MAGNETIC PERIPHERALS INC.
a Control Data Company

ENGINEERING SPECIFICATION

TWIN CITIES DISK DIVISION

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PAGE 1 of 218

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INTERFACE SPECIFICATION

FOR THE

CONTROL DATA CORPORATION

SMALL COMPUTER SYSTEM INTERFACE (SCSI)

INTER-DIVISIONAL DOCUMENT
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AA5722

Approved 12/10/85
Released D.L.

TABLE OF CONTENTS

FIGURES

1.0 SCOPE

This Specification provides the mechanical, electrical, and functional requirements for a small computer input/output bus and command sets for peripheral device types commonly used with small computers.

- The CDC SCSI implementation includes support for multiple initiators, disconnect/reconnect function, self-configuring host software, and automatic features that relieve the host from knowing the physical addressing of a specific product.

- The mandatory commands listed here will be required on every CDC product offered as compatible with this specification. This set of commands is chosen so customer software that uses only those commands will maximize functionality while allowing many interchangeable products to be used. Future revisions of this specification will never delete commands or messages from the mandatory list, but new commands or messages may become mandatory on future products.

- Optional commands listed here are not guaranteed to be available on all CDC products.

- Some products may use commands not documented here. As such instances occur, the CDC SCSI Committee will include those commands as "optional" so that implementation guidelines will be available if other new products want that function.

- The commands described in this specification conform to the requirements of the Common Command Set (CCS) document, Rev. 4.

2.0 APPLICABLE DOCUMENTS

- ANSI SCSI Standard X3T9.2

3.0 GLOSSARY AND CONVENTIONS

3.1 Glossary

Byte - This term indicates an 8-bit (octet) byte.

Command Descriptor Block (CDB) - The structure used to communicate requests from an initiator to a target.

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

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

FRU (Field Replaceable Unit) - An assembly that is believed faulty based on test results. A value of 00H indicates either an unknown cause or the end of a list of known possible causes. Non-zero values have product unique meanings.

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

INTERMEDIATE Status - A status code sent from a target to an initiator upon completion of each command in a set of linked commands except the last command in the set.

Logical Unit - A physical or virtual device addressable through a target.

Logical Unit Number - An encoded three-bit identifier for the logical unit.

LSB - Least significant byte.

LUN - Logical unit number.

mm - Millimeter.

ms - Millisecond.

MSB - Most significant byte.

ns - Nanosecond.

One - A true signal value.

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

Reserved - The term used for bits, bytes, fields, and code values that are set aside for future standardization.

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

SCSI ID - The bit-significant representation of the SCSI address referring to one of the signal lines DB(7-0).

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

Signal Assertion - The act of driving a signal to the true state.

Signal Negation - The act of driving a signal to the false state or allowing the cable terminators to bias the signal to the false state (by placing the driver in the high impedance condition).

Signal Release - The act of allowing the cable terminators to bias the signal to the false state (by placing the driver in the high impedance condition).

Status - One byte of information sent from a target to an initiator upon completion of each command.

Target - An SCSI device that performs an operation requested by an initiator.

us - Microsecond.

Vendor Unique - In this specification, this term indicates bits, fields, or code values that are vendor specific.

xxH - Numbers followed by capital H are hexadecimal values. All other numbers are decimal values.

Zero - A false signal value.

3.2 Editorial Conventions

Certain words and terms used in this specification have a specific meaning beyond the normal English meaning. These words and terms are defined either in the glossary (see 3.1) or in the text where they first appear (e.g., initiator). Names of signals, phases, conditions, messages, commands, statuses, and sense keys are in all uppercase (e.g., REQUEST SENSE). Lowercase is used for words having the normal English meaning.

■ A box (■) in the left margin indicates a difference between this
| ■ specification and the ANSI SCSI Standard Rev 17B. A double box
■ preceding a figure title indicates that an entirely new figure
■ or paragraph was added. A vertical line (|) in the left margin
■ indicates a change from the previous revision of this specification.

4.0 PHYSICAL CHARACTERISTICS

This section contains the physical definition of the SCSI. The connectors, cables, signals, terminators, and bus timing needed to implement SCSI are covered.

4.1 Physical Description

SCSI devices are daisy-chained together using a common cable. Both ends of the cable are terminated. All signals are common between
■ all SCSI devices. Four physical configurations are available:

■ • Single-ended drivers and receivers with non-shielded connectors.

■ • Single-ended drivers and receivers with shielded connectors.

■ • Differential drivers and receivers with non-shielded connectors.

■ • Differential drivers and receivers with shielded connectors.

■ Single-ended and differential drivers/receivers cannot be mixed on
■ a common SCSI bus. CDC intends to provide single-ended
■ drivers/receivers on all products with a differential option
■ offered as required by the marketplace.

4.2 Cable Requirements

An ideal impedance match with cable terminators implies a cable characteristic impedance of 132 ohms (single-ended option) or 122 ohms (differential option). A characteristic impedance of 90 to 100 ohms is recommended for unshielded flat or twisted pair ribbon cable. A characteristic impedance greater than 90 ohms is preferred for shielded cables. To minimize discontinuities and signal reflections, cables of different impedances should not be
■ used in the same bus. If shielded and unshielded cables are mixed
■ within the same SCSI bus, the effect of impedance mismatch must be
■ carefully considered.

A minimum conductor size of 28 AWG shall be employed to minimize noise effects and ensure proper distribution of optional terminator power.

4.2.1 Single-Ended Cable

A 50-conductor flat cable or 25-signal twisted-pair cable shall be used. The maximum cable length shall be 6.0 meters.

A stub length of no more than 0.1 meters is allowed off the mainline interconnection within any connected equipment.

SCSI bus termination may be internal to the SCSI devices that are at the ends of the cable.

4.2.2 Differential Cable

A 50-conductor cable or 25-signal twisted-pair cable shall be used. The maximum cable length shall be 25 meters.

A stub length of no more than 0.2 meters is allowed off the mainline interconnection within any connected equipment.

SCSI bus termination may be internal to the SCSI devices that are at the ends of the cable.

4.3 Connector Requirements

Both shielded and nonshielded connectors are specified. The nonshielded connectors are typically used for in-cabinet applications. CDC products designed to meet FCC Standards as a standalone box will use shielded connectors. Either type of connector may be used with the single-ended or differential drivers.

4.3.1 Nonshielded Connectors

The nonshielded SCSI device connector (Figure 4-1) shall be a 50-conductor connector consisting of two rows of 25 male pins with adjacent pins 2.54 mm (.1 inch) apart. A shroud and header body should be used. The header must accept keyed cable connectors.

The nonshielded cable connector (Figure 4-2) shall be a 50-conductor connector consisting of two rows of 25 female contacts with adjacent contacts 2.54 mm (.1 inch) apart. It is recommended that keyed connectors be used.

The unshielded connector pin assignments shall be as shown in Table 4-1 for single ended drivers and as shown in Table 4-2 for differential drivers.

4.3.2 Shielded Connectors

■ NOTE: This text is from Appendix D of the ANSI SCSI Standard.

The connector shielding system shall provide a dc resistance of less than 10 milliohms from the cable shield at its termination point to the SCSI device enclosure.

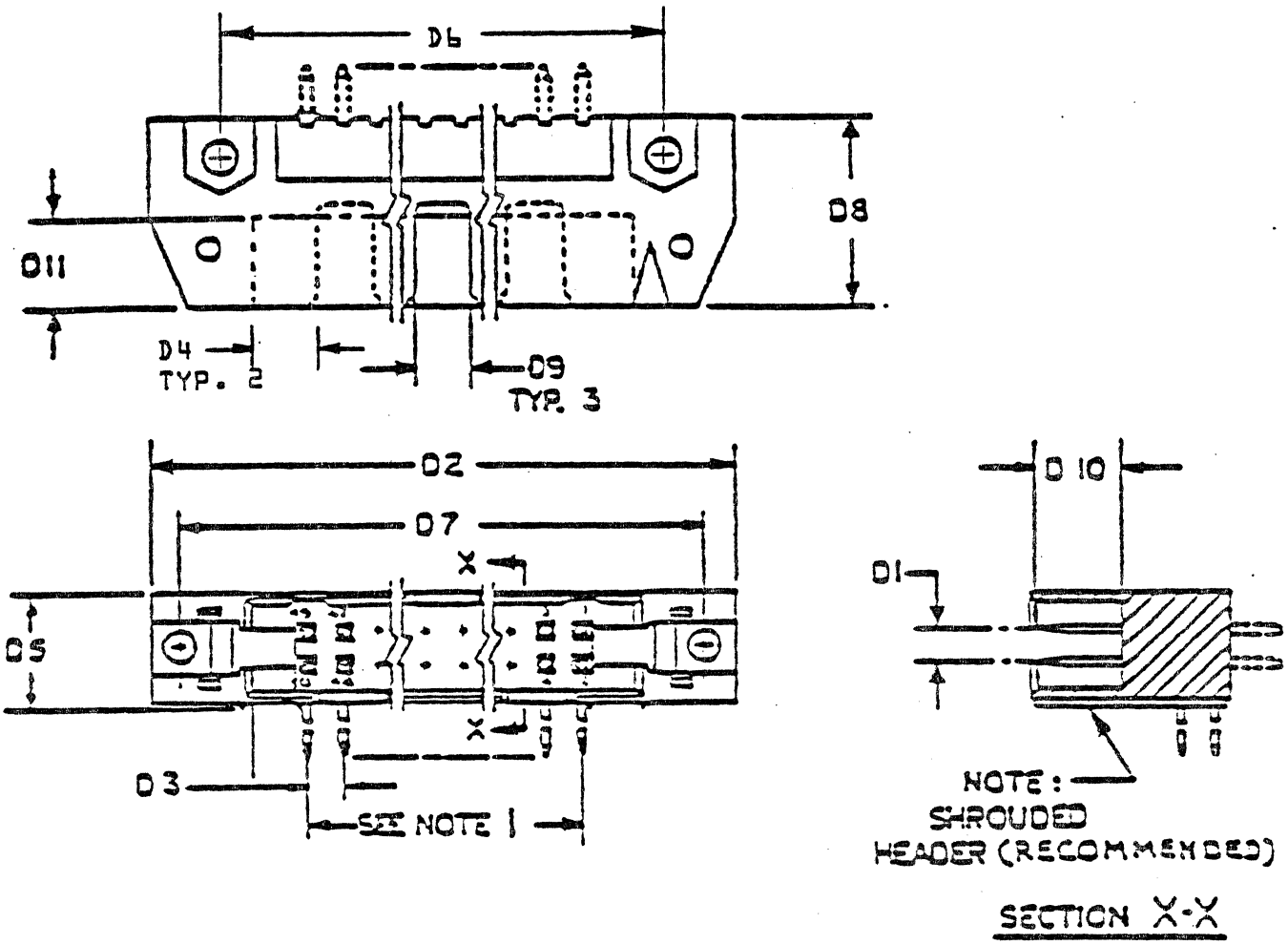
In order to support daisy-chain connections, SCSI devices that use shielded connectors will provide two shielded device connectors on the device enclosure. These two connectors may be wired "one-to-one" with a stub to the SCSI device's drivers and receivers provided the maximum stub length is not violated. Alternatively, two cables may be run from the two shielded connectors to the drivers and receivers so that the maximum stub length is not violated. The length of the cable within the device enclosure is included when calculating the total cable length of the SCSI bus.

■

The shielded device connector (Figure 4-4) shall be a 50-conductor connector consisting of two rows of ribbon contacts spaced 2.16 mm (0.085 inch) apart. The nonmating portion of the connector is shown for referance only. FCC document 68 Subpart F 68.500 should be used for reference.

The shielded cable connector (Figure 4-3) shall be a 50-conductor connector consisting of two rows of ribbon contacts spaced 2.16 mm (0.085 inch) apart. The nonmating portion of the connector is shown for reference only.

The connector pin assignments shall be as shown in Table 4-3 for single-ended drivers and as shown in Table 4-4 for differential drivers.

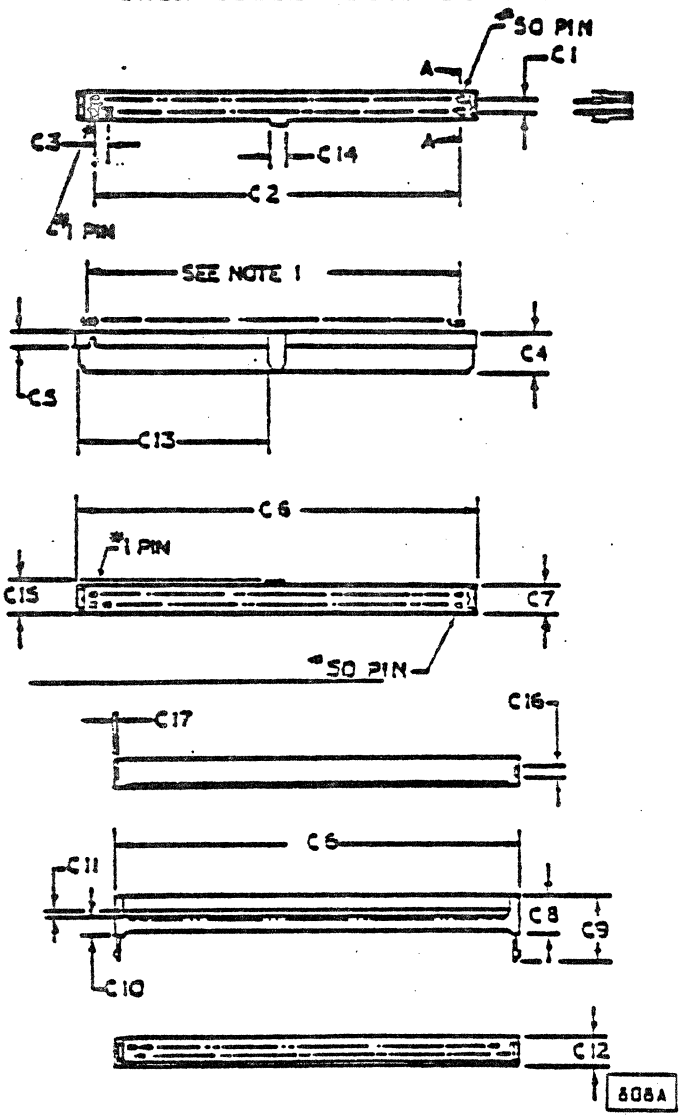


DIMENSIONS	MILLIMETERS	INCHES
D1	2.54	0.100
D2*	82.80	3.260
D3	2.54	0.100
D4	4.83	0.190
D5*	8.51	0.335
D6*	72.64	2.860
D7*	78.74	3.100
D8*	13.94	0.549
D9	4.19	0.165
D10	6.09	0.240
D11	6.60	0.260

803A

NOTES:
1. Fifty Contacts on 2.54 mm (0.100-inch) spacing = 60.96 mm (2.40 inch).
2. Tolerances ±0.127 mm (0.005 inch) noncumulative.
3. Dimensions listed with asterisks (*) are shown for reference only.

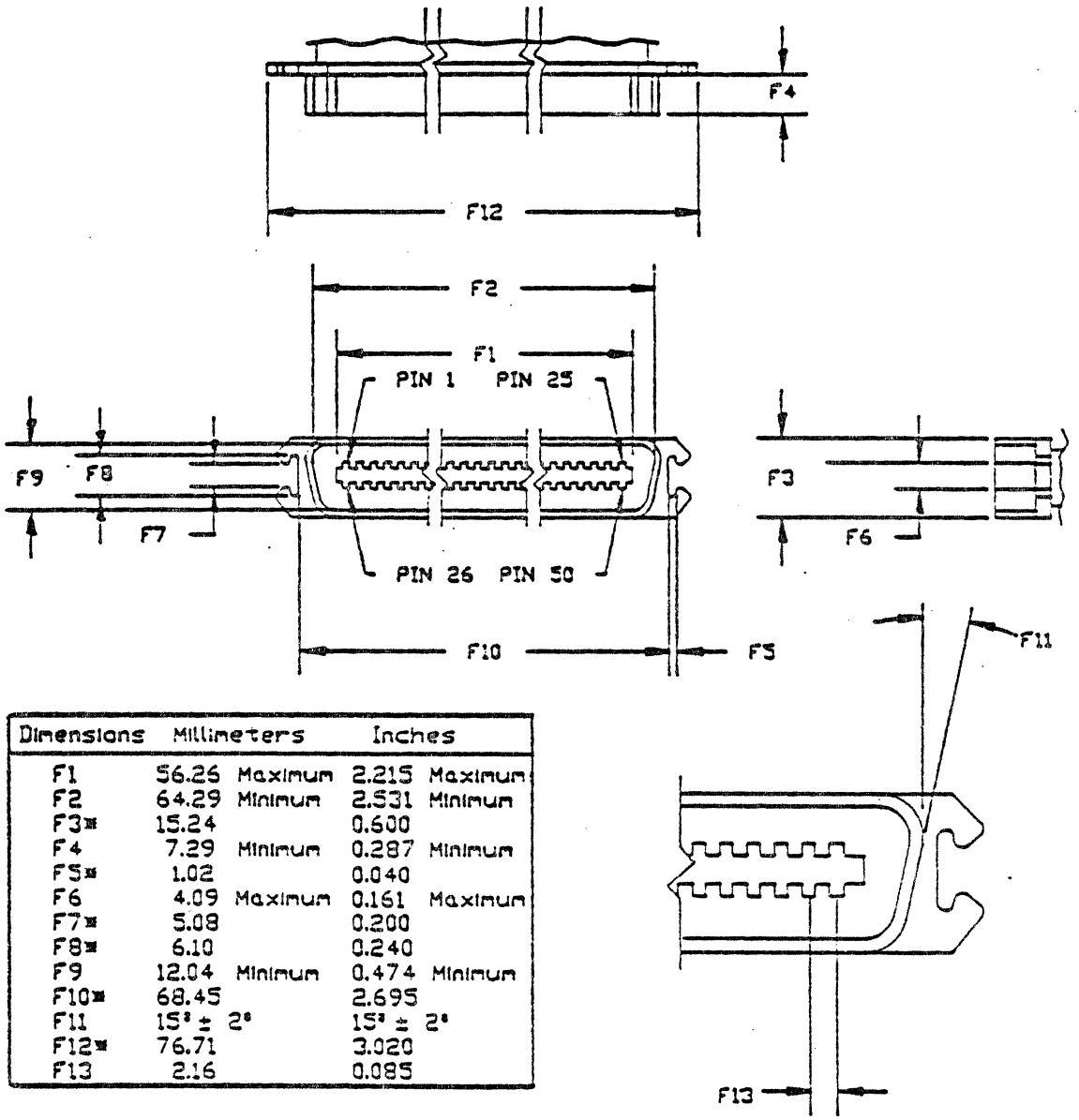
FIGURE 4-1. NONSHIELDED SCSI DEVICE CONNECTOR



DIMENSIONS	MILLIMETERS	INCHES	DIMENSIONS	MILLIMETERS	INCHES
C1	2.5400	0.100	C10*	3.8100	0.150
C2	60.9600	2.400	C11*	1.2700	0.050
C3	2.5400	0.100	C12*	6.0960	0.240
C4	8.3570	0.329	C13	32.3850	1.275
C5	3.3025	0.130	C14	3.3020	0.130
C6	68.0720	2.680	C15	7.4930	0.295
C7	6.0960	0.240	C16	2.6670	0.105
C8*	8.1530	0.321	C17	1.6250	0.064
C9*	13.4870	0.531			

NOTES:
1. Fifty contacts on 1.27 mm (0.05-inch)* staggered spacing = 62.23 mm (2.450 inch)*.
2. Tolerances ±0.127 mm (0.005 inch) noncumulative.
3. Dimensions listed with asterisks (*) are shown for reference only.

FIGURE 4-2. NONSHIELDED CABLE CONNECTOR



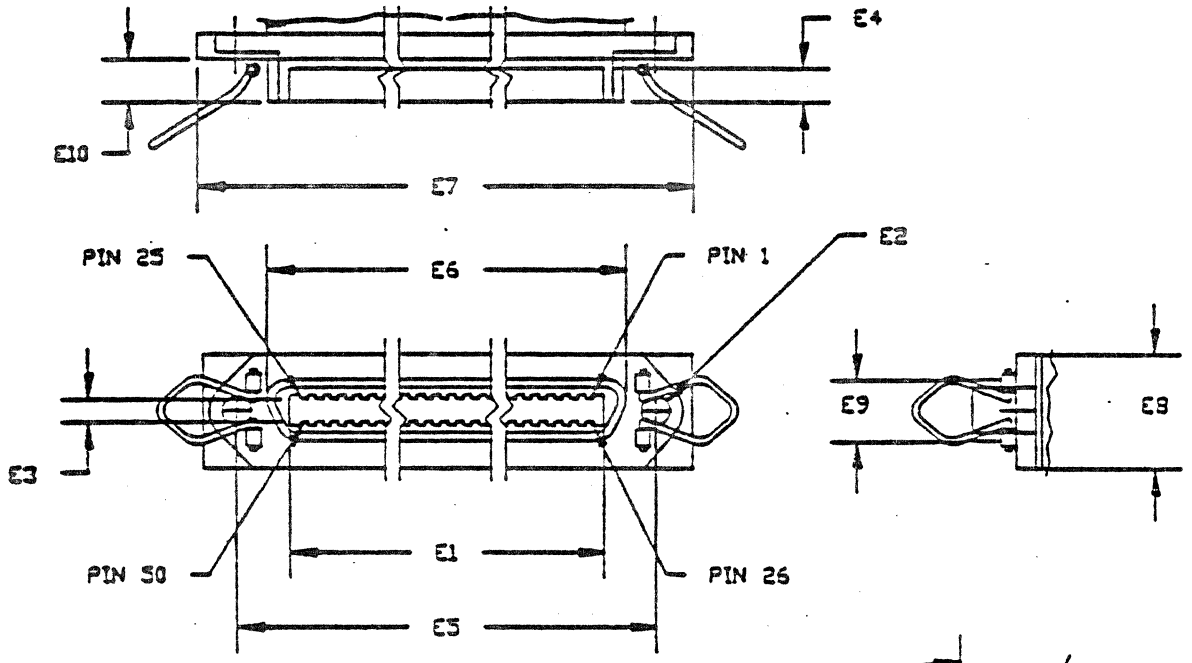
Dimensions	Millimeters		Inches	
F1	56.26	Maximum	2.215	Maximum
F2	64.29	Minimum	2.531	Minimum
F3*	15.24		0.600	
F4	7.29	Minimum	0.287	Minimum
F5*	1.02		0.040	
F6	4.09	Maximum	0.161	Maximum
F7*	5.08		0.200	
F8*	6.10		0.240	
F9	12.04	Minimum	0.474	Minimum
F10*	68.45		2.695	
F11	15° ± 2°		15° ± 2°	
F12*	76.71		3.020	
F13	2.16		0.085	

804A

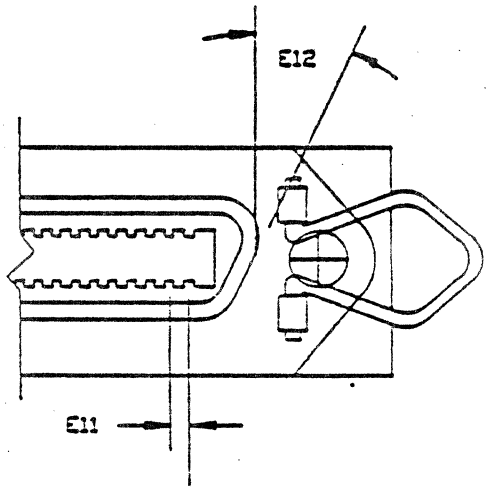
NOTES:

1. Tolerances ±0.127 mm (0.005 inch) noncumulative, unless specified otherwise.
2. Dimensions listed with asterisks (*) are shown for reference only.

