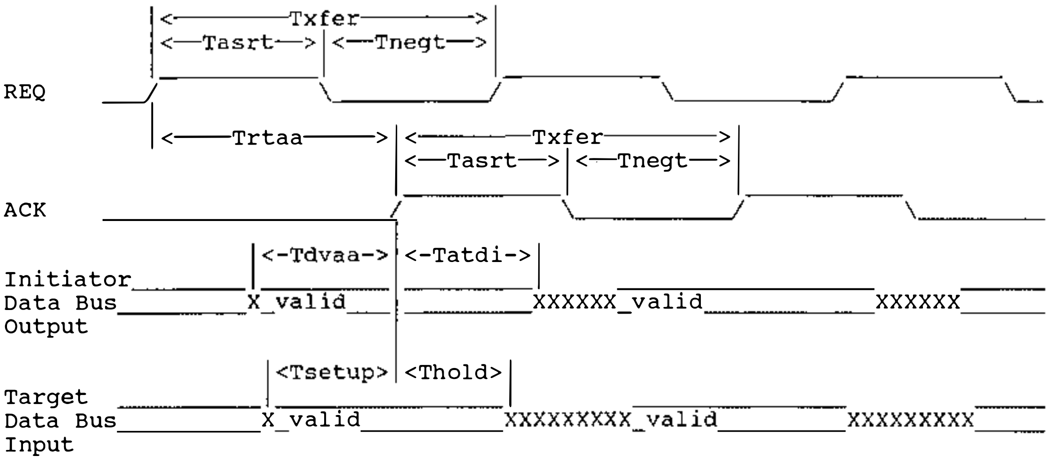
Fast (Fast–10) Synchronous Transfer In to Initiator



Time	Description	Min	Max	Units
Trtaa	Target REQ true to Initiator assert ACK (timing not named)	0	—	nsec
Tasrt	Target REQ true to Target negate REQ or Initiator ACK true to Initiator negate ACK (fast transmit assertion period)	30	—	nsec
Tnegt	Target REQ false to Target assert REQ or Initiator ACK false to Initiator assert ACK (fast transmit negation period)	30	—	nsec
Txfer	Target REQ true to Target assert REQ or Initiator ACK true to Initiator assert ACK (*1) (fast transfer period)	100	—	nsec
Tdvra	Target data output valid to Target assert REQ (fast transmit setup time)	23	—	nsec
Trtdi	Target REQ true to data output invalid (fast transmit hold time)	33	—	nsec
Tsetup	Initiator receives data output valid to Initiator detects REQ asserted (fast receive setup time)	15	—	nsec
Thold	Initiator detects REQ true to received data invalid (fast receive hold time)	25	—	nsec

(*1) As set by the Synchronous Data Transfer Request (SDTR) message (see page 92, 93).

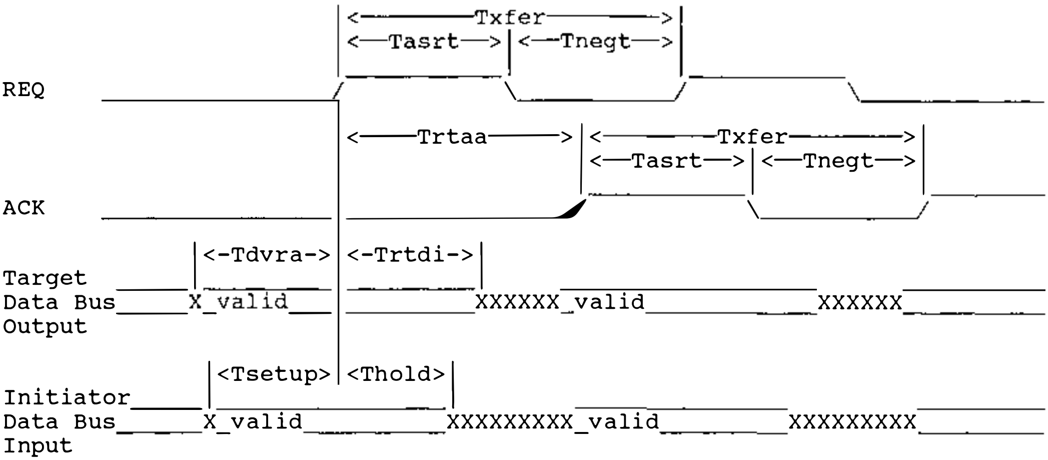
Fast–20 Synchronous Transfer Out to Target



Time	Description	Min	Max	Units
Trtaa	Target REQ true to Initiator assert ACK (timing not named)	0	—	nsec
Tasrt	Target REQ true to Target negate REQ or Initiator ACK true to Initiator negate ACK (fast-20 transmit assertion period)	15	—	nsec
Tnegt	Target REQ false to Target assert REQ or Initiator ACK false to Initiator assert ACK (fast-20 transmit negation period)	15	—	nsec
Txfer	Target REQ true to Target assert REQ or Initiator ACK true to Initiator assert ACK (*1) (fast-20 transfer period)	50	—	nsec
Tdvaa	Initiator data output valid to Initiator assert ACK (fast-20 transmit setup time)	11.5	—	nsec
Tatdi	Initiator ACK true to data output invalid (fast-20 transmit hold time)	16.5	—	nsec
Tsetup	Target receives data output valid to Target detects ACK asserted (fast-20 receive setup time)	6.5	—	nsec
Thold	Target detects ACK true to received data invalid (fast-20 receive hold time)	11.5	—	nsec

(*1) As set by the Synchronous Data Transfer Request (SDTR) message (see page 92, 93).

Fast–20 Synchronous Transfer In to Initiator



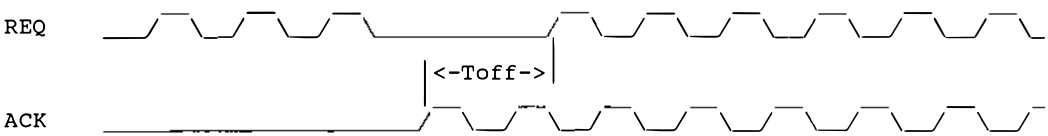
Time	Description	Min	Max	Units
Trtaa	Target REQ true to Initiator assert ACK (timing not named)	0	—	nsec
Tasrt	Target REQ true to Target negate REQ or Initiator ACK true to Initiator negate ACK (fast-20 transmit assertion period)	15	—	nsec
Tnegt	Target REQ false to Target assert REQ or Initiator ACK false to Initiator assert ACK (fast-20 transmit negation period)	15	—	nsec
Txfer	Target REQ true to Target assert REQ or Initiator ACK true to Initiator assert ACK (*1) (fast-20 transfer period)	50	—	nsec
Tdvra	Target data output valid to Target assert REQ (fast-20 transmit setup time)	11.5	—	nsec
Trtdi	Target REQ true to data output invalid (fast-20 transmit hold time)	16.5	—	nsec
Tsetup	Initiator receives data output valid to Initiator detects REQ asserted (fast-20 receive setup time)	6.5	—	nsec
Thold	Initiator detects REQ true to received data invalid (fast-20 receive hold time)	11.5	—	nsec

(*1) As set by the Synchronous Data Transfer Request (SDTR) message (see page 92, 93).

TIMING

Synchronous Offset

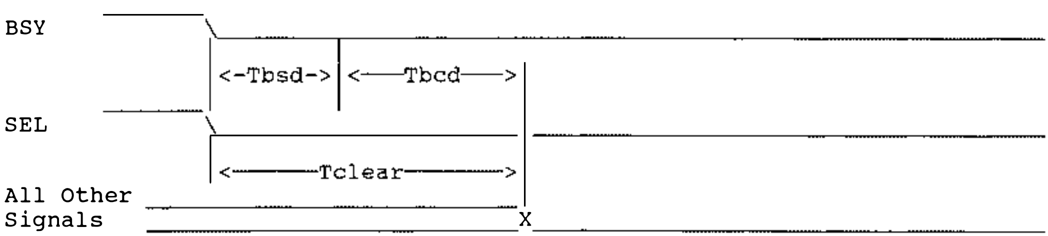
In the following example, REQ/ACK offset = 3



Time	Description	Min	Max	Units
Toff	Initiator ACK true to Target asserts REQ after stall due to reaching offset limit (*1) (timing not named)	0	—	nsec

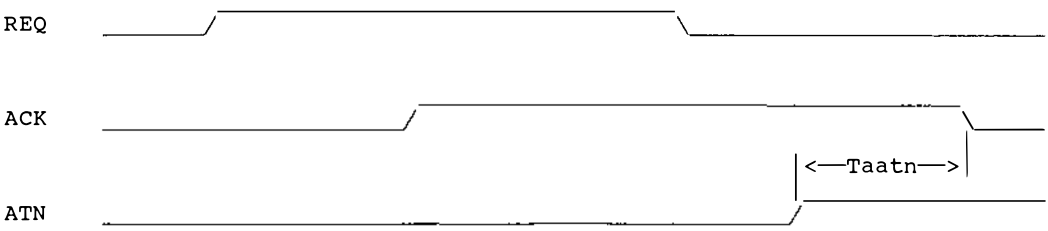
(*1) Offset is set by the Synchronous Data Transfer Request (SDTR) message (see page 92, 93).

Bus Free Phase



Time	Description	Min	Max	Units
Tbsd	BSY and SEL negated by a device (Initiator or Target) to BUS FREE phase valid (bus settle delay)	400	—	nsec
Tbcd	BUS FREE validated to all bus signals released by all devices (bus clear delay)	—	800	nsec
Tclear	BSY and SEL false to all bus signals released by all devices (bus settle delay plus bus clear delay)	—	1200	nsec

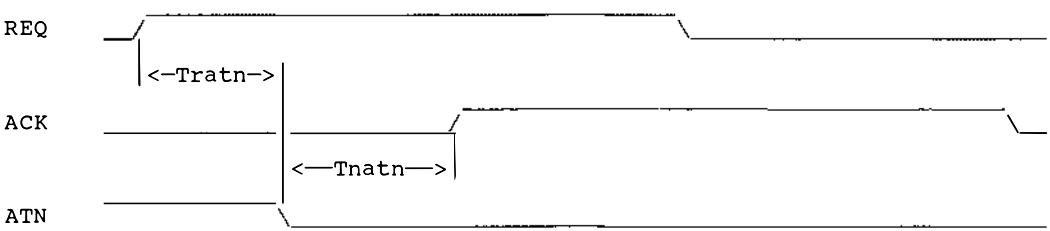
Attention Condition (Asserted by Initiator During Any Phase)



Time	Description	Min	Max	Units
Taatn	Initiator ATN true to Initiator negates ACK (two async system deskew delays) (*2)	90	—	nsec

(*2): ATN may be asserted at ANY time as long as it meets this timing relative to ACK. Also, ATN must meet this timing if it is being asserted in regard to the current byte being transferred.

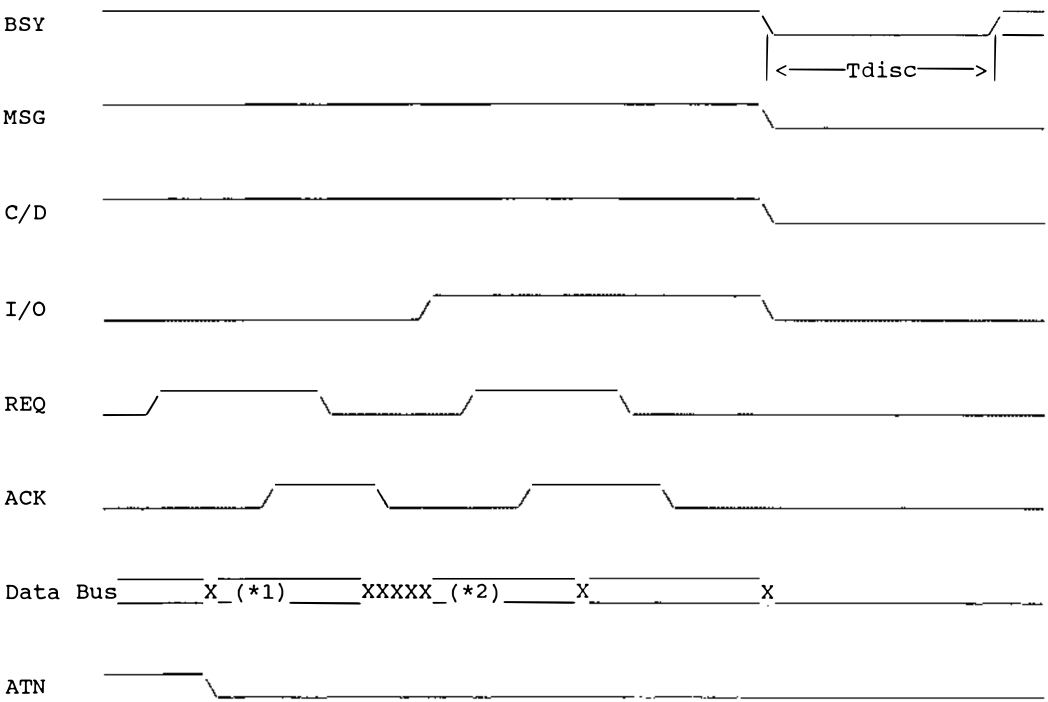
End of Attention (Negated by Initiator During Message Out Phase)



Time	Description	Min	Max	Units
Tratn	Target asserts REQ for Message Out Phase to Initiator negates ATN for last message byte (timing not named)	0	—	nsec
Tnatn	Initiator ATN false to Initiator asserts ACK of last message byte (two async system deskew delays) (*3)	90	—	nsec

(*3): ATN may not be negated when ACK is asserted during a MESSAGE OUT phase.

Initiator Disconnect Message Sequence



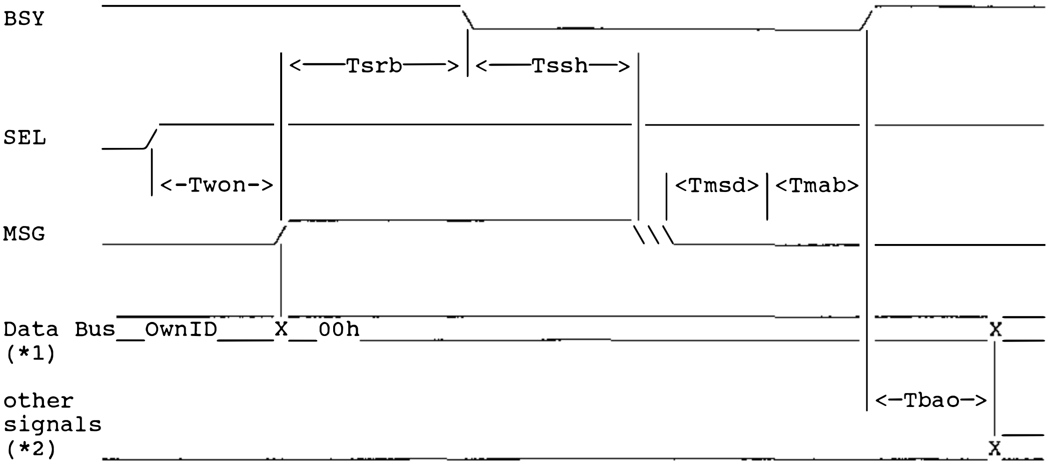
(*1): DISCONNECT MESSAGE OUT (see page 87) from Initiator to Target requesting that the Target Disconnect from the bus.

(*2): DISCONNECT MESSAGE IN from Target to Initiator to inform the Initiator that the Target will Disconnect from the bus.

Time	Description	Min	Max	Units
Tdisc	Target negates BSY to when Target may participate in ARBITRATION phase (*3); following: 1. An Initiator request for a Disconnect via a DISCONNECT MESSAGE OUT, and 2. The Target agrees and sends a DISCONNECT MESSAGE IN (disconnection delay)	200	—	μsec

(*3): If the Disconnect Time Limit in the Disconnect-Reconnect Mode Page is larger, than it overrides the 200 μsec delay. See page 146.

SCSI Configured Auto–Magically(SCAM) Selection Phase (Initiation)

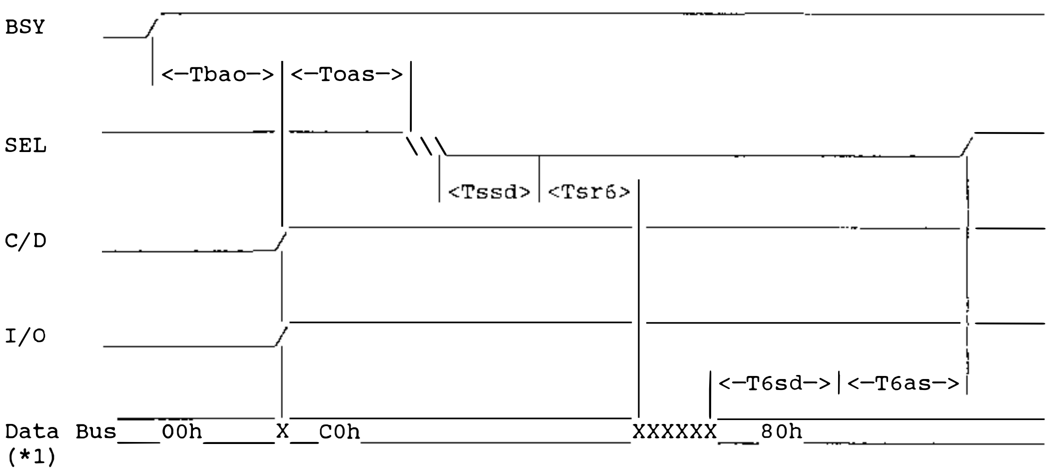


(*1) Data Bus is only DB(7-0). All other data bus signals and parity remain released during SCAM.

(*2) Other signals = C/D, I/O, DB(7), and DB(6). They may be asserted to complete SCAM initiation (see next page). REQ, ACK, and ATN remain released during the SCAM protocol.

Time	Description	Min	Max	Units
Twon	Arbitration winner asserts SEL to winner changing any bus signal (bus clear delay plus bus settle delay)	1200	—	nsec
Tsrb	SCAM Device asserts MSG and releases Data Bus to releasing BSY (two async system deskew delays)	90	—	nsec
Tssh	SCAM Devices remain in SCAM selection phase (SCAM selection response time)	250	—	msec
Tmsd	MSG false to MSG false validated (wire-OR glitch filtering) (bus settle delay)	400	—	nsec
Tmab	MSG false validated to assert BSY (timing not named)	0	—	nsec
Tbao	SCAM Device asserts BSY to SCAM Device asserting other signals (two async system deskew delays)	90	—	nsec

SCSI Configured Auto-Magically(SCAM) End of Initiation

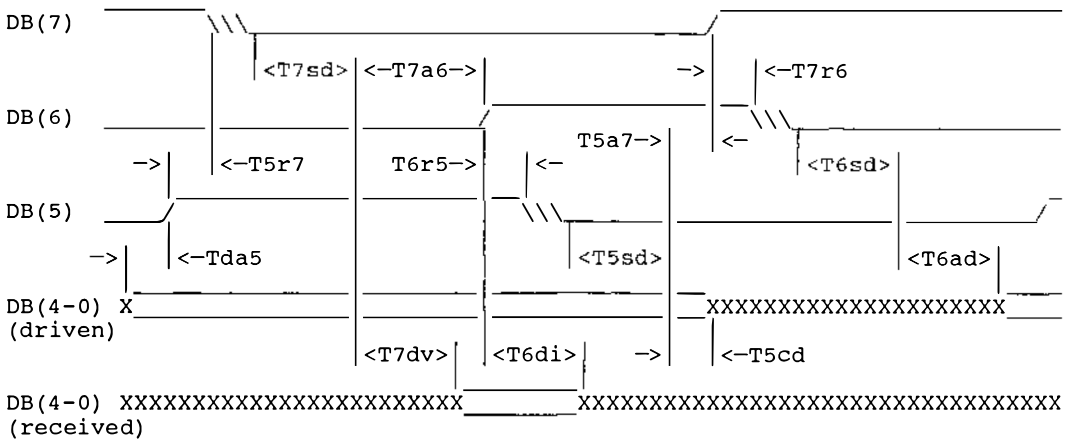


(*1) Data Bus is only DB(7-0). All other data bus signals and parity remain released during SCAM.

(*2) Other signals = C/D, I/O, DB(7), and DB(6). They may be asserted to complete SCAM initiation (see next page). REQ, ACK, and ATN remain released during the SCAM protocol.

Time	Description	Min	Max	Units
Tbao	SCAM Device asserts BSY to SCAM Device asserting C/D, I/O, DB(7), DB(6) (two async system deskew delays)	90	—	nsec
Toas	SCAM Device asserts C/D, I/O, DB(7), DB(6) to releasing SEL (two async system deskew delays)	90	—	nsec
Tssd	SEL false to SEL false validated (wire-OR glitch filtering) (bus settle delay)	400	—	nsec
Tsr6	SEL false validated to release DB(6) (timing not named)	0	—	nsec
T6sd	DB(6) false to DB(6) false validated (wire-OR glitch filtering) (bus settle delay)	400	—	nsec
T6as	DB(6) false validated to assert SEL (timing not named)	0	—	nsec

SCSI Configured Auto-Magically(SCAM) Transfer Cycle



Time	Description	Min	Max	Units
Tda5	Assert valid data on DB(4-0) to assert DB(5)(*)	0	—	nsec
T5r7	Assert DB(5) to release DB(7) (*)	0	—	nsec
T7sd	DB(7) false to DB(7) false validated (wire-OR glitch filtering) (bus settle delay)	400	—	nsec
T7dv	DB(7) false validated to DB(4-0) valid (*)	0	—	nsec
T7a6	DB(7) false validated to assert DB(6) (*)	0	—	nsec
T6di	SCAM Device reads DB(4-0) to assert DB(6) and invalidate data (*)	0	—	nsec
T6r5	Assert DB(6) to release DB(5) (*)	0	—	nsec
T5sd	DB(5) false to DB(5) false validated (wire-OR glitch filtering) (bus settle delay)	400	—	nsec
T5cd	DB(5) false validated to release DB(4-0) (*)	0	—	nsec
T5a7	DB(5) false validated to assert DB(7) (*)	0	—	nsec
T7r6	Assert DB(7) to release DB(6) (*)	0	—	nsec
T6sd	DB(6) false to DB(6) false validated (wire-OR glitch filtering) (bus settle delay)	400	—	nsec
T6ad	DB(6) false validated to assert valid data on DB(4-0), beginning the next cycle (*)	0	—	nsec

(*): This timing parameter is not named.

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Bus State Examples

Example #1: Arbitrate, Select, IDENTIFY

Initiator (Bus ID = 5) selects Target (Bus ID = 2), Logical Unit 1. SCSI Devices with Bus IDs 4 and 0 also Arbitrate and lose.

BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	DB0-7	Bus Phase or Condition
0	0	0	0	0	0	0	0	00	BUS FREE
1	0	0	0	0	0	0	0	31	ARBITRATION
1	1	0	0	0	0	0	0	31	bus winner takes bus
1	1	0	0	0	0	0	0	20	bus losers clear off the bus
1	1	0	0	0	0	0	1	24	asserts ATN and DB with IDs
0	1	0	0	0	0	0	1	24	SELECTION
1	1	0	0	0	0	0	1	24	Target responds to selection
1	0	0	0	0	0	0	1	XX	Initiator responds to Target
1	0	1	1	0	0	0	1	XX	start of phase change
1	0	1	1	0	1	0	1	XX	beginning of MESSAGE OUT phase
1	0	1	1	0	1	0	0	C1	Initiator negates ATN
1	0	1	1	0	1	1	0	C1	Initiator sends IDENTIFY message
1	0	1	1	0	0	1	0	C1	Target takes IDENTIFY message
1	0	1	1	0	0	0	0	XX	end of phase
BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	DB0-7	Bus Phase or Condition

NOTE: Signal states are "generic":

0 = Negated or Released; False
1 = Asserted; True
X = Can be either state

Data Bus (DB0-7) is shown in HEX; Data Bus Parity (DBP) is not shown.

TIMING

TIMING

Example #2: TEST UNIT READY Command

Initiator (Bus ID = 6) issues TEST UNIT READY to Target (Bus ID = 1), Logical Unit 3

BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	DB0-7	Bus Phase or Condition
0	0	0	0	0	0	0	0	00	BUS FREE
1	0	0	0	0	0	0	0	40	ARBITRATION
1	1	0	0	0	0	0	0	40	bus winner takes bus
1	1	0	0	0	0	0	1	42	asserts ATN and DB with IDs
0	1	0	0	0	0	0	1	42	SELECTION
1	1	0	0	0	0	0	1	42	Target responds to selection
1	0	0	0	0	0	0	1	XX	Initiator responds to Target
1	0	1	1	0	0	0	1	XX	start of phase change
1	0	1	1	0	1	0	1	XX	beginning of MESSAGE OUT phase
1	0	1	1	0	1	0	0	C3	Initiator negates ATN
1	0	1	1	0	1	1	0	C3	Initiator sends IDENTIFY message
1	0	1	1	0	0	1	0	C3	Target takes IDENTIFY message
1	0	1	1	0	0	0	0	XX	end of phase
1	0	0	1	0	0	0	0	XX	start of phase change
1	0	0	1	0	1	0	0	XX	beginning of COMMAND phase
1	0	0	1	0	1	1	0	00	Initiator sends COMMAND byte 0
1	0	0	1	0	0	1	0	00	Target takes COMMAND byte
1	0	0	1	0	0	0	0	XX	end of transfer
1	0	0	1	0	1	0	0	XX	byte 1 of COMMAND phase
1	0	0	1	0	1	1	0	00	Initiator sends COMMAND byte 1
1	0	0	1	0	0	1	0	00	Target takes COMMAND byte (*1)
1	0	0	1	0	0	0	0	XX	end of transfer
1	0	0	1	0	1	0	0	XX	byte 2 of COMMAND phase
1	0	0	1	0	1	1	0	00	Initiator sends COMMAND byte 2
1	0	0	1	0	0	1	0	00	Target takes COMMAND byte
1	0	0	1	0	0	0	0	XX	end of transfer
1	0	0	1	0	1	0	0	XX	byte 3 of COMMAND phase
1	0	0	1	0	1	1	0	00	Initiator sends COMMAND byte 3
1	0	0	1	0	0	1	0	00	Target takes COMMAND byte
1	0	0	1	0	0	0	0	XX	end of transfer
BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	DB0-7	Bus Phase or Condition

(*1): IDENTIFY established the Logical Unit Number. It is not necessary to repeat it in the Command Block.

BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	DB0-7	Bus Phase or Condition
1	0	0	1	0	1	0	0	XX	byte 4 of COMMAND phase
1	0	0	1	0	1	1	0	00	Initiator sends COMMAND byte 4
1	0	0	1	0	0	1	0	00	Target takes COMMAND byte
1	0	0	1	0	0	0	0	XX	end of transfer
1	0	0	1	0	1	0	0	XX	byte 5 of COMMAND phase
1	0	0	1	0	1	1	0	00	Initiator sends COMMAND byte 5
1	0	0	1	0	0	1	0	00	Target takes COMMAND byte
1	0	0	1	0	0	0	0	XX	end of transfer
1	0	0	1	1	0	0	0	XX	start of phase change
1	0	0	1	1	0	0	0	00	Target sends STATUS byte
1	0	0	1	1	1	0	0	00	beginning of STATUS phase
1	0	0	1	1	1	1	0	00	Initiator takes STATUS byte
1	0	0	1	1	0	1	0	XX	
1	0	0	1	1	0	0	0	XX	end of transfer
1	0	1	1	1	0	0	0	XX	start of phase change
1	0	1	1	1	0	0	0	00	Target sends COMMAND COMPLETE
1	0	1	1	1	1	0	0	00	beginning of MESSAGE IN phase
1	0	1	1	1	1	1	0	00	Initiator takes MESSAGE IN byte
1	0	1	1	1	0	1	0	XX	
1	0	1	1	1	0	0	0	XX	end of transfer
0	0	0	0	0	0	0	0	00	BUS FREE
BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	DB0-7	Bus Phase or Condition

TIMING

TIMING

Example #3: Synchronous Data Transfer Request (SDTR) Message

Initiator (Bus ID = 0) issues INQUIRY command to Target (Bus ID = 3), Logical Unit 0. Initiator can accept transfers up to an Offset of 12 with 200 nsec Transfer Period. Target can accept transfers up to an Offset of 16 with 250 nsec Transfer Period.

BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	DB0-7	Bus Phase or Condition
0	0	0	0	0	0	0	0	00	BUS FREE
1	0	0	0	0	0	0	0	01	ARBITRATION
1	1	0	0	0	0	0	0	01	bus winner takes bus
1	1	0	0	0	0	0	1	09	asserts ATN and DB with IDs
0	1	0	0	0	0	0	1	09	SELECTION
1	1	0	0	0	0	0	1	09	Target responds to selection
1	0	0	0	0	0	0	1	XX	Initiator responds to Target
1	0	1	1	0	0	0	1	XX	start of phase change
1	0	1	1	0	1	0	1	XX	beginning of MESSAGE OUT phase
1	0	1	1	0	1	1	1	C0	Initiator sends IDENTIFY message
1	0	1	1	0	0	1	1	C0	Target takes IDENTIFY message
1	0	1	1	0	0	0	1	XX	end of transfer
1	0	1	1	0	1	0	1	XX	next byte of MESSAGE OUT phase
1	0	1	1	0	1	1	1	01	Initiator sends EXTENDED MESSAGE
1	0	1	1	0	0	1	1	01	Target takes byte
1	0	1	1	0	0	0	1	XX	end of transfer
1	0	1	1	0	1	0	1	XX	next byte of MESSAGE OUT phase
1	0	1	1	0	1	1	1	03	Initiator sends message length
1	0	1	1	0	0	1	1	03	Target takes byte
1	0	1	1	0	0	0	1	XX	end of transfer
1	0	1	1	0	1	0	1	XX	next byte of MESSAGE OUT phase
1	0	1	1	0	1	1	1	01	Initiator sends SDTR message code
1	0	1	1	0	0	1	1	01	Target takes byte
1	0	1	1	0	0	0	1	XX	end of transfer
1	0	1	1	0	1	0	1	XX	next byte of MESSAGE OUT phase
1	0	1	1	0	1	1	1	32	Initiator sends transfer period
1	0	1	1	0	0	1	1	32	Target takes byte
1	0	1	1	0	0	0	1	XX	end of transfer
BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	DB0-7	Bus Phase or Condition

BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	DB0-7	Bus Phase or Condition
1	0	1	1	0	1	0	1	XX	last byte of MESSAGE OUT phase
1	0	1	1	0	1	0	0	0C	Initiator negates ATN
1	0	1	1	0	1	1	0	0C	Initiator sends REQ/ACK offset
1	0	1	1	0	0	1	0	0C	Target takes byte
1	0	1	1	0	0	0	0	XX	end of transfer
1	0	1	1	1	0	0	0	XX	start of phase change
1	0	1	1	1	0	0	0	01	Target sends EXTENDED MESSAGE
1	0	1	1	1	1	0	0	01	beginning of MESSAGE IN phase
1	0	1	1	1	1	1	0	01	Initiator takes byte
1	0	1	1	1	0	1	0	XX	
1	0	1	1	1	0	0	0	XX	end of transfer
1	0	1	1	1	0	0	0	03	Target sends message length
1	0	1	1	1	1	0	0	03	next byte of MESSAGE IN phase
1	0	1	1	1	1	1	0	03	Initiator takes byte
1	0	1	1	1	0	1	0	XX	
1	0	1	1	1	0	0	0	XX	end of transfer
1	0	1	1	1	0	0	0	01	Target sends SDTR message code
1	0	1	1	1	1	0	0	01	next byte of MESSAGE IN phase
1	0	1	1	1	1	1	0	01	Initiator takes byte
1	0	1	1	1	0	1	0	XX	
1	0	1	1	1	0	0	0	XX	end of transfer
1	0	1	1	1	0	0	0	3F	Target sends transfer period
1	0	1	1	1	1	0	0	3F	next byte of MESSAGE IN phase
1	0	1	1	1	1	1	0	3F	Initiator takes byte
1	0	1	1	1	0	1	0	XX	
1	0	1	1	1	0	0	0	XX	end of transfer
1	0	1	1	1	0	0	0	0C	Target sends REQ/ACK offset
1	0	1	1	1	1	0	0	0C	(agreement with Initiator)
1	0	1	1	1	1	1	0	0C	Initiator takes byte
1	0	1	1	1	0	1	0	XX	
1	0	1	1	1	0	0	0	XX	end of transfer
1	0	0	1	0	0	0	0	XX	start of phase change
1	0	0	1	0	1	0	0	XX	beginning of COMMAND phase
1	0	0	1	0	1	1	0	12	Initiator sends byte 0
1	0	0	1	0	0	1	0	12	Target takes byte
1	0	0	1	0	0	0	0	XX	end of transfer

and so on...

BSY SEL MSG C/D I/O REQ ACK ATN DB0-7 Bus Phase or Condition

WARNING: Synchronous negotiation may occur at any time! Another typical time when negotiation could happen would be prior to a DATA IN or DATA OUT phase.

EXAMPLE #4: Reselect / Synchronous Data Transfer

Target (Bus ID = 0), Logical Unit 1, reconnect to Initiator (Bus ID = 3). A 256 byte DATA OUT transfer then begins from the Initiator to the Target with a REQ/ACK Offset of 4. The connection is completed with a SAVE DATA POINTER and DISCONNECT MESSAGE IN.

BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	DB0-7	Bus Phase or Condition
0	0	0	0	0	0	0	0	00	BUS FREE
1	0	0	0	0	0	0	0	01	ARBITRATION
1	1	0	0	0	0	0	0	01	bus winner takes bus
1	1	0	0	0	0	0	0	09	asserts DB with IDs
0	1	0	0	1	0	0	0	09	RESELECTION
1	1	0	0	1	0	0	0	09	Initiator responds to RESELECTION
1	0	0	0	1	0	0	0	XX	Target responds to Initiator (*1)
1	0	1	1	1	0	0	0	XX	start of phase change
1	0	1	1	1	0	0	0	81	Target sends IDENTIFY message
1	0	1	1	1	1	0	0	81	beginning of MESSAGE IN phase
1	0	1	1	1	1	1	0	81	Initiator takes IDENTIFY message
1	0	1	1	1	0	1	0	XX	
1	0	1	1	1	0	0	0	XX	end of transfer
1	0	0	0	0	0	0	0	XX	start of phase change
1	0	0	0	0	1	0	0	XX	first REQ of DATA OUT phase
1	0	0	0	0	0	0	0	XX	negate REQ pulse
1	0	0	0	0	1	0	0	XX	next REQ
1	0	0	0	0	0	0	0	XX	negate REQ pulse
1	0	0	0	0	1	0	0	XX	next REQ
1	0	0	0	0	0	0	0	XX	negate REQ pulse
1	0	0	0	0	1	0	0	XX	next REQ: Target stalls due to
1	0	0	0	0	0	0	0	XX	REQ/ACK Offset; negate REQ pulse
1	0	0	0	0	0	0	0	01	Initiator: 1st data byte on bus
1	0	0	0	0	0	1	0	01	Initiator asserts 1st ACK pulse
1	0	0	0	0	1	1	0	01	Target asserts next REQ pulse(*2)
1	0	0	0	0	1	0	0	01	Initiator negates ACK pulse
1	0	0	0	0	0	0	0	02	next data byte on bus
BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	DB0-7	Bus Phase or Condition

(*1): The Initiator then negates BSY; the Target is still asserting BSY.