FIGURE 4-3. SHIELDED SCSI CABLE CONNECTOR, ALTERNATIVE 2



Dimensions	Millimeters		Inches	
E1	56.39	Minimum	2.220	Minimum
E2 (3)	2.62	Minimum	0.103	Minimum
E3	3.99	Minimum	0.157	Minimum
E4	5.84	Minimum	0.230	Minimum
E5	74.85		2.947	
E6	64.29	Maximum	2.531	Maximum
E7*	83.06		3.270	
E8*	15.24		0.600	
E9	12.04	Maximum	0.474	Maximum
E10	9.78	Maximum	0.385	Maximum
E11	2.16		0.085	
E12	15° ± 2°		15° ± 2°	



805A

NOTES:
1. Tolerances ±0.127 mm (0.005 inch) noncumulative, unless specified otherwise.
2. Dimensions listed with asterisks (*) are shown for reference only.
3. Dimension E2 to accomodate 4-40 or 6-32 threaded screws.

FIGURE 4-4. SHIELDED SCSI DEVICE CONNECTOR, ALTERNATIVE 2

TABLE 4-1 SINGLE-ENDED CABLE PIN ASSIGNMENTS
(NONSHIELDED ALTERNATIVE 1 CONNECTOR)

SIGNAL	PIN NUMBER
-DB(0)	2
-DB(1)	4
-DB(2)	6
-DB(3)	8
-DB(4)	10
-DB(5)	12
-DB(6)	14
-DB(7)	16
-DB(P)	18
GROUND	20
GROUND	22
GROUND	24
TERMPWR	26
GROUND	28
GROUND	30
-ATN	32
GROUND	34
-BSY	36
-ACK	38
-RST	40
-MSG	42
-SEL	44
-C/D	46
-REQ	48
-I/O	50

NOTES:

1. All odd pins except pin 25 shall be connected to ground. Pin 25 should be left open. Some products designed prior to the generation of this standard connected this pin to ground.

2. The minus sign next to the signals indicates active low.

TABLE 4-2 DIFFERENTIAL CABLE PIN ASSIGNMENTS
(NONSHIELDED ALTERNATIVE 1 CONNECTOR)

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
GROUND	23	24	GROUND
TERMPWR	25	26	TERMPWR
GROUND	27	28	GROUND
+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

NOTES:

1. SHIELD GROUND is optional on some cables.

TABLE 4-3 SINGLE-ENDED CABLE PIN ASSIGNMENTS
(SHIELDED ALTERNATIVE 2 CONNECTOR)

SIGNAL	PIN NUMBER
-DB(0)	26
-DB(1)	27
-DB(2)	28
-DB(3)	29
-DB(4)	30
-DB(5)	31
-DB(6)	32
-DB(7)	33
-DB(P)	34
GROUND	35
GROUND	36
GROUND	37
TERMPWR	38
GROUND	39
GROUND	40
-ATN	41
GROUND	42
-BSY	43
-ACK	44
-RST	45
-MSG	46
-SEL	47
-C/D	48
-REQ	49
-I/O	50

NOTES:

1. Pins 1 through 12 and 14 through 25 shall be connected to ground. Pin 13 should be left open.
2. The minus sign next to the signals indicates active low.

TABLE 4-4 DIFFERENTIAL CABLE PIN ASSIGNMENTS
(SHIELDED ALTERNATIVE 2 CONNECTOR)

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
GROUND	12	37	GROUND
TERMPWR	13	38	TERMPWR
GROUND	14	39	GROUND
+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

NOTES:

1. SHIELD GROUND is optional on some cables.

4.4 Electrical Description

NOTE: For these measurements, SCSI bus termination is assumed to be external to the SCSI device. An SCSI device may have the provision for allowing optional internal termination.

4.4.1 Single-Ended Alternative

All assigned signals shall be terminated with 220 ohms to +5 volts (nominal) and 330 ohms to ground at each end of the cable. (See Figure 4-5.) All signals shall use open-collector or three-state drivers.

4.4.1.1 Output Characteristics

Each signal driven by an SCSI device shall have the following output characteristics when measured at the SCSI device's connector:

Signal assertion = 0.0 V dc to 0.4 V dc
Minimum driver output capability = 48 milliamps (sinking) at 0.5 V dc
Signal negation = 2.5 V dc to 5.25 V dc

4.4.1.2 Input Characteristics

Each signal received by an SCSI device shall have the following input characteristics when measured at the SCSI device's connector:

Signal true = 0.0 V dc to 0.8 V dc
Maximum total input load = -0.4 milliamps at 0.4 volts dc
Signal false = 2.0 V dc to 5.25 V dc
Minimum input hysteresis = 0.2 V dc

4.4.2 Differential Alternative

All signals consist of two lines denoted +SIGNAL and -SIGNAL. A signal is true when +SIGNAL is more positive than -SIGNAL, and a signal is false when -SIGNAL is more positive than +SIGNAL. All assigned signals shall be terminated at each end of the cable as shown in Figure 4-6.

NOTE: As an option, the DIFFSENS signal of the connector is reserved for an active high enable for the differential drivers. If a single-ended receiver or terminator is inadvertently connected, this signal is grounded, disabling the drivers. (See Figure 4-7.) If this option is not implementated, this pin must be left open.

4.4.2.1 Output Characteristics

Each signal driven by an SCSI device shall have the following output characteristics when measured at the SCSI device's connector:

VOL (Low-level output voltage) = 2.0 V maximum at IOL (Low-level output current) = 55 milliamps.

VOH (High-level output voltage) = 3.0 V minimum at IOH (High-level output current) = -55 milliamps.

VOD (Differential voltage) = 1.0 V minimum with common-mode voltage ranges from -7 V dc to +12 V dc.

VOL and VOH shall be as measured between the output terminal and the SCSI device's logic ground reference.

The output characteristics shall additionally conform to EIA RS-485-1983.

4.4.2.2 Input Characteristics

Each signal received by an SCSI device shall have the following input characteristics when measured at the SCSI device's connector:

II (Input current on either input) = +2.0 milliamps maximum.

NOTE: These characteristics include both receivers and passive drivers.

This requirement shall be met with the input voltage varying between -7 V dc and +12 V dc, with power on or off, and with the hysteresis equaling 35 mv, minimum.

The input characteristics shall additionally conform to EIA RS-485-1983.

4.4.3 Terminator Power Requirements

Single-ended SCSI devices providing terminator power (TERMPWR) shall have the following characteristics:

VTerm = 4.0 V dc to 5.25 V dc
800 milliamps minimum source drive capability
1.0 milliamp maximum sink capability (except for the purposes of providing power to an internal terminator) with 1.0 amp recommended current limiting (e.g., a fuse).

Differential SCSI devices providing termination power (TERMPWR) shall have the following characteristics:

VTerm = 4.0 V dc to 5.25 V dc
600 milliamps minimum source drive capability
1.0 milliamp maximum sink capability (except for the purposes of providing power to an internal terminator) with 1.0 amp recommended current limiting (e.g., a fuse).

SCSI devices that supply terminator power shall do so through a diode or similar semiconductor that prevents the backflow of power to the SCSI device.

- CDC products will not provide terminator power to the SCSI bus for other devices. All products will be configurable to receive terminator power either from the SCSI bus (pin 26) or the CDC device's power source. CDC recommends that terminator power be provided to the SCSI bus by a host adapter device. This allows peripheral devices to be powered down without risking loss of terminator power.

- Primary power consumption specifications for CDC products will assume host supplied termination power. The additional power for the terminator, if it must be supplied by the target power supply, is defined in the product specifications.

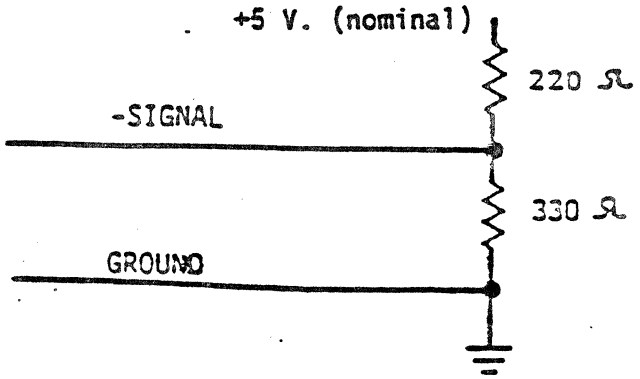


FIGURE 4-5. TERMINATION FOR SINGLE-ENDED DEVICES

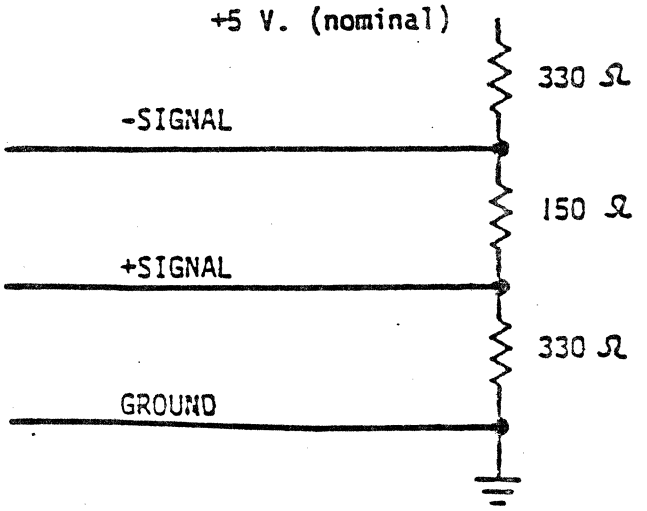


FIGURE 4-6. TERMINATION FOR DIFFERENTIAL DEVICES

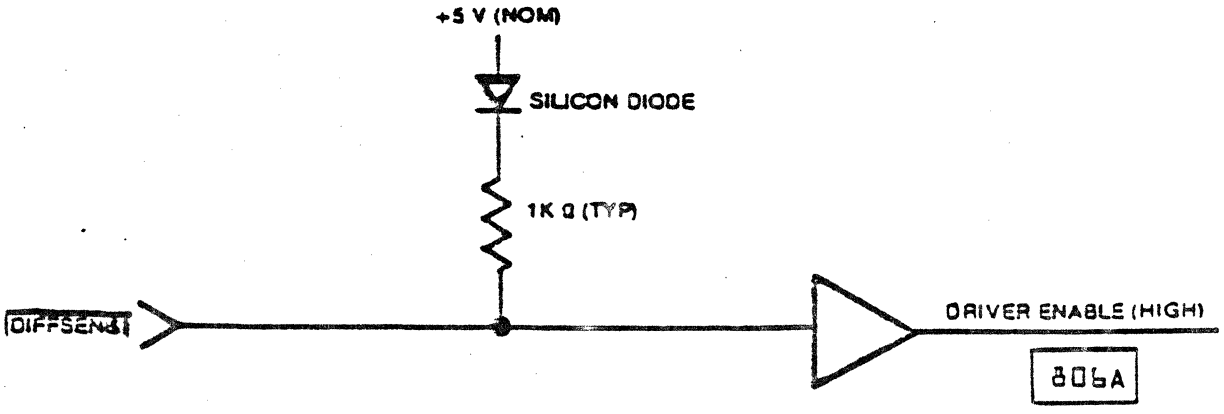


FIGURE 4-7. DIFFERENTIAL DRIVER PROTECTION CIRCUIT (OPTIONAL)

4.5 SCSI Bus

Communication on the SCSI bus is allowed between only two SCSI devices at any given time. There is a maximum of eight SCSI devices. Each SCSI device has an SCSI ID bit assigned as shown in Figure 4-8. These devices can be any combination of initiators and targets.

When two SCSI devices communicate on the SCSI bus, one acts as an initiator and the other acts as a target. The initiator originates an operation and the target performs the operation. CDC SCSI devices will always function as a target, but some CDC devices may be able to assume the initiator role also.

An initiator may address up to eight peripheral devices (referred to as logical units) that are connected to a target. Three sample system configurations are shown in Figure 4-9.

Bus functions are assigned to initiator or target as shown in Table 4-4.

Information transfers on the DATA BUS are asynchronous and follow a defined REQ/ACK handshake protocol. One byte of information may be transferred with each handshake. All CDC products will support asyncronous transfers and some may also support syncronous transfers.

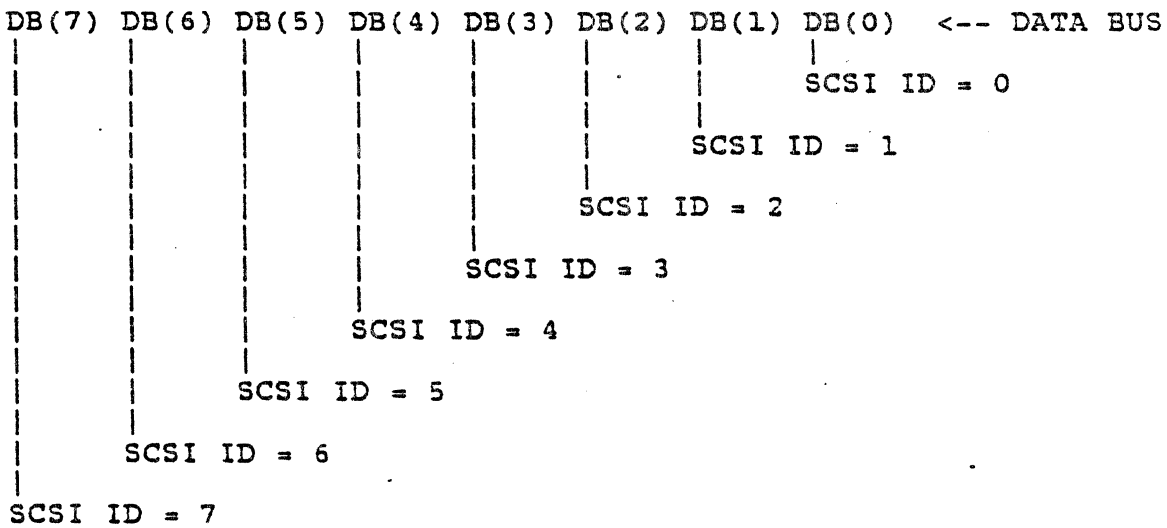
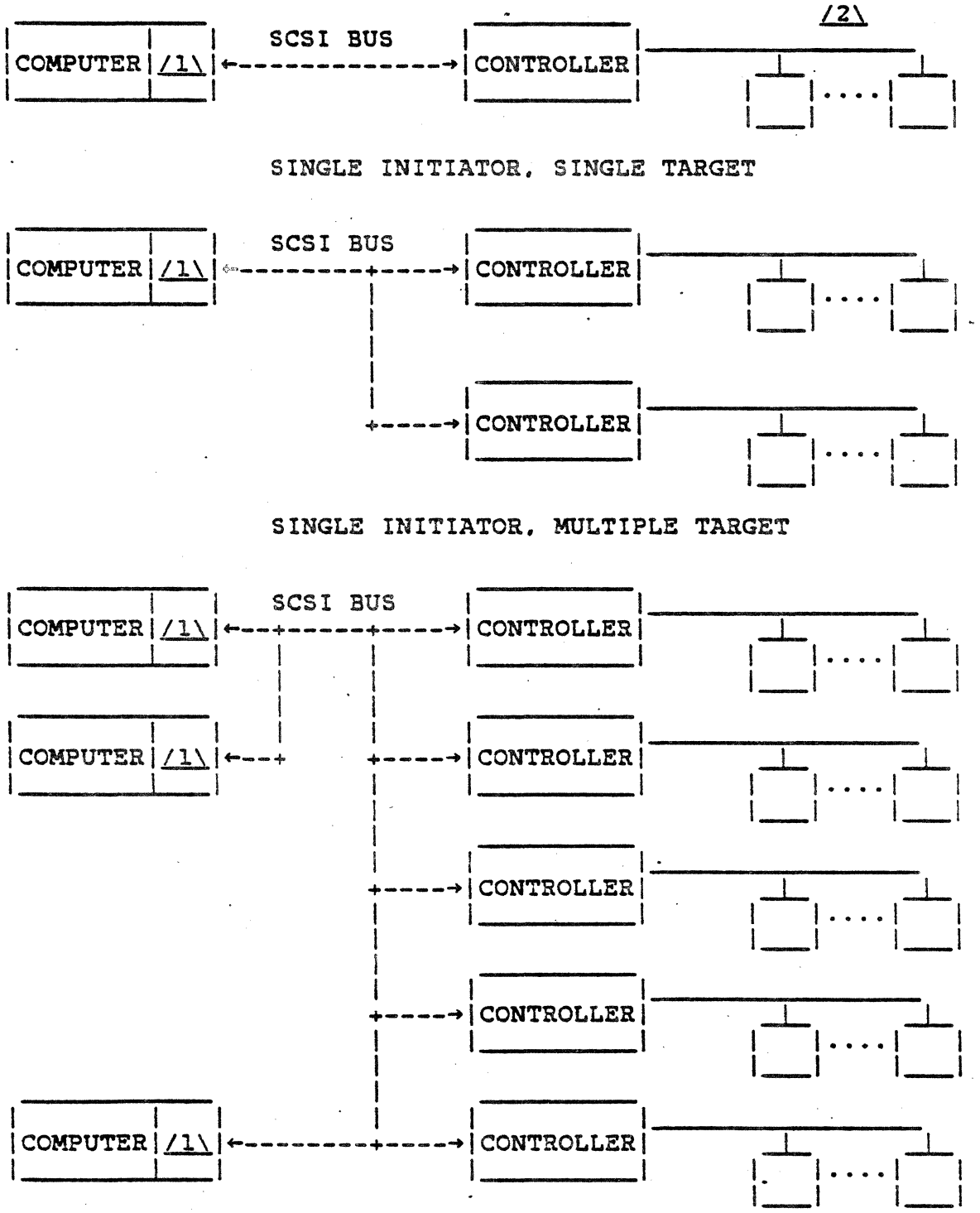


FIGURE 4-8. SCSI ID BITS



SINGLE INITIATOR, SINGLE TARGET

SINGLE INITIATOR, MULTIPLE TARGET

MULTIPLE INITIATOR, MULTIPLE TARGET

/1\ Host Adapter
/2\ Peripheral devices such as magnetic disks, tapes, printers, etc. These devices may be embedded with the controller.

FIGURE 4-9. SAMPLE SCSI CONFIGURATIONS

4.6 SCSI Bus Signals

There are a total of eighteen signals. Nine are used for control and nine are used for data. (Data signals include the parity signal option). These signals are described as follows:

BSY (BUSY) - An "OR-tied" signal that indicates that the bus is being used.

SEL (SELECT) - A signal used by an initiator to select a target or by a target to reselect an initiator.

C/D (CONTROL/DATA) - A signal driven by a target that indicates whether CONTROL or DATA information is on the DATA BUS. True indicates CONTROL.

I/O (INPUT/OUTPUT) - A signal driven by a target that controls the direction of data movement on the DATA BUS with respect to an initiator. True indicates input to the initiator. This signal is also used to distinguish between SELECTION and RESELECTION phases.

MSG (MESSAGE) - A signal driven by a target during the MESSAGE phase.

REQ (REQUEST) - A signal driven by a target to indicate a request for a REQ/ACK data transfer handshake.

ACK (ACKNOWLEDGE) - A signal driven by an initiator to indicate an acknowledgment for a REQ/ACK data transfer handshake.

ATN (ATTENTION) - A signal driven by an initiator to indicate the ATTENTION condition.

RST (RESET) - An "OR-tied" signal that indicates the RESET condition.

DB(7-0,P) (DATA BUS). Eight data-bit signals, plus a parity-bit signal that form a DATA BUS. DB(7) is the most significant bit and has the highest priority during the ARBITRATION phase. Bit number, significance, and priority decrease downward to DB(0). A data bit is defined as one when the signal value is true and is defined as zero when the signal value is false.

Data parity DB(P) is odd - The use of parity is a system option. All CDC products will generate parity, but must include the capability to enable/disable parity detection. Parity is not valid during the ARBITRATION phase.

4.6.1 Signal Values

Signals may assume true or false values. There are two methods of driving these signals. In both cases, the signal shall be actively driven true, or asserted. In the case of OR-tied drivers, the driver does not drive the signal to the false state, rather the bias circuitry of the bus terminators pulls the signal false whenever it is released by the drivers at every SCSI device. If any driver is asserted, then the signal is true. In the case of non-OR-tied drivers, the signal may be actively driven false, or negated. In this standard, wherever the term negated is used, it means that the signal may be actively driven false, or may be simply released (in which case the bias circuitry pulls it false), at the option of the implementor. The advantage to actively drive signals false is that the transition from true to false occurs more quickly, and noise margins may be somewhat improved; this may permit somewhat faster data transfer.

4.6.2 OR-Tied Signals

The BSY and RST signals shall be OR-tied only. In the ordinary operation of the bus, these signals are simultaneously driven true by several drivers. No signals other than BSY, RST, and DB(P) are simultaneously driven by two or more drivers, and any signal other than BSY and RST may employ OR-tied or non-OR-tied drivers. DB(P) shall not be driven false during the ARBITRATION phase. There is no operational problem in mixing OR-tied and non-OR-tied drivers on signals other than BSY and RST.

4.6.3 Signal Sources

Table 4-4 indicates which type of SCSI device is allowed to source each signal. All SCSI device drivers that are not active sources shall be in the passive state. Note that the RST signal may be sourced by any SCSI device at any time.

TABLE 4-4 SIGNAL SOURCES

	SIGNALS				
BUS PHASE	BSY	SEL	C/D, I/O, MSG, REQ	ACK/ATN	DB(7-0,P)
BUS FREE	None	None	None	None	None
ARBITRATION	All	Winner	None	None	SCSI ID
SELECTION	I&T	Initiator	None	Initiator	Initiator
RESELECTION	I&T	Target	Target	Initiator	Target
COMMAND	Target	None	Target	Initiator	Initiator
DATA IN	Target	None	Target	Initiator	Target
DATA OUT	Target	None	Target	Initiator	Initiator
STATUS	Target	None	Target	Initiator	Target
MESSAGE IN	Target	None	Target	Initiator	Target
MESSAGE OUT	Target	None	Target	Initiator	Initiator

All: The signal shall be driven by all SCSI devices that are actively arbitrating.

SCSI ID: A unique data bit (the SCSI ID) shall be driven by each SCSI device that is actively arbitrating; the other seven data bits shall be released (i.e., not driven) by this SCSI device. The parity bit (DB(P)) may be undriven or driven to the true state, but shall never be driven to the false state during this phase.

I&T: The signal shall be driven by the initiator, target, or both, as specified in the SELECTION phase and RESELECTION phase.

Initiator: If this signal is driven, it shall be driven only by the active initiator.

None: The signal shall be released; that is, not be driven by any SCSI device. The bias circuitry of the bus terminators pulls the signal to the false state.

Winner: The signal shall be driven by the one SCSI device that wins arbitration.

Target: If the signal is driven, it shall be driven only by the active target.

4.7 SCSI Bus Timing

Unless otherwise indicated, the delay-time measurements for each SCSI device, shown in 4.7.1 through 4.7.14, shall be calculated from signal conditions existing at that SCSI device's own SCSI bus connection. Thus, these measurements (except cable skew delay) can be made without considering delays in the cable.

4.7.1 Arbitration Delay (2.2 us)

The minimum time an SCSI device shall wait from asserting BSY for arbitration until the DATA BUS can be examined to see if arbitration has been won. There is no maximum time.

4.7.2 Assertion Period (90 ns)

The minimum time that a target shall assert REQ while using synchronous data transfers. Also, the minimum time that an initiator shall assert ACK while using synchronous data transfers.

4.7.3 Bus Clear Delay (800 ns)

The maximum time for an SCSI device to stop driving all bus signals after:

(1) The BUS FREE phase is detected (BSY and SEL both false for a bus settle delay)

(2) SEL is received from another SCSI device during the ARBITRATION phase.

(3) The transition of RST to true.

NOTE: For the first condition above, the maximum time for an SCSI device to clear the bus is 1200 ns from BSY and SEL first becoming both false. If an SCSI device requires more than a bus settle delay to detect BUS FREE phase, it shall clear the bus within a bus clear delay minus the excess time.

4.7.4 Bus Free Delay (800 ns)

The minimum time that an SCSI device shall wait from its detection of the BUS FREE phase (BSY and SEL both false for a bus settle delay) until its assertion of BSY when going to the ARBITRATION phase.

4.7.5 Bus Set Delay (1.8 us)

The maximum time for an SCSI device to assert BSY and its SCSI ID bit on the DATA BUS after it detects BUS FREE phase (BSY and SEL both false for a bus settle delay) for the purpose of entering the ARBITRATION phase.

4.7.6 Bus Settle Delay (400 ns)

The time to wait for the bus to settle after changing certain control signals as called out in the protocol definitions.

4.7.7 Cable Skew Delay (10 ns)

The maximum difference in propagation time allowed between any two SCSI bus signals when measured between any two SCSI devices.

4.7.8 Data Release Delay (400 ns)

The maximum time for an initiator to release the DATA BUS signals following the transition of the I/O signal from false to true.

4.7.9 Deskew Delay (45 ns)

The minimum time required for deskew of certain signals.

4.7.10 Hold Time (45 ns)

The minimum time added between the assertion of REQ or ACK and the changing of the data lines to provide hold time in the initiator or target, respectively, while using synchronous data transfers.

4.7.11 Negation Period (90 ns)

The minimum time that a target shall negate REQ while using synchronous data transfers. Also, the minimum time that an initiator shall negate ACK while using synchronous data transfers.

4.7.12 Reset Hold Time (25 us)

The minimum time for which RST is asserted. There is no maximum time.

4.7.13 Selection Abort Time (200 us)

The maximum time that a target (or initiator) shall take from its most recent detection of being selected (or reselected) until asserting a BSY response. This timeout is required to ensure that a target (or initiator) does not assert BSY after a SELECTION (or RESELECTION) phase has been aborted. This is not the selection timeout period; see Sections 5.1.3.5 and 5.1.4.2 for a complete description.

4.7.14 Selection Timeout Delay (250 ms, recommended)

The minimum time that an initiator (or target) should wait for a BSY response during the SELECTION (or RESELECTION) phase before starting the timeout procedure. Note that this is only a recommended time period. The specifications for the peripheral devices shall be consulted for the actual timing requirements.

4.7.15 Transfer Period (set during a MESSAGE phase)

The Transfer Period specifies the minimum time allowed between the leading edges of successive REQ pulses and of successive ACK pulses while using synchronous data transfers. (See Sections 5.1.5.2 and 5.5.4.).

5.0 LOGICAL CHARACTERISTICS

5.1 SCSI Bus Phases

The SCSI architecture includes eight distinct phases:

BUS FREE phase
ARBITRATION phase
SELECTION phase
RESELECTION phase
COMMAND phase \
DATA phase \ These phases are collectively termed the
STATUS phase / information transfer phases.
MESSAGE phase /

The SCSI bus can never be in more than one phase at any given time. Unless otherwise noted in the following descriptions, signals that are not mentioned shall not be asserted.

■ CDC products will support all eight phases, but will be equally
■ compatible with systems that do not use ARBITRATION, RESELECTION,
■ and messages other than COMMAND COMPLETE message.

5.1.1 BUS FREE Phase

The BUS FREE phase is used to indicate that no SCSI device is actively using the SCSI bus and that it is available for subsequent users.

SCSI devices shall detect the BUS FREE phase after SEL and BSY are both false for at least a bus settle delay.

SCSI devices shall release all SCSI bus signals within a bus clear delay after BSY and SEL become continuously false for a bus settle delay. If an SCSI device requires more than a bus settle delay to detect the BUS FREE phase then it shall release all SCSI bus signals within a bus clear delay minus the excess time to detect the BUS FREE phase. The total time to clear the SCSI bus shall not exceed a bus settle delay plus a bus clear delay.

■ If the initiator detects the BUS FREE phase (except as a result of
■ a RESET condition, an ABORT message, or a BUS DEVICE RESET MESSAGE)
■ without first receiving a DISCONNECT or COMMAND COMPLETE message,
■ it shall be considered to be an error condition. If the target
■ intentionally creates this condition, the target shall:

1. Clear the current command, if any, for that initiator.
2. Set up REQUEST SENSE data with appropriate Sense Key and Error Code if the LUN is known.

Whenever an initiator detects an unexpected BUS FREE, it should attempt to select and issue REQUEST SENSE to determine if the previous command was:

1. Aborted with valid REQUEST SENSE data, or
2. Aborted without any valid REQUEST SENSE data.

5.1.2 ARBITRATION Phase

The ARBITRATION phase allows one SCSI device to gain control of the SCSI bus so that it can assume the role of an initiator or target.

The procedure for an SCSI device to obtain control of the SCSI bus is as follows.

1. The SCSI device shall first wait for the BUS FREE phase to occur. The BUS FREE phase is detected whenever both BSY and SEL are simultaneously and continuously false for a minimum of a bus settle delay. (Implementers note: This bus settle delay is necessary because a transmission line phenomenon known as a "wire-OR glitch" may cause BSY to briefly appear false, even though it is being driven true.)

2. The SCSI device shall wait a minimum of a bus free delay after detection of the BUS FREE phase (i.e. after BSY and SEL are both false for a bus settle delay) before driving any signal.

3. Following the bus free delay in Step (2), the SCSI device may arbitrate for the SCSI bus by asserting both BSY and its own SCSI ID, however the SCSI device shall not arbitrate (i.e. assert BSY and its SCSI ID) if more than a bus set delay has passed since the BUS FREE phase was last observed. (Implementors Note: There is no maximum delay before asserting BSY and the SCSI ID following the bus free delay in Step (2) as long as the bus remains in the BUS FREE phase. However, SCSI devices that delay longer than a bus settle delay plus a bus set delay from the time when BSY and SEL first become false may fail to participate in arbitration when competing with faster SCSI devices.)

4. After waiting at least an arbitration delay (measured from its assertion of BSY) the SCSI device shall examine the DATA BUS. If a higher priority SCSI ID bit is true on the DATA BUS (DB(7) is the highest), then the SCSI device has lost the arbitration and the SCSI device must release its signals and return to Step (1). If no higher priority SCSI ID bit is true on the DATA BUS, then the SCSI device has won the arbitration and it shall assert SEL. Any other SCSI device that is participating in the ARBITRATION phase has lost the arbitration and shall release BSY and its SCSI ID bit within a bus clear delay after SEL becomes true. An SCSI device that loses arbitration may return to Step (1).

5. The SCSI device that wins arbitration shall wait at least a bus clear delay plus a bus settle delay after asserting SEL before changing any signals.

NOTE: The SCSI ID bit is a single bit on the DATA BUS that corresponds to the SCSI device's unique SCSI address. All other seven DATA BUS bits shall be released by the SCSI device. Parity is not valid during the ARBITRATION phase. During the ARBITRATION phase, DB(P) may be undriven or driven to the true state, but shall not be driven to the false state.

5.1.3 SELECTION Phase

The SELECTION phase allows an initiator to select a target for the purpose of initiating some target function (e.g., READ or WRITE command).

NOTE: During the SELECTION phase the I/O signal shall be negated so that this phase can be distinguished from the RESELECTION phase.

5.1.3.1 Non Arbitrating Systems

In systems with the ARBITRATION phase not implemented, the initiator shall first detect the BUS FREE phase and then wait a minimum of a bus clear delay. Then, except in certain single initiator environments with initiators employing the single initiator option (see 5.1.3.4), the initiator shall assert the desired target's SCSI ID and its own initiator SCSI ID on the DATA BUS. After two deskew delays the initiator shall assert SEL.

5.1.3.2 Arbitrating Systems

In systems with the ARBITRATION phase implemented, the SCSI device that won the arbitration has both BSY and SEL asserted and has delayed at least a bus clear delay plus a bus settle delay before ending the ARBITRATION phase. The SCSI device that won the arbitration becomes an initiator by releasing I/O. Except in certain single initiator environments with initiators employing the single initiator option (see 5.1.3.4), the initiator shall set the DATA BUS to a value which is the OR of its SCSI ID bit and the target's SCSI ID bit. The initiator shall then wait at least two deskew delays and release BSY. The initiator shall then wait at least a bus settle delay before looking for a response from the target.

5.1.3.3 All Systems

In all systems, the target shall determine that it is selected when SEL and its SCSI ID bit are true and BSY and I/O are false for at least a bus settle delay. The selected target will examine the DATA BUS in order to determine the SCSI ID of the selecting initiator unless the initiator employed the single initiator option (see 5.1.3.4). The selected target shall then assert BSY within a selection abort time of its most recent detection of being selected; this is required for correct operation of the timeout procedure. In systems with parity implemented, the target shall not respond to a selection if bad parity is detected. Also, if more than two SCSI ID bits are on the DATA BUS, the target shall not respond to selection. At least two deskew delays after the initiator detects BSY is true, it shall release SEL and may change the DATA BUS.

5.1.3.4 Single Initiator Option

Initiators that do not implement the RESELECTION phase and do not operate in the multiple initiator environment are allowed to set only the target's SCSI ID bit during the SELECTION phase. This makes it impossible for the target to determine the initiator's SCSI ID.

5.1.3.5 SELECTION Timeout Procedure

A SELECTION timeout procedure is specified for clearing the SCSI bus. If the initiator waits a minimum of a selection timeout delay and there has been no BSY response from the target, then a CDC initiator shall continue asserting SEL and shall release the DATA BUS. If the initiator has not detected BSY to be true after at least a selection abort time plus two deskew delays, the initiator shall release SEL allowing the SCSI bus to go to the BUS FREE phase. SCSI devices shall ensure that when responding to selection that the selection was still valid within a selection abort time of their assertion of BSY. Failure to comply with this requirement could result in an improper selection (two targets connected to the same initiator, wrong target connected to an initiator, or a target connected to no initiator).

5.1.4 RESELECTION Phase

- RESELECTION is a phase that allows a target to reconnect to an initiator for the purpose of continuing some operation that was previously started by the initiator but was suspended by the target (i.e., the target disconnected by allowing a BUS FREE phase to occur before the operation was complete).

  RESELECTION can only be used in systems that have ARBITRATION phase implemented.

5.1.4.1 RESELECTION Procedure

Upon completing the ARBITRATION phase, the winning SCSI device has both BSY and SEL asserted and has delayed at least a bus clear delay plus a bus settle delay. The winning SCSI device becomes a target by asserting the I/O signal. That device shall also set the DATA BUS to a value that is the OR of its SCSI ID bit and the initiator's SCSI ID bit. The target shall wait at least two deskew delays and release BSY. The target shall then wait at least a bus settle delay before looking for a response from the initiator.

The initiator shall determine that it is reselected when SEL, I/O, and its SCSI ID bit are true and BSY is false for at least a bus settle delay. The reselected initiator may examine the DATA BUS in order to determine the SCSI ID of the reselecting target.

The reselected initiator shall then assert BSY within a selection abort time of its most recent detection of being reselected; this is required for correct operation of the timeout procedure. In systems with parity implemented, the initiator shall not respond to a RESELECTION if bad parity is detected. Also, the initiator shall not respond to a RESELECTION if more than two SCSI ID bits are on the DATA BUS.

After the target detects BSY, it shall also assert BSY and wait at least two deskew delays and then release SEL. The target may then change the I/O signal and the DATA BUS. After the reselected initiator detects SEL false, it shall release BSY. The target shall continue asserting BSY until the target is ready to relinquish the SCSI bus.

NOTE: When the target is asserting BSY, a transmission line phenomenon known as a "wire-OR glitch" may cause BSY to appear false for up to a round-trip propagation delay following the release of BSY by the initiator. This is the reason why the BUS FREE phase is recognized only after both BSY and SEL are continuously false for a minimum of a bus settle delay. Cables longer than 25 meters should not be used even if the chosen driver, receiver, and cable provide adequate noise margins, because they increase the duration of the glitch and could cause SCSI devices to inadvertently detect the BUS FREE phase.

5.1.4.2 RESELECTION Timeout Procedure

This RESELECTION timeout procedure is specified for clearing the SCSI bus during a RESELECTION phase. If the target waits a minimum of a selection timeout period and there has been no BSY response from the initiator, then a CDC target shall continue asserting SEL and I/O and shall release all DATA BUS signals. If the target has not detected BSY to be true after at least a selection abort time plus two deskew delays, the target shall release SEL and I/O allowing the SCSI bus to go to the BUS FREE phase. SCSI devices that respond to RESELECTION shall ensure that the RESELECTION was still valid within a selection abort time of their assertion of BSY. Failure to comply with this requirement could result in an improper reselection (two initiators connected to the same target or the wrong initiator connected to a target).

If RESELECTION fails, the current command will be aborted. If an initiator times out while waiting to be reselected, the initiator should attempt to select and issue REQUEST SENSE to determine if the previous command is:

1. Still in process (busy STATUS will be returned),
2. Aborted with valid REQUEST SENSE data, or
3. Aborted without valid REQUEST SENSE data.

5.1.5 Information Transfer Phases

NOTE: The COMMAND, DATA, STATUS, and MESSAGE phases are all grouped together as the information transfer phases because they are all used to transfer data or control information via the DATA BUS. The actual contents of the information is beyond the scope of this section.

The C/D, I/O, and MSG signals are used to distinguish between the different information transfer phases. (See Table 5-1.) The target drives these three signals and therefore controls all changes from one phase to another. The initiator can request a MESSAGE OUT phase by asserting ATN, while the target can cause the BUS FREE phase by releasing MSG, C/D, I/O, and BSY.

TABLE 5-1. INFORMATION TRANSFER PHASES

SIGNAL					
MSG	C/D	I/O	PHASE NAME	DIRECTION OF TRANSFER	COMMENT
0	0	0	DATA OUT	Initiator to target \	Data
0	0	1	DATA IN	Initiator from target /	Phase
0	1	0	COMMAND	Initiator to target	
0	1	1	STATUS	Initiator from target	
1	0	0	*		
1	0	1	*		
1	1	0	MESSAGE OUT	Initiator to target \	Message
1	1	1	MESSAGE IN	Initiator from target /	Phase

Key: 0 = False, 1 = True, * = Reserved for future standardization.

The information transfer phases use one or more REQ/ACK handshakes to control the information transfer. Each REQ/ACK handshake allows the transfer of one byte of information. During the information transfer phases BSY shall remain true and SEL shall remain false. Additionally, during the information transfer phases, the target shall continuously envelope the REQ/ACK handshake(s) with C/D, I/O, and MSG in such a manner that these control signals are valid for a bus settle delay before the assertion of REQ of the first handshake and remain valid until the negation of ACK at the end of the last handshake.

5.1.5.1 Asynchronous Information Transfer

The target shall control the direction of information transfer by means of the I/O signal. When I/O is true, information shall be transferred from the target to the initiator. When I/O is false, information shall be transferred from the initiator to the target.

If I/O is true (transfer to the initiator), the target shall first drive DB(7-0,P) to their desired values, delay at least one deskew delay plus a cable skew delay, then assert REQ. DB(7-0,P) shall remain valid until ACK is true at the target. The initiator shall read DB(7-0,P) after REQ is true, then signal its acceptance of the data by asserting ACK. When ACK becomes true at the target, the target may change or release DB(7-0,P) and shall negate REQ. After REQ is false the initiator shall then negate ACK. After ACK is false the target may continue the transfer by driving DB(7-0,P) and asserting REQ, as described above.

If I/O is false (transfer to the target) the target shall request information by asserting REQ. The initiator shall drive DB(7-0,P) to their desired values, delay at least one deskew delay plus a cable skew delay and assert ACK. The initiator shall continue to drive DB(7-0,P) until REQ is false. When ACK becomes true at the target, the target shall read DB(7-0,P), then negate REQ. When REQ becomes false at the initiator, the initiator may change or release DB(7-0,P) and shall negate ACK. The target may continue the transfer by asserting REQ, as described above.

5.1.5.2 Synchronous Data Transfer (Optional)

Synchronous data transfer is optional, and may be used only in the data phase if previously agreed to by the initiator and target through the message system (see SYNCHRONOUS DATA TRANSFER REQUEST message, 5.5). The messages determine the use of synchronous mode by both SCSI devices and establish a REQ/ACK offset and a transfer period.

The REQ/ACK offset specifies the maximum number of REQ pulses that can be sent by the target in advance of the number of ACK pulses received from the initiator, establishing a pacing mechanism. If the number of REQ pulses exceeds the number of ACK pulses by the REQ/ACK offset, the target shall not assert REQ until the next ACK pulse is received. A requirement for successful completion of the data phase is that the number of ACK and REQ pulses be equal.

The target shall assert the REQ signal for a minimum of an assertion period. The target shall wait at least the greater of a transfer period from the last transition of REQ to true or a minimum of a negation period from the last transition of REQ to false before asserting the REQ signal.

The initiator shall send one pulse on the ACK signal for each REQ pulse received. The initiator shall assert the ACK signal for a minimum of an assertion period. The initiator shall wait at least the greater of a transfer period from the last transition of ACK to true or for a minimum of a negation period from the last transition of ACK to false before asserting the ACK signal.

If I/O is true (transfer to the initiator), the target shall first drive DB(7-0,P) to their desired values, wait at least one deskew delay plus one cable skew delay, then assert REQ. DB(7-0,P) shall be held valid for a minimum of one deskew delay plus one cable skew delay plus one hold time after the assertion of REQ. The target shall assert REQ for the minimum of an assertion period. The target may then negate REQ and change or release DB(7-0,P). The initiator shall read the value on DB(7-0,P) within one hold time of the transition of REQ to true. The initiator shall then respond with an ACK pulse.

If I/O is false (transfer to the target), the initiator shall transfer one byte for each REQ pulse received. After receiving a REQ pulse, the initiator shall first drive DB(7-0,P) to their desired values, delay at least one deskew delay plus one cable skew delay, then assert ACK. The initiator shall hold DB(7-0,P) valid for at least one deskew delay plus one cable skew delay plus one hold time after the assertion of ACK. The initiator shall assert ACK for a minimum of an assertion period. The initiator shall then negate ACK and may change or release DB(7-0,P). The target shall read the value of DB(7-0,P) within one hold time of the transition of ACK to true.

5.1.6 COMMAND Phase

The COMMAND phase allows the target to request command information from the initiator.

The target shall assert the C/D signal and negate the I/O and MSG signals during the REQ/ACK handshake(s) of this phase.

5.1.7 Data Phase

The data phase is a term that encompasses both the DATA IN phase and the DATA OUT phase.

5.1.7.1 DATA IN Phase

The DATA IN phase allows the target to request that data be sent to the initiator from the target.

The target shall assert the I/O signal and negate the C/D and MSG signals during the REQ/ACK handshake(s) of this phase.

5.1.7.2 DATA OUT Phase

The DATA OUT phase allows the target to request that data be sent from the initiator to the target.

The target shall negate the C/D, I/O, and MSG signals during the REQ/ACK handshake(s) of this phase.

5.1.8 STATUS Phase

The STATUS phase allows the target to request that status information be sent from the target to the initiator.

The target shall assert C/D and I/O and negate the MSG signal during the REQ/ACK handshake of this phase.

5.1.9 Message Phase

The message phase is a term that references either a MESSAGE IN, or a MESSAGE OUT phase. Multiple messages may be sent during either phase. The first byte transferred in either of these phases shall be either a single-byte message or the first byte of a multiple-byte message. Multiple-byte messages shall be wholly contained within a single message phase.

5.1.9.1 MESSAGE IN Phase

The MESSAGE IN phase allows the target to request that messages be sent to the initiator from the target.

The target shall assert C/D, I/O, and MSG during the REQ/ACK handshake(s) of this phase.

5.1.9.2 MESSAGE OUT Phase

The MESSAGE OUT phase allows the target to request that message(s) be sent from the initiator to the target. The target may invoke this phase at its convenience in response to the ATTENTION condition (see 5.2.1) created by the initiator.

The target shall assert C/D and MSG and negate I/O during the REQ/ACK handshake(s) of this phase. The target shall handshake byte(s) in this phase until ATN goes false, unless an error occurs (see MESSAGE REJECT, 5.5.2).

If the target detects one or more parity error(s) on the message byte(s) received, it may indicate its desire to retry the message(s) by asserting REQ after detecting ATN has gone false and prior to changing to any other phase. The initiator, upon detecting this condition, shall resend all of the previous message byte(s) sent during this phase. When resending more than one message byte, the initiator shall assert ATN prior to asserting ACK on the first byte and shall maintain ATN asserted until the last byte is sent as described in 5.2.1.

If the target receives all of the message byte(s) successfully (i.e., no parity errors), it shall indicate that it does not wish to retry by changing to any information transfer phase other than the MESSAGE OUT phase and transfer at least one byte. The target may also indicate that it has successfully received the message byte(s) by changing to the BUS FREE phase (e.g., ABORT or BUS DEVICE RESET messages).

Only the following combinations of messages will be accepted during the same MESSAGE OUT transfer (and only immediately after SELECTION):

1. IDENTIFY message followed by ABORT message
2. IDENTIFY message followed by BUS DEVICE RESET message
3. IDENTIFY message followed by NO OPERATION message
4. IDENTIFY message followed by SYNCHRONOUS DATA XFER REQUEST message.

If a target receives illegal multiple messages, it will send a MESSAGE REJECT message and go to BUS FREE and abort any command in process for that initiator.

5.1.10 Signal Restrictions Between Phases

When the SCSI bus is between two information transfer phases, the following restrictions shall apply to the SCSI bus signals:

1. The BSY, SEL, REQ, and ACK signals shall not change.

2. The C/D, I/O, MSG, and DATA BUS signals may change. When switching the DATA BUS direction from out (initiator driving) to in (target driving), the target shall delay driving the DATA BUS by at least a data release delay plus settle delay after asserting the I/O signal and the initiator shall release the DATA BUS no later than a data release delay after the transition of the I/O signal to true. When switching the DATA BUS direction from in (target driving) to out (initiator driving), the target shall release the DATA BUS no later than a deskew delay after negating the I/O signal.

3. The ATN and RST signals may change as defined under the descriptions for the ATTENTION condition (5.2.1) and RESET condition (5.2.2).

5.2 SCSI Bus Conditions

The SCSI bus has two asynchronous conditions; the ATTENTION condition and the RESET condition. These conditions cause the SCSI device to perform certain actions and can alter the phase sequence.

5.2.1 ATTENTION Condition

The ATTENTION condition allows an initiator to inform a target that the initiator has a message ready. The target will get this message at its convenience by performing a MESSAGE OUT phase.

The initiator creates the ATTENTION condition by asserting ATN at any time except during the ARBITRATION or BUS FREE phases.

The initiator must assert the ATN signal before asserting ACK for the last byte transferred in a bus phase for the ATTENTION condition to be honored before transition to a new bus phase. An ATN asserted later may not be honored until a later bus phase. A CDC target will respond with MESSAGE OUT phase as follows:

1. If ATN occurs during a DATA phase, MESSAGE OUT will occur at a logical block boundary. It may not occur until several logical blocks after ATN is first asserted.

2. If ATN occurs during a COMMAND phase, MESSAGE OUT will occur after transfer of all Command Descriptor Block bytes has been completed.