(*2): The Target can assert REQ anytime after the leading edge of the ACK. This example shows the fastest timing.

TIMING

BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	DB0-7	Bus Phase or Condition
1	0	0	0	0	0	1	0	02	Initiator asserts next ACK pulse
1	0	0	0	0	1	1	0	02	Target asserts next REQ pulse
1	0	0	0	0	1	0	0	02	Initiator negates ACK pulse
1	0	0	0	0	0	0	0	03	next data byte on bus
1	0	0	0	0	0	1	0	03	Initiator asserts next ACK pulse
1	0	0	0	0	1	1	0	03	Target asserts next REQ pulse
1	0	0	0	0	1	0	0	03	Initiator negates ACK pulse
1	0	0	0	0	0	0	0	04	next data byte on bus
and so on.... until end of transfer....									
1	0	0	0	0	0	0	0	FB	next data byte on bus
1	0	0	0	0	0	1	0	FB	Initiator asserts next ACK pulse
1	0	0	0	0	1	1	0	FB	Target asserts LAST REQ pulse
1	0	0	0	0	1	0	0	FB	Initiator negates ACK pulse
1	0	0	0	0	0	0	0	FC	next data byte on bus
1	0	0	0	0	0	1	0	FC	Initiator asserts next ACK pulse
1	0	0	0	0	0	0	0	FC	Initiator negates ACK pulse
1	0	0	0	0	0	0	0	FD	next data byte on bus
1	0	0	0	0	0	1	0	FD	Initiator asserts next ACK pulse
1	0	0	0	0	0	0	0	FD	Initiator negates ACK pulse
1	0	0	0	0	0	0	0	FE	next data byte on bus
1	0	0	0	0	0	1	0	FE	Initiator asserts next ACK pulse
1	0	0	0	0	0	0	0	FE	Initiator negates ACK pulse
1	0	0	0	0	0	0	0	FF	next data byte on bus
1	0	0	0	0	0	1	0	FF	Initiator asserts next ACK pulse
1	0	0	0	0	0	0	0	FF	Initiator negates ACK pulse
1	0	0	0	0	0	0	0	XX	end of transfer
1	0	1	1	1	0	0	0	XX	start of phase change
1	0	1	1	1	0	0	0	02	Target sends SAVE DATA POINTER
1	0	1	1	1	1	0	0	02	beginning of MESSAGE IN phase
1	0	1	1	1	1	1	0	02	Initiator takes MESSAGE IN byte
1	0	1	1	1	0	1	0	XX	
1	0	1	1	1	0	0	0	04	Target sends DISCONNECT message
1	0	1	1	1	1	0	0	04	next byte of MESSAGE IN phase
1	0	1	1	1	1	1	0	04	Initiator takes MESSAGE IN byte
1	0	1	1	1	0	1	0	XX	
1	0	1	1	1	0	0	0	XX	end of transfer
0	0	0	0	0	0	0	0	00	BUS FREE
BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	DB0-7	Bus Phase or Condition

TIMING

EXAMPLE #5: MESSAGE OUT Phase Parity Error Recovery

Initiator is sending Synchronous Data Transfer Request to Target when the Target detects a parity error during the transfer.

BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	DB0-7	Bus Phase or Condition
1	0	0	0	0	0	0	1	XX	Initiator has ATN asserted
1	0	1	1	0	0	0	1	XX	start of phase change
1	0	1	1	0	1	0	1	XX	beginning of MESSAGE OUT phase
1	0	1	1	0	1	1	1	01	Initiator sends EXTENDED MESSAGE
1	0	1	1	0	0	1	1	01	Target takes byte
1	0	1	1	0	0	0	1	XX	end of transfer
1	0	1	1	0	1	0	1	XX	next byte of MESSAGE OUT phase
1	0	1	1	0	1	1	1	03	Initiator sends message length
1	0	1	1	0	0	1	1	03	Target takes byte *PARITY ERROR!*
1	0	1	1	0	0	0	1	XX	end of transfer
1	0	1	1	0	1	0	1	XX	next byte of MESSAGE OUT phase
1	0	1	1	0	1	1	1	01	Initiator sends SDTR message code
1	0	1	1	0	0	1	1	01	Target takes byte and ignores it
1	0	1	1	0	0	0	1	XX	end of transfer
1	0	1	1	0	1	0	1	XX	next byte of MESSAGE OUT phase
1	0	1	1	0	1	1	1	64	Initiator sends transfer period
1	0	1	1	0	0	1	1	64	Target takes byte and ignores it
1	0	1	1	0	0	0	1	XX	end of transfer

BSY SEL MSG C/D I/O REQ ACK ATN DB0-7 Bus Phase or Condition

BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	DB0-7	Bus Phase or Condition
1	0	1	1	0	1	0	1	XX	last byte of MESSAGE OUT phase
1	0	1	1	0	1	0	0	0C	Initiator negates ATN
1	0	1	1	0	1	1	0	0C	Initiator sends REQ/ACK offset
1	0	1	1	0	0	1	0	0C	Target takes byte and ignores it
1	0	1	1	0	0	0	0	XX	end of transfer
1	0	1	1	0	1	0	0	XX	beginning of MESSAGE OUT retry
1	0	1	1	0	1	0	1	XX	Initiator responds with ATN
1	0	1	1	0	1	1	1	01	Initiator sends EXTENDED MESSAGE
1	0	1	1	0	0	1	1	01	Target takes byte
1	0	1	1	0	0	0	1	XX	end of transfer
1	0	1	1	0	1	0	1	XX	next byte of MESSAGE OUT phase
1	0	1	1	0	1	1	1	03	Initiator sends message length
1	0	1	1	0	0	1	1	03	Target takes byte *PARITY OKAY!*
1	0	1	1	0	0	0	1	XX	end of transfer
1	0	1	1	0	1	0	1	XX	next byte of MESSAGE OUT phase
1	0	1	1	0	1	1	1	01	Initiator sends SDTR message code
1	0	1	1	0	0	1	1	01	Target takes byte
1	0	1	1	0	0	0	1	XX	end of transfer
1	0	1	1	0	1	0	1	XX	next byte of MESSAGE OUT phase
1	0	1	1	0	1	1	1	64	Initiator sends transfer period
1	0	1	1	0	0	1	1	64	Target takes byte
1	0	1	1	0	0	0	1	XX	end of transfer
1	0	1	1	0	1	0	1	XX	last byte of MESSAGE OUT phase
1	0	1	1	0	1	0	0	0C	Initiator negates ATN
1	0	1	1	0	1	1	0	0C	Initiator sends REQ/ACK offset
1	0	1	1	0	0	1	0	0C	Target takes byte and accepts it
1	0	1	1	0	0	0	0	XX	end of transfer
1	0	1	1	1	0	0	0	XX	start of phase change

and so on....

BSY SEL MSG C/D I/O REQ ACK ATN DB0-7 Bus Phase or Condition

TIMING

EXAMPLE #6: MESSAGE IN Phase Parity Error Recovery

Initiator is receiving Synchronous Data Transfer Request from Target when the Initiator detects a parity error during the transfer.

BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	DB0-7	Bus Phase or Condition
1	0	1	1	1	0	0	0	XX	start of phase change
1	0	1	1	1	0	0	0	01	Target sends EXTENDED MESSAGE
1	0	1	1	1	1	0	0	01	beginning of MESSAGE IN phase
1	0	1	1	1	1	1	0	01	Initiator takes byte
1	0	1	1	1	0	1	0	XX	
1	0	1	1	1	0	0	0	XX	end of transfer
1	0	1	1	1	0	0	0	03	Target sends message length
1	0	1	1	1	1	0	0	03	next byte of MESSAGE IN phase
1	0	1	1	1	1	1	0	03	Initiator takes byte
1	0	1	1	1	0	1	0	XX	*PARITY ERROR!*
1	0	1	1	1	0	1	1	XX	Initiator asserts ATN before
1	0	1	1	1	0	0	1	XX	negating ACK; end of transfer
1	0	1	1	1	0	0	1	01	Target sends SDTR message code
1	0	1	1	1	1	0	1	01	next byte of MESSAGE IN phase
1	0	1	1	1	1	1	1	01	Initiator takes byte, ignores it
1	0	1	1	1	0	1	1	XX	
1	0	1	1	1	0	0	1	XX	end of transfer
1	0	1	1	1	0	0	1	3F	Target sends transfer period
1	0	1	1	1	1	0	1	3F	next byte of MESSAGE IN phase
1	0	1	1	1	1	1	1	3F	Initiator takes byte, ignores it
1	0	1	1	1	0	1	1	XX	
1	0	1	1	1	0	0	1	XX	end of transfer
1	0	1	1	1	0	0	1	0C	Target sends REQ/ACK offset
1	0	1	1	1	1	0	1	0C	next byte of MESSAGE IN phase
1	0	1	1	1	1	1	1	0C	Initiator takes byte, ignores it
1	0	1	1	1	0	1	1	XX	
1	0	1	1	1	0	0	1	XX	end of transfer
1	0	1	1	0	0	0	1	XX	start of phase change
1	0	1	1	0	1	0	1	XX	beginning of MESSAGE OUT phase
1	0	1	1	0	1	0	0	09	Initiator negates ATN
1	0	1	1	0	1	1	0	09	Initiator sends MESSAGE PARITY ERROR message
1	0	1	1	0	0	1	0	09	Target takes message
1	0	1	1	0	0	0	0	XX	end of phase
BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	DB0-7	Bus Phase or Condition

TIMING

BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	DB0-7	Bus Phase or Condition
1	0	1	1	1	0	0	0	XX	start of phase change for retry
1	0	1	1	1	0	0	0	01	Target sends EXTENDED MESSAGE
1	0	1	1	1	1	0	0	01	beginning of MESSAGE IN phase
1	0	1	1	1	1	1	0	01	Initiator takes byte
1	0	1	1	1	0	1	0	XX	
1	0	1	1	1	0	0	0	XX	end of transfer
1	0	1	1	1	0	0	0	03	Target sends message length
1	0	1	1	1	1	0	0	03	next byte of MESSAGE IN phase
1	0	1	1	1	1	1	0	03	Initiator takes byte
1	0	1	1	1	0	1	0	XX	*PARITY OKAY!*
1	0	1	1	1	0	0	0	XX	end of transfer
1	0	1	1	1	0	0	0	01	Target sends SDTR message code
1	0	1	1	1	1	0	0	01	next byte of MESSAGE IN phase
1	0	1	1	1	1	1	0	01	Initiator takes byte
1	0	1	1	1	0	1	0	XX	
1	0	1	1	1	0	0	0	XX	end of transfer
1	0	1	1	1	0	0	0	3F	Target sends transfer period
1	0	1	1	1	1	0	0	3F	next byte of MESSAGE IN phase
1	0	1	1	1	1	1	0	3F	Initiator takes byte
1	0	1	1	1	0	1	0	XX	
1	0	1	1	1	0	0	0	XX	end of transfer
1	0	1	1	1	0	0	0	0C	Target sends REQ/ACK offset
1	0	1	1	1	1	0	0	0C	next byte of MESSAGE IN phase
1	0	1	1	1	1	1	0	0C	Initiator takes byte
1	0	1	1	1	0	1	0	XX	
1	0	1	1	1	0	0	0	XX	end of transfer
1	0	0	1	0	0	0	0	XX	start of phase change
1	0	0	1	0	1	0	0	XX	beginning of COMMAND phase
1	0	0	1	0	1	1	0	12	Initiator sends Command byte 0
1	0	0	1	0	0	1	0	12	Target takes byte
1	0	0	1	0	0	0	0	XX	end of transfer

and so on...

BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	DB0-7	Bus Phase or Condition

TIMING

EXAMPLE #7: Reselect / Wide (Primary Bus) Synchronous Data Transfer

Target (Bus ID = 1), Logical Unit 0, reconnect to Initiator (Bus ID = 3). A 512 byte (256 word) DATA IN transfer then begins from the Target to the Initiator with a REQ/ACK Offset of 3. The connection is completed with a SAVE DATA POINTER and DISCONNECT MESSAGE IN.

BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	DB0-15	Bus Phase or Condition
0	0	0	0	0	0	0	0	0000	BUS FREE
1	0	0	0	0	0	0	0	0002	ARBITRATION
1	1	0	0	0	0	0	0	0002	bus winner takes bus
1	1	0	0	0	0	0	0	000A	asserts DB with IDs
0	1	0	0	1	0	0	0	0002	RESELECTION
1	1	0	0	1	0	0	0	0002	Initiator responds to RESELECTION
1	0	0	0	1	0	0	0	XXXX	Target responds to Initiator (*1)
1	0	1	1	1	0	0	0	XXXX	start of phase change
1	0	1	1	1	0	0	0	0080	Target sends IDENTIFY message
1	0	1	1	1	1	0	0	0080	beginning of MESSAGE IN phase
1	0	1	1	1	1	1	0	0080	Initiator takes IDENTIFY message
1	0	1	1	1	0	1	0	XXXX	
1	0	1	1	1	0	0	0	XXXX	end of transfer
1	0	0	0	1	0	0	0	XXXX	start of phase change
1	0	0	0	1	0	0	0	0100	Target puts 1st data word on bus
1	0	0	0	1	1	0	0	0100	first REQ of DATA IN phase
1	0	0	0	1	0	0	0	0100	negate REQ pulse
1	0	0	0	1	0	0	0	0302	next data word on bus
1	0	0	0	1	1	0	0	0302	next REQ
1	0	0	0	1	0	0	0	0302	negate REQ pulse
1	0	0	0	1	0	0	0	0504	next data word on bus
1	0	0	0	1	1	0	0	0504	next REQ: Target stalls due to
1	0	0	0	1	0	0	0	0504	REQ/ACK Offset; negate REQ pulse
1	0	0	0	1	0	1	0	XXXX	Initiator asserts 1st ACK pulse
1	0	0	0	1	0	1	0	0706	next data word on bus
1	0	0	0	1	1	1	0	0706	Target asserts next REQ pulse(*2)
1	0	0	0	1	1	0	0	0706	Initiator negates ACK pulse
BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	DB0-7	Bus Phase or Condition

(*1): The Initiator then negates BSY; the Target is still asserting BSY.

(*2): The Target can assert REQ anytime after the leading edge of the ACK. This example shows the fastest timing.

TIMING

BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	DB0-7	Bus Phase or Condition
1	0	0	0	1	0	1	0	XXXX	Initiator asserts next ACK pulse
1	0	0	0	1	0	1	0	0908	next data word on bus
1	0	0	0	1	1	1	0	0908	Target asserts next REQ pulse
1	0	0	0	1	1	0	0	0908	Initiator negates ACK pulse
1	0	0	0	1	0	1	0	XXXX	Initiator asserts next ACK pulse
1	0	0	0	1	0	1	0	0B0A	next data word on bus
1	0	0	0	1	1	1	0	0B0A	Target asserts next REQ pulse
1	0	0	0	1	1	0	0	0B0A	Initiator negates ACK pulse

and so on.... until end of transfer....

1	0	0	0	1	0	1	0	XXXX	Initiator asserts next ACK pulse
1	0	0	0	1	0	1	0	FDFC	next data word on bus
1	0	0	0	1	1	1	0	FDFC	Target asserts next REQ pulse
1	0	0	0	1	1	0	0	FDFC	Initiator negates ACK pulse
1	0	0	0	1	0	1	0	XXXX	Initiator asserts next ACK pulse
1	0	0	0	1	0	1	0	FFFE	next data word on bus
1	0	0	0	1	1	1	0	FFFE	Target asserts LAST REQ pulse
1	0	0	0	1	1	0	0	FFFE	Initiator negates ACK pulse
1	0	0	0	1	0	1	0	XXXX	Initiator asserts next ACK pulse
1	0	0	0	1	0	0	0	XXXX	Initiator negates ACK pulse
1	0	0	0	1	0	1	0	XXXX	Initiator asserts next ACK pulse
1	0	0	0	1	0	0	0	XXXX	Initiator negates ACK pulse
1	0	0	0	1	0	1	0	XXXX	Initiator asserts next ACK pulse
1	0	0	0	1	0	0	0	XXXX	Initiator negates ACK pulse
1	0	0	0	1	0	0	0	XXXX	end of transfer
1	0	1	1	1	0	0	0	XXXX	start of phase change
1	0	1	1	1	0	0	0	0002	Target sends SAVE DATA POINTER
1	0	1	1	1	1	0	0	0002	beginning of MESSAGE IN phase
1	0	1	1	1	1	1	0	0002	Initiator takes MESSAGE IN byte
1	0	1	1	1	0	1	0	XXXX	
1	0	1	1	1	0	0	0	0004	Target sends DISCONNECT message
1	0	1	1	1	1	0	0	0004	next byte of MESSAGE IN phase
1	0	1	1	1	1	1	0	0004	Initiator takes MESSAGE IN byte
1	0	1	1	1	0	1	0	XXXX	
1	0	1	1	1	0	0	0	XXXX	end of transfer
0	0	0	0	0	0	0	0	0000	BUS FREE
BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	DB0-7	Bus Phase or Condition

Example #8: Arbitrate, Select, IDENTIFY, SIMPLE (QUEUE TAG) Message

Initiator (Bus ID = 7) selects Target (Bus ID = 3), Logical Unit 0, Queue Tag 9. SCSI Devices with Bus IDs 4 and 0 also Arbitrate and lose.

BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	DB0-7	Bus Phase or Condition
0	0	0	0	0	0	0	0	00	BUS FREE
1	0	0	0	0	0	0	0	91	ARBITRATION
1	1	0	0	0	0	0	0	91	bus winner takes bus
1	1	0	0	0	0	0	0	80	bus losers clear off the bus
1	1	0	0	0	0	0	1	88	asserts ATN and DB with IDs
0	1	0	0	0	0	0	1	88	SELECTION
1	1	0	0	0	0	0	1	88	Target responds to selection
1	0	0	0	0	0	0	1	XX	Initiator responds to Target
1	0	1	1	0	0	0	1	XX	start of phase change
1	0	1	1	0	1	0	1	XX	beginning of MESSAGE OUT phase
1	0	1	1	0	1	0	1	C0	Initiator puts byte on bus
1	0	1	1	0	1	1	1	C0	Initiator sends IDENTIFY message
1	0	1	1	0	0	1	1	C0	Target takes IDENTIFY message
1	0	1	1	0	0	0	1	XX	end of phase
1	0	1	1	0	1	0	1	XX	Target requests next byte
1	0	1	1	0	1	1	1	20	Initiator sends SIMPLE (QUEUE TAG
1	0	1	1	0	0	1	1	20	Target takes the TAG message
1	0	1	1	0	0	0	1	XX	end of phase
1	0	1	1	0	1	0	1	XX	Target requests next byte
1	0	1	1	0	1	0	0	09	Initiator negates ATN
1	0	1	1	0	1	1	0	09	Initiator sends the Queue Tag
1	0	1	1	0	0	1	0	09	Target takes the Tag
1	0	1	1	0	0	0	0	XX	end of phase
BSY	SEL	MSG	C/D	I/O	REQ	ACK	ATN	DB0-7	Bus Phase or Condition

TIMING

EXAMPLE #9: Initiate SCAM Protocol, Isolate, and Assign Bus ID

The SCAM protocol is initiated, a SCAM Target is isolated, and the SCAM Initiator assigns bus ID #1 to the isolated SCAM Target. Note that the signal list in this example is different from the other examples. The REQ, ACK, ATN, and DB(31-8, Px) signals are not used by SCAM and are released during the protocol.

BSY	SEL	MSG	C/D	I/O	DB7	DB6	DB5	DB4-0	Bus Phase or Condition
0	0	0	0	0	0	0	0	00000	BUS FREE
1	0	0	0	0	0	0	0	00000	ARBITRATION (no IDs asserted!)
1	1	0	0	0	0	0	0	00000	bus winner takes bus
0	1	1	0	0	0	0	0	00000	SCAM SELECTION
0	1	0	0	0	0	0	0	00000	all devices have released MSG
1	1	0	0	0	0	0	0	00000	all devices assert BSY
1	1	0	0	1	1	1	0	00000	SCAM Target responds
1	1	0	1	1	1	1	0	00000	then SCAM Initiator responds
1	0	0	1	1	1	1	0	00000	all devices release SEL
1	0	0	1	1	1	0	0	00000	then all devices release DB6
1	1	0	1	1	1	0	0	00000	SCAM Initiation complete
1	1	0	1	1	1	0	0	11111	Initiator asserts sync function
1	1	0	1	1	1	0	1	11111	all devices assert DB5
1	1	0	1	1	0	0	1	11111	all devices release DB7
1	1	0	1	1	0	1	1	11111	all devices read DB4-0; assert DB
1	1	0	1	1	0	1	0	11111	all devices release DB5
1	1	0	1	1	1	1	0	XXXXX	all devices assert DB7
1	1	0	1	1	1	0	0	XXXXX	all devices release DB6
1	1	0	1	1	1	0	0	00000	Initiator asserts isolate fcn.
1	1	0	1	1	1	0	1	00000	all devices assert DB5
1	1	0	1	1	0	0	1	00000	all devices release DB7
1	1	0	1	1	0	1	1	00000	all devices read DB4-0; assert DB
1	1	0	1	1	0	1	0	00000	all devices release DB5
1	1	0	1	1	1	1	0	XXXXX	all devices assert DB7
1	1	0	1	1	1	0	0	XXXXX	all devices release DB6
BSY	SEL	MSG	C/D	I/O	DB7	DB6	DB5	DB4-0	Bus Phase or Condition

more....

TIMING

BSY	SEL	MSG	C/D	I/O	DB7	DB6	DB5	DB4-0	Bus Phase or Condition
1	1	0	1	1	1	0	0	00010	Target asserts Priority Code msb
1	1	0	1	1	1	0	1	00010	all devices assert DB5
1	1	0	1	1	0	0	1	00010	all devices release DB7
1	1	0	1	1	0	1	1	00010	all devices read DB4-0; assert DB
1	1	0	1	1	0	1	0	00010	all devices release DB5
1	1	0	1	1	1	1	0	XXXXX	all devices assert DB7
1	1	0	1	1	1	0	0	XXXXX	all devices release DB6
1	1	0	1	1	1	0	0	00001	Target asserts Priority Code lsb
1	1	0	1	1	1	0	1	00001	all devices assert DB5
1	1	0	1	1	0	0	1	00001	all devices release DB7
1	1	0	1	1	0	1	1	00001	all devices read DB4-0; assert DB
1	1	0	1	1	0	1	0	00001	all devices release DB5
1	1	0	1	1	1	1	0	XXXXX	all devices assert DB7
1	1	0	1	1	1	0	0	XXXXX	all devices release DB6
and so on... until one SCAM Target is left...									
1	1	0	1	1	1	0	0	10000	Initiator asserts Terminate (*1)
1	1	0	1	1	1	0	1	10000	all devices assert DB5
1	1	0	1	1	0	0	1	10000	all devices release DB7
1	1	0	1	1	0	1	1	10000	all devices read DB4-0; assert DB
1	1	0	1	1	0	1	0	10000	all devices release DB5
1	1	0	1	1	1	1	0	XXXXX	all devices assert DB7
1	1	0	1	1	1	0	0	XXXXX	all devices release DB6
1	1	0	1	1	1	0	0	11000	Initiator asserts Assign action
1	1	0	1	1	1	0	1	11000	all devices assert DB5
1	1	0	1	1	0	0	1	11000	all devices release DB7
1	1	0	1	1	0	1	1	11000	all devices read DB4-0; assert DB
1	1	0	1	1	0	1	0	11000	all devices release DB5
1	1	0	1	1	1	1	0	XXXXX	all devices assert DB7
1	1	0	1	1	1	0	0	XXXXX	all devices release DB6
1	1	0	1	1	1	0	0	10001	Initiator asserts ID code
1	1	0	1	1	1	0	1	10001	all devices assert DB5
1	1	0	1	1	0	0	1	10001	all devices release DB7
1	1	0	1	1	0	1	1	10001	all devices read DB4-0; assert DB
1	1	0	1	1	0	1	0	10001	all devices release DB5
1	1	0	1	1	1	1	0	XXXXX	all devices assert DB7
1	1	0	1	1	1	0	0	XXXXX	all devices release DB6
BSY	SEL	MSG	C/D	I/O	DB7	DB6	DB5	DB4-0	Bus Phase or Condition

(*1): Actually, the SCAM Initiator does not have to transfer the Terminate code if only one SCAM Target remains (as indicated by the 00000 pattern on the previous transfer cycle). If more than one SCAM Target remains, then the Terminate code must be asserted before an Action may be asserted.

even more....

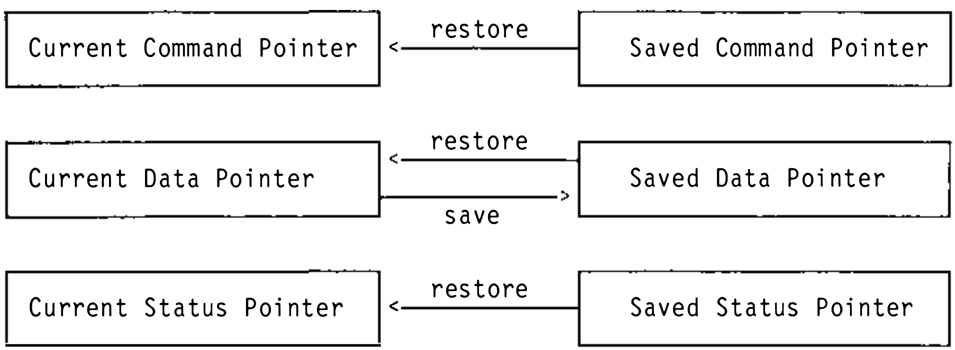
BSY	SEL	MSG	C/D	I/O	DB7	DB6	DB5	DB4-0	Bus Phase or Condition
other targets assigned as needed...									
1	1	0	1	1	1	0	0	11111	Initiator asserts sync function
1	1	0	1	1	1	0	1	11111	all devices assert DB5
1	1	0	1	1	0	0	1	11111	all devices release DB7
1	1	0	1	1	0	1	1	11111	all devices read DB4-0; assert DB
1	1	0	1	1	0	1	0	11111	all devices release DB5
1	1	0	1	1	1	1	0	XXXXX	all devices assert DB7
1	1	0	1	1	1	0	0	XXXXX	all devices release DB6
1	1	0	1	1	1	0	0	00011	Initiator asserts complete fcn.
1	1	0	1	1	1	0	1	00011	all devices assert DB5
1	1	0	1	1	0	0	1	00011	all devices release DB7
1	1	0	1	1	0	1	1	00011	all devices read DB4-0; assert DB
1	1	0	1	1	0	1	0	00011	all devices release DB5
1	1	0	1	1	1	1	0	XXXXX	all devices assert DB7
1	1	0	1	1	1	0	0	XXXXX	all devices release DB6
1	1	0	0	1	1	0	0	00000	Initiator releases C/D
0	0	0	0	0	0	0	0	00000	BUS FREE
BSY	SEL	MSG	C/D	I/O	DB7	DB6	DB5	DB4-0	Bus Phase or Condition

Pointers

Pointers are "virtual" registers that refer to a byte position relative to a particular phase. The actual physical structure within the Initiator for each pointer may be completely different. The structure and arrangement of pointers are shown below:

Current Pointers
(Used when connected)

Saved Pointers
(Copied to Current Pointers when connection is made or on a "restore"



TYPES: There are two types of pointers:

- Current Pointers are incremented by one after the transfer of one byte in its corresponding phase.
- Saved Pointers retain initial values of the Current Pointers.

Within each type, there are three pointers, one for each type of non-message phase:

- Command Pointer refers to COMMAND Phase information (see SCSI Commands, page 95).
- Status Pointer refers to STATUS Phase information (see Status Byte, page 239).
- Data Pointer refers to DATA Phase information (since a DATA OUT Phase and a DATA IN Phase may not occur during the one command execution, only one pointer is defined).

There are no pointers for MESSAGE Phase information since messages are used to control the pointers.

DEFINITIONS: The interpretation of each pointer is as follows:

- Current Command Pointer: points at the source of the next COMMAND byte to transfer during a COMMAND Phase.
- Current Status Pointer: points at the destination of the next STATUS byte to transfer during a STATUS Phase.
- Current Data Pointer: points at:
  - The source of the next byte to transfer during a DATA OUT Phase; or
  - The destination of the next byte to transfer during a DATA IN Phase.
- Saved Command Pointer: set to point at the source of the first COMMAND byte. Does not change during the execution of the command (The pointer retains its initial value).
- Saved Status Pointer: set to point at the destination of the first STATUS byte. Does not change during the execution of the command. (The pointer retains its initial value).
- Saved Data Pointer: At the start of a command, this is set to point at the first DATA byte. If the Target issues a SAVE DATA POINTER message, then the contents of the Current Data Pointer is copied into this pointer.

RESTORE: The contents of a Saved Pointer is copied into its corresponding Current Pointer whenever:

- The Initiator makes the initial Selection of the Target (begins a command); or
- The Target Reconnects to the Initiator; or
- The Target issues a RESTORE POINTERS MESSAGE IN.

MODIFY: The Current Data Pointer may also be modified by a MODIFY DATA POINTER message. The value passed in the message is two's complement added to the Current Data Pointer. Subsequent DATA phases occur from the new pointer value. This message does not affect the contents of the Saved Data Pointer.

WARNING: The contents of the Current Pointers usually cannot be trusted to contain meaningful information at the end of a transfer. This is due to pointer control (save and modify) by the Target. Pointers cannot reliably be used to determine, for example, how many bytes were actually transferred during a phase.

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SCSI Message System

Message Lengths

First Message Code Byte	Message Format
00h	One-Byte Message (COMMAND COMPLETE)
01h	"Extended" (Multiple Byte) Messages
02h - 1Fh	One-Byte Messages
20h - 2Fh	Two-Byte Messages
30h - 7Fh	Reserved for future standards
80h - FFh	One-Byte Message (IDENTIFY)

One Byte Message Codes (Alphabetic)

Message Name	Code	Direction	Must this message be the last of a MESSAGE OUT? (*2)
ABORT [ABORT TASK SET] (*3)	06h	To Target only	Yes
ABORT TAG [ABORT TASK]	0Dh	To Target only	Yes
BUS DEVICE RESET [TARGET RESET]	0Ch	To Target only	Yes
CLEAR ACA	16h	To Target only	No
CLEAR QUEUE [CLEAR TASK SET]	0Eh	To Target only	Yes
COMMAND COMPLETE [TASK COMPLETE]	00h	To Initiator only	—
CONTINUE TASK	12h	To Target only	Yes
DISCONNECT	04h	To Initiator only	—
DISCONNECT	04h	To Target only	Yes
IDENTIFY	(*1)	Both ways	No
INITIATE RECOVERY	0Fh	Both ways	Yes
INITIATOR DETECTED ERROR	05h	To Target only	Yes
LINKED COMMAND COMPLETE	0Ah	To Initiator only	—
LINKED COMMAND COMPLETE (WITH FLAG)	0Bh	To Initiator only	—
LOGICAL UNIT RESET	17h	To Target only	Yes
MESSAGE PARITY ERROR	09h	To Target only	Yes
MESSAGE REJECT	07h	Both ways	Yes
NO OPERATION	08h	To Target only	Yes
RELEASE RECOVERY	10h	To Target only	Yes
RESTORE POINTERS	03h	To Initiator only	—
SAVE DATA POINTER	02h	To Initiator only	—
TARGET TRANSFER DISABLE	13h	To Target only	Yes
TERMINATE I/O PROCESS [TERMINATE TASK]	11h	To Target only	Yes
14h,15h,18h - 1Fh	Reserved for one byte messages		
30h - 7Fh	Reserved, might (or might not) be one byte messages		

(**): see next page for notes.

MESSAGES

One Byte Message Codes (Numeric)

Message Code	Message Name	Direction	Must this message be the last of a MESSAGE OUT? (*2)
00h	COMMAND COMPLETE [TASK COMPLETE]	To Initiator only	——
02h	SAVE DATA POINTER	To Initiator only	——
03h	RESTORE POINTERS	To Initiator only	——
04h	DISCONNECT	To Initiator only	——
04h	DISCONNECT	To Target only	Yes
05h	INITIATOR DETECTED ERROR	To Target only	Yes
06h	ABORT [ABORT TASK SET] (*3)	To Target only	Yes
07h	MESSAGE REJECT	Both ways	Yes
08h	NO OPERATION	To Target only	Yes
09h	MESSAGE PARITY ERROR	To Target only	Yes
0Ah	LINKED COMMAND COMPLETE	To Initiator only	——
0Bh	LINKED COMMAND COMPLETE (WITH FLAG)	To Initiator only	——
0Ch	BUS DEVICE RESET [TARGET RESET]	To Target only	Yes
0Dh	ABORT TAG [ABORT TASK]	To Target only	Yes
0Eh	CLEAR QUEUE [CLEAR TASK SET]	To Target only	Yes
0Fh	INITIATE RECOVERY	Both ways	Yes
10h	RELEASE RECOVERY	To Target only	Yes
11h	TERMINATE I/O PROCESS [TERMINATE TASK]	To Target only	Yes
12h	CONTINUE TASK	To Target only	Yes
13h	TARGET TRANSFER DISABLE	To Target only	Yes
16h	CLEAR ACA	To Target only	No
17h	LOGICAL UNIT RESET	To Target only	Yes
(*1)	IDENTIFY	Both ways	No

14h,15h,18h - 1Fh	Reserved for one byte messages
30h - 7Fh	Reserved, might (or might not) be one byte messages

(*1): See IDENTIFY message on page 89 for message code values.

(*2): When sent by the Initiator. If this message must be the last message of a MESSAGE OUT phase, then the Initiator must negate the ATN signal before asserting ACK for the last byte of the message (see page 61). —— = Not Applicable.

(*3): Any message name changes between SCSI-2 and SCSI-3 are indicated by [].