3. If ATN occurs during a STATUS phase, MESSAGE OUT will occur after the Status byte has been acknowledged by the initiator.

4. If ATN occurs during a MESSAGE IN phase, MESSAGE OUT will occur after the last byte of the current message has been acknowledged by the initiator.

5. If ATN occurs during a SELECTION or RESELECTION phase, MESSAGE OUT will occur immediately after that SELECTION or RESELECTION phase.

The initiator shall keep ATN asserted if more than one byte is to be transferred. The initiator may negate the ATN signal at any time except it shall not negate the ATN signal while the ACK signal is asserted during a MESSAGE OUT phase. Recommended practice is that the initiator negates ATN while REQ is true and ACK is false during the last REQ/ACK handshake of the MESSAGE OUT phase.

5.2.2 RESET Condition

The RESET condition is used to immediately clear all SCSI devices from the bus. This condition shall take precedence over all other phases and conditions. Any SCSI device may create the RESET condition by asserting RST for a minimum of a reset hold time. During the RESET condition, the state of all SCSI bus signals other than RST is not defined.

CDC peripheral products will not assert RESET. Host adaptor products may assert RESET.

All SCSI devices shall release all SCSI bus signals (except RST) within a bus clear delay of the transition of RST to true. The BUS FREE phase always follows the RESET condition.

CDC SCSI devices will implement the "hard" RESET option. Upon detection of the RESET condition, they shall:

1. Clear all uncompleted commands
2. Release all SCSI device reservations
3. Return any SCSI device operating modes (MODE SELECT, PREVENT/ALLOW MEDIUM REMOVAL commands, etc) to their default conditions.
4. Activate UNIT ATTENTION condition for all initiators.

5.3 SCSI Bus Phase Sequences

The order in which phases are used on the SCSI bus follows a prescribed sequence.

In all systems, the RESET condition can abort any phase and is always followed by the BUS FREE phase. Also, any other phase can be followed by the BUS FREE phase.

5.3.1 Nonarbitrating Systems

In systems where the ARBITRATION phase is not implemented, the allowable sequences shall be shown as in Figure 5-1. The normal progression is from the BUS FREE phase to SELECTION, and from SELECTION to one or more of the information transfer phases (COMMAND, DATA, STATUS, or MESSAGE).

5.3.2 Arbitrating Systems

In systems where the ARBITRATION phase is implemented, the allowable sequences shall be as shown in Figure 5-2. The normal progression is from the BUS FREE phase to ARBITRATION, from ARBITRATION to SELECTION or RESELECTION, and from SELECTION or RESELECTION to one or more of the information transfer phases (COMMAND, DATA, STATUS, or MESSAGE).

5.3.3 All Systems

There are no restrictions on the sequences between information transfer phases. A phase type may even be followed by the same phase type (e.g., a data phase may be followed by another data phase).

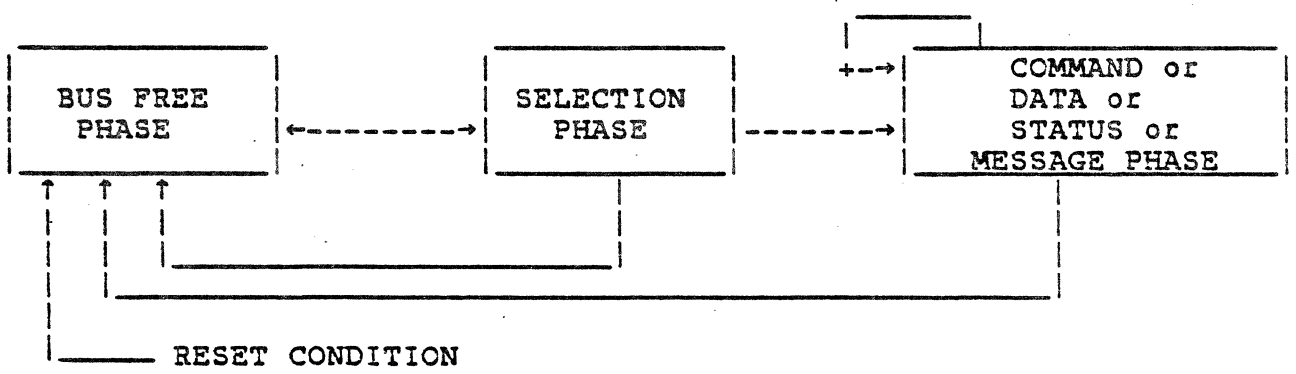


FIGURE 5-1. PHASE SEQUENCES WITHOUT ARBITRATION

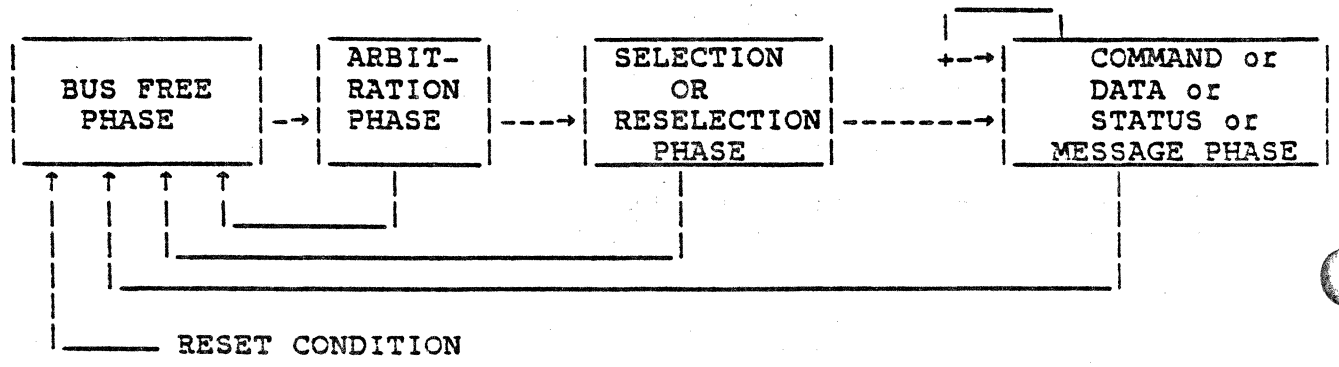


FIGURE 5-2. PHASE SEQUENCES WITH ARBITRATION

5.4 SCSI Pointers

Consider the system shown in Figure 5-2 in which an initiator and target communicate on the SCSI bus in order to execute a command.

FIGURE 5-3. SIMPLIFIED SCSI SYSTEM

The SCSI architecture provides for two sets of three pointers within each initiator. The pointers reside in the initiator path control. The first set of pointers are known as the current (or active) pointers. These pointers are used to represent the state of the interface and point to the next command, data, or status byte to be transferred between the initiator's memory and the target. There is only one set of current pointers in each initiator. The current pointers are used by the target currently connected to the initiator.

The second set of pointers are known as the saved pointers. There is one set of saved pointers for each command that is currently active (whether or not it is currently connected). The saved command pointer always points to the start of the command descriptor block (see 6.2) for the current command. The saved status pointer always points to the start of the status area for the current command. At the beginning of each command, the saved data pointer points to the start of the data area. It remains at this value until the target sends a SAVE DATA POINTER message (see 5.5.2) to the initiator. In response to this message, the initiator stores the value of the current data pointer into the saved data pointer. The target may restore the current pointers to their saved values by sending a RESTORE POINTERS message (see 5.5.2) to the initiator. The initiator moves the saved value of each pointer into the corresponding current pointer. Whenever an SCSI device disconnects from the bus, only the saved pointer values are retained. The current pointer values are restored from the saved values upon the next reconnection.

5.5 Message System Specification

The message system allows communication between an initiator and target for the purpose of physical path management.

5.5.1 Message Protocol

All SCSI devices shall implement the COMMAND COMPLETE message. Non-CDC products (initiators or targets) are only required to support the COMMAND COMPLETE message. Support for any other message will be assumed to be optional.

SCSI devices indicate their ability to accommodate more than the COMMAND COMPLETE message by asserting or responding to the ATN signal. The initiator indicates this in the SELECTION phase by asserting ATN prior to the SCSI bus condition of SEL true, and BSY false. If the target hasn't received ATN by this point, it will assume the initiator doesn't support disconnection or messages other than COMMAND COMPLETE. If the ATN signal is asserted later, it will be ignored until after the next BUS FREE phase. The target indicates its ability to accommodate more messages by responding to the ATTENTION condition with the MESSAGE OUT phase after going through the SELECTION phase.

For SCSI devices that support messages other than COMMAND COMPLETE, the first message sent by the intitator after the SELECTION phase shall be the IDENTIFY message. This allows the establishment of the physical path for a particular logical unit specified by the initiator. After the RESELECTION phase, the target's first message shall be IDENTIFY. This allows the physical path to be re-established for the target's specified logical unit number. An initiator may send the ABORT message or the BUS DEVICE RESET message instead of the IDENTIFY message, as the first message. Only one logical unit number shall be identified for any one selection sequence; a second IDENTIFY message with a new logical unit number shall not be issued before the SCSI bus has been released (BUS FREE phase).

Whenever a physical path is established in an initiator that can accommodate disconnection and reconnection, the initiator shall ensure that the active pointers of the physical path are equal to the saved pointers for that particular logical unit number. (An implied restore pointers operation occurs as a result of connect or reconnect.)

TABLE 5-2. MESSAGE CODES

CODE	CDC TARGET	CDC INIT	DESCRIPTION	DIRECTION	
00H	M	M	COMMAND COMPLETE	In	
01H/01H	O	O	SYNC DATA TRANSFER REQUEST	In	Out
01H/XXH	O	O	OTHER EXTENDED MESSAGES		
02H	M	O	SAVE DATA POINTER	In	
03H	M	O	RESTORE POINTERS	In	
04H	M	M	DISCONNECT	In	
05H	M	O	INITIATOR DETECTED ERROR		Out
06H	M	M	ABORT		Out
07H	M	M	MESSAGE REJECT	In	Out
08H	M	M	NO OPERATION		Out
09H	M	M	MESSAGE PARITY ERROR		Out
0AH	O	O	LINKED COMMAND COMPLETE	In	
0BH	O	O	LINKED COMMAND COMPLETE W/FLAG	In	
0CH	M	O	BUS DEVICE RESET		Out
0DH--7FH	R	R	RESERVED CODES		
80H--FFH	M	M	IDENTIFY	In	Out

The CDC INIT column applies to targets that become initiators to execute certain commands (e.g. COPY or COMPARE) along with applying to host adapter products.

Key: (Type definitions are defined in 6.1.2)
M = Command implementation is mandatory.
O = Command implementation is optional.
R = Operation code is reserved for future standardization.

In = Target to initiator, Out = Initiator to target.

5.5.2 Messages

The single byte messages (Table 5-2) are listed along with their code values and their definitions.

COMMAND COMPLETE 00H (Mandatory) - This message is sent from a target to an initiator to indicate that the execution of a command (or series of linked commands) has terminated and that valid status has been sent to the initiator. After successfully sending this message, the target shall go to the BUS FREE phase by releasing BSY.

NOTE: The command may have been executed successfully or unsuccessfully as indicated in the status.

EXTENDED MESSAGE 01H (Optional) - This message is sent from either the initiator or the target as the first byte of a multiple-byte message. (See 5.5.3 for descriptions of extended messages.)

- SAVE DATA POINTER 02H (Mandatory) - This message is sent from a target to direct the initiator to save a copy of the present active data pointer for the currently attached logical unit. (See 5.4 for a definition of pointers.)

- RESTORE POINTERS 03H (Mandatory) - This message is sent from a target to direct the initiator to restore the most recently saved pointers (for the currently attached logical unit) to the active state. Pointers to the command, data, and status locations for the logical unit shall be restored to the active pointers. Command and status pointers shall be restored to the beginning of the present command and status areas. The data pointer shall be restored to the value at the beginning of the data area in the absence of a SAVE DATA POINTER message or to the value at the point at which the last SAVE DATA POINTER message occurred for that logical unit.

- DISCONNECT 04H (Mandatory) - This message is sent from a target to inform an initiator that the present physical path is going to be broken (the target plans to disconnect by releasing BSY), but that a later reconnect will be required in order to complete the current operation. If the initiator detects the BUS FREE phase (other than as a result of a RESET condition) without first receiving a DISCONNECT or COMMAND COMPLETE message, the initiator shall consider this as a catastrophic error condition. If the target intentionally creates this condition, the target shall clear the current command. This message shall not cause the initiator to save the data pointer. Note: If DISCONNECT messages are used to break a long data transfer into two or more shorter transfers, then a SAVE DATA POINTER will be issued before each DISCONNECT message.
- CDC products will disconnect when a substantial delay is
- anticipated. The exact situations will be described in individual
- product specifications. These situations may only include:
- after receipt of a Command Descriptor Block or during a data
- transfer.

- INITIATOR DETECTED ERROR 05H (Mandatory) - This message is sent from an initiator to inform a target that an error (e.g., parity error) has occurred that does not preclude the target from retrying the operation. Since present pointer integrity is not assured, a RESTORE POINTERS message shall be sent by the target to cause the pointers to be restored to their defined prior state. An initiator should not issue this message unless the RESTORE POINTERS message is accepted by it. If the target is not sure it can recover properly, CHECK CONDITION status will be created with Sense Key of ABORTED COMMAND.

- ABORT 06H (Mandatory) - This message is sent from the initiator to the target to clear the present operation. If a logical unit has been identified, all pending data and status for the issuing initiator from the affected logical unit shall be cleared, and the target shall go to the BUS FREE phase. Pending data and status for other initiators shall not be cleared. If a logical unit has not been identified, the target shall go to the BUS FREE phase. No status or ending message shall be sent for the operation. It is not an error to issue this message to an logical unit that is not currently performing an operation for the initiator.

- MESSAGE REJECT 07H (Mandatory) - This message is sent from either the initiator or target to indicate that the last message it received was inappropriate or has not been implemented.

- CDC targets may optionally retry the original message. If the message is still rejected, then response will depend upon what the original message was:

ORIGINAL MESSAGE	RECOVERY ACTION
Command Complete	Go to BUS FREE state anyway.
Synchronous Request	Assume asynchronous transfers and continue.
Save Data Pointer	Don't disconnect and continue data transfer command.
Restore Pointers	Terminate command immediately with CHECK CONDITION status and HARDWARE ERROR in Sense Key.
Disconnect	Don't disconnect and continue command normally.
Message Reject	Terminate command immediately with CHECK CONDITION status and HARDWARE ERROR in Sense Key.
Linked Cmd Complete	Go to BUS FREE phase.
Identify	Go to BUS FREE (catastrophic error), save ABORTED CMD in the Sense Key.

- CDC initiators may optionally retry the original message one time.
- if the message is still rejected, response will be as follows:

ORIGINAL MESSAGE	RECOVERY ACTION
Synchronous Request	Assume asynchronous transfers and continue.
Initiator Detected Error	Send Abort message and retry the command.
Abort	Send host adapter CHECK CONDITION status (to COPY command) and HARDWARE ERROR in Sense Key.
Message Reject	Same response as Abort.
No Operation	Continue on without any special action.
Message Parity Error	Same response as Abort.
Bus Device Reset	Same response as Abort.
Identify	Same response as Abort.

In order to indicate its intentions of sending this message, the initiator shall assert the ATN signal prior to its release of ACK for the REQ/ACK handshake of the message that is to be rejected. When a target sends this message, it shall change to MESSAGE IN phase and send this message prior to requesting additional message bytes from the initiator. This provides an interlock so that the initiator can determine which message is rejected.

- NO OPERATION 08H (Mandatory) - This message is sent from an initiator in response to a target's request for a message when the initiator does not currently have any other valid message to send.

- MESSAGE PARITY ERROR 09H (Mandatory) - This message is sent from the initiator to the target to indicate that one or more bytes in the last message it received had a parity error. CDC targets that receive this message will attempt to resend the original message one time. If the retry attempt also results in a parity error, the target will go to BUS FREE phase.

In order to indicate its intentions of sending this message, the initiator shall assert the ATN signal prior to its release of ACK for the REQ/ACK handshake of the message that has the parity error. This provides an interlock so that the target can determine which message has the parity error.

LINKED COMMAND COMPLETE 0AH (Optional) - This message is sent from a target to an initiator to indicate that the execution of a linked command has completed and that status has been sent. The initiator shall then set the pointers to the initial state for the next linked command.

LINKED COMMAND COMPLETE (WITH FLAG) 0BH (Optional) - This message is sent from a target to an initiator to indicate that the execution of a linked command (with the flag bit set to one) has completed and that status has been sent. The initiator shall then set the pointers to the initial state of the next linked command. Typically this message would be used to cause an interrupt in he initiator between two linked commands.

- BUS DEVICE RESET 0CH (Mandatory) - This message is sent from an initiator to direct a target to clear all current commands on that SCSI device. This message forces the SCSI device to an initial state with no operations pending for any initiator. Upon recognizing this message, the target shall go to the BUS FREE phase.

Reserved 0DH to 7FH - These codes are reserved for future use.

- IDENTIFY 80H to FFH (Mandatory) - These messages are sent by either the initiator (after SELECTION phase) or the target (after RESELECTION phase) to establish the physical path connection between an initiator and target for a particular logical unit.

Bit 7 - This bit is always set to one to distinguish these messages from the other messages.

Bit 6 - This bit is only set to one by the initiator. When set to one, it indicates that the initiator has the ability to accommodate disconnection and reconnection. When set to zero, CDC targets will not attempt to disconnect.

Bits 5-3 - Reserved.

Bits 2-0 - These bits specify a logical unit number in a target.

Only one logical unit number shall be identified for any one selection sequence; a second IDENTIFY message with a new logical unit number shall not be issued before the bus has been released (BUS FREE phase).

When sent from a target to an initiator during reconnection, an implied RESTORE POINTERS message shall be performed by the initiator prior to completion of this message.

- If an initiator specifies an invalid LUN in the IDENTIFY message, a CDC target will accept the IDENTIFY message but will reject the next command. See 6.2.2.

5.5.3 Extended Messages (Optional)

A value of 01H in the first byte of a message indicates the beginning of a multiple-byte extended message. The minimum number of bytes sent for an extended message is three. The extended message format and the extended message codes are shown in Tables 5-3 and 5-4, respectively.

TABLE 5-3. EXTENDED MESSAGE FORMAT

BYTE	VALUE	DESCRIPTION
0	01H	Extended message
1	nH	Extended message length
2	yH	Extended message code
3 nH+1	xH	Extended message arguments

The extended message length specifies the length in bytes of the extended message code plus the extended message arguments to follow. Therefore, the total length of the message is equal to the extended message length plus two. A value of zero for the extended message length indicates 256 bytes follow.

The extended message codes are listed in Table 5-4. The extended message arguments are specified for the defined extended messages in Section 5.5.4.

TABLE 5-4. EXTENDED MESSAGE CODES

CODE (yH)	DESCRIPTION
00H	Reserved
01H	SYNCHRONOUS DATA TRANSFER REQUEST (Optional)
02H--7FH	Reserved
80H--FFH	Reserved

■ 5.5.4 SYNCHRONOUS DATA TRANSFER REQUEST Message (Optional)

TABLE 5-5. SYNCHRONOUS DATA TRANSFER REQUEST

BYTE	VALUE	DESCRIPTION
0	01H	Extended message
1	03H	Extended message length
2	01H	SYNCHRONOUS DATA TRANSFER REQUEST code
3	mH	Transfer period (mH times 4 ns)
4	xH	REQ/ACK offset

A pair of SYNCHRONOUS DATA TRANSFER REQUEST messages (Table 5-5) are exchanged between an initiator and a target whenever an SCSI device that can support synchronous data transfer recognizes that it has not communicated with the other SCSI device since receiving the last "hard" RESET condition or a BUS DEVICE RESET message. The SCSI devices may also exchange messages to establish synchronous data transfer when requested to do so. The message exchange establishes the transfer period and the REQ/ACK offset. The transfer period is the minimum time between leading edges of successive REQ pulses and of successive ACK pulses.

The REQ/ACK offset is the maximum number of REQ pulses that may be outstanding before its corresponding ACK pulse is received at the target. A REQ/ACK offset value of zero shall indicate asynchronous mode; a value of FFH shall indicate unlimited offset.

If the initiator recognizes that negotiation is required, it asserts ATN and, if the target implements message transfers, sends a SYNCHRONOUS DATA TRANSFER REQUEST message indicating an REQ/ACK offset and minimum transfer period. The REQ/ACK offset is chosen to prevent initiator buffer overflows, while the minimum transfer period is chosen to meet the data handling requirements of the initiator. The target responds in any of the following ways:

	TARGET RESPONSE	IMPLIED AGREEMENT
1.	REQ/ACK offset less than or equal to the requested value. Minimum transfer period equal to or greater than requested period.	REQ/ACK offset equal to target value. Minimum transfer period equal to the target value.
2.	REQ/ACK offset equal to zero.	Asynchronous transfer.
3.	MESSAGE REJECT.	Asynchronous transfer.

■ CDC targets will never send SYNCHRONOUS DATA TRANSFER REQUEST
■ message unless an initiator sends this message to the target first.

The implied agreement shall remain in effect until a BUS DEVICE RESET message is received, until a "hard" RESET condition occurs, or until one of the two SCSI devices elects to modify the agreement. Renegotiation at every selection is not recommended, since a significant performance impact is likely. The default mode of data transfer is asynchronous mode. The default mode is entered at power on, after a BUS DEVICE RESET message, or after a "hard" RESET condition. The SYNCHRONOUS DATA TRANSFER REQUEST message exchange can only take place following a SELECTION phase that includes the SCSI IDs for both the initiator and the target. Violation of this rule may make data transfer impossible owing to disagreements among SCSI devices about the data transfer mode.

6.0 SCSI COMMANDS

This section defines the SCSI command structure and gives several examples.

The command definitions assume a data structure providing the appearance at the interface of a contiguous set of logical blocks of a fixed or explicitly defined data length. The SCSI device maps the physical characteristics of the attached peripheral devices to one of several logical structures defined by the device type code.

A single command may transfer one or more logical blocks of data. Multiple commands may be linked if they are sent to the same logical unit. A target may disconnect from the SCSI bus to allow activity by other SCSI devices while a logical unit is being prepared to transfer data.

Upon command completion (successful or unsuccessful), the target returns a status byte to the initiator. Since most error and exception conditions cannot be adequately described with a single status byte, one status code, CHECK CONDITION, indicates that additional information is available. The initiator may issue a REQUEST SENSE command to retrieve this additional information.

By keeping to a minimum the functions essential to communicate via this protocol, a wide range of peripheral devices of varying capability can operate in the same environment.

6.1 Command Implementation Requirements

The first byte of any SCSI command shall contain an operation code as defined in this document. Three bits (bits 7 - 5) of the second byte of each SCSI command specify the logical unit if it is not specified using the IDENTIFY message (see 5.5.2). The last byte of all SCSI commands shall contain a control byte as defined in 6.2.6.

6.1.1 Reserved

Reserved bits, bytes, fields, and code values are set aside for future standardization. Their use and interpretation will be specified by future extensions to this specification. A reserved bit, field, or byte shall be set to zero, or in accordance with a future extension to this specification. A target that receives a reserved code value shall terminate the command with a CHECK CONDITION status and, if extended sense is implemented, the Sense Key shall be set to ILLEGAL REQUEST. It shall also be acceptable for a target to interpret the bit, field, byte, or code value in accordance with a future extention to this specification.

6.1.2 Operation Code Types

OPERATION CODE TYPE	DESCRIPTION
M	Mandatory - All CDC SCSI products will implement these commands. No other commands must be required for proper operation.
O	Optional - Commands so designated, if implemented, shall be implemented as defined in this specification. They are not guaranteed to be available on all CDC products.
V	Vendor unique - Operation codes so designated are available for product defined commands. See the product specification for descriptions. Caution: these commands will not be standardized for different products.
R	Reserved - Operation codes so designated shall not be used. They are reserved for future standardization.

6.1.3 Unit Attention Condition

A Unit Attention Condition shall begin (after the device becomes ready) for each initiator whenever the removable medium may have been changed, the target has been reset (by a BUS DEVICE RESET message or a "hard" RESET condition), or one or more MODE SELECT parameters affecting this initiator were changed by another initiator. The Unit Attention condition shall persist for each initiator until that initiator clears the condition as described in the following paragraphs.

If an INQUIRY command is received from an initiator with a pending Unit Attention condition (before or after the target reports CHECK CONDITION status), the target shall perform the INQUIRY command and shall not clear the Unit Attention Condition.

If a REQUEST SENSE command is received from an initiator with a pending Unit Attention Condition (before or after the target reports CHECK CONDITION status), then the target shall discard any pending sense data, report the UNIT ATTENTION Sense Key, and clear the Unit Attention condition for that initiator.

If an initiator issues a command other than INQUIRY or REQUEST SENSE while a Unit Attention Condition exists for that initiator, the target shall not perform the command and shall report CHECK CONDITION status. If a REQUEST SENSE is issued next, the Unit Attention condition will be reported and cleared as noted in the preceding paragraph. If another command other than REQUEST SENSE or INQUIRY is issued instead then the target shall perform the command and return the appropriate status. The Unit Attention condition for that initiator is cleared and the sense data is lost.

6.1.4 Command Queuing (optional)

Targets that do not implement command queuing will not accept another command, even from a different intiator, if it has a command being processed. In this case, the target will allow itself to be selected and will accept the command bytes for a new command. It will then go to the STATUS phase and send BUSY status back to the initiator (see section 14.0). After a COMMAND COMPLETE message and going to BUS FREE phase, the target will resume execution of its current command. An initiator that received BUSY status in this manner will have to resend the command later in order to have it executed.

Command queuing can only be done for initiators that support ARBITRATION and RESELECTION phases, send an IDENTIFY message after SELECTION, and allow disconnection. Initiators that don't support these options will be handled as described in the preceeding paragraph even though commands may be queued for other initiators that do meet these requirements.

CDC Targets that implement command queuing will accept one command from each initiator for each attached Logical Unit. A target may implement full queuing (for all 7 possible initiators) or limited queuing (commands are queued for a few initiators and commands from any other initiators are not queued). When commands are queued, after the target is selected it will accept the command bytes, send a DISCONNECT message, go to BUS FREE phase, and continue command execution. A BUSY status will only be returned if the command queue is full and another command cannot be stored.

A target that implements command queuing for other commands may or may not queue RESERVE commands because of the special considerations involved with queuing these commands. See the sections describing the RESERVE command for further details.

All commands that are queued will eventually be executed in accordance with the target's priority scheme unless a hard RESET, a Power On Reset, or a BUS DEVICE RESET message is received. In these cases, all queued commands will be cleared and no status will be sent to the initiator.

If a target implements both command queuing and command linking (see section 6.2.6), the target shall complete execution of all linked commands sent by the same initiator before beginning execution of any queued commands for other initiators even if the target disconnects from the SCSI bus during execution of the linked commands. However, new commands from other initiators may still be added to the command queue if space is available.

6.2 Command Descriptor Block

A request to a peripheral device is performed by sending a command descriptor block to the target. For several commands, the request is accompanied by a list of parameters sent during the DATA OUT phase. See the specific commands for detailed information.

The command descriptor block always has an operation code as the first byte of the command. This is followed by a logical unit number, command parameters (if any), and a control byte.

For all commands, if there is an invalid parameter in the command descriptor block, then the target shall terminate the command without altering the medium.

6.2.1 Operation Code

The operation code (Table 6-1) of the command descriptor block has a group code field and a command code field. The three-bit group code field provides for eight groups of command codes. The five-bit command code field provides for thirty-two command codes in each group. Thus, a total of 256 possible operation codes exist. Operation codes are defined in Sections 7 through 13.

The group code specifies one of the following groups:

Group 0 - Six-byte commands (see Table 6-2)
Group 1 - Ten-byte commands (see Table 6-3)
Group 2 - Reserved
Group 3 - Reserved
Group 4 - Reserved
Group 5 - Reserved
Group 6 - CDC proprietary manufacturing usage
Group 7 - Product Unique

TABLE 6-1. OPERATION CODE

BIT BYTE	7	6	5	4	3	2	1	0
0	Group Code			Command Code				

TABLE 6-2. TYPICAL COMMAND DESCRIPTOR BLOCK FOR SIX-BYTE COMMANDS

BIT BYTE	7	6	5	4	3	2	1	0
0	Operation Code							
1	Logical Unit Number			Logical Block Address(if required)(MSB)				
2	Logical Block Address (if required)							
3	Logical Block Address(if required)(LSB)							
4	Transfer Length (if required)							
5	Control Byte							

TABLE 6-3. TYPICAL COMMAND DESCRIPTOR BLOCK FOR TEN-BYTE COMMANDS

BIT BYTE	7	6	5	4	3	2	1	0
0	Operation Code							
1	Logical Unit Number			Reserved				RelAdr
2	Logical Block Address(if required)(MSB)							
3	Logical Block Address (if required)							
4	Logical Block Address (if required)							
5	Logical Block Address(if required)(LSB)							
6	Reserved							
7	Transfer Length (if required) (MSB)							
8	Transfer Length (if required) (LSB)							
9	Control Byte							

6.2.2 Logical Unit Number

The logical unit number addresses one of up to eight physical devices or virtual devices attached to a target. This method of addressing is provided for systems that do not implement the IDENTIFY message. A target that accepts an IDENTIFY message shall use the logical unit number specified within the message. In this case, the target shall ignore the logical unit number specified within the command descriptor block.

- CDC targets will reject commands which select an invalid LUN (except REQUEST SENSE and INQUIRY) by requesting and accepting the command bytes, then going to STATUS phase and sending CHECK CONDITION status. Note that the LUN is sent in the LUN field of a CDB (if no IDENTIFY message has been received for this selection) or by the LUN field of an IDENTIFY message.

- REQUEST SENSE commands selecting an invalid LUN will receive a Sense Data block with the ILLEGAL REQUEST Sense Key and an INVALID LUN Error Code. INQUIRY commands will return Inquiry Data with the Peripheral Device Type field set to Logical Unit Not Present (7FH). REQUEST SENSE and INQUIRY commands will not send CHECK CONDITION status due to an invalid LUN selection.

6.2.3 Logical Block Address

The logical block address on logical units shall begin with block zero and be contiguous up to the last logical block on that logical unit.

- Group 0 command descriptor blocks contain 21-bit logical block addresses. Group 1 command descriptor blocks contain 32-bit logical block addresses.

The logical block concept implies that the initiator and target shall have previously established the number of data bytes per logical block. This may be established through the use of the READ CAPACITY command or the MODE SENSE command or by prior arrangement.

6.2.4 Relative Address Bit

- CDC products will not support relative addressing.

- The relative address (RelAdr) bit of the group 1 commands is set to one to indicate that the logical block address portion of the command descriptor block is a two's complement displacement. This negative or positive displacement is to be added to the logical block address last accessed on the logical unit to form the logical block address for this command. This feature is only available when linking commands. The feature requires that a previous command in the liked group have accessed a block of data on the logical unit.

6.2.5 Transfer Length

The Transfer Length specifies the amount of data to be transferred, usually the number of blocks. For several commands the transfer length indicates the requested number of bytes to be sent as defined in the command description. For these commands the transfer length field may be identified by a different name. See the following descriptions and the individual command descriptions for further information.

Commands that use one byte for Transfer Length allow up to 256 blocks of data to be transferred by one command. A Transfer Length value of 1 to 255 indicates the number of blocks that shall transferred. A value of zero indicates 256 blocks.

Commands that use two bytes for Transfer Length allow up to 65,535 blocks of data to be transferred by one command. In this case, a Transfer Length of zero indicates that no data transfer shall take place. A value of 1 to 65,535 indicates the number of blocks that shall be transferred.

For several commands more than two bytes are allocated for Transfer Length. Refer to the specific command description for further information.

The Transfer Length of the commands that are used to send a list of parameters to a target is called the Parameter List Length. The Parameter List Length specifies the number of bytes sent during the DATA OUT phase.

The Transfer Length of the commands that are used to return sense data (e.g. REQUEST SENSE, INQUIRY, MODE SENSE, etc) to an initiator is called the Allocation Length. The Allocation Length specifies the number of bytes that the initiator has allocated for returned data. The target shall terminate the DATA IN phase when Allocation Length bytes have been transferred or when all available sense data have been transferred to the initiator, whichever is less.

- The REQUEST SENSE command is an exception. An Allocation Length of
- zero indicates that four bytes are to be transferred, not zero.

6.2.6 Control Byte

The control byte is the last byte of every command descriptor block. A typical control byte is described in Table 6-4.

TABLE 6-4. CONTROL BYTE

BIT / BYTE	7	6	5	4	3	2	1	0
Last	RESERVED						FLAG	LINK

Bit	Description
7-2	Reserved
1	Flag bit - If the link bit is zero, then the flag bit shall be set to zero. If the link bit is one, and if the command terminates successfully, the target shall send LINKED COMMAND COMPLETE message if the flag bit is zero and shall send LINKED COMMAND COMPLETE (WITH FLAG) message if the flag bit is one. Typically, this bit is used to cause an interrupt in the initiator between linked commands.
0	Link bit - This bit is set to one to indicate that the initiator desires an automatic link to the next command upon successful completion of the current command. Implementation of linked commands is optional. If the link bit is one, targets that implement linked commands, upon successful termination of the command, shall return INTERMEDIATE status and shall then send one of the two messages defined by the flag bit (above).

Targets that do not implement linked commands shall return a CHECK CONDITION status and, if extended sense is implemented, shall set the sense key to ILLEGAL REQUEST if either of the link and flag bits are set to one.

6.3 Command Examples

6.3.1 Single Command Example

A typical operation on the SCSI bus is likely to include a single READ command to a peripheral device. This operation is described in detail starting with a request from the initiator. This example assumes that no malfunctions or errors occur and is illustrated in Figure 6-1.

The initiator has active pointers and a set of stored pointers representing active disconnected SCSI devices (an initiator without disconnect capability does not require stored pointers). The initiator sets up the active pointers for the operation requested, arbitrates for the SCSI bus, and selects the target. Once this process is completed, the target assumes control of the operation.

The target obtains the command from the initiator (in this case, a READ command). The target interprets the command and executes it. In this case, the target gets the data from the peripheral device56nd sends it to the initiator. At the completion of the READ command, the target sends a status byte to the initiator. To end the operation, the target sends a COMMAND COMPLETE message to the initiator.

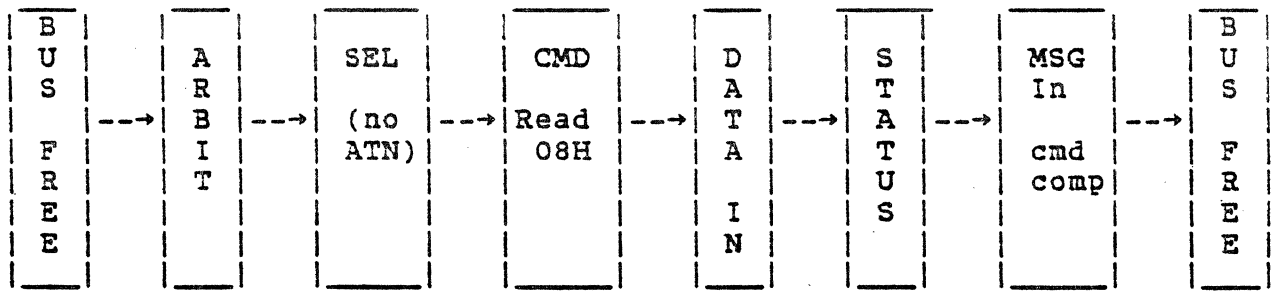


FIGURE 6-1. SIMPLE COMMAND EXAMPLE

6.3.2 Disconnect Example

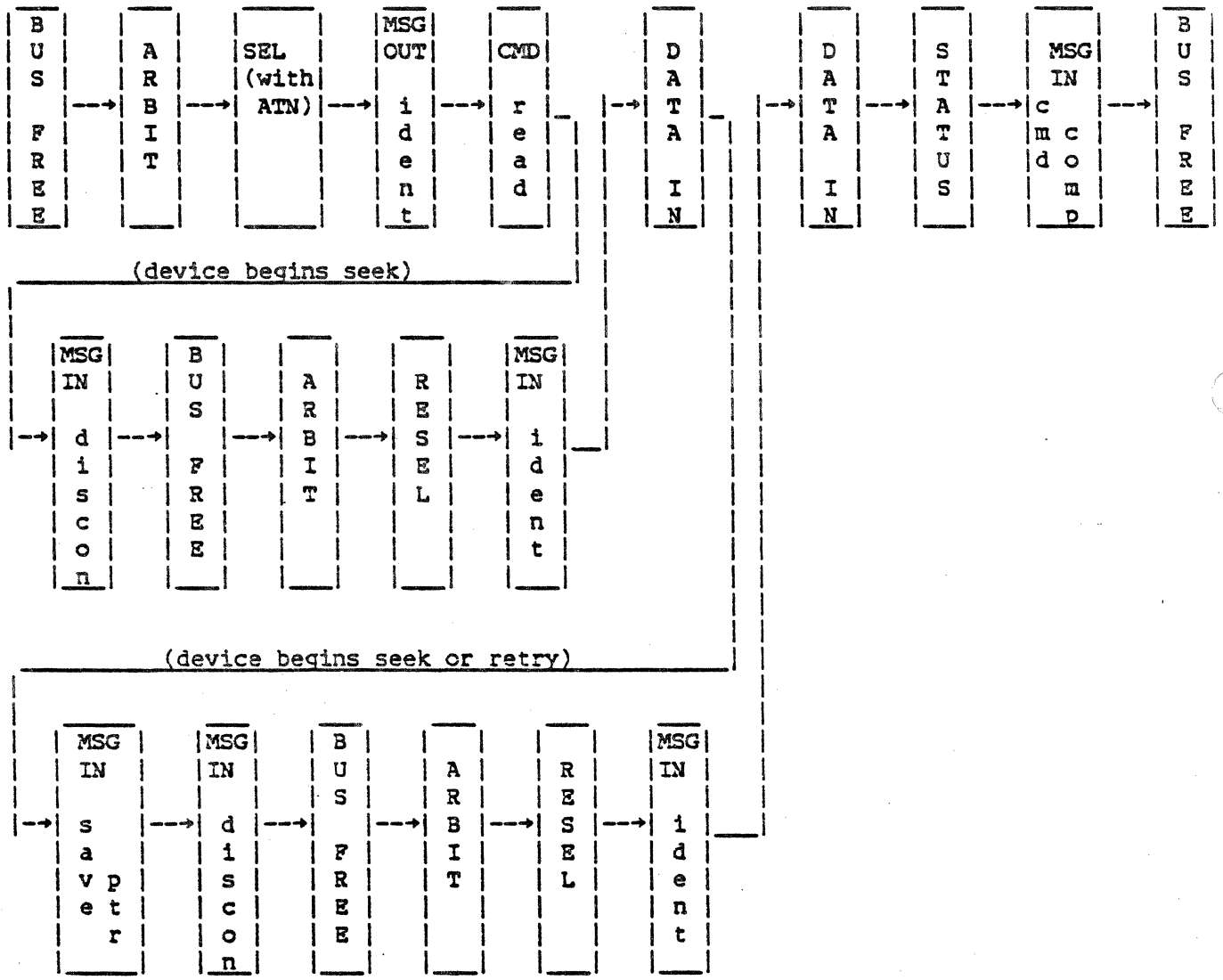
In the above single command example, the length of time necessary to obtain the data may require a time-consuming physical seek. In order to improve system throughput, the target may disconnect from the initiator, freeing the SCSI bus to allow other requests to be sent to other logical units. To do this, the initiator needs to be reselectable and capable of restoring the pointers upon reconnection. The target needs to be capable of arbitrating for the SCSI bus and reselecting the initiator. See Figure 6-2.

After the target has received the READ command (and has determined that there will be a delay), it disconnects by sending a DISCONNECT message and releasing BSY.

When the data is ready to be transferred, the target reconnects to the initiator. As a result of this reconnection, the initiator restores the pointers to their most recent saved values (which, in this case, are the initial values) and the target continues (as in the single command example) to finish the operation. The initiator recognizes that the operation is complete when COMMAND COMPLETE message is received.

If target wishes to disconnect after transferring part of the data (e.g., while crossing a cylinder boundary), it may do so by sending a SAVE DATA POINTER message and a DISCONNECT message to the initiator and then disconnecting. When reconnection is completed, the current data pointer value is restored to its value immediately prior to the SAVE DATA POINTER message.

On those occasions when an error or exception condition occurs and the target elects to repeat the information transfer, the target may repeat the transfer by either issuing a RESTORE POINTERS message or by disconnecting without issuing a SAVE DATA POINTER message. When reconnection is completed, the most recent saved pointer values are restored.



■■ FIGURE 6-2. DISCONNECT EXAMPLE

6.4 Timing Examples

TABLE 6-5. MEASUREMENTS TO DETERMINE TARGET PERFORMANCE

SYS.APPLICABILITY						DESCRIPTION	WAVEFORM SYMBOL	WAVEFORM TABLE
			A		N			
	N	O	D		O			
	O	N	D	D	N			
	N	E	L	I				
				S	D			
A	A	M	M	C	I			
R	R	S	S	O	S			
B	B	G	G	N	C			
	Y	Y	Y		Y	Target Select Time (no ARBITRATION)	T00	NA
Y		Y	Y	Y	Y	Target Select Time (with ARBITRATION)	T01	6-6,6-7
Y	Y	Y		Y	Y	Target Select to Command	T02	6-6
Y	Y		Y	Y	Y	Target Select to MSG OUT	T03	6-7
Y	Y	Y		Y	Y	IDENTIFY msg to Command	T04	6-8
Y	Y	Y	Y	Y	Y	Command to Status	T05	6-10
Y	Y	Y	Y	Y	Y	Command to Data (parameters IN)	T06	6-14
Y	Y	Y	Y	Y	Y	Command to Data (parameters OUT)	T07	6-15
Y	Y	Y	Y	Y	Y	Command to Data (Write to data buffer)	T08	6-15
Y			Y	Y		Command to DISCONNECT msg	T09	6-11
Y			Y	Y		DISCONNECT msg to Bus Free	T10	6-11,6-19
Y			Y	Y		DISCONNECT to ARBITRATION (for RESELECT)	T11	6-11
						This measures disconnected CMD overhead		
Y			Y	Y		Target win ARBITRATION (for RESELECT)	T12	6-12
Y			Y	Y		ARBITRATION to RESELECT	T13	6-12
Y			Y	Y		RESELECT to IDENTIFY msg in	T14	6-12
Y			Y	Y		RESELECT IDENTIFY msg to Status	T15	6-13
Y			Y	Y		RESELECT IDENTIFY msg to Data (media)	T16	6-16
Y	Y	Y	Y	Y	Y	Data to Status	T17	6-20
Y	Y	Y	Y	Y	Y	Status to COMMAND COMPLETE msg	T18	6-10,6-13,6-20
Y	Y	Y	Y	Y	Y	COMMAND COMPLETE msg to BUS FREE	T19	6-10,6-13,6-20
Y			Y	Y		Data to SAVE DATA POINTER msg	T20	6-19
Y			Y	Y		SAVE DATA POINTER msg to DISCONNECT msg	T21	6-19
Y	Y	Y	Y	Y	Y	Command Byte Transfer	T22	6-9
Y	Y	Y	Y	Y	Y	Next Command Byte access	T23	6-9
Y	Y	Y	Y	Y	Y	Data In Byte Transfer (parameter)	T24	6-17
Y	Y	Y	Y	Y	Y	Data Out Byte Transfer (parameter)	T25	6-18
Y	Y	Y	Y	Y	Y	Next Data In Byte access (parameter)	T26	6-17
Y	Y	Y	Y	Y	Y	Next Data Out Byte access (parameter)	T27	6-18
Y	Y	Y	Y	Y	Y	Data In Byte Transfer (media)	T28	6-17
Y	Y	Y	Y	Y	Y	Data Out Byte Transfer (media)	T29	6-18
Y	Y	Y	Y	Y	Y	Next Data In Byte access (media)	T30	6-17
Y	Y	Y	Y	Y	Y	Next Data Out Byte access (media)	T31	6-18
Y	Y	Y	Y	Y	Y	MSG IN Byte Transfer	T32	6-10,6-12, 6-13,6-19
Y	Y	Y	Y	Y	Y	MSG OUT Byte Transfer	T33	6-7
Y	Y	Y	Y	Y	Y	STATUS Byte Transfer	T34	6-10,6-13,6-20
Y			Y	Y		Bad Message to MESSAGE REJECT msg	T35	NA