MESSAGES

IDENTIFY Message

SCSI–2 Format

Bit / Byte	7	6	5	4	3	2	1	0
0	Identify	DiscPriv	LUNTAR	Reserved	Reserved	LUNTRN		

Identify: 0 = this is not an IDENTIFY message
1 = this is an IDENTIFY message

DiscPriv: when sent by the Initiator:
0 = the Target may not Disconnect
1 = the Target may Disconnect (the Target may send the DISCONNECT message

- NOTE: The DiscPriv bit must be 0 when IDENTIFY is sent by a Target.

LUNTAR: 0 = LUNTRN is Logical Unit Number
1 = LUNTRN is Target Routine Number

LUNTRN: indicates the Logical Unit Number or Target Routine Number

Possible values for the SCSI-2 IDENTIFY message:

80h - 87h: "simple" IDENTIFY for Logical Units 0-7, Disconnects disabled by the Initiator; sent by Target after RESELECTION phase.
C0h - C7h: IDENTIFY for Logical Units 0-7, Disconnects enabled by the Initiator.
A0h - A7h: IDENTIFY for Target Routines 0-7, Disconnects disabled by the Initiator (SCSI-2 only).
E0h - E7h: IDENTIFY for Target Routines 0-7, Disconnects enabled by the Initiator (SCSI-2 only).

All other values are reserved for future standardization.

SCSI–3 Format

Bit / Byte	7	6	5	4	3	2	1	0
0	Identify	DiscPriv	Logical Unit Number					

Possible values for the SCSI-3 IDENTIFY message:

80h - BFh: "simple" IDENTIFY for Logical Units 0-63, Disconnects disabled by the Initiator; sent by Target after RESELECTION phase.
C0h - FFh: IDENTIFY for Logical Units 0-63, Disconnects enabled by the Initiator.

MESSAGES

Two Byte Message Codes

Message Code	Message Name	Direction	Must this message be the last of a MESSAGE OUT? (*1)
20h	SIMPLE TAG [SIMPLE] (*2)	Both ways	No
21h	HEAD OF TAG [HEAD OF QUEUE]	To Target only	No
22h	ORDERED TAG [ORDERED]	To Target only	No
23h	IGNORE WIDE RESIDUE	To Initiator only	——
24h	ACA	To Target only	No
25h - 2FH	Reserved for two-byte messages		

(*1): When sent by the Initiator. If this message must be the last message of a MESSAGE OUT phase, then the Initiator must negate the ATN signal before asserting ACK for the last byte of the message (see page 61). —— = Not Applicable.

(*2): Any message name changes between SCSI-2 and SCSI-3 are indicated by [].

MESSAGES

TAG and ACA Message Format

Byte	Value	Description
0	20h,21h, 22h,24h	TAG or ACA Message Code
1	x	Tag (00h - FFh)

IGNORE WIDE RESIDUE Message

Byte	Value	Description
0	23h	IGNORE WIDE RESIDUE Code
1	x	Ignore Code

Ignore: Indicates the number of bytes to ignore at the end of a data transfer:

Ignore Code	Bits to ignore at end of data transfer: 16-bit data transfers	32-bit data transfers
00h	Reserved	Reserved
01h	ignore DB(15-8)	ignore DB(31-24)
02h	Reserved	ignore DB(31-16)
03h	Reserved	ignore DB(31-8)
04h - FFH	Reserved	Reserved

Multiple Byte (Extended) Message Codes

Message Code	Message Name	Direction	Must this message be the last of a MESSAGE OUT? (*3)
(*4)	MODIFY DATA POINTER	To Initiator only	——
(*4)	SYNCHRONOUS DATA TRANSFER REQUEST	Both ways	Yes
(*4)	WIDE DATA TRANSFER REQUEST	Both ways	Yes

(*3): When sent by the Initiator. If this message must be the last message of a MESSAGE OUT phase, then the Initiator must negate the ATN signal before asserting ACK for the last byte of the message (see page 61). —— = Not Applicable.

(*4): See next table.

Extended Message (Byte 0)	Additional Message Length (Byte 1)	Message Code (Byte 2)	Total Length	Description
01h	05h	00h	7 bytes	MODIFY DATA POINTER
01h	03h	01h	5 bytes	SYNCHRONOUS DATA TRANSFER REQUEST
01h	02h	03h	4 bytes	WIDE DATA TRANSFER REQUEST
01h	——	02h		not used
01h	——	04h - 7Fh		Reserved for future standards
01h	——	80h - FFh		Available for Vendor Unique messages

—— = Not Applicable

MESSAGES

Multiple Byte (Extended) Message Formats

SYNCHRONOUS DATA TRANSFER REQUEST (SDTR)

Byte	Value	Description
0	01h	Extended message
1	03h	Extended message length
2	01h	SYNCHRONOUS DATA TRANSFER REQUEST code
3	m	Transfer period (m times 4 nanoseconds)
4	x	REQ/ACK offset

Transfer Period: indicates the minimum time (in 4 nsec increments) between leading edges of REQ or ACK that the device that sends this message can accept. Some interesting values include:

- 32h = 200 nsec; 5Mtransfers/sec maximum SCSI-1 data transfer rate.
- 19h = 100 nsec; 10Mtransfers/sec maximum SCSI-2 "Fast" data transfer rate.
- 0Ch = 50 nsec (honest!); 20Mtransfers/sec maximum SCSI-3 "Fast-20" data transfer rate. (Note: "0Ch" is used because 50 nsec cannot be expressed as a multiple of four.)
- 06h? = 25 nsec; 40Mtransfers/sec maximum SCSI-3 "Fast-40" data transfer rate (this number is not official by any means; we're just guessing!)

REQ/ACK Offset: indicates the maximum number of REQ pulses that the device that sends this message can:

- (As a Target) send before receiving the leading edge of an ACK pulse.
- (As an Initiator) receive before sending the leading edge of an ACK pulse.

A value of 00h indicates asynchronous data transfer mode.

MESSAGES

WIDE DATA TRANSFER REQUEST (WDTR)

Byte	Value	Description
0	01h	Extended message
1	02h	Extended message length
2	03h	WIDE DATA TRANSFER REQUEST code
3	w	Transfer Width Exponent Code

Transfer Width Exponent Code: indicates the bus width as a power of 2 bytes:

- 00h = 8 bits/1 byte wide (SCSI-2 A Cable only).
- 01h = 16 bits/2 bytes wide (SCSI-3 Primary Bus, or SCSI-2 A/B Cable combination).
- 02h = 32 bits/4 bytes wide (SCSI-3 Primary/Secondary Bus combination, or SCSI-2 A/B Cable combination).

MODIFY DATA POINTER

Byte	Value	Description
0	01h	Extended message
1	05h	Extended message length
2	00h	MODIFY DATA POINTER code
3	x	Argument (Most Significant Byte)
4	x	Argument
5	x	Argument
6	x	Argument (Least Significant Byte)

Argument: a two's complement value that is added to the Current Data Pointer value. The Saved Data Pointer, or any other pointer, is not affected.

SCSI Target Response to Attention

The following table summarizes the requirements for SCSI Targets when responding to the ATN Signal (i.e., the Attention Condition). Many SCSI-1 Targets that are "Common Command Set (CCS)" compatible will also behave as described. Other SCSI-1 Targets will do as they please, as allowed by the SCSI-1 standard. (NOTE: These requirements were established in SCSI-2.)

If the ATN Signal goes true during:	Then the Target must enter MESSAGE OUT Phase:
COMMAND Phase	After all or part of the Command bytes are transferred
DATA IN or DATA OUT Phase	At the Target's earliest convenience ("whenever")
STATUS Phase	After the Status byte has been acknowledged
MESSAGE IN Phase	Before it sends another message to the Initiator
SELECTION Phase, before the Initiator releases BSY	Right after the SELECTION Phase
RESELECTION Phase	Right after the Target sends the IDENTIFY Message in

SCSI Commands

SCSI commands are built from a common structure, shown below:

- Operation Code byte
- "N" bytes of parameters
- Control Byte

SCSI Command Descriptor Block (CDB)

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code							
1	Parameter Byte 1							
2	Parameter Byte 2							
...	...							
N	Parameter Byte N							
N+1	Control Byte							

The number of bytes of parameters ("N") can be determined from the Operation Code byte, which is located in byte 0 of the Command Descriptor Block (CDB). See next page...

Operation Code

Bit / Byte	7	6	5	4	3	2	1	0
0	Group Code			Command Code				

Group Code: establishes the total command length, as shown in the following table:

Group Code Value	Total Command Length	Number of Parameter Bytes	Control Byte Location
000	6 bytes	4 bytes	byte 5
001	10 bytes	8 bytes	byte 9
010	10 bytes	8 bytes	byte 9
011	not defined - reserved		
100	16 bytes	14 bytes	byte 15
101	12 bytes	10 bytes	byte 11
110	vendor specific (*1)		
111	vendor specific (*1)		

Command Code: establishes the command function. Note that the same command code can indicate different functions for different group codes.

(*1): **WARNING**: These groups have been defined as six byte commands for some vendors, while other vendors have made these ten byte or twelve byte commands.

GENERAL CMDS

Logical Unit Number

In SCSI-3, the "Logical Unit Number" fields that have been in place (Parameter byte 1, bits 7-5) are no longer used, and have been reclaimed. We have maintained them in our CDB tables, but have put braces {} around them to remind you they are reserved in SCSI-3.

The Control Byte, which is located in the last byte of a Command Descriptor Block, contains control bits that define the behavior of the command:

Control Byte

Bit / Byte	7	6	5	4	3	2	1	0
Last	Vendor specific		Reserved			NACA	Flag	Link

Link: 0 = do not Link to next command
1 = Link to next command. The next phase after the LINKED COMMAND COMPLETE message is COMMAND PHASE for the next command.

Flag: 0 = no function. Must be zero if Link is zero. If Link is one then the LINKED COMMAND COMPLETE message is used to indicate the end of the command.
1 = use the LINKED COMMAND COMPLETE (WITH FLAG) message to indicate the end of the command.

NACA: 0 = SCSI-2 Contingent Allegiance condition rules apply if the command causes the Target to return CHECK CONDITION or COMMAND TERMINATED status. (*1)
1 = SCSI-3 Auto Contingent Allegiance (ACA) condition rules apply if the command causes the Target to return CHECK CONDITION or COMMAND TERMINATED status.

The Vendor Specific bits allow the vendor to create special bits that affect all commands, if needed.

(*1): Note that this definition is true only for the parallel SCSI bus. Serial SCSI implementations do neat things like returning Sense Data automatically with the Status response. Therefore, for Serial SCSI, NACA=0 means "no ACA, just return Sense Data".

Commands for All Device Types (alphabetic listing)

Command Name	See Page	SCSI-3 Section	OpCode
CHANGE DEFINITION	See SPC	SPC 7.1	40h
COMPARE	See SPC	SPC 7.2	39h
COPY	See SPC	SPC 7.3	18h
COPY AND VERIFY	See SPC	SPC 7.4	3Ah
INQUIRY	100	SPC 7.5	12h
LOG SELECT	105	SPC 7.6	4Ch
LOG SENSE	106	SPC 7.7	4Dh
MODE SELECT(6)	107	SPC 7.8	15h
MODE SELECT(10)	107	SPC 7.9	55h
MODE SENSE(6)	108	SPC 7.10	1Ah
MODE SENSE(10)	108	SPC 7.11	5Ah
MOVE MEDIUM ATTACHED	See SMC	SMC 6.3	A7h
PERSISTENT RESERVE IN	110	SPC 7.12	5Eh
PERSISTENT RESERVE OUT	114	SPC 7.13	5Fh
PREVENT/ALLOW MEDIUM REMOVAL	116	SPC 7.14	1Eh
READ BUFFER	116	SPC 7.15	3Ch
READ ELEMENT STATUS ATTACHED	See SMC	SMC 6.5	B4h
RECEIVE DIAGNOSTIC RESULTS	118	SPC 7.16	1Ch
RELEASE(6)	119	SPC 7.17	17h
RELEASE(10)	119	SPC 7.18	57h
REPORT LUNS	120	SPC 7.19	A0h
REQUEST SENSE	122	SPC 7.20	03h
RESERVE(6)	123	SPC 7.21	16h
RESERVE(10)	124	SPC 7.22	56h
SEND DIAGNOSTIC	126	SPC 7.23	1Dh
TEST UNIT READY	128	SPC 7.24	00h
WRITE BUFFER	129	SPC 7.25	3Bh

Commands for All Device Types (numeric listing)

OpCode	See Page	SCSI-3 Section	Command Name
00h	128	SPC 7.24	TEST UNIT READY
03h	122	SPC 7.20	REQUEST SENSE
12h	100	SPC 7.5	INQUIRY
15h	107	SPC 7.8	MODE SELECT(6)
16h	123	SPC 7.21	RESERVE(6)
17h	119	SPC 7.17	RELEASE(6)
18h	See SPC	SPC 7.3	COPY
1Ah	108	SPC 7.10	MODE SENSE(6)
1Ch	118	SPC 7.16	RECEIVE DIAGNOSTIC RESULTS
1Dh	126	SPC 7.23	SEND DIAGNOSTIC
1Eh	116	SPC 7.14	PREVENT/ALLOW MEDIUM REMOVAL
39h	See SPC	SPC 7.2	COMPARE
3Ah	See SPC	SPC 7.4	COPY AND VERIFY
3Bh	129	SPC 7.25	WRITE BUFFER
3Ch	116	SPC 7.15	READ BUFFER
40h	See SPC	SPC 7.1	CHANGE DEFINITION
4Ch	105	SPC 7.6	LOG SELECT
4Dh	106	SPC 7.7	LOG SENSE
55h	107	SPC 7.9	MODE SELECT(10)
56h	124	SPC 7.22	RESERVE(10)
57h	119	SPC 7.18	RELEASE(10)
5Ah	108	SPC 7.11	MODE SENSE(10)
5Eh	110	SPC 7.12	PERSISTENT RESERVE IN
5Fh	114	SPC 7.13	PERSISTENT RESERVE OUT
A0h	120	SPC 7.19	REPORT LUNS
A7h	See SMC	SMC 6.3	MOVE MEDIUM ATTACHED
B4h	See SMC	SMC 6.5	READ ELEMENT STATUS ATTACHED

INQUIRY Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (12h)							
1	{Logical Unit Number}			Reserved			CmdDt	EVPD
2	Page Code or Operation Code							
3	Reserved							
4	Allocation Length							
5	Control Byte							

* **INQUIRY** is issued to determine the device type of a particular Logical Unit. INQUIRY is also used to determine some basic information about implemented options and product name.

EVPD - CmdDt: The Combination of EVPD and CmdDt determine the use of the Page Code or Operation Code field, and the type of INQUIRY data returned:

(CmdDt | EVPD)
00 = return standard INQUIRY data (as shown below)
01 = return Vital Product Data (VPD) for the specified Page Code (see SPC)
10 = return Command Support Data for the specified Operation Code (see SPC)
11 = invalid bit combination

GENERAL CMDS

Allocation Length: maximum number of data bytes the Target may send.

Page Code or Operation Code: indicates which VPD page or Command Support data to return. VPD pages are used to return vendor specific data. The SCSI-3 Primary Commands (SPC) currently defines the following uses for VPD pages:

- Configuration data (e.g., product ID)
- Manufacturing data (e.g., date of manufacture)
- Field replaceable unit data (related to FRU code in Sense Data, see page 240)
- Identification data
- Any other device specific data

See SPC for specific details on VPD.

The Command Support data returns the CDB length in bytes and also returns a bit map that indicates which bits within the CDB are implemented by the Target. See SPC for more details.

Standard INQUIRY Data Format

Byte \ Bit	7	6	5	4	3	2	1	0
0	Peripheral Qualifier			Peripheral Device Type				
1	RMB	Device-Type Qualifier/Reserved						
2	ISO Version		ECMA Version			ANSI-Approved Version		
3	AENC	TrmIOP	NormACA	Reserved	Response Data Format			
4	Additional Length (n-4)							
5	Reserved							
6	Reserved	EncServ	VendSpec	MultiP	MChngr	ACKQREQQ	Addr32	Addr16
7	RelAdr	WBus32	WBus16	Sync	Linked	TranDis	CmdQue	VendSpec
8	(MSB)							
9								
10								
11	Vendor Identification							
12								
13								
14								
15								(LSB)

more....

GENERAL CMDS

Standard INQUIRY Data Format (continued)

Bit / Byte	7	6	5	4	3	2	1	0
16	(MSB)							
17–30	Product Identification							
31								(LSB)
32	(MSB)							
33–34	Product Revision Level							
35								(LSB)
36–55	Vendor Specific							
56–95	Reserved							
96-nn	Vendor-Specific Parameters							

Peripheral Qualifier:

000 = peripheral is connected and is specified by Device Type field.
001 = peripheral not connected, Device Type indicates what could be connected.
010 = reserved
011 = Logical Unit not supported, Device Type must be set to 1Fh (see Device Type table below).
100,101,110,111 = vendor specific Device Type.

GENERAL CMDS

Device Type: as defined below.

Device Type Code	Reference Standard	Description
00h	SBC	Direct-access device (e.g., magnetic disk)
01h	SSC	Sequential-access device (e.g., magnetic tape)
02h	SSC	Printer device
03h	SPC	Processor device (e.g., host to host)
04h	SBC	Write-once read-multiple device (some optical disks
05h	MMC	CD-ROM device
06h	SGC	Scanner device
07h	SBC	Optical memory device (e.g., some optical disks)
08h	SMC	Medium Changer device (e.g., jukeboxes)
09h	SSC	Communications device (e.g., LAN bridge)
0Ah - 0Bh	Defined by ASC IT8 for Graphics Arts Pre-Press Devices	
0Ch	SCC	Array Controller (e.g., RAID array controller)
0Dh	SES	Enclosure Services Device
0Eh - 1Eh	Reserved	
1Fh	Unknown or no device type	

RMB: 0 = physical medium fixed/not removable
1 = physical medium removable

Device-Type Qualifier: This is a vendor specific code that may further qualify the device type. NOTE: This field has been reclaimed in SCSI-3 and is now reserved.

ISO Version: see ISO IS 9316, or subsequent versions.

ECMA Version: see ECMA-111. (Note: ECMA has withdrawn this standard.)

ANSI Version: 0 = the device might or might not be an ANSI standard device
1 = SCSI-1 device (X3.131-1986)
2 = SCSI-2 device (X3.131-1994)
3 = SCSI-3 device
4-7 = reserved for "The Future"

AENC [AERC]: 0 = cannot handle Asynchronous Event Notification (AEN). See SCSI-2 or SAM.
1 = device is a processor device that can accept AEN data.

TrmIOP [TrmTsk]: 0 = does not support TERMINATE I/O PROCESS message. See SCSI-2 or SAM.
1 = supports TERMINATE I/O PROCESS message.

NormACA: 0 = does not support NACA bit in the Control Byte.
1 = supports NACA bit in the Control Byte (NACA may be set to 1).

Response Data Format:
0 = SCSI-1 standard INQUIRY data format
1 = CCS "standard" INQUIRY data format
2 = SCSI-2/SCSI-3 (SPC) standard INQUIRY data format
3-F = reserved

GENERAL CMDS

Additional Length: indicates the number of bytes following this field; also equals total data bytes minus four.

EncServ: 0 = device does not include Enclosure Services function
1 = device Enclosure Services function embedded or attached

VendSpec: Vendor specific/unique.

MultiP: 0 = device is a single SCSI port device
1 = device is a two or more SCSI port device

MChngr: 0 = device does not include medium changer function
1 = device is embedded within or attached to a medium changer

ACKQREQQ: 0 = the device does not support the Q cable.
1 = the device does support REQQ and ACKQ on a Q cable.

Addr32: 0 = the device does not support 32 bit SCSI addressing.
1 = the device does support 32 bit SCSI addressing.

Addr16: 0 = the device does not support 16 bit SCSI addressing.
1 = the device does support 16 bit SCSI addressing.

RelAdr: 0 = Relative Addressing not supported
1 = Relative Addressing (RelAdr bit, see page 153) supported (disk-like devices only)

WBus32: 0 = does not support 32 bit data transfer
1 = supports 32 bit data transfer

WBus16: 0 = does not support 16 bit data transfer
1 = supports 16 bit data transfer

Sync: 0 = does not support Synchronous Data Transfer
1 = supports Synchronous Data Transfer

Linked: 0 = does not support Linked commands (see Control Byte, page 97)
1 = supports Linked commands

TranDis: 0 = does not support CONTINUE TASK and TARGET TRANSFER DISABLE messages
1 = supports CONTINUE TASK and TARGET TRANSFER DISABLE messages

CmdQue: 0 = does not support Tagged command queueing
1 = supports Tagged command queueing

Vendor Identification: 8 byte ASCII field indicates the product vendor of the Target. See the file "vendorid.txt" on the SCSI BBS or the X3T10 web pages (see page 2) for the current list.)

Product Identification: 16 byte ASCII field indicates the product name of the Target.

Product Revision Level: 4 byte ASCII field indicates the product revision level of the Target.

GENERAL CMDS

LOG SELECT Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (4Ch)							
1	{Logical Unit Number}			Reserved			PCR	SP
2	PC		Reserved					
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB) Parameter List Length							
8								(LSB)
9	Control Byte							

* **LOG SELECT** is issued to manage statistical information the Target maintains about the Logical Unit.

PCR: 0 = do not reset parameters
1 = reset parameter to Target default values (parameter list length must be 0).

SP: 0 = do not save Pages
1 = the Target saves the Log Pages it can to some non-volatile storage. The Initiator determines which Pages can be saved by looking at the DS bit in the returned LOG SENSE Page data.

PC: Page Control:

00 = select current threshold values.
01 = select current cumulative values.
10 = select default threshold values.
11 = select default cumulative values.

Parameter List Length: the number of data bytes the Target fetches from the Initiator.

See page 131 for a description of data formats for all devices. See specific device type for defined codes for those devices:

- disk: page 180
- tape: page 220

GENERAL CMDS

LOG SENSE Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (4Dh)							
1	{Logical Unit Number}			Reserved			PPC	SP
2	PC		Page Code					
3	Reserved							
4	Reserved							
5	(MSB) Parameter Pointer							
6								(LSB)
7	(MSB) Allocation Length							
8								(LSB)
9	Control Byte							

* **LOG SENSE** is issued to read statistical information from the Target for the Logical Unit.

PPC: 0 = Target returns the page subject to limits described below.
1 = Target returns the page only parameters that changed since last LOG SENSE or LOG SELECT command, subject to the limits described below.

SP: 0 = do not save Pages
1 = the Target saves the Log Pages it can to some non-volatile storage. The Initiator determines which Pages can be saved by looking at the DS bit in the returned LOG SENSE Page data.

PC: Page Control:

00 = return threshold values.
01 = return cumulative values.
10 = return default threshold values.
11 = return default cumulative values.

Page Code: the Page Code requested by the Initiator.

Parameter Pointer: first parameter code to return in the page.

Allocation Length: maximum number of data bytes the Target may send.

See page 131 for a description of data formats for all devices. See specific device type for defined codes for those devices:

- disk: page 180
- tape: page 220

GENERAL CMDS

MODE SELECT(6) Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (15h)							
1	{Logical Unit Number}			PF	Reserved			SP
2	Reserved							
3	Reserved							
4	Parameter List Length							
5	Control Byte							

MODE SELECT(10) Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (55h)							
1	{Logical Unit Number}			PF	Reserved			SP
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB) Parameter List Length							
8								(LSB)
9	Control Byte							

GENERAL CMDS

* **MODE SELECT** is issued to set variable parameters in the Target for the Logical Unit.

PF:
0 = SCSI-1 data format
1 = SCSI-2/SCSI-3 data format

SP:
0 = do not save Pages
1 = the Target saves the Pages it can to some non-volatile storage. The Initiator determines which Pages can be saved by looking at the SP bit in the returned MODE SENSE Page data. **WARNING**: Some Targets can save different "data sets" for each Logical Unit and for each Initiator. Other Targets can save only one "data set" per Logical Unit.

Parameter List Length: the number of data bytes the Target fetches from the Initiator.

See page 137 for a description of data formats for all devices. See specific device type for data formats for those devices:

- disk: page 181
- tape: page 222

MODE SENSE(6) Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (1Ah)							
1	{Logical Unit Number}			Reserved	DBD	Reserved		
2	PC		Page Code					
3	Reserved							
4	Allocation Length							
5	Control Byte							

MODE SENSE(10) Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (5Ah)							
1	{Logical Unit Number}			Reserved	DBD	Reserved		
2	PC		Page Code					
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB) Allocation Length							
8	(LSB)							
9	Control Byte							

* **MODE SENSE** is issued to read variable and fixed parameters in the Target for the Logical Unit.

DBD: 0 = the Target may return Block Descriptors (see page 140, 141) if it so chooses.
1 = the Target does not return Block Descriptors.

GENERAL CMDS

PC: Page control:

00 = return Current Parameter settings; i.e., what the Target is using for current operations.

01 = return Changeable (variable) Parameters; i.e., what can be changed by the Initiator. The data requested by the Initiator is a "mask" that indicates which parameters may be changed by the Initiator. If a field (bit, bits, byte, or bytes) has all of its bits set to one, then the field is variable. If all of the bits are zero, then it is fixed (constant) or not implemented.

10 = return Default Parameter settings; i.e., what the Target uses at power-up until Saved or Current Parameters are established by the Initiator. These are the parameters that the Target would use "right out of the box", until the Initiator chooses new Current and/or Saved Parameters.

11 = return Saved Parameter settings; i.e., what the Initiator designates as the defaults. After setting up the Target parameters, the Initiator can make those parameters the default by saving them (see SP bit in MODE SELECT, page 105, 106, 107).

Page Code: the Page Code requested by the Initiator. A Page Code of 3Fh requests that the Target return all implemented Pages. See the description of data formats on page 137.

Allocation Length: maximum number of data bytes the Target may send.

See page 137 for a description of data formats for all devices. See specific device type for data formats for those devices:

- disk: page 181
- tape: page 222

PERSISTENT RESERVE IN Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (5Eh)							
1	{Logical Unit Number}			Service Action				
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB) Allocation Length							
8								(LSB)
9	Control Byte							

* **PERSISTENT RESERVE IN** is issued to retrieve reservations and reservation keys that are active within a Logical Unit.

Service Action: Defines the service action to be performed by the command:

00h = Read Keys: return all registered Reservation Keys.
01h = Read Reservations: return all current reservations.
02h-1Fh = reserved.

Allocation Length: maximum number of data bytes the Target may send.

GENERAL CMDS

PERSISTENT RESERVATION IN Parameters for "Read Keys" Action

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1				Generation				
2								
3								(LSB)
4	(MSB)							
5				Additional Length				
6								
7								(LSB)
				Reservation Key List				
0-7				First Reservation Key				
				⋮				
0-7				Last Reservation Key				

Generation: a 32 bit counter that is incremented every time a PERSISTENT RESERVE OUT command requests a Register, Preempt, or a Preempt and Clear operation.

Additional Length: length of the following bytes; also, the number of Reservation Keys times eight.

Reservation Key: the Key List contains all of the 8 byte Reservation Keys sent via a PERSISTENT RESERVE OUT command.

PERSISTENT RESERVATION IN Parameters for "Read Reservations" Action

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1	Generation							
2								
3								(LSB)
4	(MSB)							
5	Additional Length							
6								
7								(LSB)
	Reservation Descriptors							
0	(MSB)							
1								
2								
3	Reservation Key							
4								
5								
6								
7								(LSB)
8	(MSB)							
9	Scope-Specific Address							
10								
11								(LSB)
12	Reserved							
13	Scope				Type			
14	(MSB) Extent Length							
15								(LSB)

Generation: a 32 bit counter that is incremented every time a PERSISTENT RESERVE OUT command requests a Register, Preempt, or a Preempt and Clear operation.

Additional Length: length of the following bytes; also, the number of Reservation Descriptors times 16.

The following are repeated for each Reservation Descriptor:

Reservation Key: the key under which the reservation is held.

Scope-Specific Address: the Logical Block Address of the first block of the reserved Extent (Scope=1), or the address of the reserved Element (Scope=2).

Scope: the scope of the reservation:
- 0 = persistent reservation applies to the whole Logical Unit.
- 1 = persistent reservation applies to the specified Extent.
- 2 = persistent reservation applies to the specified Element.
- 3-F = reserved

Type: the type of the reservation:
- 0 = read shared for all; write prohibited for all Initiators.
- 1 = read shared for all; write exclusive for the reserving Initiator.
- 2 = read exclusive for the reserving Initiator; write shared for all.
- 3 = read exclusive and write exclusive for only the reserving Initiator.
- 4 = read shared for all; write shared for all.
- 5-F = reserved

Extent Length: the number of blocks to reserve if scope is Extent.

PERSISTENT RESERVE OUT Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (5Fh)							
1	{Logical Unit Number}			Service Action				
2	Scope				Type			
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB) Parameter List Length							
8								(LSB)
9	Control Byte							

* **PERSISTENT RESERVE OUT** is issued to reserve a Logical Unit, an Extent within the Logical Unit, or an Element within the Logical Unit.

Service Action: Defines the service action to be performed by the command:

00h = register a Reservation Key.
01h = create a persistent reservation using a Reservation Key.
02h = release a persistent reservation.
03h = clear all Reservation Keys and all persistent reservations.
04h = preempt presistent reservations from another Initiator.
05h = preempt presistent reservations and clear the preempted Initiator's task set.
06h-1Fh = reserved.

GENERAL CMDS

Scope: the scope of the reservation:
0 = persistent reservation applies to the whole Logical Unit.
1 = persistent reservation applies to the specified Extent.
2 = persistent reservation applies to the specified Element.
3-F = reserved

Type: the type of the reservation:
0 = read shared for all; write prohibited for all Initiators.
1 = read shared for all; write exclusive for the reserving Initiator.
2 = read exclusive for the reserving Initiator; write shared for all.
3 = read exclusive and write exclusive for only the reserving Initiator.
4 = read shared for all; write shared for all.
5-F = reserved

Parameter List Length: number of bytes in parameter list; must be set to 24 (18h).

PERSISTENT RESERVATION OUT Parameter List

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1–6				Reservation Key				
7								(LSB)
8	(MSB)							
9–14				Service Action Reservation Key				
15								(LSB)
16	(MSB)							
17–18				Scope-Specific Address				
19								(LSB)
20				Reserved				
21				Reserved				APTPL
22	(MSB)			Extent Length				
23								(LSB)

Reservation Key: the Reservation Key of the Initiator performing the command.

Service Action Reservation Key: the Reservation Key of the Initiator whose reservation is being changed, as indicated by the Service Action field.

Scope-Specific Address: the Logical Block Address of the first block of the reserved Extent (Scope=1), or the address of the reserved Element (Scope=2).

APTPL: 0 = loss of power releases all persistent reservations.
1 = persistent reservations are retained through a power loss.

Extent Length: the number of blocks to reserve if scope is Extent.

PREVENT/ALLOW MEDIUM REMOVAL Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (1Eh)							
1	{Logical Unit Number}			Reserved				
2	Reserved							
3	Reserved							
4	Reserved						Prevent	
5	Control Byte							

* **PREVENT ALLOW MEDIUM REMOVAL** controls a mechanical interlock on the Target (if any) that prevents the user from removing the medium.

Prevent: 00 = allow removal
01 = prevent removal from I/O device
10 = prevent removal from medium changer
11 = prevent removal from both I/O device and medium changer

READ BUFFER Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (3Ch)							
1	{Logical Unit Number}			Reserved		Mode		
2	Buffer ID							
3	(MSB)							
4	Buffer Offset							
5								(LSB)
6	(MSB)							
7	Allocation Length							
8								(LSB)
9	Control Byte							

* **READ BUFFER** is used to transfer data from the Target's data buffer to the Initiator. It is usually issued immediately following the WRITE BUFFER command.

Mode: indicates the command mode and data format:
000 = transfer 4 byte Header followed by data
001 = vendor specific
010 = transfer data only
011 = transfer a Buffer Descriptor only
100 - 111 = reserved

GENERAL CMDS

Buffer ID: selects a buffer in the Target. A Target that has any buffer will always have a Buffer ID zero.

Buffer Offset: indicates a byte offset from the beginning of the selected buffer.

Allocation Length: maximum number of data bytes the Target may send.

READ BUFFER Header for Mode 000

Byte \ Bit	7	6	5	4	3	2	1	0
0	Reserved							
1	(MSB)							
2	Buffer Capacity							
3								(LSB)

READ BUFFER Descriptor for Mode 011

Byte \ Bit	7	6	5	4	3	2	1	0
0	Offset Boundary							
1	(MSB)							
2	Buffer Capacity							
3								(LSB)

Offset Boundary: "power-of-two" representation of the data size within the buffer. A value of zero indicates byte (8-bit) boundaries. A value of one indicates word (16-bit) boundaries, and so on.

Buffer Capacity: size of the selected buffer in bytes.

RECEIVE DIAGNOSTIC RESULTS Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (1Ch)							
1	{Logical Unit Number}			Reserved				PVC
2	Page Code							
3	(MSB) Allocation Length							
4								(LSB)
5	Control Byte							

* **RECEIVE DIAGNOSTIC RESULTS** is used to retrieve data concerning the results of a diagnostic function commanded by a prior SEND DIAGNOSTIC command; or to retrieve data related to the selected Page Code.

PCV: 0 = Page Code not valid (SCSI-1/SCSI-2 operation).
1 = Page Code field valid.

Page Code: indicates the function to perform. If Page Code is 00h, then return results based on the previous SEND DIAGNOSTIC command.

Allocation Length: maximum number of data bytes the Target may send.

See page 127 for a description of parameter data formats for all devices. See specific device type for data formats for those devices (disk only: page 176).

RELEASE(6) Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (17h)							
1	{Logical Unit Number}			3rdPty	Third Party Device ID			Extent
2	Reservation Identification							
3	Reserved							
4	Reserved							
5	Control Byte							

RELEASE(10) Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (57h)							
1	{Logical Unit Number}			3rdPty	Reserved		LongID	Extent
2	Reservation Identification							
3	Third Party Device ID							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB) Parameter List Length							
8								(LSB)
9	Control Byte							

GENERAL CMDS

* **RELEASE** is used to cancel a reservation made via a RESERVE command. It is not an error to release non-existent reservations.

3rdPty: 0 = release the reservation that was made to the Initiator issuing the command.
1 = release the reservation that was made to the Initiator specified in the Third Party Device ID field.

LongID: 0 = use Third Party Device ID in byte 3 of CDB and no parameter list.
1 = use parameter list for Third Party Device ID.

Extent: 0 = release reservation for entire disk
1 = release reservation for a partition (Extent)

Reservation Identification: identifies the Extent to release

Third Party Device ID: specifies which Initiator has the reservation to release when the 3rdPty bit is 1.

Parameter List Length: if LongID = 0, this is zero; if LongID = 1, this is 8.

RELEASE(10) Parameter List

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1								
2								
3				Third Party Device ID				
4								
5								
6								
7								(LSB)

REPORT LUNS Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (A0h)							
1	Reserved							
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	(MSB)							
7				Allocation Length				
8								
9								(LSB)
10	Reserved							
11	Control Byte							

* **REPORT LUNS** returns a list of Logical Unit Numbers to which commands may be issued.

Allocation Length: maximum number of data bytes the Target may send.

GENERAL CMDS

REPORT LUNS Parameter List

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1				LUN List Length				
2								
3								(LSB)
4				Reserved				
5				Reserved				
6				Reserved				
7				Reserved				
				LUN List				
0-7				First LUN				
				⋮				
0-7				Last LUN				

LUN List Length: the number of LUNs reported times 8.

LUN: a Logical Unit to which commands may be issued. The number is justified to the LSB; for example, LUN #1 would be 00 00 00 00 00 00 00 01h.

GENERAL CMDS

REQUEST SENSE Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (03h)							
1	{Logical Unit Number}			Reserved				
2	Reserved							
3	Reserved							
4	Allocation Length							
5	Control Byte							

* **REQUEST SENSE** is used to retrieve Sense Data concerning an error or other condition. REQUEST SENSE is usually issued following the completion of a command that had CHECK CONDITION status. Commands that end with CONDITION MET or COMMAND TERMINATED status may also have Sense Data available.

Allocation Length: maximum number of data bytes the Target may send.

The data format for Sense Data returned by this command is given in the section on SENSE DATA, page 240.

RESERVE(6) Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (16h)							
1	{Logical Unit Number}			3rdPty	Third Party Device ID			Extent
2	Reservation Identification							
3	(MSB) Extent List Length							
4								(LSB)
5	Control Byte							

* **RESERVE** is used to reserve a disk or partition of a disk for exclusive use by an Initiator.

3rdPty: 0 = reservation is made to the Initiator issuing the command.
1 = reservation is made to the Initiator specified in the Third Party Device ID field.

Third Party Device ID: specifies which Initiator gets the reservation when the 3rdPty bit is 1.

Extent: 0 = entire disk is reserved
1 = partition (Extent) is reserved

Reservation Identification: identifies Extent when issuing the RELEASE command.

Extent List Length: number of bytes in the Extent list; also, number of Extents times eight.

GENERAL CMDS

RESERVE(6) Extent Descriptor Format

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved					RelAdr	Reservation Type	
1	(MSB)							
2	Number of Blocks							
3								(LSB)
4	(MSB)							
5								
6	Logical Block Address							
7								(LSB)

Number of Blocks: if zero, then reserve the rest of the disk.

Reservation Type: indicates how access to Extent is to be reserved:
00 = reserved for any write (no Initiator may write, all may read)
01 = reserved for exclusive write (other Initiators may read only)
10 = reserved for exclusive read (other Initiators may write only)
11 = reserved for all access (other Initiators may not read or write)

RESERVE(10) Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (56h)							
1	{Logical Unit Number}			3rdPty	Reserved		LongID	Extent
2	Reservation Identification							
3	Third Party Device ID							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB) Parameter List Length							
8								(LSB)
9	Control Byte							

* **RESERVE** is used to reserve a disk or partition of a disk for exclusive use by an Initiator.

3rdPty: 0 = reservation is made to the Initiator issuing the command.
1 = reservation is made to the Initiator specified in the Third Party Device ID field.

LongID: 0 = use Third Party Device ID in byte 3 of CDB and no ID in the parameter list.
1 = use parameter list for Third Party Device ID.

Extent: 0 = entire disk is reserved
1 = partition (Extent) is reserved; extent descriptors sent in Parameter List.

Reservation Identification: identifies Extent when issuing the RELEASE command.

Third Party Device ID: specifies which Initiator gets the reservation when the 3rdPty bit is 1.

Parameter List Length: number of bytes in the Parameter List; length based on setting of LongID and Extent:

LongID = 0, Extent = 0: length is 0.
LongID = 0, Extent = 1: length is number of Extents times 8.
LongID = 1, Extent = 0: length is 8.
LongID = 1, Extent = 1: length is 8 plus number of Extents times 8.

RESERVE(10) Parameter List and Extent Descriptors

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB) Third Party Device ID							
1								
2								
3								
4								
5								
6								
7								(LSB)
	Extent Descriptor(s) (if any)							
0	Reserved					RelAdr	Reservation Type	
1	(MSB) Number of Blocks							
2								
3								(LSB)
4	(MSB) Logical Block Address							
5								
6								
7								(LSB)

The RESERVE(10) Parameter List may contain either a Third Party Device ID, an Extent list, or both, as determined by the setting of the LongID and Extent bits in the CDB (see above).

Number of Blocks: if zero, then reserve the rest of the disk.

Reservation Type: indicates how access to Extent is to be reserved:

00 = reserved for any write (no Initiator may write, all may read)
01 = reserved for exclusive write (other Initiators may read only)
10 = reserved for exclusive read (other Initiators may write only)
11 = reserved for all access (other Initiators may not read or write)

SEND DIAGNOSTIC Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (1Dh)							
1	{Logical Unit Number}			PF	Reserved	SelfTest	DevOfL	UnitOfL
2	Reserved							
3	(MSB) Parameter List Length							
4	Parameter List Length (LSB)							
5	Control Byte							

* **SEND DIAGNOSTIC** is used to request that the Target perform a diagnostic on all or part of the Target.

PF: 0 = SCSI-1 data format
1 = SCSI-2/SCSI-3 Paged data format

SelfTest: 0 = perform function specified by parameter list
1 = perform self test

DevOfl: 0 = diagnostic does not affect later processes on other Logical Units
1 = diagnostic may affect later processes on other Logical Units

UnitOfl: 0 = diagnostic does not affect later processes on this Logical Unit
1 = diagnostic may affect later processes on this Logical Unit

Parameter List Length: the number of data bytes the Target fetches from the Initiator.

GENERAL CMDS

See page 127 for a description of parameter data formats for all devices. See specific device type for data formats for those devices (disk only: page 176).

Diagnostic Page Format

Bit / Byte	7	6	5	4	3	2	1	0
0	Page Code							
1	Reserved							
2	(MSB) Page Length (n-3)							
3								(LSB)
4 - n	Diagnostic Parameters							

The **Diagnostic Page Format** is used when the PF bit is set to one; it may also be used when PF is zero in some devices. Diagnostic Pages are used to issue standard SCSI-2 and SCSI-3 diagnostic functions; they are also used to perform SCSI-3 Enclosure Services functions.

Page Code: indicates the function to perform. The Page Codes for all device types are shown below:

Diagnostic Page Codes

Page Code	Description	SCSI-3 Section
00h	Supported Diagnostics Pages	SPC 7.3.1.1
01h - 3Fh	Reserved (for all device type Pages)	
40h - 7Fh	See specific device type for definition (disk only: page 176)	
80h - FFh	Vendor Specific Pages	

Page Length: the length of bytes following this field; also equal to the whole Page length minus 4.

Diagnostic Parameters: specific to the requested function.

Supported Diagnostic Pages

Byte \ Bit	7	6	5	4	3	2	1	0
0	Page Code (00h)							
1	Reserved							
2	(MSB) Page Length (n-3)							
3								(LSB)
4 … n	Supported Page List							

Supported Diagnostic Pages is used to report to the Initiator which Page Codes are implemented by the Target. First, the SEND DIAGNOSTIC command is issued and only the first four bytes of the Page are sent (Set Page Length to zero). The RECEIVE DIAGNOSTIC RESULTS command is then issued and the Target returns the first four bytes of the Page followed by a list of supported Page Codes.

GENERAL CMDS

TEST UNIT READY Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (00h)							
1	{Logical Unit Number}			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Control Byte							

* **TEST UNIT READY** is used to check to see if the Logical Unit is powered up and ready to do reads and writes. The Target responds with GOOD Status if all is ready, and returns CHECK CONDITION with NOT READY Sense Key if it is not ready. See page 245 for a list of typical TEST UNIT READY responses.

WRITE BUFFER Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (3Bh)							
1	{Logical Unit Number}			Reserved		Mode		
2	Buffer ID							
3	(MSB)							
4	Buffer Offset							
5								(LSB)
6	(MSB)							
7	Parameter List Length							
8								(LSB)
9	Control Byte							

*** The WRITE BUFFER Command** is used to transfer data to the Target's data buffer from the Initiator. It is usually issued immediately prior to the READ BUFFER command.

Mode: indicates the command mode and data format:
000 = transfer 4 byte header followed by data
001 = vendor specific
010 = transfer data only
011 = reserved
100 = download microcode
101 = download microcode and save
110 = download microcode with offsets
111 = download microcode with offsets and save

Buffer ID: selects a buffer in the Target. A Target that has any buffer must at least have a buffer with a Buffer ID of zero.

Buffer Offset: indicates a byte offset from the beginning of the selected buffer.

Parameter List Length: the number of data bytes the Target fetches from the Initiator.

WRITE BUFFER Header for Mode 000

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved							
1	Reserved							
2	Reserved							
3	Reserved							

The **WRITE BUFFER header** is four reserved bytes (all zero).

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Log Select/Log Sense Standard Parameters

Log Page Data Format

Bit / Byte	7	6	5	4	3	2	1	0
0 - 3	Log Page Header (Table A below)							
4 - n	Log Parameters (Table B below)							

The data sent by the Initiator during the LOG SELECT command, or sent by the Target during the LOG SENSE command, is made up of:

- A Log Page Header; and
- Zero or more variable length Log Parameters.

Log Page Header Format
(Table A)

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved		Page Code					
1	Reserved							
2	(MSB) Page Length (n-3)							
3	(LSB)							

The **Log Page Header** contains the page code and length of the data following.

Page Code: The code of the Log Page Code requested by the Initiator (LOG SELECT), or returned by the Target (LOG SENSE). Most Log Pages contain one or more Log Parameters.

Page Length: Indicates the length of following bytes in the Page, also equals the total Page length minus three.

GENERAL CMDS

Log Parameter Format
(Table B)

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB) Parameter Code							
1								(LSB)
2	DU	DS	TSD	ETC	TMC		LBIN	LP
3	Parameter Length (m-3)							
4	Parameter Value							
m								

Each **Log Parameter** begins with a four byte header followed by one or more bytes of parameter data.

Parameter Code: identifies the parameter.

DU: 0 = Target updates the parameter by event.
1 = Initiator updates the parameter by LOG SELECT.

DS: 0 = Target supports saving the parameter via Initiator setting SP to one.
1 = Target does not support saving the parameter via the SP bit.

TSD: 0 = Target performs periodic implicit save of the parameter.
1 = Target does not periodically save the parameter.

ETC: 0 = Target does not compare the parameter to the threshold when the parameter is updated.
1 = Target compares the parameter to the threshold when the parameter is updated.

TMC: Threshold Met Criteria (enabled by ETC):

00 = Threshold met on every update of the parameter.
01 = Threshold met when the cumulative value equals the threshold value.
10 = Threshold met when the cumulative value is not equal to the threshold value.
11 = Threshold met when the cumulative value is greater than the threshold value.

LBIN: 0 = the list parameter (LP bit must be 1) is an ASCII string.
1 = the list parameter (LP bit must be 1) is binary information.

LP: 0 = the parameter is a data counter.
1 = the parameter is a list parameter.

Parameter Length: the length of bytes following this field; also equal to the whole log parameter length minus 4.

Parameter Value: the actual value of the log parameter.

GENERAL CMDS

Parameter Codes for Log Pages

Log Page Codes

Page Code	Description	SCSI-3 Section
00h	Supported Log Pages Page	SPC 8.2.6
01h	Buffer Over-run/Under-run Page	SPC 8.2.1
02h	Error Counter Page (Write)	SPC 8.2.2
03h	Error Counter Page (Read)	SPC 8.2.2
04h	Error Counter Page (Read Reverse)	SPC 8.2.2
05h	Error Counter Page (Verify)	SPC 8.2.2
06h	Non-Medium Error Page	SPC 8.2.5
07h	Last n Error Events Page	SPC 8.2.4
08h - 0Ah	Reserved	
0Bh	Last n Deferred or Asynchronous Error Events Page	SPC 8.2.3
0Ch - 2Fh	Reserved	
30h - 3Eh	Vendor specific Pages	
3Fh	Reserved	

Parameter Codes for Buffer Over-run/Under-run Page

NOTE: Byte 0 of the Parameter Code is Reserved and is always 00h.

Parameter Code	Count Basis	Cause	Over-run or Under-run?
00h	Undefined	Undefined	under-run
01h	Undefined	Undefined	over-run
02h	Undefined	SCSI bus was busy	under-run
03h	Undefined	SCSI bus was busy	over-run
04h	Undefined	Transfer rate too slow	under-run
05h	Undefined	Transfer rate too slow	over-run
06h-1Fh	Reserved Codes		
20h	Increment per Command	Undefined	under-run
21h	Increment per Command	Undefined	over-run
22h	Increment per Command	SCSI bus was busy	under-run
23h	Increment per Command	SCSI bus was busy	over-run
24h	Increment per Command	Transfer rate too slow	under-run
25h	Increment per Command	Transfer rate too slow	over-run
26h-3Fh	Reserved Codes		
40h	Increment per Failed Reconnect	Undefined	under-run
41h	Increment per Failed Reconnect	Undefined	over-run
42h	Increment per Failed Reconnect	SCSI bus was busy	under-run
43h	Increment per Failed Reconnect	SCSI bus was busy	over-run
44h	Increment per Failed Reconnect	Transfer rate too slow	under-run
45h	Increment per Failed Reconnect	Transfer rate too slow	over-run
46h-5Fh	Reserved Codes		
60h	Increment per Unit of Time	Undefined	under-run
61h	Increment per Unit of Time	Undefined	over-run
62h	Increment per Unit of Time	SCSI bus was busy	under-run
63h	Increment per Unit of Time	SCSI bus was busy	over-run
64h	Increment per Unit of Time	Transfer rate too slow	under-run
65h	Increment per Unit of Time	Transfer rate too slow	over-run
66h-FFh	Reserved Codes		

Parameter Codes for Error Counter Pages

Parameter Code	Description
0000h	Count of errors corrected without "substantial delay"
0001h	Count of errors corrected with "possible delays"
0002h	Total re-writes or re-reads
0003h	Total errors corrected
0004h	Total times error correction algorithm processed
0005h	Total bytes processed
0006h	Total uncorrected errors
0007h-7FFFh	Reserved
8000h-FFFFh	Vendor Specific

Parameter Codes for Last n Error Events Page

The parameter codes indicate when in time the recorded event actually occurred. A higher code number occurred later in time. The contents of the parameter value field are a vendor specific ASCII string.

Parameter Codes for Non-Medium Error Page

Parameter Code	Description
0000h	Non-medium error count
0001h-7FFFh	Reserved
8000h-FFFFh	Vendor Specific

Supported Log Pages Page Format

Byte \ Bit	7	6	5	4	3	2	1	0
0	Reserved		Page Code (00h)					
1	Reserved							
2	(MSB)	Page Length (n-3)						
3								(LSB)
4	Supported Page List							
n								

The **Log Page Header** contains the page code and length of the data following.

Page Length: Indicates the length of following bytes in the Page, also equals the total Page length minus three.

Supported Page List: A list of page codes supported by the Target beginning with 00h in ascending order.

GENERAL CMDS

Mode Select/Mode Sense Standard Parameters

Mode Parameter List Data Format

Bit / Byte	7	6	5	4	3	2	1	0
0 - n	Mode Parameter Header (Table A or B below)							
0 - n	Block Descriptor(s) (Table C or D below)							
0 - n	Page(s) (Table E below)							

The data sent by the Initiator during the MODE SELECT command, or sent by the Target during the MODE SENSE command, is made up of:

- A Mode Parameter Header, the length of which is determined by the command that was issued (6 byte or 10 byte versions); and
- Zero or more Block Descriptors (most Targets use just one); and
- Zero or more Pages for general parameter passing.

Mode Parameter Header for Use by Six Byte MODE SELECT/SENSE Command
(Table A)

Byte \ Bit	7	6	5	4	3	2	1	0
0	Mode Data Length							
1	Medium Type							
2	Device-Specific Parameter							
3	Block Descriptor Length							

Mode Parameter Header for Use by Ten Byte MODE SELECT/SENSE Command
(Table B)

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB) Mode Data Length							
1	Mode Data Length (LSB)							
2	Medium Type							
3	Device-Specific Parameter							
4	Reserved							
5	Reserved							
6	(MSB) Block Descriptor Length							
7	Block Descriptor Length (LSB)							

GENERAL CMDS

The **Mode Parameter Header** (Tables A and B) contains some variable parameters and also indicates the organization of the rest of the data.

Mode Data Length: (MODE SENSE ONLY) used by the Target to indicate how many bytes were sent to the Initiator. This field is set to zero for MODE SELECT.

Medium Type: (MODE SELECT and MODE SENSE) one of two fields (see Density Code, page 140, 141) that indicates what physical medium is being used or is to be used. This field may also indicate what physical format to use. This field is not used by Sequential Access devices.

Block Descriptor Length: (MODE SELECT AND MODE SENSE) indicates how many Block Descriptors follow; equal to the number of Block Descriptors times eight. Zero indicates no Block Descriptors follow. Eight indicates one Block Descriptor follows.

Device Specific Parameter: (MODE SELECT and MODE SENSE) a byte which indicates some optional settings for a particular device type, as follows:

Device Specific Parameter

Bit / Device	7	6	5	4	3	2	1	0
disk	WP	Reserved		DPOFUA	Reserved			
tape	WP	Buffered Mode			Speed			

WP: 0 = medium is write enabled
1 = medium is write protected

DPOFUA: (MODE SENSE ONLY) (NOTE: This bit was formerly called the "Cache" bit)
0 = the Target does not support the DPO and FUA bits.
1 = the Target supports the DPO and FUA bits, which appear in the disk command set to support cache functions.

Buffered Mode: tape mode to enhance streaming performance:
000 = report status after data is written to tape
001 = report status after data transfer complete to buffer
010 = report status after data transfer complete to buffer and previous data from other Initiators is written to tape
011 to 111 = reserved

Speed: indicates speed setting:
0000 = default speed
0001 = lowest speed
0010 = next fastest speed
0011 = faster
0100 = faster!
0101 = YEEEE HAH!
0110 to 1111 = faster and faster on up as needed

GENERAL CMDS

General Mode Parameter Block Descriptor
(Table C)

Bit / Byte	7	6	5	4	3	2	1	0
0	Density Code							
1	(MSB)							
2	Number of Blocks							
3								(LSB)
4	Reserved							
5	(MSB)							
6	Block Length							
7								(LSB)

The **Block Descriptor** describes a partition of the medium that is of a particular format, is a certain size in blocks which are of a fixed size. Most Targets use only one Block Descriptor which defines all blocks in the Logical Unit. See the next page for the SCSI-3 Block Descriptor for Disks.

Density Code: (MODE SELECT and MODE SENSE) one of two fields (see Medium Type, page 138) that indicates what physical medium is being used or is to be used. This field may also indicate what physical format to use.

Number of Blocks: (MODE SELECT and MODE SENSE) indicates the size in logical blocks of the medium partition.

Block Length: (MODE SELECT and MODE SENSE) indicates the size of a logical block within the partition in bytes.

SCSI–3 Block Device (Disk) Mode Parameter Block Descriptor
(Table D)

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB)							
1				Number of Blocks				
2								
3								(LSB)
4				Density Code				
5	(MSB)							
6				Block Length				
7								(LSB)

The **Disk Block Descriptor** describes a partition of the medium that is of a particular format, is a certain size in blocks which are of a fixed size. Most Targets use only one Block Descriptor which defines all blocks in the Logical Unit.

Number of Blocks: (MODE SELECT and MODE SENSE) indicates the size in logical blocks of the medium partition.

Density Code: (MODE SELECT and MODE SENSE) one of two fields (see Medium Type, page 138) that indicates what physical medium is being used or is to be used. This field may also indicate what physical format to use. This field is not used by Direct Access devices.

Block Length: (MODE SELECT and MODE SENSE) indicates the size of a logical block within the partition in bytes.

Mode Page Format
(Table E)

Bit / Byte	7	6	5	4	3	2	1	0
0	PS	Reserved	Page Code					
1	Page Length							
2 - n	Mode Parameters							

The **Mode Parameter Page** is used to organize related parameters into a single data structure.

PS: 0 = Page cannot be saved (i.e., is not retained after a hard reset or power down).
1 = Page can be saved (see SP bit, page 105, 106, 107)

Page Code: The Page Code requested by the Initiator (MODE SELECT), or returned by the Target (MODE SENSE). Some Pages are defined for all devices and are shown below. Pages specific to devices are shown in the device sections.

Page Length: Indicates the length of following bytes in the Page, also equals the total Page length minus two.

Mode Parameters: Parameters which can be read and perhaps controlled within a Page.

Mode Page Codes

Page Code	Description	SCSI-3 Section
00h	Vendor specific (does not require Page format)	
01h	(See specific device type)	
02h	Disconnect-Reconnect Page	SPC 8.3.5
03h - 08h	(See specific device type)	
09h	Peripheral Device Page (see SPC standard)	SPC 8.3.7
0Ah	Control Mode Page	SPC 8.3.4
0Bh - 0Ch	(See specific device type)	
0Dh	Power Condition Page (Direct Access device only)	SPC 8.3.8
0Eh - 19h	(See specific device type)	
1Ah	Power Condition Page (all other device types)	SPC 8.3.8
1Bh	(See specific device type)	
1Ch	Informational Exceptions Control Page	SPC 8.3.6
1Dh - 1Fh	(See specific device type)	
20h - 3Eh	Vendor specific (Page format required)	
3Fh	Return all Pages (valid only for the MODE SENSE command)	

Control Mode Page

Byte \ Bit	7	6	5	4	3	2	1	0
0	PS	Reserved	Page Code (0Ah)					
1	Page Length (06h)							
2	Reserved						GLTSD	RLEC
3	Queue Algorithm Modifier				Reserved		QErr	DQue
4	{EECA}	RAC	Reserved	Reserved	SWP	RAENP	UAAENP	EAENP
5	Reserved							
6	(MSB) Ready AEN Holdoff Period							
7								(LSB)
8	(MSB) Busy Timeout Period							
9								(LSB)
10	Reserved							
11	Reserved							

The **Control Mode Page** is used to control several different SCSI features: error logging, Tagged Queueing, SCSI-2 Extended Contingent Allegiance (ECA), and Asynchronous Event Notification (AEN). NOTE: For what it's worth, SCSI-3 calls it "Asynchronous Event Reporting (AER)".

GENERAL CMDS

GLTSD: 0 = enable Target-defined method of saving log parameters
1 = disable Target-defined method of saving log parameters

RLEC: 0 = do not report log exception conditions
1 = report exception conditions caused by logging activities

Queue Algorithm Modifier: controls the ordering of Tagged commands when the order is not otherwise indicated (commands were issued with the SIMPLE QUEUE TAG message). See the SPC standard for more explanation:

0000 = indicates that the Target is responsible to ensure data integrity.
0001 = indicates that the Initiator is responsible to ensure data integrity.
0010-0111 = reserved
1000-1111 = vendor specific

QErr: 0 = continue remaining commands in queue after command error
1 = abort remaining commands in queue after command error

DQue: 0 = Tagged Queueing enabled (accept queue tag messages)
1 = Tagged Queueing disabled (reject queue tag messages)

EECA: 0 = Extended Contingent Allegiance disabled (SCSI-2 ONLY)
1 = Extended Contingent Allegiance enabled (SCSI-2 ONLY)

RAC: 0 = long busy conditions may be reported
1 = CHECK CONDITION status should be reported rather than a long busy condition

SWP: 0 = allow writing to the medium (subject to other settings, of course)
1 = inhibit writing to the medium after writing all cached or buffered write data

RAENP: 0 = Target does not do AEN/AER after initialization
1 = Target may do AEN/AER after initialization

UAAENP: 0 = Target does not do AEN/AER for a Unit Attention condition
1 = Target may do AEN/AER to report a Unit Attention condition

EAENP: 0 = Target does not do AEN/AER to report deferred errors
1 = Target may do AEN/AER to report deferred errors

Ready AEN Holdoff Period: delay time in milliseconds between the start of Target initialization and the reporting of initialization complete via AEN/AER.

Busy Timeout Period: maximum time in 100 millisecond increments that a Target may remain busy for exception conditions that are not a routine part of command processing. FFFFh indicates the period is unlimited.

Disconnect Reconnect Page

Bit / Byte	7	6	5	4	3	2	1	0
0	PS	Reserved	Page Code (02h)					
1	Page Length (0Eh)							
2	Buffer Full Ratio							
3	Buffer Empty Ratio							
4	(MSB)	Bus Inactivity Limit						
5								(LSB)
6	(MSB)	Disconnect Time Limit						
7								(LSB)
8	(MSB)	Connect Time Limit						
9								(LSB)
10	(MSB)	Maximum Burst Size						
11								(LSB)
12	EMDP	FARd	FAWrt	FAStat	DImm	DTDC		
13	Reserved							
14	(MSB)	First Burst Size						
15								(LSB)

The **Disconnect-Reconnect Page** is used to control when the Target may or may not disconnect during a command. This page allows control of the buffer in the following ways:

- as a function of data in the Target data buffer;
- as a function of time;
- as a function of Bus Phase.

In general, the DTDC field dominates over the effects of all other fields. Also, the Time Limit fields dominate over the effects of the Buffer Ratio fields.

NOTE: This page contains several parameters that are specific only to the parallel SCSI bus. Some parameters have meaning only to serial SCSI implementations, and other have meaning for both parallel and serial SCSI. We have listed the parallel SCSI meanings, and shown the serial SCSI parameters. Check the specific serial SCSI standard (such as FCP) for the specific usage of this page.

Buffer Full Ratio (BFR): indicates how full (BFR/256) the Target's data buffer should be during a read before attempting to Reconnect to the Initiator. Zero equals Target's choice.

Buffer Empty Ratio (BER): indicates how empty (BER/256) the Target's data buffer should be during a write before attempting to Reconnect to the Initiator. Zero equals Target's choice.

Bus Inactivity Limit: the maximum time (in 0.1 millisecond increments) between REQ assertions while a Target has BSY asserted. Zero equals no limit.

Disconnect Time Limit: the minimum time (in 0.1 millisecond increments) between when the Target releases the bus (goes to BUS FREE) before it may attempt to Reconnect to the Initiator. Zero equals no limit.

Connect Time Limit: the maximum time (in 0.1 millisecond increments) between the start of a Connection to when the Target releases the bus. Zero equals no limit.

Maximum Burst Size: the maximum transfer size (in 0.5 KByte increments) that a Target may transfer in one Connection. Zero equals no limit.

EMDP: 0 = Target may not re-order the data transfer
1 = Target is allowed to re-order the data transfer

DImm: 0 = the Target may transfer data in the same connection or tenancy in which it receives the command.
1 = the Target may not transfer data in the same connection or tenancy.

DTDC: Data Transfer Disconnect Control; field provides gross control over when the Target must Disconnect (DTDC setting takes precedence over all other settings):
000 = no control
001 = transfer all data with no Disconnect; Disconnect at other times is allowed. The Connect Time Limit and Bus Inactivity Limit are ignored during the data transfer.
010 = reserved
011 = transfer all data and complete the command with no Disconnect; Disconnect before data transfer starts is allowed. The Connect Time Limit and Bus Inactivity Limit are ignored after the data transfer has started.
100-111 = reserved

The following fields are NOT defined for parallel SCSI (they are provided for serial interfaces) but we're including them anyway:

FARd: 0 = use unfair arbitration to get a tenancy for read data transfer
1 = use fair arbitration for read data transfer

FAWrt: 0 = use unfair arbitration to get a tenancy for write data transfer
1 = use fair arbitration for write data transfer

FARStat: 0 = use unfair arbitration to get a tenancy for status/message transfer
1 = use fair arbitration for status/message transfer

First Burst Size: the maximum transfer size (in 0.5 KByte increments) that a Target may transfer in the same tenancy in which it receives the command. Zero equals no limit.

Informational Exceptions Control Page

<table>
<tr><th>Bit
Byte</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td>PS</td><td>Reserved</td><td colspan="6">Page Code (1Ch)</td></tr>
<tr><td>1</td><td colspan="8">Page Length (0Ah)</td></tr>
<tr><td>2</td><td>Perf</td><td colspan="3">Reserved</td><td>DExcpt</td><td>Test</td><td>Reserved</td><td>LogErr</td></tr>
<tr><td>3</td><td colspan="4">Reserved</td><td colspan="4">MRIE</td></tr>
<tr><td>4</td><td colspan="8">(MSB)</td></tr>
<tr><td>5</td><td colspan="8" rowspan="2">Interval Timer</td></tr>
<tr><td>6</td></tr>
<tr><td>7</td><td colspan="8">(LSB)</td></tr>
<tr><td>8</td><td colspan="8">(MSB)</td></tr>
<tr><td>9</td><td colspan="8" rowspan="2">Report Count</td></tr>
<tr><td>10</td></tr>
<tr><td>11</td><td colspan="8">(LSB)</td></tr>
</table>

The **Informational Exceptions Control Page** is used to control the reporting and operations of certain "informational exceptions" (that sounds Politically Correct!); in other words, this page controls the behavior of a Target that has failure prediction capability. In the IDE/ATA world, this is known as "SMART".

Perf: 0 = delays caused by performing informational exception operations are acceptable.
1 = the Target may not cause delays while performing informational exception operations.

DExcpt: 0 = enable informational exception operations.
1 = disable informational exception operations.

Test: 0 = do not generate false device failures.
1 = generate a false device failure at the next interval time.

LogErr: 0 = logging of informational exception conditions is vendor specific.
1 = logging of informational exception conditions is enabled.

MRIE: Method of Reporting Informational Exceptions:
0 = do not report informational exceptions.
1 = report informational exceptions via Asynchronous Event Reporting.
2 = report informational exceptions via Unit Attention.
3 = report via RECOVERED ERROR dependent on setting of PER bit (see page 191).
4 = report via RECOVERED ERROR independent of setting of PER bit.
5 = report via CHECK CONDITION and NO SENSE sense code.
6 = report via unsolicited REQUEST SENSE command.
7-B = reserved
C-F = vendor specific

Interval Timer: minimum period in 100 millisecond intervals between reporting.

Report Count: the number of times to report an informational exception condition.

GENERAL CMDS

Power Condition Page

Byte \ Bit	7	6	5	4	3	2	1	0
0	PS	Reserved	Page Code (0Dh or 1Ah)					
1	Page Length (0Ah)							
2	Reserved							
3	Reserved						Idle	Standby
4	(MSB) Idle Condition Timer							
5								
6								
7								(LSB)
8	(MSB) Standby Condition Timer							
9								
10								
11								(LSB)

The **Power Condition Page** is used to control how the Logical Unit transitions to lower power modes.

Page Code: Yes, it's true. For Direct Access Devices, the Page Code is 0Dh. For all other device types, the Page Code is 1Ah.

Idle: 0 = the Logical Unit does not enter the Idle Condition
1 = wait based on the Idle Condition Timer before entering the Idle Condition.

Standby: 0 = the Logical Unit does not enter the Standby Condition
1 = wait based on the Standby Condition Timer before entering the Standby Condition.

Idle Condition Timer: minimum period in 100 millisecond increments before entering the Idle Condition.

Standby Condition Timer: minimum period in 100 millisecond increments before entering the Standby Condition.

GENERAL CMDS

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Commands for Direct Access Devices (alphabetic listing)

Command Name	Type	See Page	SCSI-3 Section	OpCode
CHANGE DEFINITION	O	See SPC	SPC 7.1	40h
COMPARE	O	See SPC	SPC 7.2	39h
COPY	O	See SPC	SPC 7.3	18h
COPY AND VERIFY	O	See SPC	SPC 7.4	3Ah
FORMAT UNIT	M	156	SBC 6.1.1	04h
INQUIRY	M	100	SPC 7.5	12h
LOCK/UNLOCK CACHE	O	162	SBC 6.1.2	36h
LOG SELECT	O	105	SPC 7.6	4Ch
LOG SENSE	O	106	SPC 7.7	4Dh
MODE SELECT(6)	O	107	SPC 7.8/9	15h
MODE SELECT(10)	O	107	SPC 7.8/9	55h
MODE SENSE(6)	O	108	SPC 7.10/11	1Ah
MODE SENSE(10)	O	108	SPC 7.10/11	5Ah
MOVE MEDIUM ATTACHED	O	See SMC	SMC 6.3	A7h
PERSISTENT RESERVE IN	O	110	SPC 7.12	5Eh
PERSISTENT RESERVE OUT	O	114	SPC 7.13	5Fh
PRE-FETCH	O	163	SBC 6.1.3	34h
PREVENT/ALLOW MEDIUM REMOVAL	O	116	SPC 7.14	1Eh
READ(6)	M	164	SBC 6.1.4	08h
READ(10)	M	164	SBC 6.1.5	28h
READ BUFFER	O	116	SPC 7.15	3Ch
READ CAPACITY	M	165	SBC 6.1.6	25h
READ DEFECT DATA	O	166	SBC 6.1.7	37h
READ ELEMENT STATUS ATTACHED	O	See SMC	SMC 6.5	B4h
READ LONG	O	168	SBC 6.1.8	3Eh
REASSIGN BLOCKS	O	169	SBC 6.1.9	07h
RECEIVE DIAGNOSTIC RESULTS	O	118	SPC 7.16	1Ch
RELEASE(6)	M	119	SPC 7.17	17h
RELEASE(10)	O	119	SPC 7.18	57h
REPORT LUNS	O	120	SPC 7.19	A0h
REQUEST SENSE	M	122	SPC 7.20	03h
RESERVE(6)	M	123	SPC 7.21	16h
RESERVE(10)	O	124	SPC 7.22	56h
REZERO UNIT	O	170	SBC 6.1.10	01h
SEARCH DATA HIGH/EQUAL/LOW	O	See SBC	SBC 6.1.11	30h/31h/32h
SEEK(6)	O	170	SBC 6.1.12	0Bh
SEEK(10)	O	170	SBC 6.1.12	2Bh
SEND DIAGNOSTIC	M	126	SPC 7.23	1Dh
SET LIMITS	O	See SBC	SBC 6.1.13	33h
START STOP UNIT	O	171	SBC 6.1.14	1Bh
SYNCHRONIZE CACHE	O	172	SBC 6.1.15	35h
TEST UNIT READY	M	128	SPC 7.24	00h
VERIFY	O	172	SBC 6.1.16	2Fh
WRITE(6)	M	173	SBC 6.1.17	0Ah
WRITE(10)	M	173	SBC 6.1.18	2Ah
WRITE AND VERIFY	O	174	SBC 6.1.19	2Eh
WRITE BUFFER	O	129	SPC 7.25	3Bh
WRITE LONG	O	174	SBC 6.1.20	3Fh
WRITE SAME	O	175	SBC 6.1.21	41h

Key: M = Command implementation is mandatory; O = Command implementation is optional.