TABLE 6-6. ARBITRATION, SELECTION (NO ATN), and COMMAND PHASE

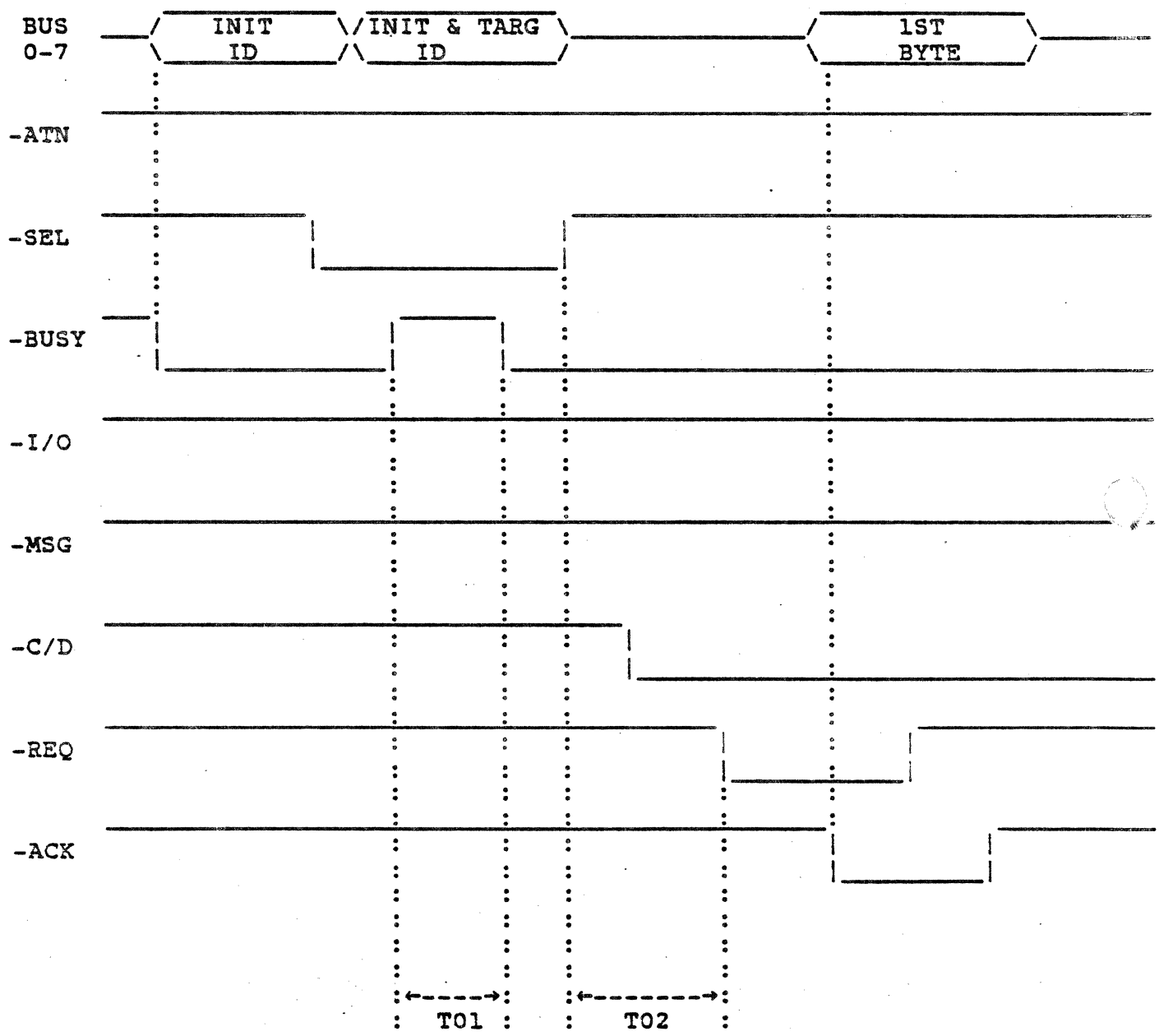
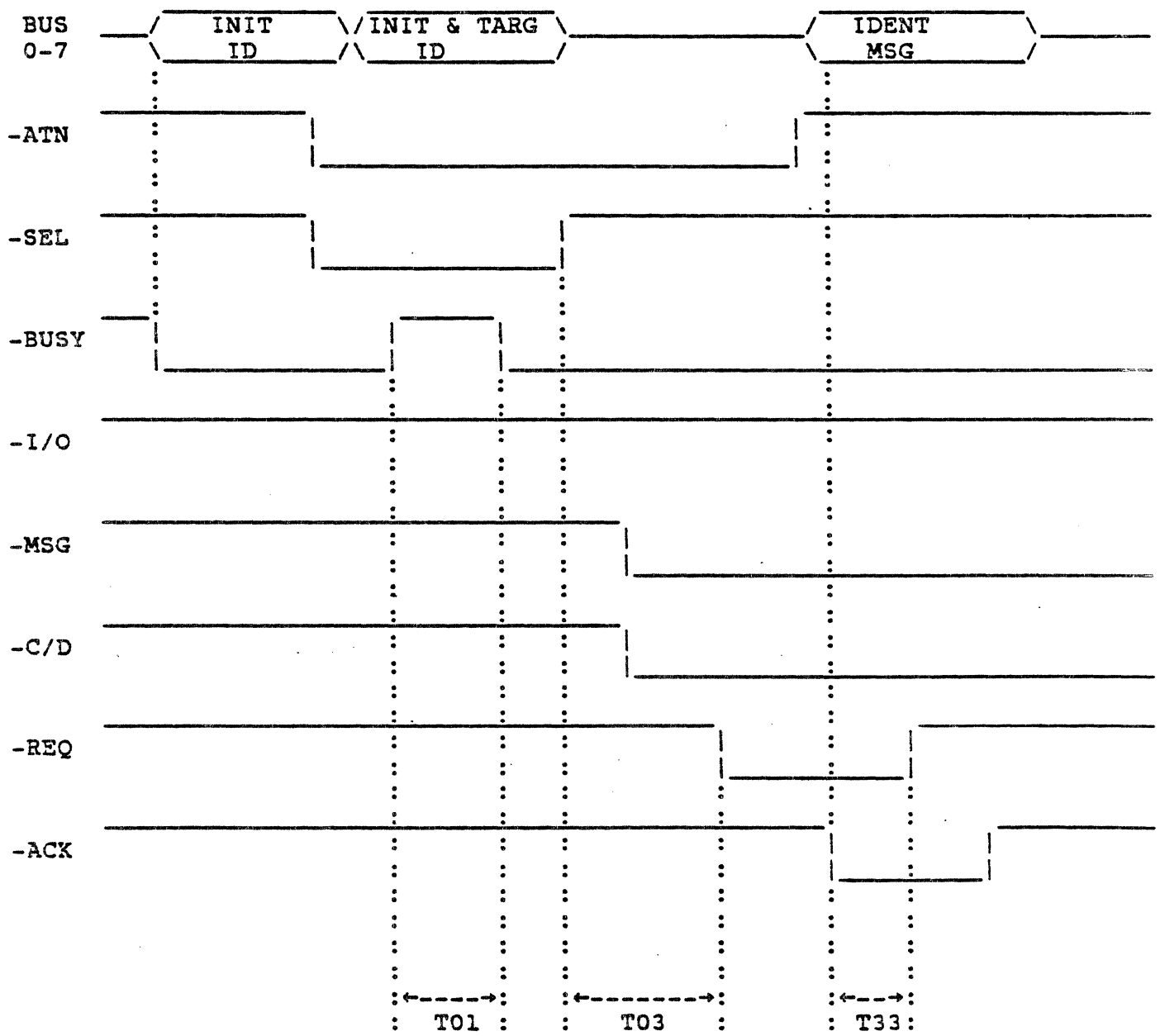
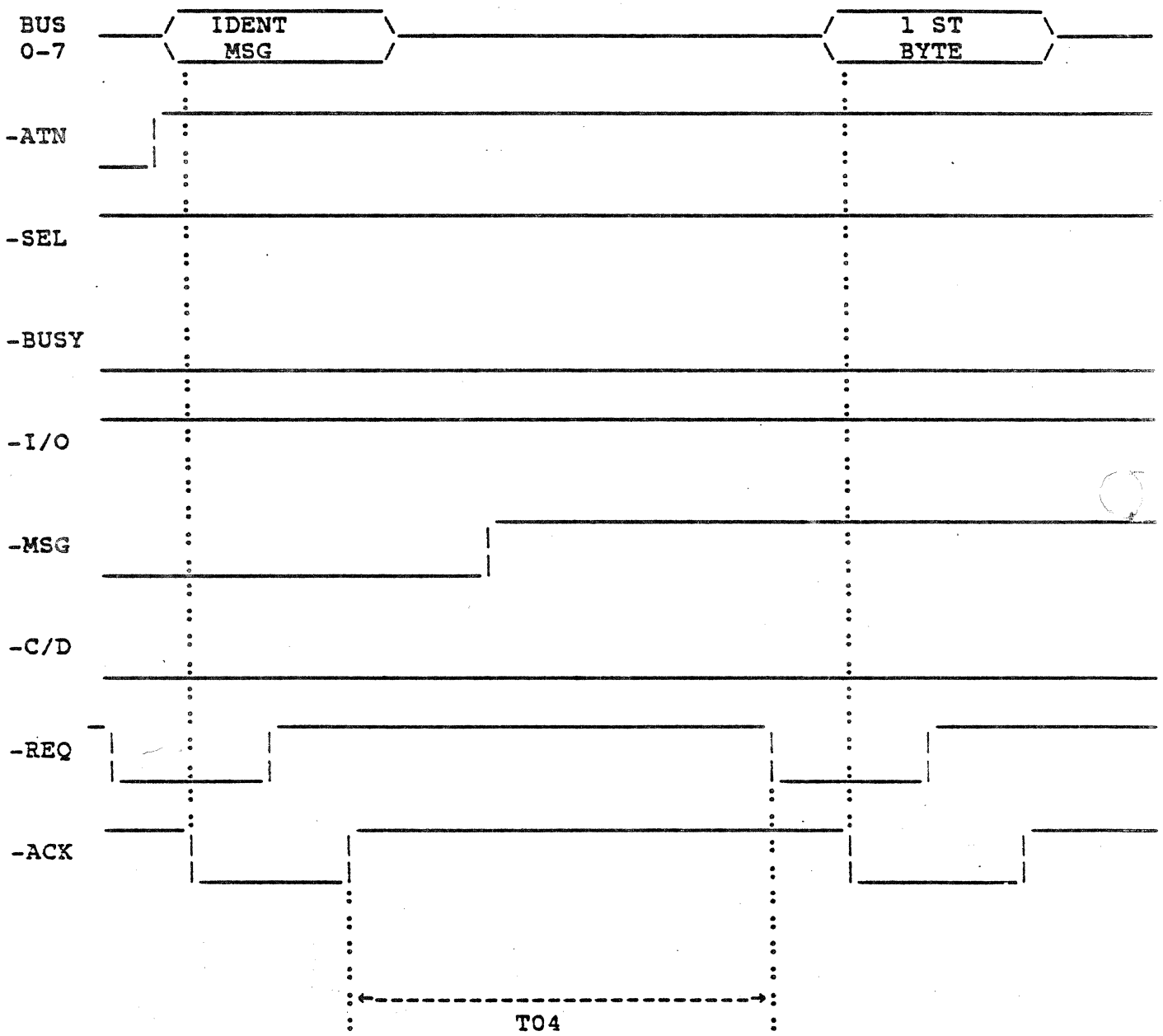


TABLE 6-7. ARBITRATION, SELECTION (with ATN), and MESSAGE OUT



■■ TABLE 6-8. IDENTIFY MSG OUT TO COMMAND PHASE



■■ TABLE 6-9. COMMAND DESCRIPTOR BLOCK TRANSFER

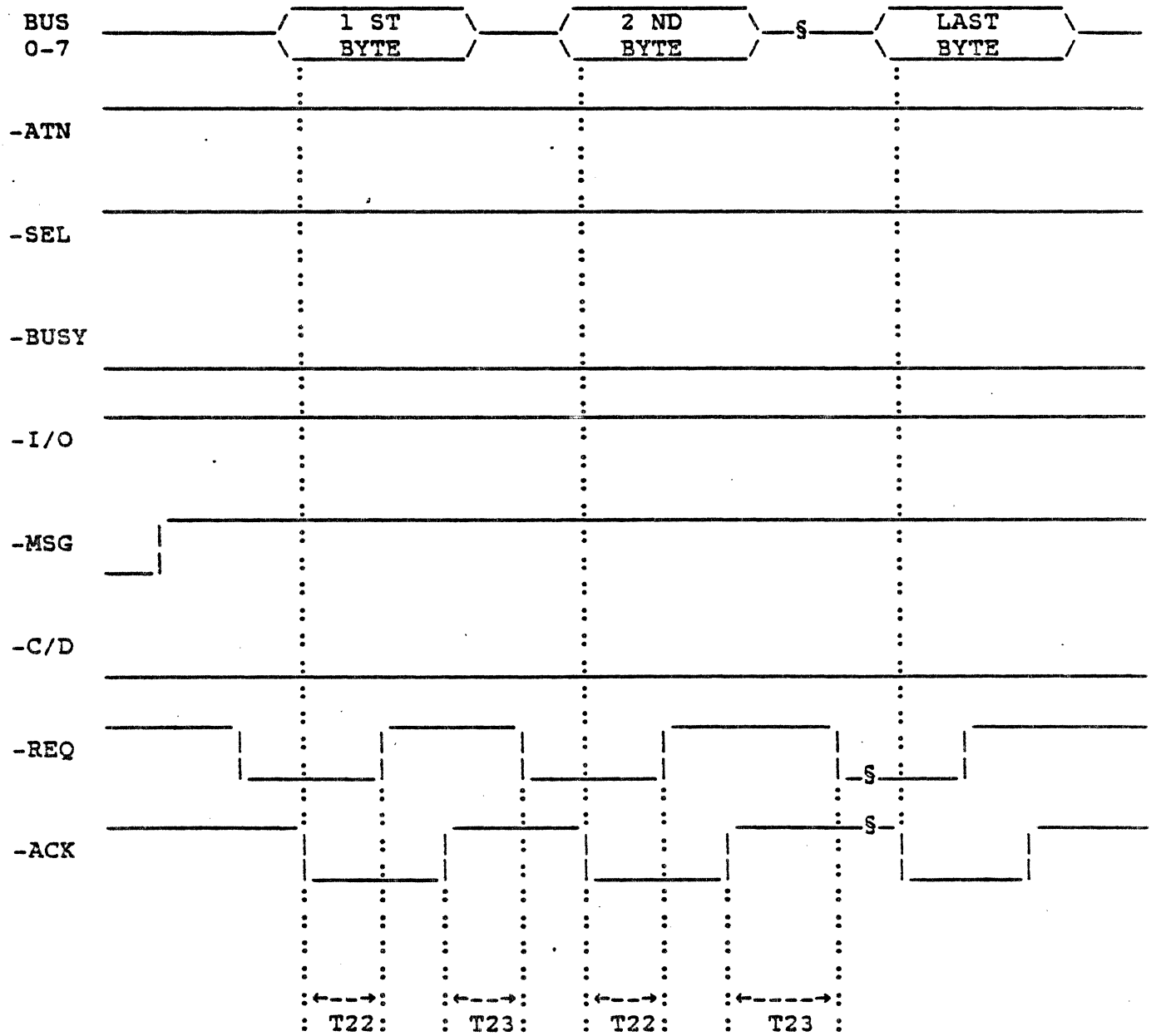


TABLE 6-10. COMMAND PHASE, STATUS PHASE, COMMAND COMPLETE MSG AND BUS FREE

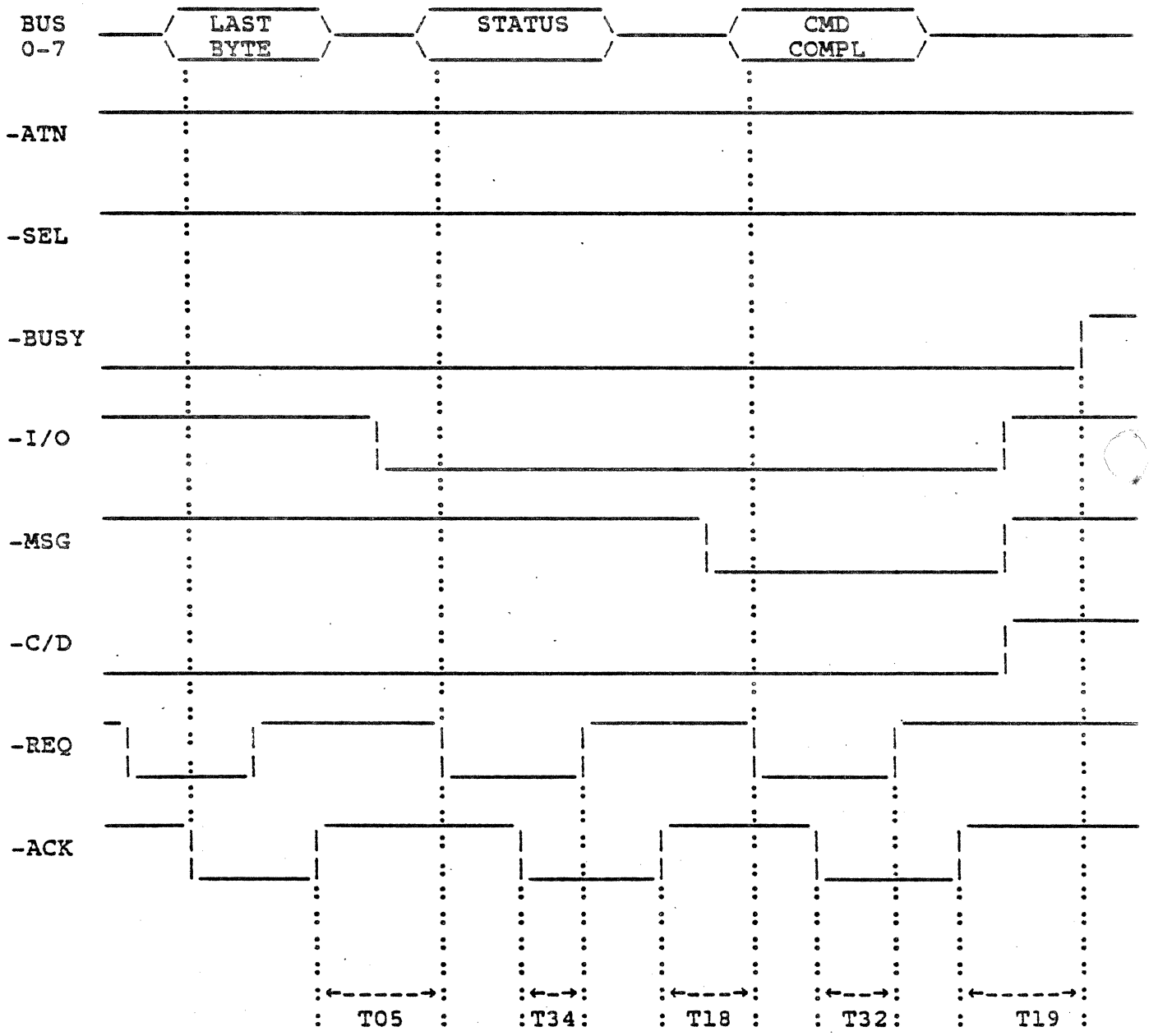
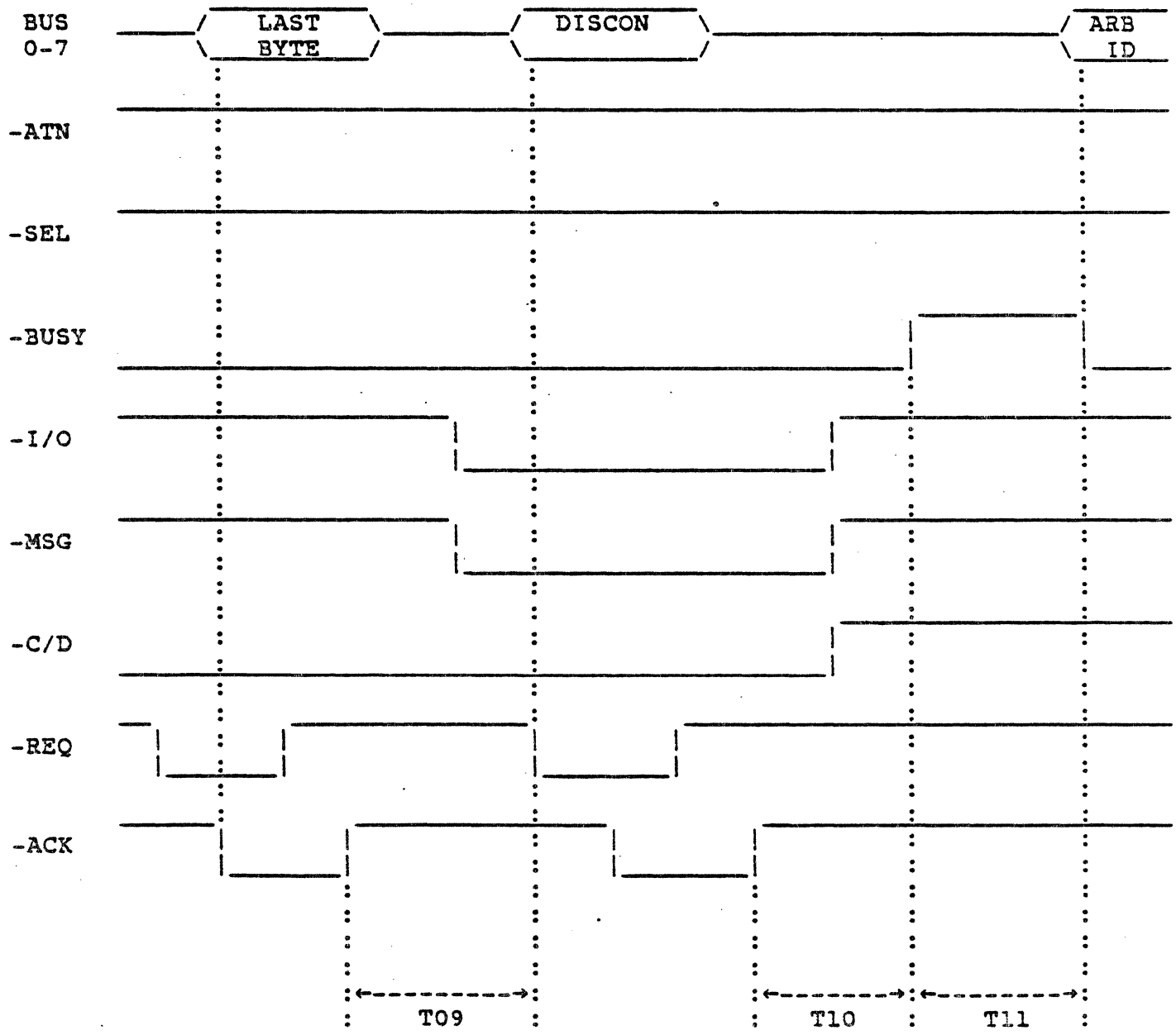
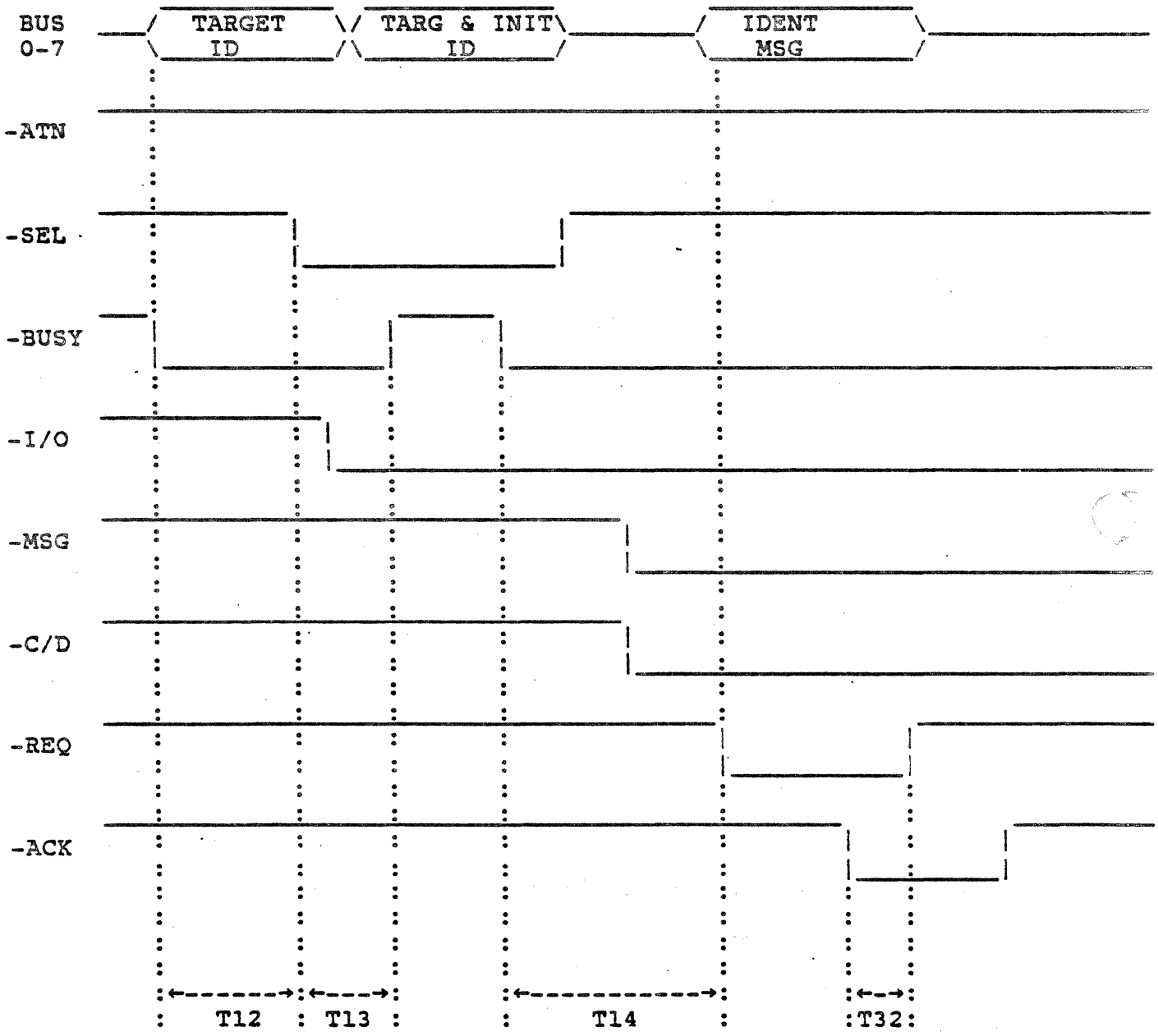