Commands for Direct Access Devices (numeric listing)

OpCode	Type	See Page	SCSI-3 Section	Command Name
00h	M	128	SPC 7.24	TEST UNIT READY
01h	O	170	SBC 6.1.10	REZERO UNIT
03h	M	122	SPC 7.20	REQUEST SENSE
04h	M	156	SBC 6.1.1	FORMAT UNIT
07h	O	169	SBC 6.1.9	REASSIGN BLOCKS
08h	M	164	SBC 6.1.4	READ(6)
0Ah	M	173	SBC 6.1.17	WRITE(6)
0Bh	O	170	SBC 6.1.12	SEEK(6)
12h	M	100	SPC 7.5	INQUIRY
15h	O	107	SPC 7.8/9	MODE SELECT(6)
16h	M	123	SPC 7.21	RESERVE(6)
17h	M	119	SPC 7.17	RELEASE(6)
18h	O	See SPC	SPC 7.3	COPY
1Ah	O	108	SPC 7.10/11	MODE SENSE(6)
1Bh	O	171	SBC 6.1.14	START STOP UNIT
1Ch	O	118	SPC 7.16	RECEIVE DIAGNOSTIC RESULTS
1Dh	M	126	SPC 7.23	SEND DIAGNOSTIC
1Eh	O	116	SPC 7.14	PREVENT/ALLOW MEDIUM REMOVAL
25h	M	165	SBC 6.1.6	READ CAPACITY
28h	M	164	SBC 6.1.5	READ(10)
2Ah	M	173	SBC 6.1.18	WRITE(10)
2Bh	O	170	SBC 6.1.12	SEEK(10)
2Eh	O	174	SBC 6.1.19	WRITE AND VERIFY
2Fh	O	172	SBC 6.1.16	VERIFY
30h/31h/32h	O	See SBC	SBC 6.1.11	SEARCH DATA HIGH/EQUAL/LOW
33h	O	See SBC	SBC 6.1.13	SET LIMITS
34h	O	163	SBC 6.1.3	PRE-FETCH
35h	O	172	SBC 6.1.15	SYNCHRONIZE CACHE
36h	O	162	SBC 6.1.2	LOCK/UNLOCK CACHE
37h	O	166	SBC 6.1.7	READ DEFECT DATA
39h	O	See SPC	SPC 7.2	COMPARE
3Ah	O	See SPC	SPC 7.4	COPY AND VERIFY
3Bh	O	129	SPC 7.25	WRITE BUFFER
3Ch	O	116	SPC 7.15	READ BUFFER
3Eh	O	168	SBC 6.1.8	READ LONG
3Fh	O	174	SBC 6.1.20	WRITE LONG
40h	O	See SPC	SPC 7.1	CHANGE DEFINITION
41h	O	175	SBC 6.1.21	WRITE SAME
4Ch	O	105	SPC 7.6	LOG SELECT
4Dh	O	106	SPC 7.7	LOG SENSE
55h	O	107	SPC 7.8/9	MODE SELECT(10)
56h	O	124	SPC 7.22	RESERVE(10)
57h	O	119	SPC 7.18	RELEASE(10)
5Ah	O	108	SPC 7.10/11	MODE SENSE(10)
5Eh	O	110	SPC 7.12	PERSISTENT RESERVE IN
5Fh	O	114	SPC 7.13	PERSISTENT RESERVE OUT
A0h	O	120	SPC 7.19	REPORT LUNS
A7h	O	See SMC	SMC 6.3	MOVE MEDIUM ATTACHED
B4h	O	See SMC	SMC 6.5	READ ELEMENT STATUS ATTACHED

Key: M = Command implementation is mandatory; O = Command implementation is optional.

DISK CMDS

Common Fields Used In Direct Access Device Commands

Allocation Length: the maximum number of bytes that the Target may send to the Initiator.

DPO:
0 = any blocks transferred by this command may force blocks in the cache out of the cache
1 = any blocks transferred by this command do not force blocks in the cache out of the cache

FUA:
0 = Target may access the medium or the cache to transfer the data
1 = Target must access the medium

Logical Block Address (LBA): First logical block of requested operation.

RelAdr:
0 = Logical Block Address is absolute address
1 = Logical Block Address is relative to last address of previous command if this command is linked to the previous command:

- LBA field = 0 refers to the last block accessed in the previous command
- LBA field = 1 refers to the next block after the last block of the previous command

Transfer Length: Number of blocks or bytes to transfer.

The following "XOR" commands were not included in this edition of the SCSI Bench Reference. After they get fully incorporated into SBC, and if they prove popular, they will be included in the next edition.

- REBUILD (81h)
- REGENERATE (82h)
- XDREAD (52h)
- XDWRITE (50h)
- XDWRITE EXTENDED (80h)
- XPWRITE (51h)

CDB/Bit Cross Reference

Command Name	3rdPty	BytChk	CmdDt	CmpLst	CORRCT	DBD	DevOfl	DPO	EVPD	Extent	FmtData	FUA	Glist	Immed	Invert	LBdata	Lock	LoEj	LongID	Pad	PBdata	PCR	PF	Plist	PMI	PPC	Rdinh	RelAdr	Save	SelfTst	SP	SpnDat	Start	UnitOfl	Wrinh
CHANGE DEFINITION																													X						
COMPARE																				X															
COPY																				X															
COPY AND VERIFY																				X															
FORMAT UNIT				X							X																								
INQUIRY			X						X																										
LOCK/UNLOCK CACHE																	X											X							
LOG SELECT																						X									X				
LOG SENSE																										X					X				
MODE SELECT(6)																							X								X				
MODE SELECT(10)																							X								X				
MODE SENSE(6)						X																													
MODE SENSE(10)						X																													
PERSISTENT RESERVE IN																																			
PERSISTENT RESERVE OUT																																			
PRE-FETCH														X														X							
PREVENT/ALLOW MEDIUM REMOVAL																																			
READ(6)																																			
READ(10)								X				X																X							
READ BUFFER																																			
READ CAPACITY																									X			X							
READ DEFECT DATA													X											X											
READ LONG					X																							X							
REASSIGN BLOCKS																																			

Command Name	3rdPty	BytChk	CmdDt	CmpLst	CORRCT	DBD	DevOfl	DPO	EVPD	Extent	FmtData	FUA	Glist	Immed	Invert	LBdata	Lock	LoEj	LongID	Pad	PBdata	PCR	PF	Plist	PMI	PPC	Rdinh	RelAdr	Save	SelfTst	SP	SpnDat	Start	UnitOfl	Wrinh
RECEIVE DIAGNOSTIC RESULTS																																			
RELEASE(6)	X									X																									
RELEASE(10)	X									X									X																
REPORT LUNS																																			
REQUEST SENSE																																			
RESERVE(6)	X									X																									
RESERVE(10)	X									X									X																
REZERO UNIT																																			
SEARCH DATA EQUAL															X																	X			
SEARCH DATA HIGH															X																	X			
SEARCH DATA LOW															X																	X			
SEEK(6)																																			
SEEK(10)																																			
SEND DIAGNOSTIC							X																X							X				X	
SET LIMITS																											X								X
START/STOP UNIT														X				X															X		
SYNCHRONIZE CACHE														X														X							
TEST UNIT READY																																			
VERIFY		X						X																				X							
WRITE(6)																																			
WRITE(10)								X				X																X							
WRITE AND VERIFY		X						X																				X							
WRITE BUFFER																																			
WRITE LONG																												X							
WRITE SAME																X					X							X							

DISK CMDS

FORMAT UNIT Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (04h)							
1	{Logical Unit Number}			FmtData	CmpLst	Defect List Format		
2	Vendor-Specific							
3	(MSB) Interleave							
4								(LSB)
5	Control Byte							

* **FORMAT UNIT** is used to perform a "low level" format of the disk. SCSI disks perform management of defects from up to four different defect information sources:

Primary Defects (Plist): detected and stored on the disk by the manufacturer.

Certification (Clist): detected during the FORMAT UNIT command by verify passes after the format write passes.

Data list (Dlist): Transferred from the Initiator to the Target as part of a data transfer.

Grown Defects (Glist): Detected and stored on the disk as a result of previous FORMAT UNIT commands, REASSIGN BLOCKS commands, or automatic reassignments.

FmtData: 0 = no data transfer
1 = defect data and/or parameter data is transferred

CmpLst: 0 = add new Dlist to old Glist to make new Glist; use old Glist (see table, page 160)
1 = do not use Glist; delete old Glist; new Dlist becomes new Glist

Defect List Format: format of all Defect Descriptors in the defect list (see page 159):
000 = block format
001-011 = reserved
100 = bytes from index format
101 = physical sector format
110 = vendor specific format
111 = reserved

Interleave: usually specifies the average spacing between sectors:
00h = Target's default
01h = 1:1 interleave
02h and up = not defined by SCSI, but usually means 2:1 interleave and up.

DISK CMDS

FORMAT UNIT Defect List Data Transfer Format

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved							
1	FOV	DPRY	DCRT	STPF	IP	DSP	Immed	VU
2	(MSB) Defect List Length							
3								(LSB)
	Initialization Pattern Descriptor (if any)							
0	IP Modifier		Reserved					
1	Pattern Type							
2	(MSB) Initialization Pattern Length							
3								(LSB)
0 - xx	Initialization Pattern (if any)							
	Defect Descriptor(s) (if any)							
0 - xx	Defect Descriptor 0 (see page 159)							
	. . .							
0 - xx	Defect Descriptor n							

The **Format Defect List** is used to specify defects that are known by the Initiator, to control which defect sources are used or not used, and to specify the pattern to which each sector is initialized. If only part or none of the defect list is sent, the Target defaults hold.

FOV: 0 = no options set; DPRY, DCRT, STPF, IP, and DSP must be zero.
1 = DPRY, DCRT, STPF, IP, and DSP are valid. (see table, page 160)

DPRY: 0 = use the Primary Defect List (Plist).
1 = do not use the Plist (see table, page 160).

DCRT: 0 = do a certify pass; "Clist" is enabled (verify after format write).
1 = do not certify/verify after format write; Clist is disabled (see table, page 160).

STPF: 0 = do not stop if Target cannot find Plist or Glist (see note after table, page 161).
1 = stop if Target cannot find Plist and/or Glist, if that list has been selected to be during the format.

IP: 0 = no Initialization Pattern specified.
1 = initialization Pattern is included in the data transfer.

DSP: 0 = save all MODE SELECT savable parameters.
1 = do not save.

Immed: 0 = return status when format is complete.
1 = return status after all data is transferred from the Initiator.

VU: "vendor specific"

Defect List Length: length of Defect Descriptors (equals size of descriptor plus number of descriptors); does not include Initialization Pattern Length.

Initialization Pattern: specifies the initial data in each logical block.

IP Modifier: indicates how the pattern that follows is modified (by overlaying the first four bytes of the pattern):

00 = do not modify pattern
01 = four byte Logical Block Address is written at the start of each logical block.
10 = four byte Logical Block Address is written at the start of each physical sector.
11 = reserved

Pattern Type: 00h = default pattern; Pattern Length must be zero.
01h = repeat pattern to fill logical block; Pattern must be transferred.
02h - 7Fh = reserved
80h - FFh = vendor specific

Pattern Length: length of following bytes of pattern (not including Defect Descriptors).

Pattern: actual bytes that specify the pattern.

Defect Descriptor – Block Format

Byte	Defect Descriptor
0	(MSB)
1	Defective Block Address
2	
3	(LSB)

WARNING: Block Address may be a Logical Block Address or a physical block address, depending on the implementation. This is a real oddball. Probably the best thing to do is to not use it. Instead, if you must indicate logical blocks as defective, use the REASSIGN BLOCKS command before FORMAT UNIT. Another method is to issue a SEND DIAGNOSTIC command with the Translate Address page, and get back Bytes From Index defect data, which you can then use as Defect List data.

Defect Descriptor – Bytes From Index Format

Byte	Defect Descriptor
0	(MSB)
1	Cylinder Number of Defect
2	(LSB)
3	Head Number of Defect
4	(MSB)
5	Defect Bytes From Index
6	
7	(LSB)

Defect Descriptor – Physical Sector Format

Byte	Defect Descriptor
0	(MSB)
1	Cylinder Number of Defect
2	(LSB)
3	Head Number of Defect
4	(MSB)
5	Defective Sector Number
6	
7	(LSB)

DISK CMDS

Use of Defect Sources

FmtData	CmpLst	FOV	DPRY	DCRT	DLL	Description of Defect Sources
0	X	X	X	X	X	Dlist not used; Plist, Clist, Glist per default
1	0	0	X	X	0	Dlist not used; Glist used; Plist, Clist, per default
1	0	0	X	X	>0	Dlist, Glist used; Plist, Clist, per default
1	1	0	X	X	0	Dlist, Glist not used; previous Glist deleted; Plist, Clist, per default
1	1	0	X	X	>0	Dlist used; Glist not used; previous Glist deleted Plist, Clist, per default
1	0	1	0	0	0	Dlist not used; (*)Glist, (*)Plist, Clist used
1	0	1	0	0	>0	Dlist, (*)Glist, (*)Plist, Clist used
1	1	1	0	0	0	Dlist, Glist not used; previous Glist deleted; (*)Plist, Clist used
1	1	1	0	0	>0	Dlist, (*)Plist, Clist used; Glist not used; previous Glist deleted
1	0	1	0	1	0	Dlist, Clist not used; (*)Glist, (*)Plist used
1	0	1	0	1	>0	Dlist, (*)Glist, (*)Plist used; Clist not used
1	1	1	0	1	0	Dlist, Glist, Clist not used; previous Glist deleted; (*)Plist used
1	1	1	0	1	>0	Dlist, (*)Plist used; Clist not used; Glist not used; previous Glist deleted

DLL = Defect List Length in Defect List, ">0" means "length greater than zero"

(*): see footnote on next page....

DISK CMDS

Use of Defect Sources

FmtData	CmpLst	FOV	DPRY	DCRT	DLL	Description of Defect Sources
1	0	1	1	0	0	Dlist, Plist not used; (*)Glist, Clist used
1	0	1	1	0	>0	Dlist, (*)Glist, Clist used; Plist not used
1	1	1	1	0	0	Dlist, Plist, Glist not used; previous Glist deleted; Clist used
1	1	1	1	0	>0	Dlist, Clist used; Plist not used; Glist not used; previous Glist deleted
1	0	1	1	1	0	Dlist, Plist, Clist not used; Glist used
1	0	1	1	1	>0	Dlist, (*)Glist used; Plist, Clist not used
1	1	1	1	1	0	Dlist, Plist, Glist, Clist not used previous Glist deleted
1	1	1	1	1	>0	Dlist used; Clist, Plist not used; Glist not used; previous Glist deleted

DLL = Defect List Length in Defect List, ">0" means "length greater than zero"

(*): When the Initiator commands the Target to use the Plist and/or Glist, and either or both lists cannot be found, the STPF bit controls whether or not the format completes successfully (see page 157):

- STPF = 0: the Target continues even if the list(s) cannot be recovered.
- STPF = 1: the Target stops formatting the disk.

DISK CMDS

LOCK/UNLOCK CACHE Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (36h)							
1	{Logical Unit Number}			Reserved			Lock	RelAdr
2	(MSB) Logical Block Address							
3								
4								
5								(LSB)
6	Reserved							
7	(MSB) Number of Blocks							
8								(LSB)
9	Control Byte							

* **LOCK/UNLOCK CACHE** is used to specifify which logical blocks are to be kept available in cache. Usually used to keep often-used blocks handy. **WARNING**: Data must already be in the cache (use READ or PRE-FETCH) for the data to be locked.

Lock: 0 = allow blocks specified to be removed (unlock)
1 = lock specified blocks in cache if they are currently in the cache.

Number of Blocks: range of blocks to lock or unlock. Zero means do the rest of the disk.

DISK CMDS

PRE-FETCH Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (34h)							
1	{Logical Unit Number}			Reserved			Immed	RelAdr
2	(MSB)							
3	Logical Block Address							
4								
5								(LSB)
6	Reserved							
7	(MSB) Transfer Length							
8								(LSB)
9	Control Byte							

* **PRE-FETCH** is used to get the specified logical blocks into the cache memory. No data phase occurs.

Immed: 0 = return status when pre-fetch is complete
1 = return status after command is validated

DISK CMDS

READ(6) Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (08h)							
1	{Logical Unit Number}			(MSB)				
2	Logical Block Address							
3								(LSB)
4	Transfer Length							
5	Control Byte							

READ(10) Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (28h)							
1	{Logical Unit Number}			DPO	FUA	Reserved		RelAdr
2	(MSB)							
3	Logical Block Address							
4								
5								(LSB)
6	Reserved							
7	(MSB) Transfer Length							
8								(LSB)
9	Control Byte							

DISK CMDS

* **The READ commands** are used to transfer logical blocks from the Target to the Initiator.

See page 153 for a description of the DPO, FUA, RelAdr, Logical Block Address, and Transfer Length fields.

READ CAPACITY Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (25h)							
1	{Logical Unit Number}			Reserved				RelAdr
2	(MSB) Logical Block Address							
3								
4								
5								(LSB)
6	Reserved							
7	Reserved							
8	Reserved							PMI
9	Control Byte							

* **READ CAPACITY** is used to report the total number of blocks and block size of the disk.

PMI: 0 = report total capacity; the Logical Block Address in the READ CAPACITY Data is the last valid address
1 = report the next Logical Block Address after which a delay in access may occur. Causes for the delay may include:
- cylinder boundary
- head switch
- zone crossing
- seek to alternate sector or track

WARNING: Different SCSI disks will have different criteria for a delay.

DISK CMDS

READ CAPACITY Data

Byte	Description
0	(MSB) Logical Block Address
1	
2	
3	(LSB)
4	(MSB) Block Length
5	
6	
7	(LSB)

READ DEFECT DATA Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (37h)							
1	{Logical Unit Number}			Reserved				
2	Reserved			PList	GList	Defect List Format		
3	Reserved							
4								
5								
6								
7	(MSB) Allocation Length							
8	(LSB)							
9	Control Byte							

* **READ DEFECT DATA** reports the contents of the Plist and Glist which are recorded on the disk. See FORMAT UNIT command, page 156.

PList: 0 = do not return primary list (see page 156)
1 = return primary list

GList: 0 = do not return grown list (see page 156)
1 = return grown list

NOTE: If both the PList and GList bits are set to one, then both the lists are returned. The order in which they are returned is up to the Target.

DISK CMDS

Defect List Format: format of all defect descriptors in the defect list:
000 = block format
100 = bytes from index format
101 = physical sector format
110 = vendor specific format

Allocation Length: the maximum number of bytes that the Target may send to the Initiator.

READ DEFECT DATA Defect List

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved							
1	Reserved			PList	GList	Defect List Format		
2	(MSB) Defect List Length							
3								(LSB)
	Defect Descriptors							
0-n								

The **READ DEFECT DATA Defect List** begins with a four byte header which is followed by Defect Descriptors. See the FORMAT UNIT command for Defect Descriptor formats (page 156).

PList: 0 = Target did not return Plist data (see page 156)
1 = Target returned PList data

GList: 0 = Target did not return Glist data (see page 156)
1 = Target returned GList data

Defect List Format: format of the returned list:
000 = block format
100 = bytes from index format
101 = physical sector format
110 = vendor specific format

Defect List Length: number of following bytes; also, total data block length minus four.

DISK CMDS

READ LONG Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (3Eh)							
1	{Logical Unit Number}			Reserved			CORRCT	RelAdr
2	(MSB) Logical Block Address							
3								
4								
5								(LSB)
6	Reserved							
7	(MSB) Byte Transfer Length							
8								(LSB)
9	Control Byte							

* **READ LONG** is used to transfer to the Initiator the physical data recorded in a logical block, including the error correcting codes (ECC) and synchronization data.

CORRCT: 0 = do not correct errors with ECC
1 = correct data with ECC if necessary

Byte Transfer Length: exact number of bytes in physical sector data. See product documentation for physical sector size plus overhead byte length. Or, use the Quick and Dirty Method:

(1) Issue READ LONG with Byte Transfer Length equal to one. CHECK CONDITION Status is returned.

(2) Then issue REQUEST SENSE. If the ILI bit equals one, then the Information Bytes in the Sense Data will equal the number of bytes of physical data minus one.

REASSIGN BLOCKS Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (07h)							
1	{Logical Unit Number}			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Control Byte							

* **REASSIGN BLOCKS** is used to map out bad blocks without performing a **FORMAT UNIT** command.

WARNING: The Target does not have to move the data from the old physical location to the new location, though some do. The Initiator should perform data recovery before issuing this command.

REASSIGN BLOCKS Defect List

Byte	Defect List Header
0	Reserved
1	Reserved
2	(MSB) Defect List Length
3	(LSB)
	Defect Descriptor(s)
0	(MSB) Defect Logical Block Address
1	
2	
3	(LSB)

The **REASSIGN BLOCKS Defect List** specifies the bad blocks to relocate.

Defect List Length: length of following bytes; also, number of bad blocks times four.

DISK CMDS

REZERO UNIT Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (01h)							
1	{Logical Unit Number}			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Control Byte							

* **REZERO UNIT** requests that the disk be brought to a known state. Some disks will seek to physical track zero, others will seek to a location near logical block 0, others will do nothing.

SEEK(6) Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (0Bh)							
1	{Logical Unit Number}			(MSB)				
2	Logical Block Address							
3								(LSB)
4	Reserved							
5	Control Byte							

SEEK(10) Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (2Bh)							
1	{Logical Unit Number}			Reserved				
2	(MSB)							
3	Logical Block Address							
4								
5								(LSB)
6	Reserved							
7	Reserved							
8	Reserved							
9	Control Byte							

* **The SEEK Commands** request the Target to seek to the logical block, or somewhere near it. Some Targets do nothing in response to this command.

DISK CMDS

START/STOP UNIT Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (1Bh)							
1	{Logical Unit Number}			Reserved				Immed
2	Reserved							
3	Reserved							
4	Power Conditions				Reserved		LoEj	Start
5	Control Byte							

* **START/STOP UNIT** is typically used to spin up and spin down a rotating disk drive.

Immed: 0 = return status after operation is done
1 = return status after validating command

Power Conditions: controls the power condition of the Logical Unit:
0 = no change in power condition
1 = change to Active condition
2 = change to Idle condition
3 = change to Standby condition
4 = reserved
5 = change to Sleep condition
6 = reserved
7 = give control of power conditions to Logical Unit
8-9 = reserved
A = force Idle Condition Timer to zero
B = force Standby Condition Timer to zero
C-F = reserved

LoEj: 0 = don't load or unload/eject the medium
1 = load on start or unload/eject on stop

Start: 0 = stop (spin down)
1 = start (spin up)

SYNCHRONIZE CACHE Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (35h)							
1	{Logical Unit Number}			Reserved			Immed	RelAdr
2	(MSB) Logical Block Address							
3								
4								
5								(LSB)
6	Reserved							
7	(MSB) Number of Blocks							
8								(LSB)
9	Control Byte							

* **SYNCHRONIZE CACHE** is used to ensure that any data in the cache that has not been written to the medium is safely recorded on the medium.

Number of Blocks: Indicates the range (starting with the LBA) in which to ensure data is recorded on the medium. If this field is set to zero, then do all remaining logical blocks.

VERIFY Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (2Fh)							
1	{Logical Unit Number}			DPO	Reserved	Reserved	BytChk	RelAdr
2	(MSB) Logical Block Address							
3								
4								
5								(LSB)
6	Reserved							
7	(MSB) Verification Length							
8								(LSB)
9	Control Byte							

* **VERIFY** is used to verify data on the medium.

BytChk: 0 = do verify without data compare (use ECC, etc.); no data is transferred
1 = do verify with data compare; data is transferred

Verification Length: number of blocks to verify

DISK CMDS

WRITE(6) Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (0Ah)							
1	{Logical Unit Number}			(MSB)				
2	Logical Block Address							
3								(LSB)
4	Transfer Length							
5	Control Byte							

WRITE(10) Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (2Ah)							
1	{Logical Unit Number}			DPO	FUA	Reserved	Reserved	RelAdr
2	(MSB)							
3	Logical Block Address							
4								
5								(LSB)
6	Reserved							
7	(MSB)							
8	Transfer Length							(LSB)
9	Control Byte							

* **The WRITE Commands** are used to transfer logical blocks to the Target from the Initiator.

See page 153 for a description of the DPO, FUA, RelAdr, Logical Block Address, and Transfer Length fields.

DISK CMDS

WRITE AND VERIFY Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (2Eh)							
1	{Logical Unit Number}			DPO	Reserved	Reserved	BytChk	RelAdr
2	(MSB)							
3				Logical Block Address				
4								
5								(LSB)
6	Reserved							
7	(MSB)			Transfer Length				
8								(LSB)
9	Control Byte							

* **WRITE AND VERIFY** is used to transfer logical blocks to the Target from the Initiator and then verify the write.

BytChk: 0 = do verify without data compare (use ECC, etc.)
1 = do verify with data compare

WRITE LONG Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (3Fh)							
1	{Logical Unit Number}			Reserved				RelAdr
2	(MSB)							
3				Logical Block Address				
4								
5								(LSB)
6	Reserved							
7	(MSB)			Byte Transfer Length				
8								(LSB)
9	Control Byte							

* **WRITE LONG** is used to transfer the physical data to be recorded in a logical block, including the error correcting codes (ECC) and synchronization data.

Byte Transfer Length: exact number of bytes in physical sector data. See READ LONG, page 168.

WRITE SAME Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (41h)							
1	{Logical Unit Number}			Reserved		PBdata	LBdata	RelAdr
2	(MSB)							
3				Logical Block Address				
4								
5								(LSB)
6	Reserved							
7	(MSB)			Number of Blocks				
8								(LSB)
9	Control Byte							

* **WRITE SAME** is used to initialize a large number of blocks to the same data pattern. One logical block's worth of data is transferred from the Initiator.

PBdata: 0 = no function
1 = replace first eight bytes of data written to each physical sector with the physical sector address (the first eight bytes of data in each sector are overwritten).

LBdata: 0 = no function
1 = replace first four bytes of data written to each logical block with the Logical Block Address (the first four bytes of data in each sector are overwritten).

DISK CMDS

Direct Access Device Diagnostic Page Codes

Page Code	Description	SCSI-3 Section
00h	List of supported Pages (see page 128)	SPC 8.1.1
01h - 3Fh	Reserved (for all device type Pages)	
40h	Translate Address Page	SBC 7.1.1.1
41h	Drive Status Page	SBC 7.1.1.3
42h - 7Fh	Reserved	
80h - FFh	Vendor-specific Pages	

Translate Address Page – SEND DIAGNOSTIC

<table>
<tr><th>Byte \ Bit</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="8">Page Code (40h)</td></tr>
<tr><td>1</td><td colspan="8">Reserved</td></tr>
<tr><td>2</td><td colspan="8">(MSB)
Page Length (000Ah)</td></tr>
<tr><td>3</td><td colspan="8">(LSB)</td></tr>
<tr><td>4</td><td colspan="5">Reserved</td><td colspan="3">Supplied Format</td></tr>
<tr><td>5</td><td colspan="5">Reserved</td><td colspan="3">Translate Format</td></tr>
<tr><td>6</td><td colspan="8" rowspan="8">Address to Translate</td></tr>
<tr><td>7</td></tr>
<tr><td>8</td></tr>
<tr><td>9</td></tr>
<tr><td>10</td></tr>
<tr><td>11</td></tr>
<tr><td>12</td></tr>
<tr><td>13</td></tr>
</table>

Translate Address Page – RECEIVE DIAGNOSTIC

Byte \ Bit	7	6	5	4	3	2	1	0
0	Page Code (40h)							
1	Reserved							
2	(MSB) Page Length							
3								(LSB)
4	Reserved					Supplied Format		
5	RAREA	ALTSEC	ALTTRK	Reserved		Translated Format		
6–13	Translated Address 1							
14–21	Translated Address 2 (if required)							
n–nn	Translated Address n (if required)							

The **Translate Address Pages** are used to convert an address into another kind of address; usually a Logical Block Address into a physical address of some kind.

Page Length: the length of following bytes; also, equal to total Page length minus four.

Supplied Format and *Translate Format*:

000 = logical block format
100 = bytes from index format
101 = physical sector format
110 = vendor specific format

Address to Translate: format is specified by Supplied Format field

Translated Addresses: format is specified by Translate Format. More than one is returned if the physical position is not certain.

RAREA: 0 = translated address does not fall into a reserved area of the disk
1 = all or part of translated address lands in a reserved area of the disk

ALTSEC: 0 = translated address does not fall into an alternate sector of the disk
1 = all or part of translated address lands in an alternate sector of the disk

ALTTRK: 0 = translated address does not fall into an alternate track of the disk
1 = all or part of translated address lands in an alternate track of the disk

Drive Status Page – SEND DIAGNOSTIC

Bit / Byte	7	6	5	4	3	2	1	0
0	Page Code (41h)							
1	Reserved							
2	(MSB) Page Length (0008h)							
3								(LSB)
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							
8	Reserved							
9	Reserved							
10	Reserved							
11	Reserved							

DISK CMDS

Drive Status Page – RECEIVE DIAGNOSTIC

Byte \ Bit	7	6	5	4	3	2	1	0
0	Page Code (41h)							
1	Reserved							
2	(MSB) Page Length							
3								(LSB)
4	Reserved							
5	Reserved							
6	Reserved				Synchronization		RPL	
7	Reserved					SSIS	SSIE	SSSL
8 – 47	Reserved							
48 – nn	Vendor Specific							

The **Drive Status Pages** are used to determine the operational status of the drive.

Page Length: the length of following bytes; also, equal to total Page length minus four.

Synchronization: spindle sync status:
- 00 = status reporting not supported or status cannot be determined.
- 01 = spindle is synchronized with the reference signal.
- 10 = spindle cannot synchronize with the reference signal or reference signal is not present.
- 11 = spindle is in process of synchronizing with the reference signal.

RPL: as reported in Rigid Disk Drive Geometry Mode Page:
- 00 = sync disabled or not supported
- 01 = disk is a Slave
- 10 = disk is a Master
- 11 = disk is a Master Control

SSIS: 0 = valid spindle reference signal is being received.
1 = spindle reference signal is invalid.

SSIE: 0 = no internal failure.
1 = synchronous spindle electronics detected an internal failure.

SSSL: 0 = spindle reference signal is being received.
1 = no spindle reference signal is being received.

Log Page Codes for Direct Access Devices

Page Code	Description	SCSI-3 Section
00h	Supported Log Pages Page	SPC 8.2.6
01h	Buffer Over-run/Under-run Page	SPC 8.2.1
02h	Error Counter Page (Write)	SPC 8.2.2
03h	Error Counter Page (Read)	SPC 8.2.2
04h	Reserved	
05h	Error Counter Page (Verify)	SPC 8.2.2
06h	Non-Medium Error Page	SPC 8.2.5
07h	Last n Error Events Page	SPC 8.2.4
08h	Format Status Page	
09h - 0Ah	Reserved	
0Bh	Last n Deferred or Asynchronous Error Events Page	SPC 8.2.3
0Ch - 2Fh	Reserved	
30h - 3Eh	Vendor specific Pages	
3Fh	Reserved	

Parameter Codes for Format Status Page

Parameter Code	Description
0000h	Format DATA OUT Phase Data
0001h	Number of Grown Defects detected during Certification
0002h	Total blocks reallocated since last Format
0003h	Total blocks reallocated
0004h	Power-on minutes since last Format
0005h-7FFFh	Reserved
8000h-FFFFh	Vendor Specific

Direct Access Device Mode Parameters

The Density Code field in the Block Descriptor is not used for Direct Access devices.

Mode Page Codes (alphabetic)

Description	Page Code	SCSI-3 Section
Caching Page	08h	SBC 7.1.3.1
Control Mode Page (see page 144)	0Ah	SPC 8.3.4
Disconnect-Reconnect Page (see page 146)	02h	SPC 8.3.5
Flexible Disk Page (see SBC)	05h	SBC 7.1.3.2
Format Device Page	03h	SBC 7.1.3.3
Informational Exceptions Control Page (see page 148)	1Ch	SPC 8.3.6
Medium Types Supported Page (see SBC)	0Bh	SBC 7.1.3.4
Notch and Partition Page	0Ch	SBC 7.1.3.5
Peripheral Device Page (see SPC)	09h	SPC 8.3.7
Power Condition Page (see page 149)	0Dh	SPC 8.3.8
Read-Write Error Recovery Page	01h	SBC 7.1.3.6
Rigid Disk Geometry Page	04h	SBC 7.1.3.7
Verify Error Recovery Page	07h	SBC 7.1.3.8
XOR Control Mode Page (see SBC)	10h	SBC 7.1.3.9
Reserved	06h	
Reserved	0Dh - 0Fh	
Reserved	11h - 1Bh	
Reserved	1Dh - 1Fh	
Vendor-Specific (no Page format)	00h	
Vendor-Specific	20h - 3Eh	
Return all Pages (valid only for the MODE SENSE command)	3Fh	

Mode Page Codes (numeric)

Page Code	Description	SCSI-3 Section
00h	Vendor Specific (does not require Page format)	
01h	Read-Write Error Recovery Page	SBC 7.1.3.6
02h	Disconnect-Reconnect Page (see page 146)	SPC 8.3.5
03h	Format Device Page	SBC 7.1.3.3
04h	Rigid Disk Geometry Page	SBC 7.1.3.7
05h	Flexible Disk Page (see SBC)	SBC 7.1.3.2
06h	Reserved	
07h	Verify Error Recovery Page	SBC 7.1.3.8
08h	Caching Page	SBC 7.1.3.1
09h	Peripheral Device Page (see SPC)	SPC 8.3.7
0Ah	Control Mode Page (see page 144)	SPC 8.3.4
0Bh	Medium Types Supported Page (see SBC)	SBC 7.1.3.4
0Ch	Notch and Partition Page	SBC 7.1.3.5
0Dh	Power Condition Page (see page 149)	SPC 8.3.8
0Dh - 0Fh	Reserved	
10h	XOR Control Mode Page (see SBC)	SBC 7.1.3.9
11h - 1Bh	Reserved	
1Ch	Informational Exceptions Control Page (see page 148)	SPC 8.3.6
1Dh - 1Fh	Reserved	
20h - 3Eh	Vendor Specific	
3Fh	Return all Pages (valid only for the MODE SENSE command)	

DISK CMDS

Caching Page

Bit / Byte	7	6	5	4	3	2	1	0
0	PS	Reserved	Page Code (08h)					
1	Page Length (12h)							
2	IC	ABPF	CAP	DISC	SIZE	WCE	MF	RCD
3	Demand Read Retention Priority				Write Retention Priority			
4	(MSB)	Disable Pre-fetch Transfer Length						
5								(LSB)
6	(MSB)	Minimum Pre-fetch						
7								(LSB)
8	(MSB)	Maximum Pre-fetch						
9								(LSB)
10	(MSB)	Maximum Pre-fetch Ceiling						
11								(LSB)
12	FSW	LBCSS	DRA	VendSpec	VendSpec	Reserved		
13	Number of Cache Segments							
14	(MSB)	Cache Segment Size						
15								(LSB)
16	Reserved							
17	(MSB)	Non-Cache Segment Size						
18								
19								

The **Caching Page** is used to control the behavior of the cache memory.

IC: 0 = use Logical Units own caching algorithm.
1 = use Number of Cache Segments or Cache Segment Size field to establish the caching algorithm.

ABPF: 0 = Minimum Pre-fetch field is used to end a pre-fetch.
1 = abort prefetch upon selection, overrides Minimum Pre-fetch setting.

CAP: 0 = do not perform caching analysis.
1 = perform caching analysis during subsequent operations.

DISC: 0 = truncate pre-fetch at time discontinuity (e.g., cylinder boundary)
1 = pre-fetch may continue across a time discontinuity

SIZE: 0 = Number of Cache Seqments field is used to control cache segmentation.
1 = Cache Segment Size field is used to control cache segmentation.

DISK CMDS

WCE: 0 = write cache disabled: return status after data is written to disk
1 = write cache enabled: Target may return status after data is written to cache

MF: see Minimum Pre-fetch and Maximum Pre-fetch next page.

RCD: 0 = read cache enabled: Target can transfer data from cache
1 = read cache disabled: Target must get data from disk

Demand Read Retention Priority:
0000 = Target default
0001 = replace read data sooner than pre-fetch data
1111 = replace pre-fetch data sooner than read data
0010 - 1110 = reserved

Write Retention Priority:
0000 = Target default
0001 = replace write data sooner than pre-fetch data
1111 = replace pre-fetch data sooner than write data
0010 - 1110 = reserved

Disable Pre-fetch Transfer Length (DPTL): (advisory)
- if READ command transfer count > DPTL: don't do hidden pre-fetch after READ command is complete
- if READ command transfer count < DPTL: do hidden pre-fetch after READ command is complete

Minimum Pre-fetch: (adivsory) value that defines the minimum number of blocks to pre-fetch before servicing new read or write command. A value of zero indicates that the Target should stop pre-fetching whenever a new command is received:

if MF = 0: minimum pre-fetch blocks = Minimum Pre-fetch field
if MF = 1: minimum pre-fetch blocks = Minimum Pre-fetch field * Command Transfer Length from current command block

Maximum Pre-fetch: (advisory) value that defines the maximum number of blocks to pre-fetch. If the resulting value of this field is greater than the Maximum Pre-fetch Ceiling field, then the ceiling is used as the maximum number of blocks to pre-fetch:

if MF = 0: maximum pre-fetch blocks = Maximum Pre-fetch field
if MF = 1: maximum pre-fetch blocks = Maximum Pre-fetch field * Command Transfer Length from current command block

Maximum Pre-fetch Ceiling: (advisory) maximum number of blocks to pre-fetch if maximum pre-fetch blocks is greater than this field (see above).

FSW: 0 = the Logical Unit may re-order a write transfer to achieve faster completion.
1 = multiple block writes are transferred and written in ascending sequential logical block order.

LBCSS: 0 = Cache Segment Size field is the number of bytes in a cache segment.
1 = Cache Segment Size field is the number of Logical Blocks in a cache segment.

DRA: 0 = enable read-ahead.
1 = disable read-ahead (overrides all other pre-fetch fields).

Number of Cache Segments: (advisory) the number of segments to divide the cache.

Cache Segment Size: (advisory) the size of each segment in the cache, in units defined by the LBCSS bit (see above).

Non-Cache Buffer Size: (advisory) the size of the buffer in bytes to use for data transfer in the event of a cache miss.

Format Device Page

Byte \ Bit	7	6	5	4	3	2	1	0
0	PS	Reserved	Page Code (03h)					
1	Page Length in bytes (16h)							
2	(MSB) Tracks per Zone							
3								(LSB)
4	(MSB) Alternate Sectors per Zone							
5								(LSB)
6	(MSB) Alternate Tracks per Zone							
7								(LSB)
8	(MSB) Alternate Tracks per Logical Unit							
9								(LSB)
10	(MSB) Sectors per Track							
11								(LSB)
12	(MSB) Data Bytes per Physical Sector							
13								(LSB)
14	(MSB) Interleave							
15								(LSB)
16	(MSB) Track Skew Factor							
17								(LSB)
18	(MSB) Cylinder Skew Factor							
19								(LSB)
20	SSEC	HSEC	RMB	SURF	Reserved			
21	Reserved							
22	Reserved							
23	Reserved							

The **FORMAT DEVICE Page** is used to establish defect management and performance parameters relative to the disk format:

- Number and location of alternate sectors and tracks
- Physical sectors per track, sector size, and type
- Interleave and skew factors

In the following definitions, do not confuse the 'zones' defined here with what is sometimes known as 'Zoned Bit Recording' (ZBR). SCSI calls these zones 'Notches'. Zones here are defined only for alternate sector and track allocation, and may be allocated over a whole disk or over a Notch. When using a 'Notched' disk, the fields below may have different values defined for each Notch.

Tracks per Zone: Number of tracks (not cylinders) in which alternate sectors and tracks may be allocated. For example, if alternate sectors are allocated per cylinder, and there are eight tracks (heads) per cylinder, then set this field to eight.

Alternate Sectors per Zone: Specifies the number of alternate sectors in each of the zones defined by the Tracks per Zone field.

Alternate Tracks per Zone: Specifies the number of alternate tracks in each of the zones defined by the Tracks per Zone field.

Alternate Tracks per Logical Unit: Specifies the number of alternate tracks allocated for use by the entire disk. This field allocates alternate tracks separate from the Alternate Tracks per Zone field.

Sectors per Track: Number of physical sectors within a track.

Data Bytes per Physical Sector: Physical sector size; not necessarily the same as the logical block size.

Interleave: Same as the value passed in the FORMAT UNIT command. This field is only for reporting via MODE SENSE, and cannot be set via MODE SELECT.

Track Skew Factor: Number of physical sectors between the last logical block of one track and the first logical block of the next track within a cylinder.

Cylinder Skew Factor: Number of physical sectors between the last block on one cylinder and the first block of the next cylinder.

SSEC - HSEC: The combination of the two bits are defined differently for MODE SELECT and for different types of MODE SENSE data **(WARNING**: use these carefully):

MODE SENSE default values:

(SSEC | HSEC)
00 = invalid combination
01 = supports hard sector only
10 = supports soft sector only
11 = supports both

MODE SENSE changeable values:

(SSEC | HSEC)
00 = not changeable
01 = invalid combination
10 = invalid combination
11 = supports both

MODE SENSE current values:

(SSEC | HSEC)
00 = invalid combination
01 = currently set to format as hard sector
10 = currently set to format as soft sector
11 = invalid combination

MODE SENSE saved values:

(SSEC | HSEC)
00 = invalid combination
01 = currently formatted as hard sector
10 = currently formatted as soft sector
11 = invalid combination

MODE SELECT:

(SSEC | HSEC)
00 = invalid combination
01 = commands Target to format as hard sector
10 = commands Target to format as soft sector
11 = invalid combination

RMB (MODE SENSE ONLY):
0 = fixed media
1 = removable media

SURF: 0 = format by cylinder
1 = format by surface

Notch and Partition Page

Byte \ Bit	7	6	5	4	3	2	1	0
0	PS	Reserved	Page Code (0Ch)					
1	Page Length (16h)							
2	ND	LPN	Reserved					
3	Reserved							
4	(MSB) Maximum Number of Notches							
5								(LSB)
6	(MSB) Active Notch							
7								(LSB)
8	(MSB) Starting Boundary							
9								
10								
11								(LSB)
12	(MSB) Ending Boundary							
13								
14								
15								(LSB)
16	(MSB) Pages Notched							
17								
18								
19								
20								
21								
22								
23								(LSB)

The **NOTCH Page** is used to establish partitions or 'Notches' for what is sometimes called 'zoned bit recording' or 'constant bit density recording', where cylinders near the outer edge of the disk have more sectors per track than cylinders near the inner edge.

ND: 0 = no Notches
1 = Notched

LPN: (see Starting Boundary and Ending Boundary below):
0 = Notch boundaries defined by physical parameters
1 = Notch boundaries defined by Logical Block Addresses

DISK CMDS

Maximum Number of Notches: (MODE SENSE ONLY) number of Notches on the disk.

Active Notch: indicates the current Notch setting for MODE SELECT and MODE SENSE purposes. Zero indicates that subsequent MODE SELECT or MODE SENSE commands apply to all Notches. Any other value (less than the Maximum) indicates the Notch to which subsequent MODE SELECT or MODE SENSE commands apply.

Starting Boundary: determined by the state of the PLN bit (see above):
(LPN = 0) Four bytes indicate CYL:CYL:CYL:HEAD.
(LPN = 1) Four bytes indicate LBA.

Ending Boundary: determined by the state of the PLN bit (see above):
(LPN = 0) Four bytes indicate CYL:CYL:CYL:HEAD.
(LPN = 1) Four bytes indicate LBA.

Pages Notched: indicates which pages have parameters that can be set for each Notch. Bit 7 of Byte 16 corresponds to Page Code 3Fh, Bit 6 is 3Eh, and Bit 0 of Byte 23 is Page Code 00h.

Read/Write Error Recovery Page

Bit / Byte	7	6	5	4	3	2	1	0
0	PS	Reserved	Page Code (01h)					
1	Page Length (0Ah)							
2	AWRE	ARRE	TB	RC	EER	PER	DTE	DCR
3	Read Retry Count							
4	Correction Span							
5	Head Offset Count							
6	Data Strobe Offset Count							
7	Reserved							
8	Write Retry Count							
9	Reserved							
10	(MSB) Recovery Time Limit							
11	(LSB)							

The **Read/Write Error Recovery Page** is used to control the error recovery algorithm of the disk.

AWRE: 0 = do not reallocate on error during write
1 = reallocate defective blocks during write

ARRE: 0 = do not reallocate on error during read
1 = reallocate defective blocks during read

DISK CMDS

TB: 0 = do not transfer unrecoverable block
1 = transfer unrecoverable block

RC: 0 = error recovery may cause delay
1 = error recovery may not cause delay; data may be fabricated

EER: 0 = minimize miscorrection probability
1 = use most expedient error recovery

PER: 0 = do not report recovered errors
1 = report recovered errors

DTE: 0 = do not stop on recovered error
1 = stop after recovered error

DCR: 0 = use of ECC for error correction is allowed
1 = use ECC for error detection only

WARNING: The EER, PER, DTE, and DCR bits have "combination" meanings as well as separate definitions. Refer to the SBC standard for more detailed information.

NOTE: Invalid combinations of EER:PER:DTE:DCR are: 0010, 0011, 1001, 1010, 1011, 1101, 1111.

Read Retry Count: number of times to apply read recovery algorithm.

Correction Span: size in bits of largest error burst on which to attempt error correction.

WARNING: Different disk drives may handle the Correction Span field differently, particularly those with multiple burst capability. In any case, refer to the product documentation when using this field to regulate miscorrection probability.

Head Offset Count: signed position from track center.

Data Strobe Offset Count: signed position from nominal position of disk's read data recovery circuit.

Write Retry Count: number of times to apply write recovery algorithm.

Recovery Time Limit: number of milliseconds allowed for data recovery. NOTE: When this field and the Retry Counts are specified, use the lowest time duration.

Rigid Disk Drive Geometry Page

Bit / Byte	7	6	5	4	3	2	1	0
0	PS	Reserved	Page Code (04h)					
1	Page Length in bytes (16h)							
2	(MSB)							
3	Number of Cylinders							
4								(LSB)
5	Number of Heads							
6	(MSB)							
7	Starting Cylinder-Write Precompensation							
8								(LSB)
9	(MSB)							
10	Starting Cylinder-Reduced Write Current							
11								(LSB)
12	(MSB)							
13	Drive Step Rate							(LSB)
14	(MSB)							
15	Landing Zone Cylinder							
16								(LSB)
17	Reserved						RPL	
18	Rotational Offset							
19	Reserved							
20	(MSB)							
21	Medium Rotation Rate							(LSB)
22	Reserved							
23	Reserved							

The **Rigid Disk Drive Geometry Page** is used to read or set the physical geometry of the disk drive. It is mostly used for "bridge" controllers that must interface to a wide variety of separate disk drives (e.g., ST506 type).

Number of Cylinders: cylinders used for "data storage".

Number of Heads: heads used for "data storage", not counting heads dedicated for servo.

DISK CMDS

Drive Step Rate: number of 0.1 microsecond steps for a seek pulse.

RPL: used to control synchronize spindles:
00 = sync disabled or not supported
01 = disk is a Slave
10 = disk is a Master
11 = disk is a Master Control

Rotational Offset: rotational skew when synchronized (RO/256) to another disk spindle. A value of 128 indicates 1/2 revolution skew.

Medium Rotation Rate: disk rotation speed in revolutions per minute.

Verify Error Recovery Page

Byte \ Bit	7	6	5	4	3	2	1	0
0	PS	Reserved	Page Code (07h)					
1	Page Length (0Ah)							
2	Reserved				EER	PER	DTE	DCR
3	Verify Retry Count							
4	Verify Correction Span							
5	Reserved							
6	Reserved							
7	Reserved							
8	Reserved							
9	Reserved							
10	(MSB) Verify Recovery Time Limit							
11								(LSB)

The **Verify Error Recovery Page** is used to control the error recovery algorithm of the disk during verify.

DISK CMDS

EER: 0 = minimize miscorrection probability
1 = use most expedient error recovery

PER: 0 = do not report recovered errors
1 = report recovered errors

DTE: 0 = do not stop on recovered error
1 = stop after recovered error

DCR: 0 = use of ECC for error correction is allowed
1 = use ECC for error detection only

WARNING: The EER, PER, DTE, and DCR bits have "combination" meanings as well as separate definitions. Refer to the SCSI-2 or SBC standard for more detailed information.

NOTE: Invalid combinations of EER:PER:DTE:DCR are: 0010, 0011, 1001, 1010, 1011, 1101, 1111.

NOTE: Most rigorous verify is achieved when EER:PER:DTE:DCR is set to 0111 and retries and recovery limit are set to zero. This is probably the fastest verify as well.

Verify Retry Count: number of times to apply verify recovery algorithm.

Verify Correction Span: size in bits of largest error burst on which to attempt error correction.

Verify Recovery Time Limit: number of milliseconds allowed for data recovery. NOTE: When this field and the retry counts are specified, use the lowest time duration.

Commands for Sequential Access Devices (alphabetic listing)

Command Name	Type	See Page	SCSI-3 Section	OpCode
CHANGE DEFINITION	O	See SPC	SPC 7.1	40h
COMPARE	O	See SPC	SPC 7.2	39h
COPY	O	See SPC	SPC 7.3	18h
COPY AND VERIFY	O	See SPC	SPC 7.4	3Ah
ERASE	M	200	SSC 5.2.1	19h
FORMAT MEDIUM	O	200	SSC 5.2.2	04h
INQUIRY	M	100	SPC 7.5	12h
LOAD/UNLOAD	O	201	SSC 5.2.3	1Bh
LOCATE	O	202	SSC 5.2.4	2Bh
LOG SELECT	O	105	SPC 7.6	4Ch
LOG SENSE	O	106	SPC 7.7	4Dh
MODE SELECT(6)	M	107	SPC 7.8	15h
MODE SELECT(10)	O	107	SPC 7.9	55h
MODE SENSE(6)	M	108	SPC 7.10	1Ah
MODE SENSE(10)	O	108	SPC 7.11	5Ah
MOVE MEDIUM ATTACHED	O	See SMC	SMC 6.3	A7h
PERSISTENT RESERVE IN	O	110	SPC 7.12	5Eh
PERSISTENT RESERVE OUT	O	114	SPC 7.13	5Fh
PREVENT/ALLOW MEDIUM REMOVAL	O	116	SPC 7.14	1Eh
READ	M	203	SSC 5.2.5	08h
READ BLOCK LIMITS	M	204	SSC 5.2.6	05h
READ BUFFER	O	116	SPC 7.15	3Ch
READ ELEMENT STATUS ATTACHED	O	See SMC	SMC 6.5	B4h
READ POSITION	O	205	SSC 5.2.7	34h
READ REVERSE	O	210	SSC 5.2.8	0Fh
RECEIVE DIAGNOSTIC RESULTS	O	118	SPC 7.16	1Ch
RECOVER BUFFERED DATA	O	210	SSC 5.2.9	14h
RELEASE(6)	M	119	SPC 7.17	17h
RELEASE(10)	M	119	SPC 7.18	57h
REPORT DENSITY SUPPORT	M	211	SSC 5.2.10	44h
REPORT LUNS	O	120	SPC 7.19	A0h
REQUEST SENSE	M	122	SPC 7.20	03h
RESERVE(6)	M	123	SPC 7.21	16h
RESERVE(10)	M	124	SPC 7.22	56h
REWIND	M	214	SSC 5.2.11	01h
SEND DIAGNOSTIC	M	126	SPC 7.23	1Dh
SPACE	M	215	SSC 5.2.12	11h
TEST UNIT READY	M	128	SPC 7.24	00h
VERIFY	O	218	SSC 5.2.13	13h
WRITE	M	218	SSC 5.2.14	0Ah
WRITE BUFFER	O	129	SPC 7.25	3Bh
WRITE FILEMARKS	M	219	SSC 5.2.15	10h

Key: M = Command implementation is mandatory; O = Command implementation is optional.

TAPE CMDS

Commands for Sequential Access Devices (numeric listing)

OpCode	Type	See Page	SCSI-3 Section	Command Name
00h	M	128	SPC 7.24	TEST UNIT READY
01h	M	214	SSC 5.2.11	REWIND
03h	M	122	SPC 7.20	REQUEST SENSE
04h	O	200	SSC 5.2.2	FORMAT MEDIUM
05h	M	204	SSC 5.2.6	READ BLOCK LIMITS
08h	M	203	SSC 5.2.5	READ
0Ah	M	218	SSC 5.2.14	WRITE
0Fh	O	210	SSC 5.2.8	READ REVERSE
10h	M	219	SSC 5.2.15	WRITE FILEMARKS
11h	M	215	SSC 5.2.12	SPACE
12h	M	100	SPC 7.5	INQUIRY
13h	O	218	SSC 5.2.13	VERIFY
14h	O	210	SSC 5.2.9	RECOVER BUFFERED DATA
15h	M	107	SPC 7.8	MODE SELECT(6)
16h	M	123	SPC 7.21	RESERVE(6)
17h	M	119	SPC 7.17	RELEASE(6)
18h	O	See SPC	SPC 7.3	COPY
19h	M	200	SSC 5.2.1	ERASE
1Ah	M	108	SPC 7.10	MODE SENSE(6)
1Bh	O	201	SSC 5.2.3	LOAD/UNLOAD
1Ch	O	118	SPC 7.16	RECEIVE DIAGNOSTIC RESULTS
1Dh	M	126	SPC 7.23	SEND DIAGNOSTIC
1Eh	O	116	SPC 7.14	PREVENT/ALLOW MEDIUM REMOVAL
2Bh	O	202	SSC 5.2.4	LOCATE
34h	O	205	SSC 5.2.7	READ POSITION
39h	O	See SPC	SPC 7.2	COMPARE
3Ah	O	See SPC	SPC 7.4	COPY AND VERIFY
3Bh	O	129	SPC 7.25	WRITE BUFFER
3Ch	O	116	SPC 7.15	READ BUFFER
40h	O	See SPC	SPC 7.1	CHANGE DEFINITION
44h	M	211	SSC 5.2.10	REPORT DENSITY SUPPORT
4Ch	O	105	SPC 7.6	LOG SELECT
4Dh	O	106	SPC 7.7	LOG SENSE
55h	O	107	SPC 7.9	MODE SELECT(10)
56h	M	124	SPC 7.22	RESERVE(10)
57h	M	119	SPC 7.18	RELEASE(10)
5Ah	O	108	SPC 7.11	MODE SENSE(10)
5Eh	O	110	SPC 7.12	PERSISTENT RESERVE IN
5Fh	O	114	SPC 7.13	PERSISTENT RESERVE OUT
A0h	O	120	SPC 7.19	REPORT LUNS
A7h	O	See SMC	SMC 6.3	MOVE MEDIUM ATTACHED
B4h	O	See SMC	SMC 6.5	READ ELEMENT STATUS ATTACHED

Key: M = Command implementation is mandatory; O = Command implementation is optional.

Common Fields Used in Sequential Access Device Commands

Allocation Length: the maximum number of bytes that the Target may send to the Initiator.

Fixed:
- 0 = transfer one variable length block with length in bytes specified by the Transfer Length
- 1 = return the number of fixed length blocks specified by the Transfer Length; block length is specified in the MODE SELECT command

Immed:
- 0 = return status when operation is completed
- 1 = return status when command block has been validated

SILI:
- 0 = report incorrect block length when it occurs
- 1 = do not report incorrect block length when it occurs

Transfer Length: number of blocks or bytes to transfer.

TAPE CMDS

CDB/Bit Cross Reference

Command Name	3rdPty	BT	BytChk	BytCmp	CmdDt	CP	DBD	DevOfl	EOT	EVPD	Fixed	Immed	Load	Long	LongID	Media	Pad	PCR	PF	PPC	ReTen	Save	SelfTst	SILI	SP	TCLP	UnitOfl	Verify	WSmk
READ BUFFER																													
READ POSITION		X												X												X			
READ REVERSE											X													X					
RECEIVE DIAGNOSTIC RESULTS																													
RECOVER BUFFERED DATA											X													X					
RELEASE(6)	X																												
RELEASE(10)	X														X														
REPORT DENSITY SUPPORT																X													
REPORT LUNS																													
REQUEST SENSE																													
RESERVE(6)	X																												
RESERVE(10)	X														X														
REWIND												X																	
SEND DIAGNOSTIC								X											X				X				X		
SPACE																													
TEST UNIT READY																													
VERIFY				X							X	X																	
WRITE											X																		
WRITE BUFFER																													
WRITE FILEMARKS												X																	X
Command Name	3rdPty	BT	BytChk	BytCmp	CmdDt	CP	DBD	DevOfl	EOT	EVPD	Fixed	Immed	Load	Long	LongID	Media	Pad	PCR	PF	PPC	ReTen	Save	SelfTst	SILI	SP	TCLP	UnitOfl	Verify	WSmk

Command Name	3rdPty	BT	BytChk	BytCmp	CmdDt	CP	DBD	DevOfl	EOT	EVPD	Fixed	Immed	Load	Long	LongID	Media	Pad	PCR	PF	PPC	ReTen	Save	SelfTst	SILI	SP	TCLP	UnitOfl	Verify	WSmk
CHANGE DEFINITION																						X							
COMPARE																	X												
COPY																	X												
COPY AND VERIFY			X														X												
ERASE												X		X															
FORMAT MEDIUM														X														X	
INQUIRY					X					X																			
LOAD/UNLOAD									X			X	X								X								
LOCATE		X				X						X																	
LOG SELECT																		X							X				
LOG SENSE																				X					X				
MODE SELECT(6)																			X						X				
MODE SELECT(10)																			X						X				
MODE SENSE(6)							X																						
MODE SENSE(10)							X																						
PERSISTENT RESERVE IN																													
PERSISTENT RESERVE OUT																													
PREVENT/ALLOW MEDIUM REMOVAL																													
READ											X													X					
READ BLOCK LIMITS																													

TAPE CMDS

ERASE Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (19h)							
1	{Logical Unit Number}			Reserved			Immed	Long
2	Reserved							
3	Reserved							
4	Reserved							
5	Control Byte							

* **ERASE** causes all or part of the tape to be erased. Position at completion is not defined.

Long: 0 = write/erase a gap on the tape (see device configuration MODE SELECT Page, on page 228)
1 = erase from present position to End-Of-Medium

FORMAT MEDIUM Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (04h)							
1	{Logical Unit Number}			Reserved			Verify	Immed
2	Reserved				Format			
3	(MSB) Transfer Length							
4								(LSB)
5	Control Byte							

* **FORMAT MEDIUM** is used to prepare a tape for use by the Logical Unit.

Verify: 0 = do not perform a verify check.
1 = perform a verify check after the format.

Format: Specifies the format to use:
0 = use default format
1-7 = reserved
8-F = vendor specific

Transfer Length: number of bytes of format information to transfer. The format information is vendor specific.

TAPE CMDS

LOAD/UNLOAD Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (1Bh)							
1	{Logical Unit Number}			Reserved				Immed
2	Reserved							
3	Reserved							
4	Reserved					EOT	Re-Ten	Load
5	Control Byte							

* **LOAD/UNLOAD** is used to bring a tape on-line or take it off-line. Also does tape re-tension.

WARNING: This command does NOT transfer buffered data and/or marks to the medium. Do a WRITE FILEMARKS command (or similar operation) to complete transfer to tape before unload.

EOT: 0 = position tape at Beginning-Of-Medium when unloading
1 = position tape at End-Of-Medium when unloading

Re-Ten: 0 = do not re-tension
1 = re-tension the tape

Load: 0 = unload
1 = load and position to Beginning-Of-Partition zero

TAPE CMDS

LOCATE Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (2Bh)							
1	{Logical Unit Number}			Reserved		BT	CP	Immed
2	Reserved							
3	(MSB)							
4	Block Address							
5								
6								(LSB)
7	Reserved							
8	Partition							
9	Control Byte							

* **LOCATE** positions the tape to a location before the specified logical block and partition.

WARNING: This command does NOT transfer buffered data and/or marks to the medium. Do a WRITE FILEMARKS command (or similar operation) to complete transfer to tape before moving the tape to a new location.

BT: 0 = Block Address is SCSI Logical Block Address
1 = Block Address is vendor specific interpretation

CP: 0 = do not change partition; ignore Partition field
1 = change partition to the one specified in the *Partition* field prior to positioning to the Block Address

TAPE CMDS

READ Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (08h)							
1	{Logical Unit Number}			Reserved			SILI	Fixed
2	(MSB)							
3	Transfer Length							
4								(LSB)
5	Control Byte							

* **READ** is used to transfer one or more blocks from the Target to the Initiator beginning with the next block on the tape. Position at completion is after the last block transferred.

SILI: 0 = report incorrect block length when it occurs
1 = do not report incorrect block length when it occurs

Fixed: 0 = return one variable length block with length in bytes specified by the Transfer Length
1 = return the number of fixed length blocks specified by the Transfer Length; block length is specified in the MODE SELECT command (see page 140, 141).

TAPE CMDS

READ BLOCK LIMITS Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (05h)							
1	{Logical Unit Number}			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Control Byte							

* **READ BLOCK LIMITS** returns the possible block lengths for the logical unit. Position at completion is not defined; in most cases, position does not change.

READ BLOCK LIMITS Data

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved			Granularity				
1	(MSB) Maximum Block Length							
2								
3								(LSB)
4	(MSB) Minimum Block Length							
5								(LSB)

Granularity: supported block size granularity. The Granularity is a power of two; the desired block length minus the Minimum Block Length must be a multiple of $2^{Granularity}$

Maximum Block Length and *Minimum Block Length*:

- If the Maximum Block Length equals the Minimum Block Length, then only fixed length blocks of the indicated length are supported.
- If the Maximum Block Length is set to zero, there is no upper limit.

TAPE CMDS

READ POSITION Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (34h)							
1	{Logical Unit Number}			Reserved		TCLP	LONG	BT
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							
8	Reserved							
9	Control Byte							

* **READ POSITION** reports the current partition and logical position of the tape; and also reports on the state of the data buffer. Tape does not move.

TCLP: 0 = return data specifying the first and last block location with the number of bytes and blocks in the buffer.
1 = return data specifying the partition, file, and set number with the current logical position.

LONG: 0 = return 20 bytes of data (short data format); TCLP must be 0.
1 = return 32 bytes of data (long data format); TCLP must be 1.

BT: 0 = Block Address is SCSI Logical Block Address.
1 = Block Address is vendor specific interpretation.

TAPE CMDS

READ POSITION – Short Data Format

Bit / Byte	7	6	5	4	3	2	1	0
0	BOP	EOP	BCU	BYCU	Reserved	BPU	PERR	Reserved
1	Partition Number							
2	Reserved							
3	Reserved							
4	(MSB) First Block Location							
5								
6								
7								(LSB)
8	(MSB) Last Block Location							
9								
10								
11								(LSB)
12	Reserved							
13	(MSB) Number of Blocks in Buffer							
14								
15								(LSB)
16	(MSB) Number of Bytes in Buffer							
17								
18								
19								(LSB)

TAPE CMDS

BOP: 0 = current position is not Beginning-Of-Current-Partition
1 = current position is Beginning-Of-Current-Partition

EOP: 0 = current position is not between Early-Warning and End-of-Current-Partition
1 = current position is between Early-Warning and End-of-Current-Partition

BCU: 0 = Number of Blocks in Buffer field is valid.
1 = Number of Blocks in Buffer field is invalid; block count is unknown.

BYCU: 0 = Number of Bytes in Buffer field is valid.
1 = Number of Bytes in Buffer field is invalid; byte count is unknown.

BPU: 0 = First Block Location and Last Block Location fields are valid
1 = block positions are unknown

PERR: 0 = no overflow has occurred.
1 = the Logical Unit cannot return position data due to an overflow.

Partition Number: current partition number; zero if only one partition is supported

First Block Location: current logical block position: where a READ or WRITE would access next

Last Block Location: block address where last block of data currently in the buffer will be written.

TAPE CMDS

READ POSITION – Long Data Format

Byte \ Bit	7	6	5	4	3	2	1	0
0	BOP	EOP	Reserved		MPU	BPU	Reserved	
1	Reserved							
2	Reserved							
3	Reserved							
4	(MSB)							
5–6	Partition Number							
7								(LSB)
8	(MSB)							
9–14	Block Number							
15								(LSB)
16	(MSB)							
17–22	File Number							
23								(LSB)
24	(MSB)							
25–30	Set Number							
31								(LSB)

TAPE CMDS

BOP: 0 = current position is not Beginning-Of-Current-Partition
1 = current position is Beginning-Of-Current-Partition

EOP: 0 = current position is not between Early-Warning and End-of-Current-Partition
1 = current position is between Early-Warning and End-of-Current-Partition

MPU: 0 = File Number and Set Number fields are valid
1 = File Number and Set Number fields are unknown

BPU: 0 = Partition Number and Block Number fields are valid
1 = Partition Number and Block Number fields are unknown

Partition Number: current partition number; zero if only one partition is supported

Block Number: number of logical blocks between the beginning of partition and the current logical position.

File Number: number of filemarks between the beginning of partition and the current logical position.

Set Number: number of setmarks between the beginning of partition and the current logical position.

READ REVERSE Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (0Fh)							
1	{Logical Unit Number}			Reserved			SILI	Fixed
2	(MSB)							
3	Transfer Length							
4								(LSB)
5	Control Byte							

* **READ REVERSE** acts just like the READ command except tape motion is in the reverse direction. Byte order in the block(s) is reversed, but bit order is not. Position at completion is before the last block transferred.

RECOVER BUFFERED DATA Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (14h)							
1	{Logical Unit Number}			Reserved			SILI	Fixed
2	(MSB)							
3	Transfer Length							
4								(LSB)
5	Control Byte							

* **RECOVER BUFFERED DATA** acts just like the READ command except that data is transferred from the buffer instead of the tape. Block order is as defined by the RBO bit (see MODE SELECT Device Configuration Page, on page 228); default is: blocks are transferred to the Initiator in the same manner as they would be transferred to the medium. Tape does not move.

REPORT DENSITY SUPPORT Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (44h)							
1	{Logical Unit Number}			Reserved				Media
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB) Allocation Length							
8								(LSB)
9	Control Byte							

* **REPORT DENSITY SUPPORT** returns information regarding the supported densities.

Media: 0 = return density support information for any supported media.
1 = return density support information for the mounted medium.

TAPE CMDS

REPORT DENSITY SUPPORT Returned Data Format

Bit / Byte	7	6	5	4	3	2	1	0
0	(MSB)	Available Density Support Length						
1								(LSB)
2	Reserved							
3	Reserved							
	Density Support Data Block(s)							
0	Primary Density Code							
1	Secondary Density Code							
2	WrtOK	Dup	Deflt	Reserved				
3	Reserved							
4	Reserved							
5	(MSB)	Bits per mm						
6								
7								(LSB)
8	(MSB)	Media Width						
9								(LSB)
10	(MSB)	Tracks						
11								(LSB)
12	(MSB)	Capacity						
13								
14								
15								(LSB)
16 - 23	(MSB)	Assigning Organization (ASCII)						(LSB)
24 - 31	(MSB)	Density Name (ASCII)						(LSB)
32 - 51	(MSB)	Description (ASCII)						(LSB)

Available Density Support Length: number of bytes in following data; also, the number of Density Support Data Blocks times 52, plus 2.

The four byte header is followed by one or more Density Support Data Blocks.

TAPE CMDS

Primary Density Code: the MODE SELECT/MODE SENSE Density Code for the density described by this data block. See page 222 for the list of "recommended" Sequential Access Density Codes.

Secondary Density Code: if the density being reported can also be assigned to another Density Code value, the code is reported here. Otherwise, this is set equal to the Primary Density Code.

WrtOK: 0 = the Logical Unit cannot write this density.
1 = the Logical Unit is capable of writing this density.

Dup: 0 = this density has exactly one Density Support Data Block.
1 = this density has more than one Density Support Data Block.

Deflt: 0 = this density is not the default.
1 = this density is the default for the Logical Unit.

Bits per mm: the number of bits per millimeter per track, rounded to the nearest mm.

Media Width: the width of the medium in units of 0.1 millimeter.

Tracks: the number of tracks supported on the medium by this density.

Capacity: if the Media bit in the CDB is zero, this is the approximate capacity in megabytes of the longest supported medium in this density using one partition. If the Media bit is one, this is the approximate capacity in megabytes of the current medium. (One megabyte = 1,000,000 bytes.)