TABLE 6-11. LAST COMMAND BYTE, DISCONNECT MSG, BUS FREE, AND RESELECT

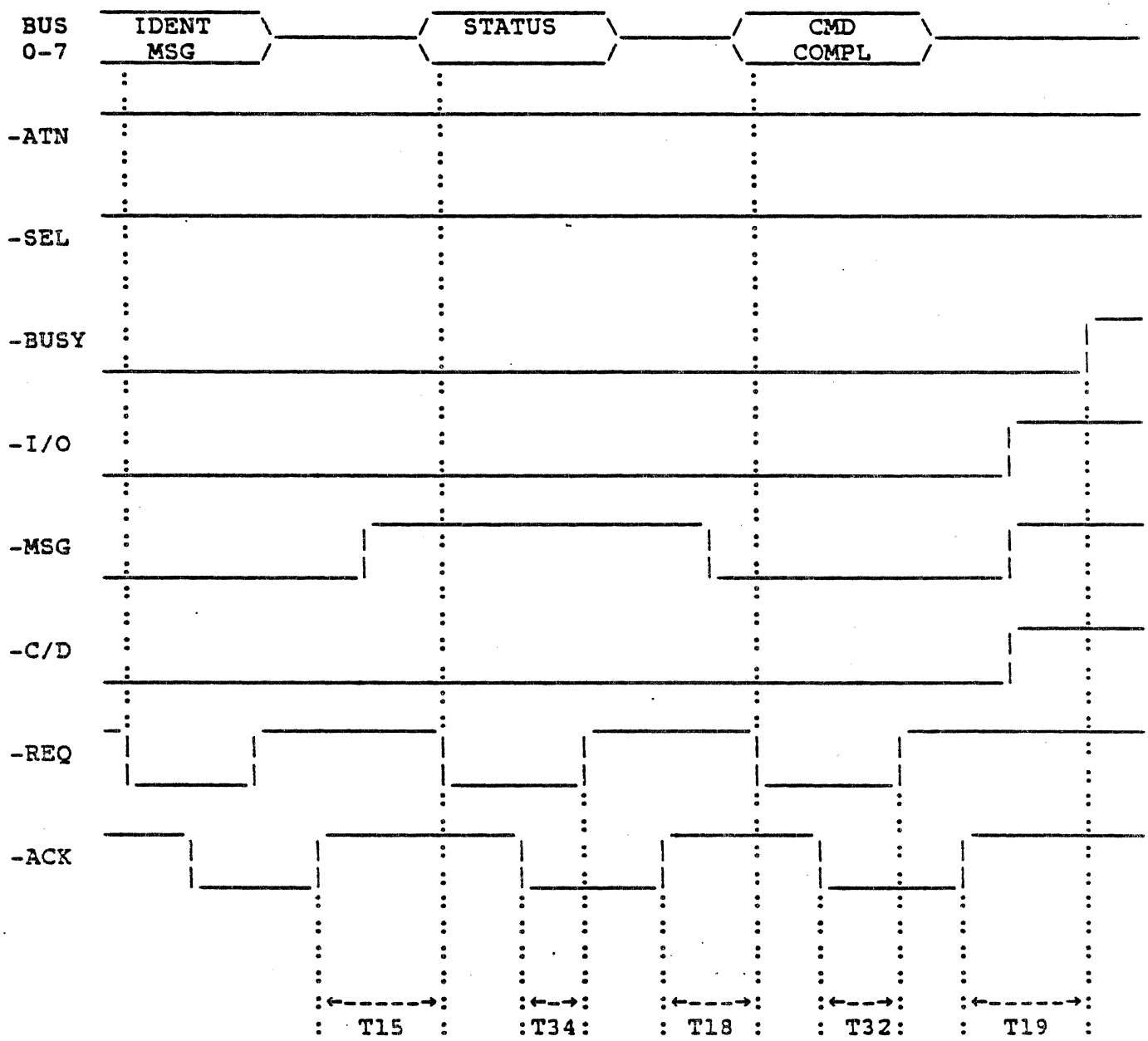


NOTE: To properly measure T11, there must be no other device contending for the SCSI bus.

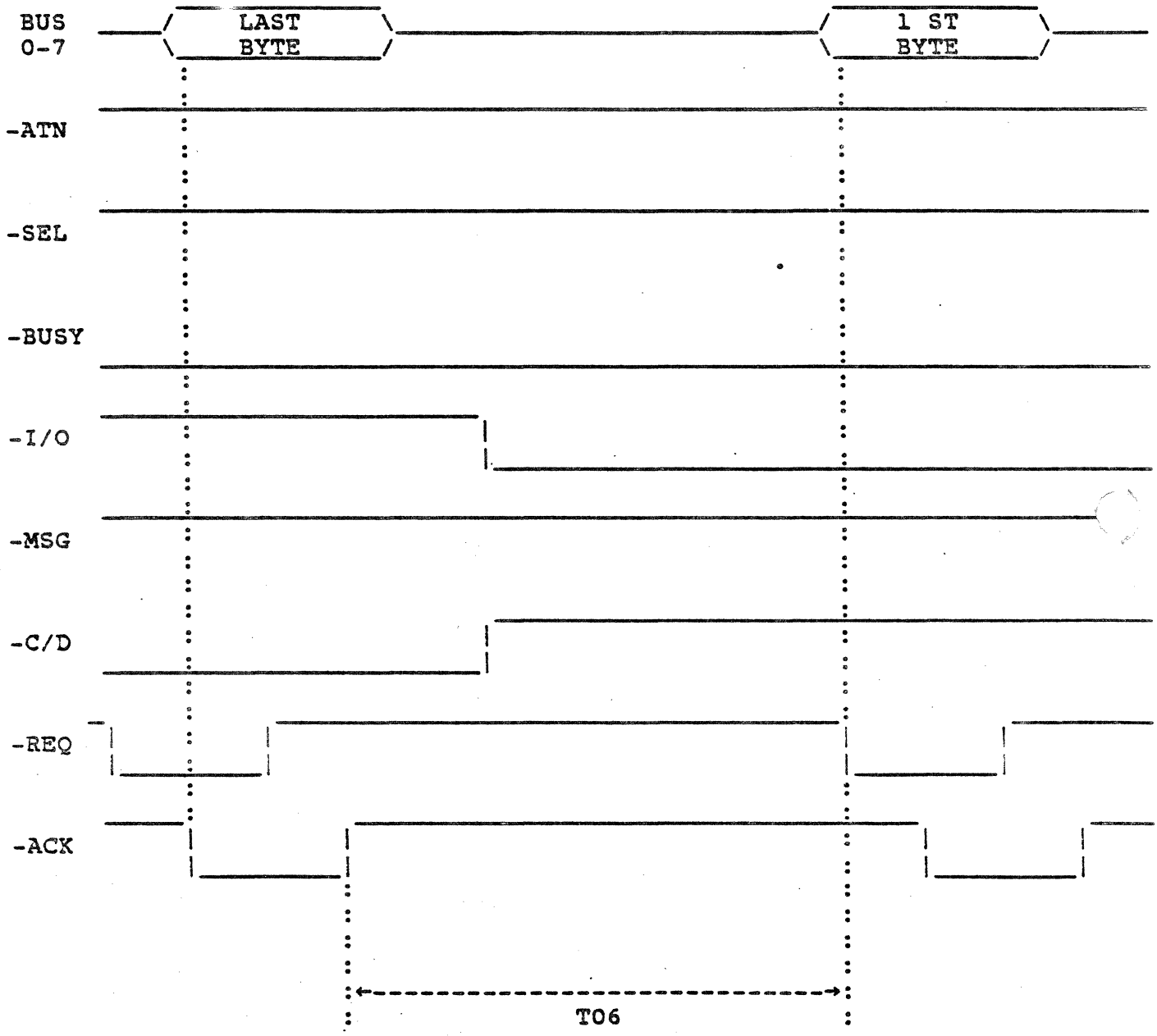
TABLE 6-12. ARBITRATION, RESELECTION AND MESSAGE IN



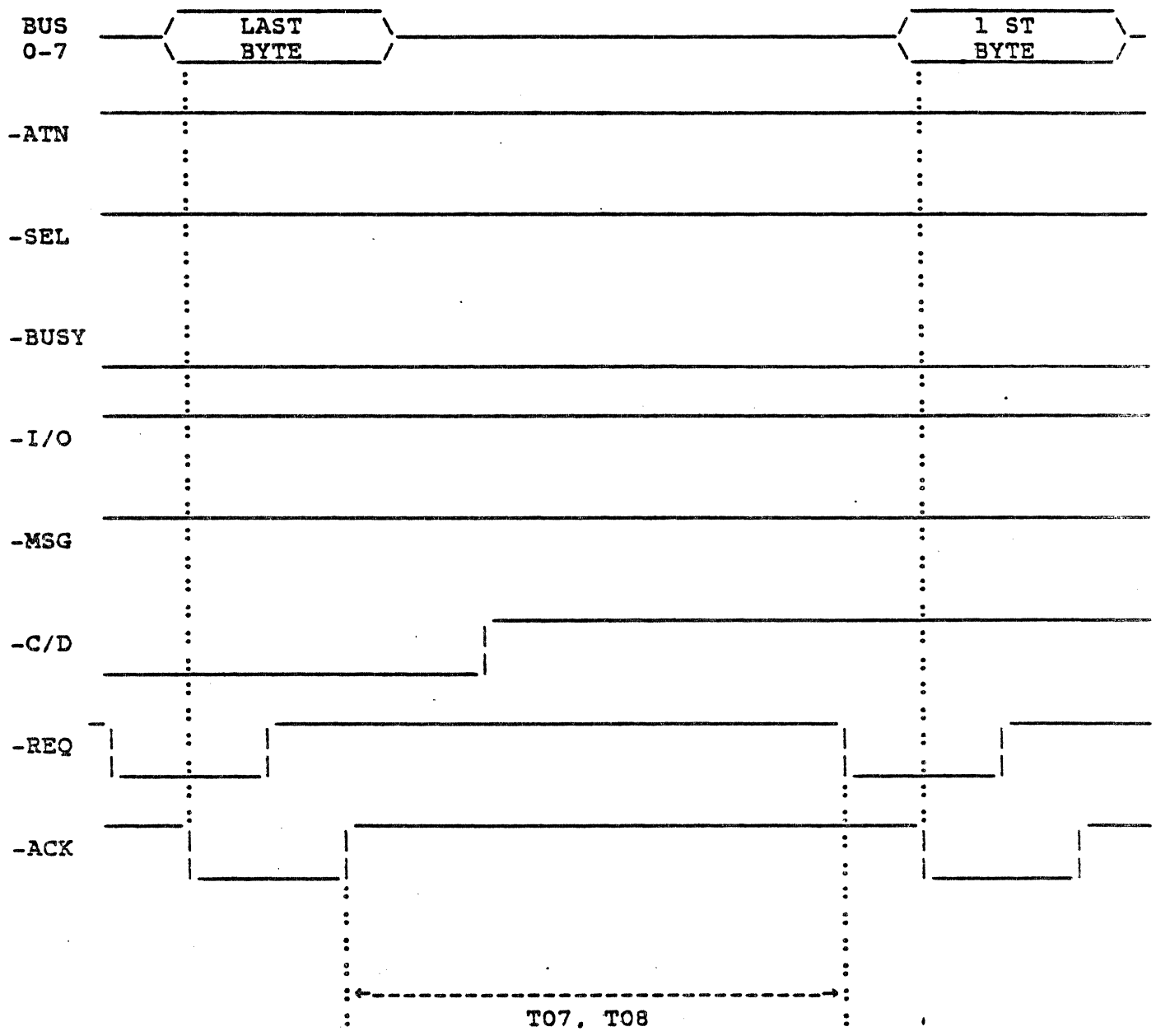
■■ TABLE 6-13. RESELECT IDENTIFY MSG, STATUS PHASE, COMMAND COMPLETE MSG AND BUS FREE



■■ TABLE 6-14. LAST COMMAND BYTE TO DATA IN PHASE



■■ TABLE 6-15. LAST COMMAND BYTE TO DATA OUT PHASE



■■ TABLE 6-16. RESELECT IDENTIFY MSG TO DATA IN PHASE

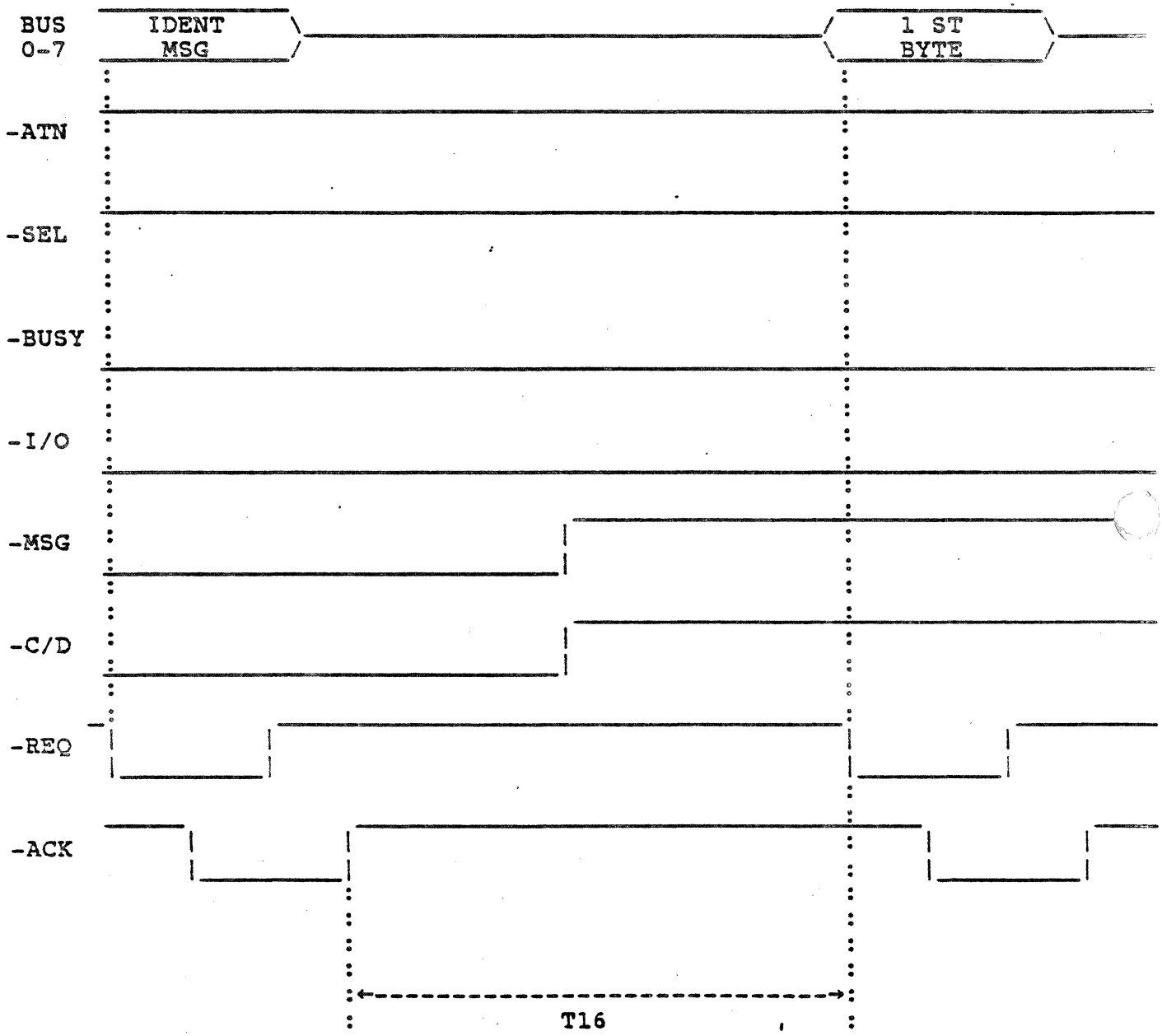
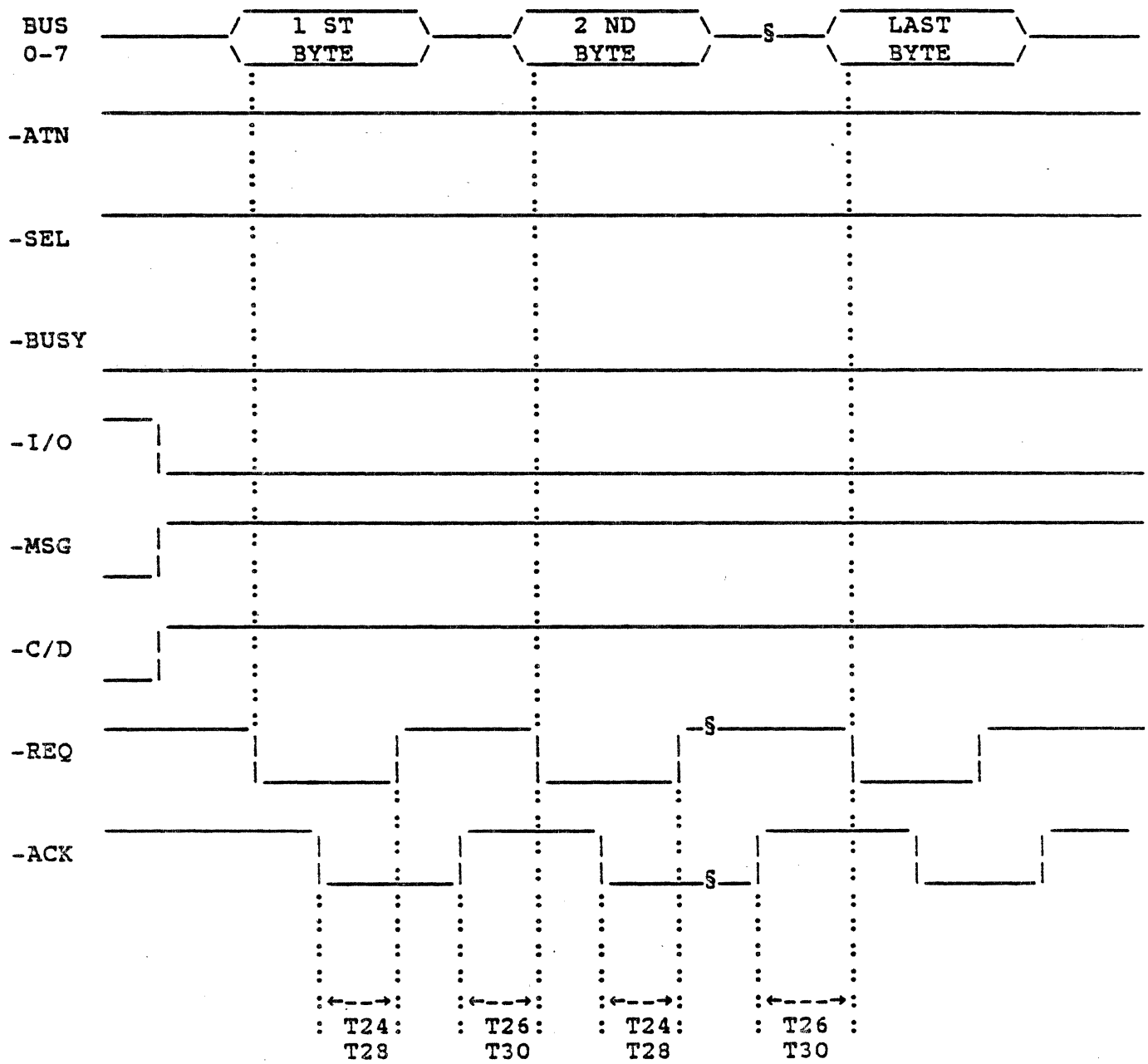
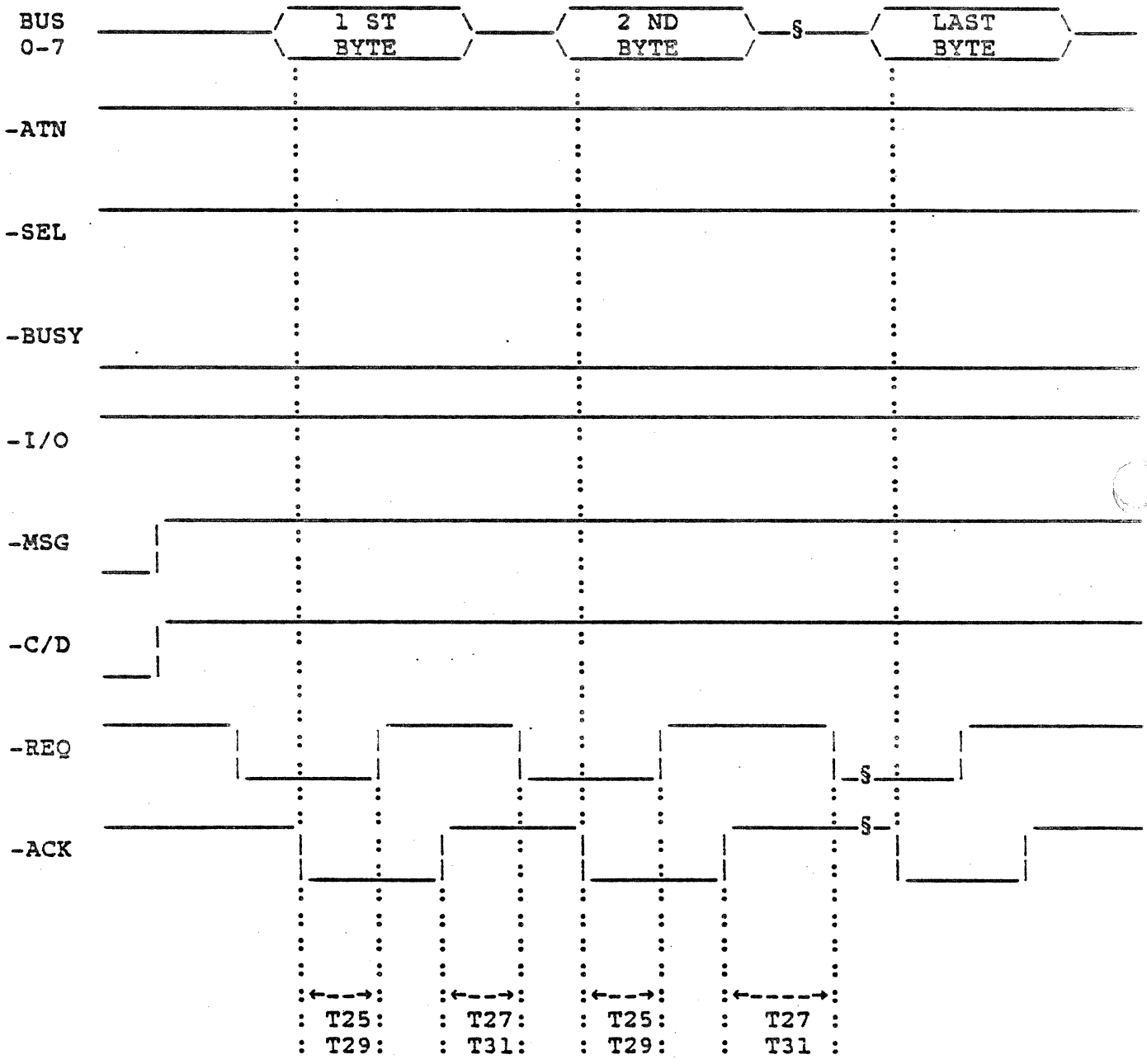