Assigning Organization: eight bytes of ASCII data that identifies the organization responsible for the specifications for this density.

Density Name: eight bytes of ASCII data that identifies the name of this density.

Description: twenty bytes of ASCII data that describes this density.

REWIND Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (01h)							
1	{Logical Unit Number}			Reserved				Immed
2	Reserved							
3	Reserved							
4	Reserved							
5	Control Byte							

* **REWIND** causes the tape to be positioned to the Beginning-Of-Current-Partition; Beginning-Of-Medium if there is only one partition.

TAPE CMDS

SPACE Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation (11h)							
1	{Logical Unit Number}			Reserved		Code		
2	(MSB)							
3	Count							
4								(LSB)
5	Control Byte							

* **SPACE** causes the tape to be positioned as specified by the *Count* and *Code* fields. The following table summarizes the possible combinations of Code, Count, and other parameters that affect the behavior of this command. The SPACE command is also affected by the setting of the RSmk and REW bits in the MODE SELECT Device Configuration Page (see page 228).

TAPE CMDS

Code	Count	Dir(*1)	Space over:	Stop positioning:
000	N	forward	blocks	• after N blocks • after a filemark • after a setmark when RSmk = 1 • after Early-Warning when REW = 1 • after End-Of-Data • at End-Of-Partition
000	-N	reverse	blocks	• after N blocks • after a filemark • after a setmark when RSmk = 1 • after Early-Warning when REW = 1 • after Beginning-Of-Data • at Beginning-Of-Partition
000	0	none	blocks	• do no positioning
001	N	forward	filemarks	• after N filemarks • after a setmark when RSmk = 1 • after Early-Warning when REW = 1 • after End-Of-Data • at End-Of-Partition
001	-N	reverse	filemarks	• after N filemarks • after a setmark when RSmk = 1 • after Early-Warning when REW = 1 • after Beginning-Of-Data • at Beginning-Of-Partition
001	0	none	filemarks	• do no positioning
010	N	forward	sequential filemarks	• after a group of N consecutive filemarks are detected • after a setmark when RSmk = 1 • after Early-Warning when REW = 1 • after End-Of-Data • at End-Of-Partition
010	-N	reverse	sequential filemarks	• after a group of N consecutive filemarks are detected • after a setmark when RSmk = 1 • after Early-Warning when REW = 1 • after Beginning-Of-Data • at Beginning-Of-Partition
010	0	none	sequential filemarks	• do no positioning

(*1): see footnote next page...

Code	Count	Dir(*1)	Space over:	Stop positioning:
011	N	forward	End Of Data	• after End-Of-Data
011	-N	forward	End Of Data	• after End-Of-Data
011	0	forward	End of Data	• after End-Of-Data
100	N	forward	setmarks	• after N setmarks • after Early-Warning when REW = 1 • after End-Of-Data • at End-Of-Partition
100	-N	reverse	setmarks	• after N setmarks • after Early-Warning when REW = 1 • after End-Of-Data • at Beginning-Of-Partition
100	0	none	setmarks	• do no positioning
101	N	forward	sequential setmarks	• after a group of N consecutive setmarks are detected • after Early-Warning when REW = 1 • after End-Of-Data • at End-Of-Partition
101	-N	reverse	sequential setmarks	• after a group of N consecutive setmarks are detected • after Early-Warning when REW = 1 • after Beginning-Of-Data • at Beginning-Of-Partition
101	0	none	sequential setmarks	• do no positioning
110	X	none	none	Reserved
111	X	none	none	Reserved

(*1): Direction to SPACE:

- forward indicates that the tape stops on the End-Of-Partition side of the object.
- reverse indicates that the tape stops on the Beginning-Of-Partition side of the object.

TAPE CMDS

VERIFY Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (13h)							
1	{Logical Unit Number}			Reserved		Immed	BytCmp	Fixed
2	(MSB)							
3	Verification Length							
4								(LSB)
5	Control Byte							

* **VERIFY** requests the verification of one or more blocks of data beginning with the next block on the tape. Position at completion is after the last block transferred.

BytCmp: 0 = verify with CRC, ECC, etc.
1 = transfer data from Initiator and do byte by byte compare

Verification Length: the number of bytes or blocks to verify, as defined by the Fixed bit.

WRITE Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (0Ah)							
1	{Logical Unit Number}			Reserved				Fixed
2	(MSB)							
3	Transfer Length							
4								(LSB)
5	Control Byte							

* **WRITE** requests the writing of one or more blocks of data beginning with the next block on the tape. Position at completion is after the last block transferred.

Fixed: 0 = write one variable length block with length in bytes specified by the Transfer Length
1 = write the number of fixed length blocks specified by the Transfer Length; Block Length is specified in the MODE SELECT command (see page 140, 141).

TAPE CMDS

WRITE FILEMARKS Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (10h)							
1	{Logical Unit Number}			Reserved			WSmk	Immed
2	(MSB)							
3	Transfer Length							
4								(LSB)
5	Control Byte							

* **WRITE FILEMARKS** is used to write one or more filemarks on the tape starting at the current position.

WSmk: 0 = Transfer Length is the number of filemarks to write
1 = Transfer Length is the number of setmarks to write

TAPE CMDS

Log Page Codes for Sequential Access Devices

Page Code	Description	SCSI-3 Section
00h	Supported Log Pages Page	SPC 8.2.6
01h	Buffer Over-run/Under-run Page	SPC 8.2.1
02h	Error Counter Page (Write)	SPC 8.2.2
03h	Error Counter Page (Read)	SPC 8.2.2
04h	Error Counter Page (Read Reverse)	SPC 8.2.2
05h	Error Counter Page (Verify)	SPC 8.2.2
06h	Non-Medium Error Page	SPC 8.2.5
07h	Last n Error Events Page	SPC 8.2.4
08h - 0Ah	Reserved	
0Bh	Last n Deferred or Asynchronous Error Events Page	SPC 8.2.3
0Ch	Sequential Access Device Page	SSC 5.3.2.1
0Dh - 2Fh	Reserved	
30h - 3Eh	Vendor specific Pages	
3Fh	Reserved	

Parameter Codes for Sequential Access Device Page

Parameter Code	Description
0000h	Number of bytes received from Initiator by WRITE commands
0001h	Number of data bytes written to media by WRITE commands
0002h	Number of data bytes read from media by READ commands
0003h	Number of data bytes sent to Initiator by READ commands
0004h-00FFh	Reserved
0100h	Cleaning required
0101h-7FFFh	Reserved
8000h-FFFFh	Vendor Specific

TAPE CMDS

Sequential Access Device Mode Parameters

Sequential Access Device Density Codes

Code Value	--Width--- mm	(Inch)	Tracks	--Density--- bpmm	(bpi)	Code	Type	Standard Reference	Record Mode
00h	Default (Target or peripheral device's default or only density)								
01h	12.7	(0.5)	9	32	(800)	NRZI	R	X3.22-1983	parallel
02h	12.7	(0.5)	9	63	(1,600)	PE	R	X3.39-1986	parallel
03h	12.7	(0.5)	9	246	(6,250)	GCR	R	X3.54-1986	parallel
04h	6.3	(0.25)	4/9	315	(8,000)	GCR	C	X3.136-1986	(*1)
05h	6.3	(0.25)	4/9	315	(8,000)	GCR	C	X3.136-1986	serial
06h	12.7	(0.5)	9	126	(3,200)	PE	R	X3.157-1987	parallel
07h	6.3	(0.25)	4	252	(6,400)	IMFM	C	X3.116-1986	serial
08h	3.81	(0.15)	4	315	(8,000)	GCR	CS	X3.158-1987	serial
09h	12.7	(0.5)	18	1491	(37,871)	GCR	C	X3B5/87-099	parallel
0Ah	12.7	(0.5)	22	262	(6,667)	MFM	C	X3B5/86-199	serial
0Bh	6.3	(0.25)	4	63	(1,600)	PE	C	X3.56-1986	serial
0Ch	12.7	(0.5)	24	500	(12,690)	GCR	C	HI-TC1	serial
0Dh	12.7	(0.5)	24	999	(25,380)	GCR	C	HI-TC2	serial
0Eh	Reserved for ECMA								
0Fh	6.3	(.25)	15	394	(10,000)	GCR	C	QIC120	serial
10h	6.3	(.25)	18	394	(10,000)	GCR	C	QIC150	serial
11h	6.3	(.25)	26	630	(16,000)	GCR	C	QIC320	serial
12h	6.3	(.25)	30	2034	(51,667)	RLL	C	QIC1350	serial
13h	3.81	(0.15)	1	2400	(61,000)	DDS	CS	X3B5/88-185A	helical
14h	8.0	(0.315)	1	1703	(43,245)	RLL	CS	X3.202-1991	helical
15h	8.0	(0.315)	1	1789	(45,434)	RLL	CS	ECMA TC17	helical
16h	12.7	(0.5)	48	394	(10,000)	MFM	C	X3.193-1990	serial
17h	12.7	(0.5)	48	1673	(42,500)	MFM	C	X3B5/91-174	serial
18h	12.7	(0.5)	112	1673	(42,500)	MFM	C	X3B5/92-50	serial
19h	(*3)								
1Ah	(*3)								
1Bh	(*3)								
1Ch	6.3	(0.25)	34	1654	(42,000)	MFM	C	QIC-385M	serial
1Dh	6.3	(0.25)	32	1512	(38,400)	GCR	C	QIC-410M	serial
1Eh	6.3	(0.25)	30	1385	(36,000)	GCR	C	QIC-1000C	serial
1Fh	6.3	(0.25)	30	2666	(67,733)	RLL	C	QIC-2100C	serial
20h	6.3	(0.25)	144	2666	(67,733)	RLL	C	QIC-6GB(M)	serial
21h	6.3	(0.25)	144	2666	(67,733)	RLL	C	QIC-20GB(C)	serial
22h	6.3	(0.25)	42	1600	(40,640)	GCR	C	QIC-2GB(C)	serial
23h	6.3	(0.25)	38	2666	(67,733)	RLL	C	QIC-875M	serial
24h	3.81	(0.15)	1	2400	(61,000)	(*3)	CS	DDS-2	helical
25h	3.81	(0.15)	1	3816	(97,000)	(*3)	CS	DDS-3	helical
26h	3.81	(0.15)	1	3816	(97,000)	(*3)	CS	DDS-4	helical
27h	8.0	(0.315)	1	3056	(77,611)	RLL	CS	(*3)	helical
28h	12.7	(0.5)	36	1491	(37,871)	GCR	C	X3B5/94-043A	serial
29h - 7Eh	Reserved								
7Fh	No change from previous density (NO-OP)								(*2)
80h - FFh	Vendor Unique								

Key:

Code		Type	
NRZI	Non Return to Zero, change on ones	R	Reel-to-Reel
GCR	Group Code Recording	C	Cartridge
PE	Phase Encoded	CS	Cassette
IMFM	Inverted Modified Frequency Modulation		
MFM	Modified Frequency Modulation		
DDS	DAT Data Storage		

(*1): Old format known as QIC-11; serially recorded.
(*2): MODE SELECT only; this code is not returned by MODE SENSE.
(*3): Information not available when we went to press.

GENERAL NOTE: With SCSI-3, Logical Units are no longer required to use the density codes listed in this table. However, it is highly recommended!

Mode Page Codes (alphabetic)

Description	Page Code	SCSI-3 Section
Control Mode Page (see page 144)	0Ah	SPC 8.3.4
Data Compression Page	0Fh	SSC 5.3.3.1
Device Configuration Page	10h	SSC 5.3.3.2
Disconnect-Reconnect Page (see page 146)	02h	SPC 8.3.5
Informational Exceptions Control Page (see page 148)	1Ch	SPC 8.3.6
Medium Partition Page(1)	11h	SSC 5.3.3.3
Medium Partition Page(2)	12h	SSC 5.3.3.4
Medium Partition Page(3)	13h	SSC 5.3.3.4
Medium Partition Page(4)	14h	SSC 5.3.3.4
Peripheral Device Page (see SPC)	09h	SPC 8.3.7
Power Condition Page (see page 149)	1Ah	SPC 8.3.8
Read-Write Error Recovery Page	01h	SSC 5.3.3.5
Reserved	03h - 08h	
Reserved	0Bh - 0Eh	
Reserved	15h - 19h	
Reserved	1Bh	
Reserved	1Dh - 1Fh	
Vendor Specific (no Page format)	00h	
Vendor Specific (Page format required)	15h - 3Eh	
Returns all Pages (valid only for the MODE SENSE command)	3Fh	

TAPE CMDS

Mode Page Codes (numeric)

Page Code	Description	SCSI-3 Section
00h	Vendor Specific (does not require Page format)	
01h	Read-Write Error Recovery Page	SSC 5.3.3.5
02h	Disconnect-Reconnect Page (see page 146)	SPC 8.3.5
03h - 08h	Reserved	
09h	Peripheral Device Page (see SPC)	SPC 8.3.7
0Ah	Control Mode Page (see page 144)	SPC 8.3.4
0Bh - 0Eh	Reserved	
0Fh	Data Compression Page	SSC 5.3.3.1
10h	Device Configuration Page	SSC 5.3.3.2
11h	Medium Partition Page(1)	SSC 5.3.3.3
12h	Medium Partition Page(2)	SSC 5.3.3.4
13h	Medium Partition Page(3)	SSC 5.3.3.4
14h	Medium Partition Page(4)	SSC 5.3.3.4
15h - 19h	Reserved	
1Ah	Power Condition Page (see page 149)	SPC 8.3.8
1Bh	Reserved	
1Ch	Informational Exceptions Control Page (see page 148)	SPC 8.3.6
1Dh - 1Fh	Reserved	
20h - 3Eh	Vendor Specific (Page format required)	
3Fh	Returns all Pages (valid only for the MODE SENSE command)	

TAPE CMDS

Data Compression Page

Byte \ Bit	7	6	5	4	3	2	1	0
0	PS	Reserved	Page Code (0Fh)					
1	Page Length (0Eh)							
2	DCE	DCC	Reserved					
3	DDE	RED		Reserved				
4	(MSB) Compression Algorithm							
5								
6								
7								(LSB)
8	(MSB) Decompression Algorithm							
9								
10								
11								(LSB)
12	Reserved							
13	Reserved							
14	Reserved							
15	Reserved							

The **Data Compression Page** is used to control data compression.

DCE: 0 = disable data compression
1 = enable data compression

DCC: 0 = device does not support data compression
1 = device supports data compression

DDE: 0 = disable data decompression
1 = enable data decompression

TAPE CMDS

RED:
- 00 = return CHECK CONDITION when boundary between decompressible/uncompressed data and un-decompressible data is detected.
- 01 = same as 00, also return CHECK CONDITION when boundary between un-decompressible data and decompressible/uncompressed data is detected.
- 10 = same as 01, also return CHECK CONDITION when boundary between uncompressed data and decompressible data, or when boundary between data compressed using two different algorithms is detected.
- 11 = reserved

Compression Algorithm: indicates the algorithm to use when compressing data:
- 00000000h = no algorithm selected/uncompressed data
- 00000010h = IBM IDRC data compaction algorithm
- 00000020h = DCLZ data compression algorithm
- 000000FFh = unregistered (with ISO/IEC JTC1) algorithm
- all other values = reserved.

Decompression Algorithm: indicates the algorithm to use when decompressing data, or the algorithm that was last used. Same values in table above.

TAPE CMDS

Device Configuration Page

Byte \ Bit	7	6	5	4	3	2	1	0
0	PS	Reserved	Page Code (10h)					
1	Page Length (0Eh)							
2	Reserved	CAP	CAF	Active Format				
3	Active Partition							
4	Write Buffer Full Ratio							
5	Read Buffer Empty Ratio							
6	(MSB) Write Delay Time							
7								(LSB)
8	DBR	BIS	RSmk	AVC	SOCF		RBO	REW
9	Gap Size							
10	EOD Defined			EEG	SEW	SWP	Reserved	
11	(MSB) Buffer Size at Early-Warning							
12								
13								(LSB)
14	Select Data Compression Algorithm							
15	Reserved							

The **Device Configuration Page** is used for assorted sequential access device parameters.

CAP: 0 = do not change partition
1 = change logical partition to the one specified by the Active Partition field

CAF: 0 = do not change active format
1 = change the active format to the one specified by the Active Format field

Active Format: 00000 = default recording format
00001 - 11111 = format to use with selected density code

Active Partition: Current logical partition

Write Buffer Full Ratio (WBFR): indicates how full the buffer should be (WBFR/256) on a WRITE command before writing the data to the tape.

Read Buffer Empty Ratio (RBER): indicates how empty the buffer should be (RBER/256) on a READ command before reading the data from the tape

Write Delay Time: maximum time (in 0.1 second increments) to hold data in the buffer before writing data to the tape

DBR: 0 = Target does not support RECOVERED BUFFERED DATA command
1 = Target supports RECOVERED BUFFERED DATA command

BIS: 0 = tape format does not support block identifiers
1 = tape format supports block identifiers relative to a partition

RSmk: 0 = do not report setmarks
1 = report setmarks

AVC: 0 = use speed selected by the Speed field in the MODE SELECT/MODE SENSE Header (see page 139)
1 = select speed appropriate for best streaming activity (e.g., less "shoe-shine" on streaming tape)

SOCF: 00 = in Buffered Mode, pre-read to buffer limit ignoring filemarks
01 = in Buffered Mode, stop read if one consecutive filemark is detected
10 = in Buffered Mode, stop read if two consecutive filemarks are detected
11 = in Buffered Mode, stop read if three consecutive filemarks are detected

RBO: 0 = for a RECOVERED BUFFERED DATA command (see page 210), data is returned in First-In-First-Out order relative to the order written into the buffer
1 = for a RECOVERED BUFFERED DATA command, data is returned in Last-In-First-Out order relative to the order written into the buffer

REW: 0 = do not report Early-Warning during READ or SPACE; report Early-Warning during write
1 = report Early-Warning as End-Of-Medium

Gap Size: 00h = Target defined gap size
01h = gap size big enough to perform update-in-place
02h - 0Fh = multiples of Target defined gap size
10h - 7Fh = reserved
80h - FFh = Target defined

EOD Defined:
000 = Target defined End-Of-Data definition
001 = End-Of-Data is defined by an erased area of medium appropriate to the format
010 = End-Of-Data is equivalent to the number of consecutive filemarks indicated by the SOCF field (see above)
011 = Target cannot detect or generate End-Of-Data area
100-111 = reserved

EEG: 0 = End-Of-Data generation indicated by the EOD Defined field is disabled
1 = End-Of-Data generation indicated by the EOD Defined field is enabled

SEW: 0 = do not write buffered data, filemarks, or setmarks to tape when Early-Warning is detected
1 = write buffered data, filemarks, or setmarks to tape when Early-Warning is detected

SWP: 0 = do not inhibit writes due to this bit
1 = inhibit all writes to medium for subsequent commands

Buffer Size at Early-Warning: the reduced size of the Target data buffer when tape is positioned between Early-Warning and End-Of-Partition

Select Data Compression Algorithm:
- 00h = do not do data compression
- 01h = Target default compression algorithm
- 02h - 7Fh = reserved
- 80h - FFh = Target defined

Medium Partition Page(1)

Byte \ Bit	7	6	5	4	3	2	1	0
0	PS	Reserved	Page Code (11h)					
1	Page Length (n-1)							
2	Maximum Additional Partitions							
3	Additional Partitions Defined							
4	FDP	SDP	IDP	PSUM		Reserved	CLEAR	ADDP
5	Medium Format Recognition							
6	Reserved				Partition Units			
7	Reserved							
8 - n	Partition Size Descriptor(s)							
0	(MSB) Partition Size							
1								(LSB)

The **Medium Partition Page (1)** is used to specify the first group of partitions.

Page Length: set to the number of Partition Size Descriptors plus eight.

Maximum Additional Partitions: maximum number of partitions supported by the Target. Zero indicates that the maximum is not specified.

The following table defines the use of the *Additional Partitions Defined (APD) field*, the *FDP*, *SDP*, and *IDP* bits, the *PSUM* field, and the *Partition Size Descriptors (PSDs)*:

FDP	SDP	IDP	PSUM	APD definition	PSD definition	Description
0	0	0	XX	no function	no function	no function
1	0	0	XX	no function	no function	Target defined partition assignment
0	1	0	XX	number of partitions to create	no function	Initiator defined number of partitions
0	0	1	00	number of partitions to create	size of each partition in bytes	Initiator defined number and size of partitions
0	0	1	01	number of partitions to create	size of each partition in kilobytes	Initiator defined number and size of partitions
0	0	1	10	number of partitions to create	size of each partition in megabytes	Initiator defined number and size of partitions
0	0	1	11	number of partitions to create	size of each partition in 10^P.U. bytes	Initiator defined number and size of partitions
1	1	0	XX		not allowed	
1	0	1	XX		not allowed	
0	1	1	XX		not allowed	
1	1	1	XX		not allowed	

CLEAR: 0 = do not erase partitions.
1 = erase partitions based on ADDP bit.

ADDP: 0 = when CLEAR = 1, logically erase every partition if IDP, FDP, or SDP is one.
1 = when CLEAR = 0, do not logically erase existing partitions even if size changes.
when CLEAR = 1, logically erase only existing partitions whose size changes.

Medium Format Recognition:
00h = Logical Unit cannot recognize format or partition
01h = Logical Unit can only recognize format
02h = Logical Unit can only recognize partition
03h = Logical Unit can recognize both format and partition
04h - FFh = reserved

Partition Size Descriptors: define the sizes (when IDP is set) of partitions 0 - 255. Units are defined by the PSUM field as shown in the table above. Partitions 64 - 255 are defined by the Pages described on the next page.

Partition Units: the power of 10 units of measure when PSUM = 11; e.g., when P.U. = 9, the units of measure are gigabytes.

TAPE CMDS

Medium Partition Page(2-4)

Bit / Byte	7	6	5	4	3	2	1	0
0	PS	Reserved	Page Code (p)					
1	Page Length (n-1)							
2 - n	Partition Size Descriptor(s)							
0	(MSB) Partition Size							
1								(LSB)

The **Medium Partition Pages (2), (3), and (4)** are used to specify the sizes of partitions beyond the ones that can be specified by Medium Partition Page (1).

Page Code (p): is set corresponding to the range of Partition Sizes to define (see below).

Page Length: set to the number of Partition Size Descriptors plus two.

Partition Size Descriptors: the units of the size field are defined in the Medium Partition Page (1) (above). The partition size descriptor is not used if the IDP bit of Page (1) is zero.

- Medium Partition Page (2): Page Code 12h. Define the sizes of partitions 64 - 127.
- Medium Partition Page (3): Page Code 13h. Define the sizes of partitions 128 - 191.
- Medium Partition Page (4): Page Code 14h. Define the sizes of partitions 192 - 255.

Read Write Error Recovery Page

Bit / Byte	7	6	5	4	3	2	1	0
0	PS	Reserved	Page Code (01h)					
1	Page Length (0Ah)							
2	Reserved	Reserved	TB	Reserved	EER	PER	DTE	DCR
3	Read Retry Count							
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							
8	Write Retry Count							
9	Reserved							
10	Reserved							
11	Reserved							

TAPE CMDS

The **Read-Write Error Recovery Page** is used to specify the error recovery by the Logical Unit when transferring data between the Initiator and the medium.

TB: 0 = unrecoverable data block is not transferred to the Initiator
1 = unrecoverable data block is transferred to the Initiator

EER: 0 = use most deliberate error recovery algorithm
1 = use most expedient error recovery algorithm

PER: 0 = do not report recovered errors
1 = report recovered errors

DTE: 0 = do not terminate on a recovered error
1 = terminate on a recovered error

DCR: 0 = use of error correcting codes is allowed
1 = do not use error correcting codes

WARNING: Unlike disk, the EER, PER, DTE, and DCR bits have no combination meanings or invalid combinations.

Read Retry Count: number of read recovery attempts before reporting an unrecoverable error. Zero means disable recovery.

Write Retry Count: number of write recovery attempts before reporting an unrecoverable error. Zero means disable recovery.

Commands for Processor Devices (alphabetic listing)

Command Name	Type	See Page	SCSI-3 Section	OpCode
CHANGE DEFINITION	O	See SPC	SPC 7.1	40h
COMPARE	O	See SPC	SPC 7.2	39h
COPY	O	See SPC	SPC 7.3	18h
COPY AND VERIFY	O	See SPC	SPC 7.4	3Ah
INQUIRY	M	100	SPC 7.5	12h
LOG SELECT	O	105	SPC 7.6	4Ch
LOG SENSE	O	106	SPC 7.7	4Dh
READ BUFFER	O	116	SPC 7.15	3Ch
RECEIVE	O	236	SPC 9.1	08h
RECEIVE DIAGNOSTIC RESULTS	O	118	SPC 7.16	1Ch
RELEASE(6)	M	119	SPC 7.17	17h
RELEASE(10)	M	119	SPC 7.18	57h
REPORT LUNS	O	120	SPC 7.19	A0h
REQUEST SENSE	M	122	SPC 7.20	03h
RESERVE(6)	M	123	SPC 7.21	16h
RESERVE(10)	M	124	SPC 7.22	56h
SEND	M	237	SPC 9.2	0Ah
SEND DIAGNOSTIC	M	126	SPC 7.23	1Dh
TEST UNIT READY	M	128	SPC 7.24	00h
WRITE BUFFER	O	129	SPC 7.25	3Bh

Key: M = Command implementation is mandatory; O = Command implementation is optional.

TAPE CMDS

Commands for Processor Devices (numeric listing)

OpCode	Type	See Page	SCSI-3 Section	Command Name
00h	M	128	SPC 7.24	TEST UNIT READY
03h	M	122	SPC 7.20	REQUEST SENSE
08h	O	236	SPC 9.1	RECEIVE
0Ah	M	237	SPC 9.2	SEND
12h	M	100	SPC 7.5	INQUIRY
16h	M	123	SPC 7.21	RESERVE(6)
17h	M	119	SPC 7.17	RELEASE(6)
18h	O	See SPC	SPC 7.3	COPY
1Ch	O	118	SPC 7.16	RECEIVE DIAGNOSTIC RESULTS
1Dh	M	126	SPC 7.23	SEND DIAGNOSTIC
39h	O	See SPC	SPC 7.2	COMPARE
3Ah	O	See SPC	SPC 7.4	COPY AND VERIFY
3Bh	O	129	SPC 7.25	WRITE BUFFER
3Ch	O	116	SPC 7.15	READ BUFFER
40h	O	See SPC	SPC 7.1	CHANGE DEFINITION
4Ch	O	105	SPC 7.6	LOG SELECT
4Dh	O	106	SPC 7.7	LOG SENSE
56h	M	124	SPC 7.22	RESERVE(10)
57h	M	119	SPC 7.18	RELEASE(10)
A0h	O	120	SPC 7.19	REPORT LUNS

Key: M = Command implementation is mandatory; O = Command implementation is optional.

TAPE CMDS

RECEIVE Command

Byte \ Bit	7	6	5	4	3	2	1	0
0	Operation Code (08h)							
1	{Logical Unit Number}			Reserved				
2	(MSB)							
3	Allocation Length							
4								(LSB)
5	Control Byte							

* **RECEIVE** requests a data packet from the Target.

Allocation Length: maximum number of bytes that the Target may send.

TAPE CMDS

SEND Command

Bit / Byte	7	6	5	4	3	2	1	0
0	Operation Code (0Ah)							
1	{Logical Unit Number}			Reserved				AEN
2	(MSB)							
3	Transfer Length							
4								(LSB)
5	Control Byte							

* **SEND** is used to send a data packet to the Target.

AEN: Called "AER" in SPC:
0: data not defined by SCSI standard
1: data format is as shown below

Transfer Length: number of bytes the Initiator wishes to send.

SCSI–2 SEND Command AEN Data Format

Bit / Byte	7	6	5	4	3	2	1	0
0	SCSI-3	Reserved	LUNTAR	Reserved		Logical Unit Number/LUNTRN		
1	Sub-logical Unit Number							
2	Reserved							
3	Reserved							
4 to	Sense Data Byte (0)							
n-4	Sense Data Byte (n)							

The **Asynchronous Event Notification (AEN) Data Format** is used by a device to inform another device in the system of a deferred error or other exception without waiting for the other device to send a command. This data is only sent to Processor devices that return INQUIRY data with the AENC bit set to one.

SCSI-3: 0 = SCSI-2 format as shown above.
1 = SCSI-3 format as shown on the following page.

LUNTAR: 0 = bits 2-0 of this byte indicate the Logical Unit that had the error
1 = bits 2-0 of this byte indicate the Target Process that had the error

LUNTRN: as defined by LUNTAR.

Sense Data: as it would be returned using the REQUEST SENSE command.

SCSI-3 SEND Command AER Data Format

Byte \ Bit	7	6	5	4	3	2	1	0
0	SCSI-3	Reserved						
1	Reserved							
2	Reserved							
3	Reserved							
4	(MSB)							
5								
6								
7								
8	Logical Unit Number							
9								
10								
11								(LSB)
12 to	Sense Data Byte (0)							
n+12	Sense Data Byte (n)							

The **Asynchronous Event Reporting (AER) Data Format** is used by a device to inform another device in the system of a deferred error or other exception without waiting for the other device to send a command. This data is only sent to Processor devices that return INQUIRY data with the AENC bit set to one.

SCSI-3: 0 = SCSI-2 format as shown on the previous page.
1 = SCSI-3 format as shown above.

Logical Unit Number: Logical Unit that had the event to report.

Sense Data: as it would be returned using the REQUEST SENSE command.

TAPE CMDS

Status

Status Byte Format

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved		Status Byte Code					Reserved

Status Byte Code Values

Bits of Status Byte									
7	6	5	4	3	2	1	0	Hex Value	Status(es) Represented
R	R	0	0	0	0	0	R	00h	GOOD
R	R	0	0	0	0	1	R	02h	CHECK CONDITION
R	R	0	0	0	1	0	R	04h	CONDITION MET/GOOD
R	R	0	0	1	0	0	R	08h	BUSY
R	R	0	1	0	0	0	R	10h	INTERMEDIATE/GOOD
R	R	0	1	0	1	0	R	14h	INTERMEDIATE/CONDITION MET/GOOD
R	R	0	1	1	0	0	R	18h	RESERVATION CONFLICT
R	R	1	0	0	0	1	R	22h	COMMAND TERMINATED
R	R	1	0	1	0	0	R	28h	QUEUE FULL [TASK SET FULL]
R	R	1	1	0	0	0	R	30h	ACA ACTIVE
All Other Codes									Reserved

Key: R - Reserved bit

Status Definitions

GOOD: The command completed successfully; no errors. LINK bit in command block is zero.

CHECK CONDITION : Literally, "check for Sense Data". Usually means some error or failure occurred, or any condition that Initiator should be informed of.

CONDITION MET: See SCSI-2 or SAM.

BUSY: Too busy to talk to another Initiator. Try again later.

INTERMEDIATE : Equivalent to GOOD status, except LINK bit set to one in command block. Indicates good status for a command that is part of a series of Linked commands.

RESERVATION CONFLICT : Reserved to another Initiator. Try again later.

COMMAND TERMINATED : Command completed successfully after being prematurely terminated by a TERMINATE I/O PROCESS [TERMINATE TASK] message. Sense Data indicates what was left to do.

QUEUE FULL [TASK SET FULL]: The Queue [Task Set] is full.

ACA ACTIVE: An ACA condition exists. Try again later.

Sense Data and Sense Keys

Sense Data Format

Byte \ Bit	7	6	5	4	3	2	1	0
0	Valid	Error Code [Response Code]						
1	Segment Number							
2	Filemark	EOM	ILI	Reserved	Sense Key			
3	(MSB)							
4	Information							
5								
6								(LSB)
7	Additional Sense Length (n-7)							
8	(MSB)							
9	Command-Specific Information							
10								
11								(LSB)
12	Additional Sense Code							
13	Additional Sense Code Qualifier							
14	Field Replaceable Unit Code							
15	SKSV	Sense-Key Specific						
16								
17								
18 to n	Additional Sense Bytes							

Sense Data Fields:

Valid: 0 = bytes 3 thru 6 are not valid
1 = bytes 3 thru 6 contain valid data

Error Code: indicates format of the Sense Data. Error Codes 70h and 71h are the only two codes defined as standard for SCSI-2/3, and both codes use the sense data format shown here. (For SCSI-3, this field has been renamed "Response Code".)
70h = not a deferred error
71h = deferred error

Segment number: number of COPY segment in error. See SPC.

Filemark (Tape): 0 = not positioned at filemark on tape
1 = positioned at filemark on tape

STATUS/ SENSE

EOM (Tape): 0 = not positioned at end of medium
1 = positioned at end of medium

ILI (Tape): 0 = no length error
1 = block length requested did not match block length on medium. The Information Bytes (see below) indicate the difference between the requested length and the length on the medium.

ILI (Disk): 0 = no length error
1 = READ LONG or WRITE LONG Byte Transfer Length was incorrect. The Information Bytes (see below) indicate the difference between the requested length and the length on the medium.

Sense Key: error recovery indication (see Sense Key Table, page 243)

Information: contains data concerning the error if the Valid bit is one. For example:
- the logical block address where the error indicated by the sense key occurred
- the magnitude of the length mismatch indicated by ILI (above).
- residue between a requested operation and the actual result.

Additional Sense Length: the first eight bytes of sense data are "Standard". This field indicates how many more bytes follow. For example, if this field = 10, then a total of 18 bytes are valid in the sense data.

Command Specific Information: contains data that varies by command:
- REASSIGN BLOCKS: first defective block not reassigned.
- SEARCH DATA: see SBC.
- COPY: see SPC.
- All other commands: not used.

Additional Sense Code: additional information that describes cause of error associated with Sense Key (see Additional Sense Code tables beginning on page 247).

Additional Sense Code Qualifier: modifier of Additional Sense Code (see Additional Sense Code tables beginning on page 247).

Field Replaceable Unit (FRU) Code: vendor specific value that indicates which part of the device failed miserably. Zero indicates no unit failed or failed unit unknown.

Additional Sense Bytes: contain vendor specific data.

Sense Key Specific Bytes: contains data that varies by sense key. These bytes are currently defined for the data formats shown on the next page.

ILLEGAL REQUEST: Field Pointer Bytes

Byte \ Bit	7	6	5	4	3	2	1	0
15	SKSV	C/D	Reserved	Reserved	BPV	Bit Pointer		
16	(MSB)			Field Pointer				
17								(LSB)

SKSV: 0 = Sense Key Specific Bytes invalid
1 = Sense Key Specific Bytes contain valid data

C/D: 0 = error is in data parameters sent during DATA OUT phase
1 = error is in command sent during COMMAND phase

BPV: 0 = Bit Pointer field not used: error was a whole byte
1 = Bit Pointer field valid: error was one or more bits in byte

Bit Pointer: indicates which bit in the byte was illegal

Field Pointer: indicates which byte was illegal

RECOVERED ERROR, MEDIUM ERROR, HARDWARE ERROR: Actual Retry Count

Byte \ Bit	7	6	5	4	3	2	1	0
15	SKSV	Reserved						
16	(MSB)			Actual Retry Count				
17								(LSB)

SKSV: 0 = Sense Key Specific Bytes invalid
1 = Sense Key Specific Bytes contain valid data

Actual Retry Count: the number of retries attempted during error recovery

NOT READY: Progress Indication Bytes

Byte \ Bit	7	6	5	4	3	2	1	0
15	SKSV	Reserved						
16	(MSB)			Progress Indication				
17								(LSB)

SKSV: 0 = Sense Key Specific Bytes invalid
1 = Sense Key Specific Bytes contain valid data

Progress Indication (PI): percent completion (PI/65536) of a command (such as FORMAT UNIT (disk)) which was issued with the immediate (*Immed*) bit set to one.

Sense Keys (Alphabetic)

Name	Sense Key
ABORTED COMMAND	B
BLANK CHECK	8
COPY ABORTED	A
DATA PROTECT	7
EQUAL	C
HARDWARE ERROR	4
ILLEGAL REQUEST	5
MEDIUM ERROR	3
MISCOMPARE	E
NO SENSE	0
NOT READY	2
RECOVERED ERROR	1
Reserved	F
UNIT ATTENTION	6
Vendor Specific	9
VOLUME OVERFLOW	D

Sense Keys (Numeric)

Sense Key	Name
0	NO SENSE
1	RECOVERED ERROR
2	NOT READY
3	MEDIUM ERROR
4	HARDWARE ERROR
5	ILLEGAL REQUEST
6	UNIT ATTENTION
7	DATA PROTECT
8	BLANK CHECK
9	Vendor Specific
A	COPY ABORTED
B	ABORTED COMMAND
C	EQUAL
D	VOLUME OVERFLOW
E	MISCOMPARE
F	Reserved

TEST UNIT READY Responses

BY CODE

Status Byte	Sense Key	Sense Code	Sense Code Qualifier	Description of Cause
00h	0	00h	00h	unit is ready
02h	5	25h	00h	Logical Unit not supported
02h	2	05h	00h	Logical Unit does not respond to selection
02h	2	3Ah	00h	medium not present
02h	2	04h	00h	Logical Unit not ready, cause not reportable
02h	2	04h	01h	Logical Unit is in process of becoming ready
02h	2	04h	02h	Logical Unit not ready, initializing command required
02h	2	04h	03h	Logical Unit not ready, manual intervention required
02h	2	04h	04h	Logical Unit not ready, format in progress

TEST UNIT READY Responses

BY NAME

Status	Sense Key	Additional Sense Code and Additional Sense Code Qualifier
GOOD	NO SENSE	no additional sense information or other valid additional sense code.
CHECK CONDITION	ILLEGAL REQUEST	Logical Unit not supported
CHECK CONDITION	NOT READY	Logical Unit does not respond to selection
CHECK CONDITION	NOT READY	medium not present
CHECK CONDITION	NOT READY	Logical Unit not ready, cause not reportable
CHECK CONDITION	NOT READY	Logical Unit is in process of becoming ready
CHECK CONDITION	NOT READY	Logical Unit not ready, initializing command required
CHECK CONDITION	NOT READY	Logical Unit not ready, manual intervention required
CHECK CONDITION	NOT READY	Logical Unit not ready, FORMAT in progress

Additional Sense Codes

Sense Codes for Direct Access Devices
ALPHABETIC ORDER

Description	ASC	ASCQ
address mark not found for data field	13	00
address mark not found for ID field	12	00
block not compressable	0C	06
BUS DEVICE RESET function occurred	29	03
cannot decompress using declared algorithm	11	0E
cannot format medium - incompatible medium	30	06
cannot read medium - incompatible format	30	02
cannot read medium - unknown format	30	01
cannot write medium - incompatible format	30	05
cannot write medium - unknown format	30	04
changed operating definition	3F	02
cleaning cartridge installed	30	03
cleaning failure	30	07
cleaning requested	00	17
COMMAND phase error	4A	00
command sequence error	2C	00
commands cleared by another Initiator	2F	00
compression check miscompare error	0C	04
COPY cannot execute since host cannot disconnect	2B	00
data expansion occurred during compression	0C	05
data path failure (should use 40 nn)	41	00
DATA phase error	4B	00
data sync error - data auto-reallocated	16	03
data sync error - data rewritten	16	01
data sync error - recommend reassignment	16	04
data sync error - recommend rewrite	16	02
data synchronization mark error	16	00
de-compression CRC error	11	0D
defect list error	19	00
defect list error in grown list	19	03
defect list error in primary list	19	02
defect list not available	19	01
defect list not found	1C	00
defect list update failure	32	01
diagnostic failure on component nn (80h-ffh)	40	NN
error log overflow	0A	00
error too long to correct	11	02
failure prediction threshold exceeded	5D	00
failure prediction threshold exceeded (false)	5D	FF
FORMAT command failed	31	01
Grown defect list not found	1C	02
head select fault	09	04

Sense Codes for Direct Access Devices

ALPHABETIC ORDER (CONTINUED)

Description	ASC	ASCQ
I/O process terminated	00	06
ID CRC or ECC error	10	00
idle condition activated by command	5E	03
idle condition activated by timer	5E	01
illegal function (should use 20 00, 24 00, or 26 00)	22	00
import or export element accessed	28	01
incompatible medium installed	30	00
Initiator detected error message received	48	00
INQUIRY data has changed	3F	03
internal Target failure	44	00
invalid bits in IDENTIFY message	3D	00
invalid command operation code	20	00
invalid element address	21	01
invalid field in CDB	24	00
invalid field in parameter list	26	00
invalid message error	49	00
invalid release of active persistent reservation	26	04
log counter at maximum	5B	02
log exception	5B	00
log list codes exhausted	5B	03
log parameters changed	2A	02
Logical Block Address out of range	21	00
Logical Unit communication failure	08	00
Logical Unit communication parity error	08	02
Logical Unit communication time-out	08	01
Logical Unit does not respond to selection	05	00
Logical Unit failed self-configuration	4C	00
Logical Unit has not self-configured yet	3E	00
Logical Unit is in process of becoming ready	04	01
Logical Unit not ready, cause not reportable	04	00
Logical Unit not ready, FORMAT in progress	04	04
Logical Unit not ready, initializing command required	04	02
Logical Unit not ready, manual intervention required	04	03
Logical Unit not ready, operation in progress	04	07
Logical Unit not supported	25	00
low power condition on	5E	00
mechanical positioning error	15	01
media load or eject failed	53	00
medium destination element full	3B	0D
medium format corrupted	31	00
medium magazine inserted	3B	13
medium magazine locked	3B	14
medium magazine not accessible	3B	11

Sense Codes for Direct Access Devices

ALPHABETIC ORDER (CONTINUED)

Description	ASC	ASCQ
medium magazine removed	3B	12
medium magazine unlocked	3B	15
medium not present	3A	00
medium removal prevented	53	02
medium source element empty	3B	0E
message error	43	00
microcode has been changed	3F	01
miscompare during verify operation	1D	00
miscorrected error	11	0A
Mode parameters changed	2A	01
multiple peripheral devices selected	07	00
multiple read errors	11	03
no additional sense information	00	00
no defect spare location available	32	00
no index/sector signal	01	00
no reference position found	06	00
no seek complete	02	00
not ready to ready transition, medium may have changed	28	00
operation in progress	00	16
operator medium removal request	5A	01
operator request or state change input (unspecified)	5A	00
operator selected write permit	5A	03
operator selected write protect	5A	02
overlapped commands attempted	4E	00
Parameter List Length error	1A	00
parameter not supported	26	01
parameter value invalid	26	02
parameters changed	2A	00
partial defect list transfer	1F	00
peripheral device write fault	03	00
positioning error detected by read of medium	15	02
power on occurred	29	01
power on, reset, or BUS DEVICE RESET occurred	29	00
power-on or self-test failure (should use 40 nn)	42	00
Primary defect list not found	1C	01
RAM failure (should use 40 nn)	40	00
random positioning error	15	00
read retries exhausted	11	01
record not found	14	01
record not found - data auto-reallocated	14	06
record not found - recommend reassignment	14	05
recorded entity not found	14	00

Sense Codes for Direct Access Devices

ALPHABETIC ORDER (CONTINUED)

Description	ASC	ASCQ
recovered data - data auto-reallocated	18	02
recovered data - recommend reassignment	18	05
recovered data - recommend rewrite	18	06
recovered data using previous sector ID	17	05
recovered data with ECC - data rewritten	18	07
recovered data with error correction & retries applied	18	01
recovered data with error correction applied	18	00
recovered data with negative head offset	17	03
recovered data with no error correction applied	17	00
recovered data with positive head offset	17	02
recovered data with retries	17	01
recovered data without ECC - data auto-reallocated	17	06
recovered data without ECC - data rewritten	17	09
recovered data without ECC - recommend reassignment	17	07
recovered data without ECC - recommend rewrite	17	08
recovered ID with ECC correction	1E	00
rounded parameter	37	00
RPL status change	5C	00
reservations preempted	2A	03
saving parameters not supported	39	00
SCSI bus reset occurred	29	02
SCSI parity error	47	00
select or reselect failure	45	00
spindles not synchronized	5C	02
spindles synchronized	5C	01
standby condition activated by command	5E	04
standby condition activated by timer	5E	02
synchronous data transfer error	1B	00
system buffer full	55	01
tagged overlapped commands (nn = queue tag)	4D	NN
Target operating conditions have changed	3F	00
threshold condition met	5B	01
threshold parameters not supported	26	03
track following error	09	00
unrecovered read error	11	00
unrecovered read error - auto reallocate failed	11	04
unrecovered read error - recommend reassignment	11	0B
unrecovered read error - recommend rewrite the data	11	0C
unsuccessful soft reset	46	00
voltage fault	65	00
warning	0B	00
warning - specified temperature exceeded	0B	01
write error - auto reallocation failed	0C	02
write error - recommend reassignment	0C	03
write protected	27	00

Sense Codes for Direct Access Devices

NUMERIC ORDER

ASC	ASCQ	Description
00	00	no additional sense information
00	06	I/O process terminated
00	16	operation in progress
00	17	cleaning requested
01	00	no index/sector signal
02	00	no seek complete
03	00	peripheral device write fault
04	00	Logical Unit not ready, cause not reportable
04	01	Logical Unit is in process of becoming ready
04	02	Logical Unit not ready, initializing command required
04	03	Logical Unit not ready, manual intervention required
04	04	Logical Unit not ready, FORMAT in progress
04	07	Logical Unit not ready, operation in progress
05	00	Logical Unit does not respond to selection
06	00	no reference position found
07	00	multiple peripheral devices selected
08	00	Logical Unit communication failure
08	01	Logical Unit communication time-out
08	02	Logical Unit communication parity error
09	00	track following error
09	04	head select fault
0A	00	error log overflow
0B	00	warning
0B	01	warning - specified temperature exceeded
0C	02	write error - auto reallocation failed
0C	03	write error - recommend reassignment
0C	04	compression check miscompare error
0C	05	data expansion occurred during compression
0C	06	block not compressable
10	00	ID CRC or ECC error
11	00	unrecovered read error
11	01	read retries exhausted
11	02	error too long to correct
11	03	multiple read errors
11	04	unrecovered read error - auto reallocate failed
11	0A	miscorrected error
11	0B	unrecovered read error - recommend reassignment
11	0C	unrecovered read error - recommend rewrite the data
11	0D	de-compression CRC error
11	0E	cannot decompress using declared algorithm
12	00	address mark not found for ID field
13	00	address mark not found for data field

Sense Codes for Direct Access Devices

NUMERIC ORDER (CONTINUED)

ASC	ASCQ	Description
14	00	recorded entity not found
14	01	record not found
14	05	record not found - recommend reassignment
14	06	record not found - data auto-reallocated
15	00	random positioning error
15	01	mechanical positioning error
15	02	positioning error detected by read of medium
16	00	data synchronization mark error
16	01	data sync error - data rewritten
16	02	data sync error - recommend rewrite
16	03	data sync error - data auto-reallocated
16	04	data sync error - recommend reassignment
17	00	recovered data with no error correction applied
17	01	recovered data with retries
17	02	recovered data with positive head offset
17	03	recovered data with negative head offset
17	05	recovered data using previous sector ID
17	06	recovered data without ECC - data auto-reallocated
17	07	recovered data without ECC - recommend reassignment
17	08	recovered data without ECC - recommend rewrite
17	09	recovered data without ECC - data rewritten
18	00	recovered data with error correction applied
18	01	recovered data with error correction & retries applied
18	02	recovered data - data auto-reallocated
18	05	recovered data - recommend reassignment
18	06	recovered data - recommend rewrite
18	07	recovered data with ECC - data rewritten
19	00	defect list error
19	01	defect list not available
19	02	defect list error in primary list
19	03	defect list error in grown list
1A	00	Parameter List Length error
1B	00	synchronous data transfer error
1C	00	defect list not found
1C	01	Primary defect list not found
1C	02	Grown defect list not found
1D	00	miscompare during verify operation
1E	00	recovered ID with ECC correction
1F	00	partial defect list transfer
20	00	invalid command operation code
21	00	Logical Block Address out of range
21	01	invalid element address
22	00	illegal function (should use 20 00, 24 00, or 26 00)
24	00	invalid field in CDB
25	00	Logical Unit not supported

Sense Codes for Direct Access Devices

NUMERIC ORDER (CONTINUED)

ASC	ASCQ	Description
26	00	invalid field in parameter list
26	01	parameter not supported
26	02	parameter value invalid
26	03	threshold parameters not supported
26	04	invalid release of active persistent reservation
27	00	write protected
28	00	not ready to ready transition, medium may have changed
28	01	import or export element accessed
29	00	power on, reset, or BUS DEVICE RESET occurred
29	01	power on occurred
29	02	SCSI bus reset occurred
29	03	BUS DEVICE RESET function occurred
2A	00	parameters changed
2A	01	Mode parameters changed
2A	02	log parameters changed
2A	03	reservations preempted
2B	00	COPY cannot execute since host cannot disconnect
2C	00	command sequence error
2F	00	commands cleared by another Initiator
30	00	incompatible medium installed
30	01	cannot read medium - unknown format
30	02	cannot read medium - incompatible format
30	03	cleaning cartridge installed
30	04	cannot write medium - unknown format
30	05	cannot write medium - incompatible format
30	06	cannot format medium - incompatible medium
30	07	cleaning failure
31	00	medium format corrupted
31	01	FORMAT command failed
32	00	no defect spare location available
32	01	defect list update failure
37	00	rounded parameter
39	00	saving parameters not supported
3A	00	medium not present
3B	0D	medium destination element full
3B	0E	medium source element empty
3B	11	medium magazine not accessible
3B	12	medium magazine removed
3B	13	medium magazine inserted
3B	14	medium magazine locked
3B	15	medium magazine unlocked
3D	00	invalid bits in IDENTIFY message
3E	00	Logical Unit has not self-configured yet

Sense Codes for Direct Access Devices

NUMERIC ORDER (CONTINUED)

ASC	ASCQ	Description
3F	00	Target operating conditions have changed
3F	01	microcode has been changed
3F	02	changed operating definition
3F	03	INQUIRY data has changed
40	00	RAM failure (should use 40 nn)
40	NN	diagnostic failure on component nn (80h-ffh)
41	00	data path failure (should use 40 nn)
42	00	power-on or self-test failure (should use 40 nn)
43	00	message error
44	00	internal Target failure
45	00	select or reselect failure
46	00	unsuccessful soft reset
47	00	SCSI parity error
48	00	Initiator detected error message received
49	00	invalid message error
4A	00	COMMAND phase error
4B	00	DATA phase error
4C	00	Logical Unit failed self-configuration
4D	NN	tagged overlapped commands (nn = queue tag)
4E	00	overlapped commands attempted
53	00	media load or eject failed
53	02	medium removal prevented
55	01	system buffer full
5A	00	operator request or state change input (unspecified)
5A	01	operator medium removal request
5A	02	operator selected write protect
5A	03	operator selected write permit
5B	00	log exception
5B	01	threshold condition met
5B	02	log counter at maximum
5B	03	log list codes exhausted
5C	00	RPL status change
5C	01	spindles synchronized
5C	02	spindles not synchronized
5D	00	failure prediction threshold exceeded
5D	FF	failure prediction threshold exceeded (false)
5E	00	low power condition on
5E	01	idle condition activated by timer
5E	02	standby condition activated by timer
5E	03	idle condition activated by command
5E	04	standby condition activated by command
65	00	voltage fault

Sense Codes for Sequential Access Devices

ALPHABETIC ORDER

Description	ASC	ASCQ
beginning-of-partition/medium detected	00	04
block not compressable	0C	06
block sequence error	14	04
BUS DEVICE RESET function occurred	29	03
cannot decompress using declared algorithm	11	0E
cannot format medium - incompatible medium	30	06
cannot read medium - incompatible format	30	02
cannot read medium - unknown format	30	01
cannot write medium - incompatible format	30	05
cannot write medium - unknown format	30	04
cartridge fault	52	00
changed operating definition	3F	02
cleaning cartridge installed	30	03
cleaning failure	30	07
cleaning requested	00	17
COMMAND phase error	4A	00
command sequence error	2C	00
commands cleared by another Initiator	2F	00
compression check miscompare error	0C	04
COPY cannot execute since host cannot disconnect	2B	00
data expansion occurred during compression	0C	05
DATA phase error	4B	00
de-compression CRC error	11	0D
decompression exception long algorithm ID	71	00
decompression exception short algorithm ID of nn	70	NN
diagnostic failure on component nn (80h-ffh)	40	NN
end-of-data detected	00	05
end-of-data not found	14	03
end-of-partition/medium detected	00	02
erase failure	51	00
error log overflow	0A	00
error too long to correct	11	02
excessive write errors	03	02
failure prediction threshold exceeded	5D	00
failure prediction threshold exceeded (false)	5D	FF
filemark detected	00	01
filemark or setmark not found	14	02
head select fault	09	04
I/O process terminated	00	06
idle condition activated by command	5E	03
idle condition activated by timer	5E	01
import or export element accessed	28	01
incompatible medium installed	30	00
incomplete block read	11	08

Sense Codes for Sequential Access Devices
ALPHABETIC ORDER (CONTINUED)

Description	ASC	ASCQ
Initiator detected error message received	48	00
INQUIRY data has changed	3F	03
internal Target failure	44	00
invalid bits in IDENTIFY message	3D	00
invalid command operation code	20	00
invalid element address	21	01
invalid field in CDB	24	00
invalid field in parameter list	26	00
invalid message error	49	00
invalid release of active persistent reservation	26	04
log counter at maximum	5B	02
log exception	5B	00
log list codes exhausted	5B	03
log parameters changed	2A	02
Logical Block Address out of range	21	00
Logical Unit communication failure	08	00
Logical Unit communication parity error	08	02
Logical Unit communication time-out	08	01
Logical Unit does not respond to selection	05	00
Logical Unit failed self-configuration	4C	00
Logical Unit has not self-configured yet	3E	00
Logical Unit is in process of becoming ready	04	01
Logical Unit not ready, cause not reportable	04	00
Logical Unit not ready, FORMAT in progress	04	04
Logical Unit not ready, initializing command required	04	02
Logical Unit not ready, manual intervention required	04	03
Logical Unit not ready, operation in progress	04	07
Logical Unit not supported	25	00
low power condition on	5E	00
mechanical positioning error	15	01
media load or eject failed	53	00
medium destination element full	3B	0D
medium format corrupted	31	00
medium magazine inserted	3B	13
medium magazine locked	3B	14
medium magazine not accessible	3B	11
medium magazine removed	3B	12
medium magazine unlocked	3B	15
medium not present	3A	00
medium removal prevented	53	02
medium source element empty	3B	0E
message error	43	00
microcode has been changed	3F	01
miscorrected error	11	0A

Sense Codes for Sequential Access Devices

ALPHABETIC ORDER (CONTINUED)

Description	ASC	ASCQ
Mode parameters changed	2A	01
multiple peripheral devices selected	07	00
multiple read errors	11	03
no additional sense information	00	00
no gap found	11	09
no write current	03	01
not ready to ready transition, medium may have changed	28	00
operation in progress	00	16
operator medium removal request	5A	01
operator request or state change input (unspecified)	5A	00
operator selected write permit	5A	03
operator selected write protect	5A	02
overlapped commands attempted	4E	00
overwrite error on update in place	2D	00
Parameter List Length error	1A	00
parameter not supported	26	01
parameter value invalid	26	02
parameters changed	2A	00
peripheral device write fault	03	00
position error related to timing	50	02
position past beginning of medium	3B	0C
positioning error detected by read of medium	15	02
power on occurred	29	01
power on, reset, or BUS DEVICE RESET occurred	29	00
random positioning error	15	00
read retries exhausted	11	01
record not found	14	01
record not found - data auto-reallocated	14	06
record not found - recommend reassignment	14	05
recorded entity not found	14	00
recovered data with error correction applied	18	00
recovered data with negative head offset	17	03
recovered data with no error correction applied	17	00
recovered data with positive head offset	17	02
recovered data with retries	17	01
reposition error	3B	08
rounded parameter	37	00
reservations preempted	2A	03

Sense Codes for Sequential Access Devices

ALPHABETIC ORDER (CONTINUED)

Description	ASC	ASCQ
saving parameters not supported	39	00
SCSI bus reset occurred	29	02
SCSI parity error	47	00
select or reselect failure	45	00
sequential positioning error	3B	00
setmark detected	00	03
standby condition activated by command	5E	04
standby condition activated by timer	5E	02
synchronous data transfer error	1B	00
tagged overlapped commands (nn = queue tag)	4D	NN
tape length error	33	00
tape position error at beginning-of-medium	3B	01
tape position error at end-of-medium	3B	02
Target operating conditions have changed	3F	00
threshold condition met	5B	01
threshold parameters not supported	26	03
track following error	09	00
unload tape failure	53	01
unrecovered read error	11	00
unsuccessful soft reset	46	00
voltage fault	65	00
warning	0B	00
warning - specified temperature exceeded	0B	01
write append error	50	00
write append position error	50	01
write error	0C	00
write protected	27	00

Sense Codes for Sequential Access Devices

NUMERIC ORDER

ASC	ASCQ	Description
00	00	no additional sense information
00	01	filemark detected
00	02	end-of-partition/medium detected
00	03	setmark detected
00	04	beginning-of-partition/medium detected
00	05	end-of-data detected
00	06	I/O process terminated
00	16	operation in progress
00	17	cleaning requested
03	00	peripheral device write fault
03	01	no write current
03	02	excessive write errors
04	00	Logical Unit not ready, cause not reportable
04	01	Logical Unit is in process of becoming ready
04	02	Logical Unit not ready, initializing command required
04	03	Logical Unit not ready, manual intervention required
04	04	Logical Unit not ready, FORMAT in progress
04	07	Logical Unit not ready, operation in progress
05	00	Logical Unit does not respond to selection
07	00	multiple peripheral devices selected
08	00	Logical Unit communication failure
08	01	Logical Unit communication time-out
08	02	Logical Unit communication parity error
09	00	track following error
09	04	head select fault
0A	00	error log overflow
0B	00	warning
0B	01	warning - specified temperature exceeded
0C	00	write error
0C	04	compression check miscompare error
0C	05	data expansion occurred during compression
0C	06	block not compressable
11	00	unrecovered read error
11	01	read retries exhausted
11	02	error too long to correct
11	03	multiple read errors
11	08	incomplete block read
11	09	no gap found
11	0A	miscorrected error
11	0D	de-compression CRC error
11	0E	cannot decompress using declared algorithm

Sense Codes for Sequential Access Devices

NUMERIC ORDER (CONTINUED)

ASC	ASCQ	Description
14	00	recorded entity not found
14	01	record not found
14	02	filemark or setmark not found
14	03	end-of-data not found
14	04	block sequence error
14	05	record not found - recommend reassignment
14	06	record not found - data auto-reallocated
15	00	random positioning error
15	01	mechanical positioning error
15	02	positioning error detected by read of medium
17	00	recovered data with no error correction applied
17	01	recovered data with retries
17	02	recovered data with positive head offset
17	03	recovered data with negative head offset
18	00	recovered data with error correction applied
1A	00	Parameter List Length error
1B	00	synchronous data transfer error
20	00	invalid command operation code
21	00	Logical Block Address out of range
21	01	invalid element address
24	00	invalid field in CDB
25	00	Logical Unit not supported
26	00	invalid field in parameter list
26	01	parameter not supported
26	02	parameter value invalid
26	03	threshold parameters not supported
26	04	invalid release of active persistent reservation
27	00	write protected
28	00	not ready to ready transition, medium may have changed
28	01	import or export element accessed
29	00	power on, reset, or BUS DEVICE RESET occurred
29	01	power on occurred
29	02	SCSI bus reset occurred
29	03	BUS DEVICE RESET function occurred
2A	00	parameters changed
2A	01	Mode parameters changed
2A	02	log parameters changed
2A	03	reservations preempted
2B	00	COPY cannot execute since host cannot disconnect
2C	00	command sequence error
2D	00	overwrite error on update in place
2F	00	commands cleared by another Initiator

Sense Codes for Sequential Access Devices

NUMERIC ORDER (CONTINUED)

ASC	ASCQ	Description
30	00	incompatible medium installed
30	01	cannot read medium - unknown format
30	02	cannot read medium - incompatible format
30	03	cleaning cartridge installed
30	04	cannot write medium - unknown format
30	05	cannot write medium - incompatible format
30	06	cannot format medium - incompatible medium
30	07	cleaning failure
31	00	medium format corrupted
33	00	tape length error
37	00	rounded parameter
39	00	saving parameters not supported
3A	00	medium not present
3B	00	sequential positioning error
3B	01	tape position error at beginning-of-medium
3B	02	tape position error at end-of-medium
3B	08	reposition error
3B	0C	position past beginning of medium
3B	0D	medium destination element full
3B	0E	medium source element empty
3B	11	medium magazine not accessible
3B	12	medium magazine removed
3B	13	medium magazine inserted
3B	14	medium magazine locked
3B	15	medium magazine unlocked
3D	00	invalid bits in IDENTIFY message
3E	00	Logical Unit has not self-configured yet
3F	00	Target operating conditions have changed
3F	01	microcode has been changed
3F	02	changed operating definition
3F	03	INQUIRY data has changed
40	NN	diagnostic failure on component nn (80h-ffh)
43	00	message error
44	00	internal Target failure
45	00	select or reselect failure
46	00	unsuccessful soft reset
47	00	SCSI parity error
48	00	Initiator detected error message received
49	00	invalid message error
4A	00	COMMAND phase error
4B	00	DATA phase error
4C	00	Logical Unit failed self-configuration
4D	NN	tagged overlapped commands (nn = queue tag)
4E	00	overlapped commands attempted

Sense Codes for Sequential Access Devices

NUMERIC ORDER (CONTINUED)

ASC	ASCQ	Description
50	00	write append error
50	01	write append position error
50	02	position error related to timing
51	00	erase failure
52	00	cartridge fault
53	00	media load or eject failed
53	01	unload tape failure
53	02	medium removal prevented
5A	00	operator request or state change input (unspecified)
5A	01	operator medium removal request
5A	02	operator selected write protect
5A	03	operator selected write permit
5B	00	log exception
5B	01	threshold condition met
5B	02	log counter at maximum
5B	03	log list codes exhausted
5D	00	failure prediction threshold exceeded
5D	FF	failure prediction threshold exceeded (false)
5E	00	low power condition on
5E	01	idle condition activated by timer
5E	02	standby condition activated by timer
5E	03	idle condition activated by command
5E	04	standby condition activated by command
65	00	voltage fault
70	NN	decompression exception short algorithm ID of nn
71	00	decompression exception long algorithm ID

Sense Codes for Processor Devices
ALPHABETIC ORDER

Description	ASC	ASCQ
BUS DEVICE RESET function occurred	29	03
changed operating definition	3F	02
COMMAND phase error	4A	00
command sequence error	2C	00
commands cleared by another Initiator	2F	00
COPY cannot execute since host cannot disconnect	2B	00
DATA phase error	4B	00
diagnostic failure on component nn (80h-ffh)	40	NN
error log overflow	0A	00
failure prediction threshold exceeded	5D	00
failure prediction threshold exceeded (false)	5D	FF
I/O process terminated	00	06
idle condition activated by command	5E	03
idle condition activated by timer	5E	01
Initiator detected error message received	48	00
INQUIRY data has changed	3F	03
internal Target failure	44	00
invalid bits in IDENTIFY message	3D	00
invalid command operation code	20	00
invalid field in CDB	24	00
invalid field in parameter list	26	00
invalid message error	49	00
invalid release of active persistent reservation	26	04
log counter at maximum	5B	02
log exception	5B	00
log list codes exhausted	5B	03
Logical Unit failed self-configuration	4C	00
Logical Unit has not self-configured yet	3E	00
Logical Unit is in process of becoming ready	04	01
Logical Unit not ready, cause not reportable	04	00
Logical Unit not ready, initializing command required	04	02
Logical Unit not ready, manual intervention required	04	03
Logical Unit not ready, operation in progress	04	07
Logical Unit not supported	25	00
low power condition on	5E	00
message error	43	00
microcode has been changed	3F	01
no additional sense information	00	00
not ready to ready transition, medium may have changed	28	00
operation in progress	00	16
operator request or state change input (unspecified)	5A	00
overlapped commands attempted	4E	00

Sense Codes for Processor Devices
ALPHABETIC ORDER (CONTINUED)

Description	ASC	ASCQ
Parameter List Length error	1A	00
parameter not supported	26	01
parameter value invalid	26	02
power on occurred	29	01
power on, reset, or BUS DEVICE RESET occurred	29	00
reservations preempted	2A	03
SCSI bus reset occurred	29	02
SCSI parity error	47	00
SCSI to host system interface failure	54	00
select or reselect failure	45	00
standby condition activated by command	5E	04
standby condition activated by timer	5E	02
synchronous data transfer error	1B	00
system resource failure	55	00
tagged overlapped commands (nn = queue tag)	4D	NN
Target operating conditions have changed	3F	00
threshold condition met	5B	01
threshold parameters not supported	26	03
unsuccessful soft reset	46	00
voltage fault	65	00
warning	0B	00
warning - specified temperature exceeded	0B	01

Sense Codes for Processor Devices
NUMERIC ORDER

ASC	ASCQ	Description
00	00	no additional sense information
00	06	I/O process terminated
00	16	operation in progress
04	00	Logical Unit not ready, cause not reportable
04	01	Logical Unit is in process of becoming ready
04	02	Logical Unit not ready, initializing command required
04	03	Logical Unit not ready, manual intervention required
04	07	Logical Unit not ready, operation in progress
0A	00	error log overflow
0B	00	warning
0B	01	warning - specified temperature exceeded
1A	00	Parameter List Length error
1B	00	synchronous data transfer error
20	00	invalid command operation code
24	00	invalid field in CDB
25	00	Logical Unit not supported
26	00	invalid field in parameter list
26	01	parameter not supported
26	02	parameter value invalid
26	03	threshold parameters not supported
26	04	invalid release of active persistent reservation
28	00	not ready to ready transition, medium may have changed
29	00	power on, reset, or BUS DEVICE RESET occurred
29	01	power on occurred
29	02	SCSI bus reset occurred
29	03	BUS DEVICE RESET function occurred
2A	03	reservations preempted
2B	00	COPY cannot execute since host cannot disconnect
2C	00	command sequence error
2F	00	commands cleared by another Initiator
3D	00	invalid bits in IDENTIFY message
3E	00	Logical Unit has not self-configured yet
3F	00	Target operating conditions have changed
3F	01	microcode has been changed
3F	02	changed operating definition
3F	03	INQUIRY data has changed

Sense Codes for Processor Devices

NUMERIC ORDER (CONTINUED)

ASC	ASCQ	Description
40	NN	diagnostic failure on component nn (80h-ffh)
43	00	message error
44	00	internal Target failure
45	00	select or reselect failure
46	00	unsuccessful soft reset
47	00	SCSI parity error
48	00	Initiator detected error message received
49	00	invalid message error
4A	00	COMMAND phase error
4B	00	DATA phase error
4C	00	Logical Unit failed self-configuration
4D	NN	tagged overlapped commands (nn = queue tag)
4E	00	overlapped commands attempted
54	00	SCSI to host system interface failure
55	00	system resource failure
5A	00	operator request or state change input (unspecified)
5B	00	log exception
5B	01	threshold condition met
5B	02	log counter at maximum
5B	03	log list codes exhausted
5D	00	failure prediction threshold exceeded
5D	FF	failure prediction threshold exceeded (false)
5E	00	low power condition on
5E	01	idle condition activated by timer
5E	02	standby condition activated by timer
5E	03	idle condition activated by command
5E	04	standby condition activated by command
65	00	voltage fault

Unit Attention Condition

The Unit Attention Condition is a state the Target enters when some significant state in the Target changes. The Unit Attention Condition is relative to each Initiator; i.e., the Unit Attention Condition may exist with one Initiator but not another.

CAUSES: The types of things that can cause the Unit Attention Condition are:

- a removable medium (cartridge, etc) may have changed.
- MODE parameters changed by another Initiator, or changed by any other occurrance.
- microcode load or change.
- tasks cleared by another Initiator.
- INQUIRY data changed.
- other internal parameter changes (e.g., Saved Parameters on disk become available because the disk became ready).
- a change in the state of a synchronized spindle.
- any other event the Target feels an Initiator should be informed of.

REPORTING: The following is a summary of the rules of reporting the Unit Attention Condition:

- An existing Unit Attention Condition is reported whenever the Initiator issues any command other than INQUIRY and REQUEST SENSE.
- If the command is INQUIRY and a Unit Attention Condition exists, the command is executed and the Unit Attention Condition is not yet reported.
- If the command is REQUEST SENSE and a Unit Attention Condition exists, the Target may or may not report the Unit Attention Condition and clear it, depending on implementation.

SEQUENCE: The sequence of events that occurs when the Unit Attention Condition is created is as follows:

- The Target creates the Unit Attention Condition for one or more Initiators, depending on the nature of the event.
- The Unit Attention Condition now must be reported. When the Initiator issues a command, CHECK CONDITION status is returned, and Sense Data describing the Unit Attention Condition is created. This process clears the Unit Attention Condition, though the Sense Data remains to be reported.
- The Initiator gets the Sense Data (via the REQUEST SENSE command) to see what changed.

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