TABLE 6-17. DATA IN BLOCK TRANSFER



■■ TABLE 6-18. DATA OUT BLOCK TRANSFER



■■ TABLE 6-19. LAST DATA BYTE, SAVE POINTER MSG, AND DISCONNECT MSG

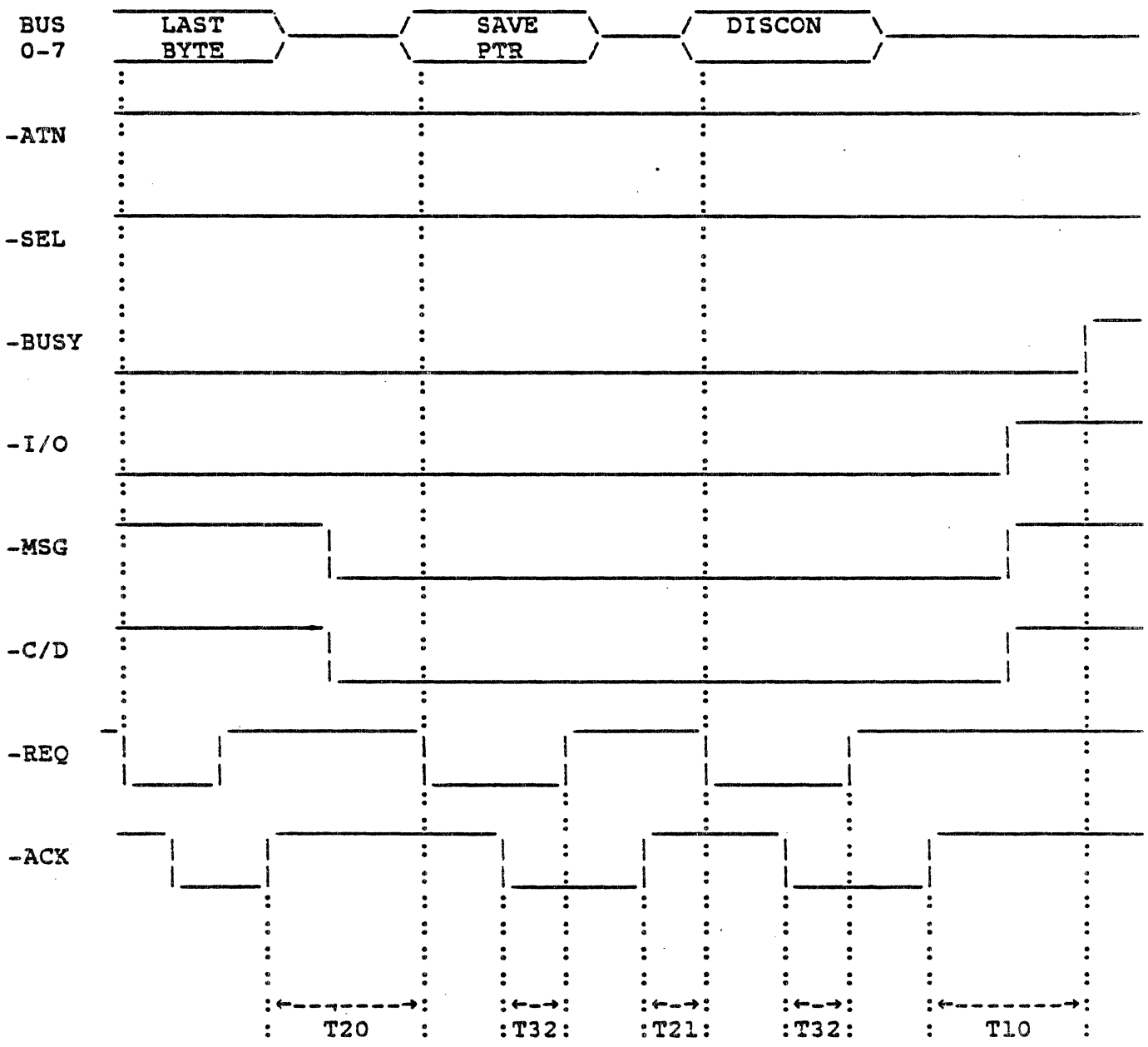
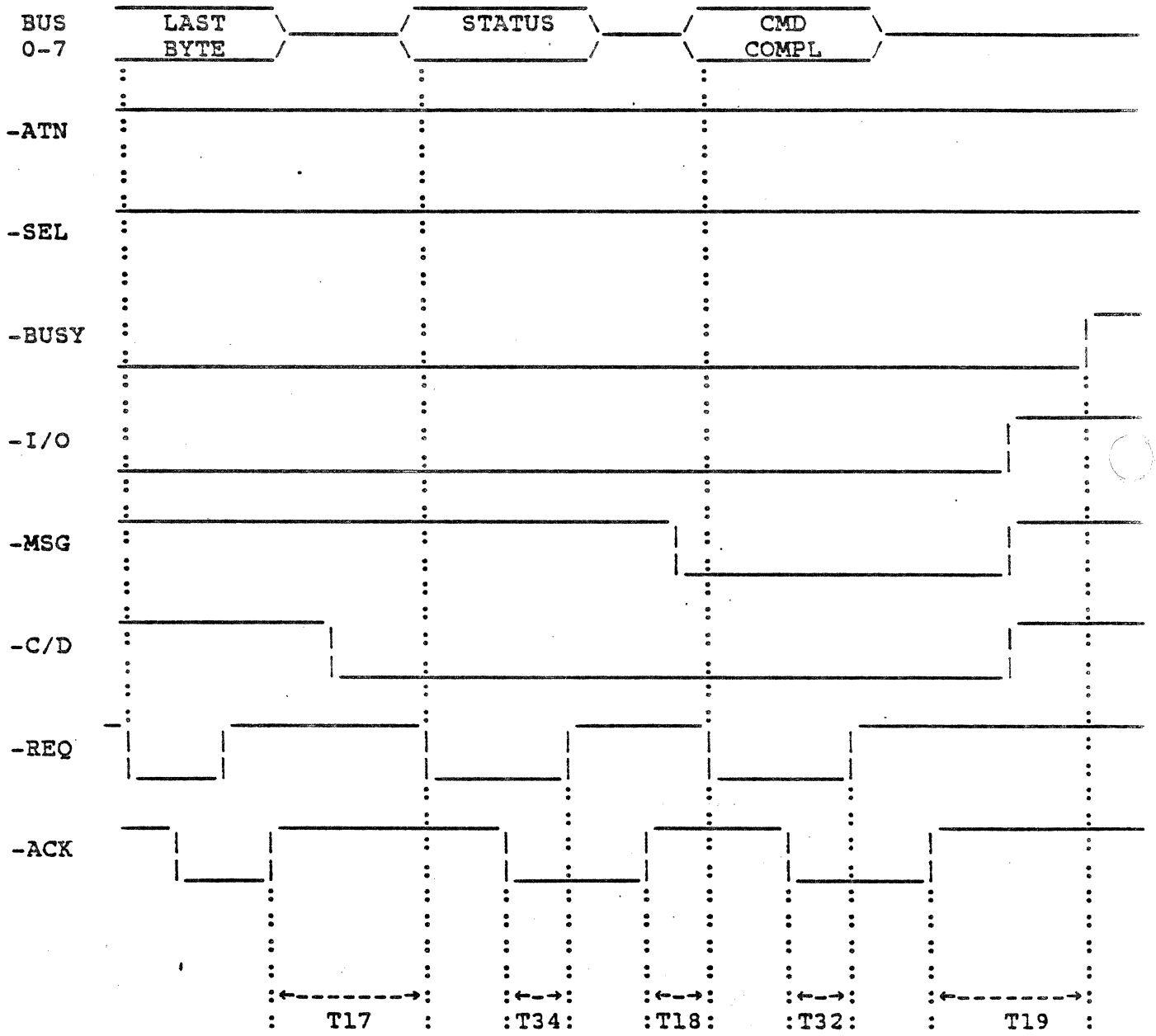


TABLE 6-20. DATA IN PHASE, STATUS PHASE, COMMAND COMPLETE MSG, AND BUS FREE



7.0 COMMAND DESCRIPTIONS FOR ALL DEVICE TYPES

7.1 Group 0 Commands for All Device Types

These commands shall be as listed in Table 7-1.

TABLE 7-1. GROUP 0 COMMON COMMANDS FOR ALL DEVICE TYPES

OPERATION CODE	TYPE	COMMAND NAME	SECTION
00H	M	TEST UNIT READY	7.1.1
01H	*		
02H	R		
03H	M	REQUEST SENSE	7.1.2
04H	*		
05H	*		
06H	R		
07H	*		
08H	*		
09H	R		
0AH	*		
0BH	*		
0CH	R		
0DH	R		
0EH	R		
0FH	*		
10H	*		
11H	*		
12H	M	INQUIRY	7.1.3
13H	*		
14H	*		
15H	*		
16H	*		
17H	*		
18H	O	COPY	7.1.4
19H	*		
1AH	*		
1BH	*		
1CH	O	RECEIVE DIAGNOSTIC RESULTS	7.1.5
1DH	M	SEND DIAGNOSTIC	7.1.6
1EH	*		
1FH	R		

Key: (Type definitions are defined in 6.1.2)
M = Command implementation is mandatory.
O = Command implementation is optional.
R = Operation code is reserved for future standardization.
* = These operation codes may have different meanings for specific types of peripheral devices. (See the appropriate section for further information.)

7.1.1 TEST UNIT READY Command (00H)

Peripheral Device Type: All
Operation Code Type: Mandatory

TABLE 7-2. TEST UNIT READY COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0
1	Logical Unit Number			0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	Flag	Link

The TEST UNIT READY command (Table 7-2) provides a means to check if the logical unit is ready. This is not a request for a self test. If the logical unit would accept an appropriate medium-access command without returning CHECK CONDITION status, this command shall return a GOOD status.

7.1.2 REQUEST SENSE Command (03H)

Peripheral Device Type: All
Operation Code Type: Mandatory

TABLE 7-3. REQUEST SENSE COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	1	1
1	Logical Unit Number			0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	Allocation Length							
5	0	0	0	0	0	0	Flag	Link

The REQUEST SENSE command (Table 7-3) requests that the target transfer sense data to the initiator.

The sense data shall be valid for a CHECK CONDITION status returned on the prior command. This sense data shall be preserved by the target for the initiator until retrieved by the REQUEST SENSE command or until the receipt of any other command for the same logical unit from the initiator that issued the command resulting in the CHECK CONDITION status. Sense data shall be cleared upon receipt of any subsequent command to the logical unit from the initiator receiving the CHECK CONDITION status.

The Allocation Length specifies the number of bytes that the initiator has allocated for returned sense data. An Allocation Length of zero indicates that four bytes of sense data shall be transferred. Any other value indicates the maximum number of bytes that shall be transferred. The target shall terminate the DATA IN phase when allocation length bytes have been transferred or when all available sense data have been transferred to the initiator, whichever is less.

The REQUEST SENSE command shall return the CHECK CONDITION status only to report fatal errors for the REQUEST SENSE command. For example:

1. The target receives a nonzero reserved bit in the command descriptor block.
2. An unrecovered parity error occurs on the DATA BUS.
3. A target malfunction prevents return of the sense data.

If any non-fatal error occurs during execution of REQUEST SENSE, the target shall return sense data with GOOD status. Following a fatal error on a REQUEST SENSE comand, sense data may be invalid.

CDC products are required to support the extended sense data format and will not support the non-extended sense format.

7.1.2.1 Extended Sense

Error class 7 specifies extended sense. Error code zero specifies the extended sense data format. Error codes 1H through FH are reserved.

The extended sense data format is shown in Table 7-4.

TABLE 7-4. EXTENDED SENSE DATA FORMAT

BIT / BYTE	7	6	5	4	3	2	1	0
0	Valid	1	1	1	0	0	0	0
1	Segment Number							
2	Filemrk	EOM	ILI	0	Sense Key			
3	Information Byte (MSB)							
4	Information Byte							
5	Information Byte							
6	Information Byte (LSB)							
7	Additional Sense Length (n)							
8	bytes 8-11 are Reserved for use by COPY or SEARCH commands							
9								
10								
11								
12	Error Code							
13	Reserved							
14	FRU Code							
15	FPV	C/D	0	0	BPV	Bit Pointer		
16	Field Pointer (MSB)							
17	Field Pointer (LSB)							
18-n	Product Unique Sense Data							

The Information Bytes are not defined if the Valid bit is zero. If the Valid bit is one, the Information Bytes contain valid information as follows:

1. The unsigned logical block address associated with the Sense Key, for direct-access devices (Type 0), write-once read-multiple devices (Type 4), and read-only direct-access devices (Type 5). Unless otherwise specified, the information bytes will contain the address of the current logical block. For example, if Sense Key is MEDIUM ERROR, it will be the Logical Block Address of the failing block.

2. The difference (residue) of the requested length minus the actual length in either bytes or blocks, as determined by the command, for sequential-access devices (Type 1), printer devices (Type 2), and processor devices (Type 3). (Negative values are indicated by two's complement notation.)

3. The difference (residue) of the requested number of blocks minus the actual number of blocks copied or compared for the current segment descriptor of a COPY command.

The Segment Number contains the number of the current segment descriptor if the extended sense is in response to a COPY command. Up to 256 segments are supported beginning with segment zero.

The Filemark bit indicates that the current command has read a filemark. This bit is only used for sequential-access devices.

The End-Of-Medium (EOM) bit indicates that an end-of-medium condition (end-of-tape, beginning-of-tape, out-of-paper, etc) exists on a sequential access device or printer device. For sequential-access devices, this bit indicates that the unit is at or past the early-warning end-of-tape if the direction was forward or that the command could not be completed because beginning-of-tape was encountered if the direction was reverse. Direct-access devices shall not use this bit; instead, these devices shall report attempts to access beyond the end-of-medium as ILLEGAL REQUEST sense key (see Table 7-5).

The Incorrect Length Indicator (ILI) bit indicates that the requested logical block length did not match the logical block length of the data on the medium.

The Sense Keys are described in Tables 7-5 and 7-6.

The Additional Sense Length specifies the number of additional sense bytes to follow. If the Allocation Length of the command descriptor block is too small to transfer all of the additional sense bytes, the additional sense length is not adjusted to reflect the truncation.

The additional sense bytes contain command-specific, peripheral-device-specific data, or both kinds of data that further define the nature of the CHECK CONDITION status. For example, the COPY command defines a standard purpose for some of these bytes. The use of any additional sense bytes by products is optional; such additional bytes will be product unique.

The Error Code provides additional clarification of errors whenever the SENSE KEY is valid. Each Peripheral Device Type (as defined in the INQUIRY command) will have a unique list of Error Code definitions. Table 7-7 contains definitions for Direct Access Devices. Other Device Types have not been defined yet.

The FRU (Field Replaceable Unit) Code is a product unique field that indicates which assembly may have failed.

The Field Pointer Valid (FPV) bit, when set to one, indicates that the C/D bit and bytes 16 and 17 are valid. When set to zero, these fields shall be ignored.

The Command/Data (C/D) bit, when set to one, indicates that the value reported in the Field Pointer bytes is the CDB's byte number for which an Illegal Request sense key was issued. When set to zero, it indicates that the value reported in the Field Pointer bytes is the byte number in the DATA phase for which an Illegal Request sense key was issued.

The Bit Pointer Valid (BPV) bit, when set to one, indicates that the Bit Pointer field is valid. The Bit Pointer field indicates which bit of the byte indicated by the Field Pointer caused the Illegal Request sense key. A value of 7 indicates the left most bit and zero indicates the right most bit.

The Field Pointer bytes provide a 16 bit pointer to the first byte that caused the target to generate the Illegal Request sense key.

TABLE 7-5. SENSE KEY (0H-4H) DESCRIPTIONS

SENSE KEY	DESCRIPTION
0H	NO SENSE - Indicates that there is no specific sense key information to be reported for the designated logical unit. This would be the case for a successful command or a command that received a CHECK CONDITION status because one of the Filemark, EOM, or ILI bits is set to one.
1H	RECOVERED ERROR - Indicates that the last command completed successfully with some recovery action performed by the target. NOTE: For some Mode settings, the last command may have terminated before completing.
2H	NOT READY - Indicates that the logical unit addressed cannot be accessed. Operator intervention may be required to correct this condition.
3H	MEDIUM ERROR - Indicates that the command terminated with a nonrecovered error condition that was probably caused by a flaw in the medium or an error in the recorded data.
4H	HARDWARE ERROR - Indicates that the target detected a nonrecoverable hardware failure while performing the command or during a self test. This includes SCSI interface parity error, controller failure, device failure, etc.

TABLE 7-6. SENSE KEY (5H-FH) DESCRIPTIONS

SENSE KEY	DESCRIPTION
5H	ILLEGAL REQUEST - Indicates that there was an illegal parameter in the command descriptor block or in the additional parameters supplied as data for some commands. (FORMAT UNIT, SEARCH DATA, etc). If the target detects an invalid parameter in the command descriptor block, then it shall terminate the command without altering the medium. If the target detects an invalid parameter in the additional parameters supplied as data, then the target may have already altered the medium.
6H	UNIT ATTENTION - Indicates that the removable medium may have been changed or the target has been reset. See 6.1.3 for more detailed information about the Unit Attention Condition.
7H	DATA PROTECT - Indicates that a command that reads or writes the medium was attempted on a block that is protected from this operation. The read or write operation is not performed.
8H	BLANK CHECK - Indicates that a write-once read-multiple device or a sequential-access device encountered a blank block while reading or a write-once read-multiple device encountered a nonblank block while writing.
■ 9H	Reserved for future CDC standardization.
AH	COPY ABORTED - Indicates a COPY, COMPARE, or COPY AND VERIFY command was aborted due to an error condition on the source device, the destination device, or both. (See 7.1.4.2 for additional information about this sense key.)
BH	ABORTED COMMAND - Indicates that the target aborted the command. The initiator may be able to recover by trying the command again.
■ CH	EQUAL - Reserved and not implemented on CDC products.
DH	VOLUME OVERFLOW - Indicates that a buffered peripheral device has reached the end-of-medium and data remains in the buffer that has not been written to the medium.
EH	MISCOMPARE - Indicates that the source data did not match the data read from the medium.
FH	This sense key is reserved.

TABLE 7-7A. DIRECT ACCESS DEVICE ERROR CODE DEFINITIONS

ERROR CODE	DESCRIPTION	RECOMMENDED SENSE KEY
00	No additional information	NO SENSE
01	No index/sector signal	HARDWARE ERROR
02	No seek complete	HARDWARE ERROR
03	Write fault	HARDWARE ERROR or RECOVERED ERROR
04	Drive not ready	NOT READY or RECOVERED ERROR
05	Drive not selected	NOT READY
06	No track zero found	HARDWARE ERROR
08	Logical Unit communication failure	HARDWARE ERROR or RECOVERED ERROR
09	Track following error	HARDWARE ERROR or RECOVERED ERROR
10	ID CRC or ECC error	MEDIUM ERROR or RECOVERED ERROR
11	Unrecovered Read error of data	MEDIUM ERROR
12	No Address Mark found in ID field	MEDIUM ERROR or RECOVERED ERROR
13	No Address Mark found in Data field	MEDIUM ERROR or RECOVERED ERROR
14	No record found	MEDIUM ERROR or RECOVERED ERROR
15	Seek positioning error	HARDWARE ERROR or MEDIUM ERROR or RECOVERED ERROR
17	Read Retries applied to recover data	RECOVERED ERROR
18	ECC applied to recover data	RECOVERED ERROR
19	Defect list error	MEDIUM ERROR or RECOVERED ERROR
1A	Parameter overrun	ILLEGAL REQUEST
1B	Synchronous transfer error	HARDWARE ERROR
1C	Primary Defect List not found	MEDIUM ERROR
1D	Compare error	MISCOMPARE
20	Invalid Command Operation Code	ILLEGAL REQUEST
21	Invalid Logical Block Address	ILLEGAL REQUEST
22	Illegal function for device type	ILLEGAL REQUEST
24	Illegal use of bit or byte in CDB	ILLEGAL REQUEST
25	Invalid LUN	ILLEGAL REQUEST
26	Invalid field in parameter list	ILLEGAL REQUEST
27	Write protected	HARDWARE ERROR
28	Medium changed	UNIT ATTENTION
29	Power On Reset, hard RESET, or BUS DEVICE RESET message occured	UNIT ATTENTION
2A	MODE SELECT parameters changed by another initiator	UNIT ATTENTION
30	Incompatible cartridge	MEDIUM ERROR
31	Medium format corrupted	MEDIUM ERROR
32	No spare defect location available	MEDIUM ERROR

TABLE 7-7B. DIRECT ACCESS DEVICE ERROR CODE DEFINITIONS

ERROR CODE	DESCRIPTION	RECOMMENDED SENSE KEY
40	RAM failure	HARDWARE ERROR
41	Data Path diagnostic failure	HARDWARE ERROR
42	Power On diagnostic failure	HARDWARE ERROR
43	MESSAGE REJECT message retry failure	ABORTED COMMAND
44	Target internal parity/hardware error	HARDWARE ERROR or RECOVERED ERROR
45	SELECTION/RESELECTION failure	ABORTED COMMAND
46	Unsuccessful soft RESET	HARDWARE ERROR or ABORTED COMMAND
47	SCSI Bus parity error	HARDWARE ERROR
48	INITIATOR DETECTED ERROR retry failure	ABORTED COMMAND
49	Inappropriate/illegal message	ABORTED COMMAND
80-FF	Product Unique error codes	

NOTE: All other codes are Reserved for future use.

Table numbers 7-8, 7-9, and 7-10 are reserved for future Error Code Description tables.

7.1.3 INQUIRY Command (12H)

Peripheral Device Type: All
Operation Code Type: Mandatory

TABLE 7-11. INQUIRY COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	1	0	0	1	0
1	Logical Unit Number			0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	Allocation Length							
5	0	0	0	0	0	0	Flag	Link

The INQUIRY command (Table 7-11) requests that information regarding parameters of the target and its attached peripheral device(s) be sent to the initiator.

The Allocation Length specifies the number of bytes that the initiator has allocated for returned INQUIRY data. An Allocation Length of zero indicates that no INQUIRY data shall be transferred. This condition shall not be considered as an error. Any other value indicates the maximum number of bytes that shall be transferred. The target shall terminate the DATA IN phase when allocation length bytes have been transferred or when all available INQUIRY data have been transferred to the initiator, whichever is less.

A CHECK CONDITION status shall only be reported when the target cannot return the requested INQUIRY data. (Implementors note: It is recommended that the INQUIRY data be returned even though the peripheral device may not be ready for other commands.)

If an INQUIRY command is received from an initiator with a pending Unit Attention Condition (before the target reports check condition status), the target shall perform the INQUIRY command and shall not clear the Unit Attention Condition. (See 6.1.3.)

The INQUIRY data (Table 7-12) contains a five byte header, followed by the vendor unique parameters, if any.

TABLE 7-12. INQUIRY DATA

BIT / BYTE	7	6	5	4	3	2	1	0
0	Peripheral Device Type							
1	RMB	Device-Type Qualifier						
2	ISO Version		ECMA Version			ANSI Version		
3	0	0	0	0	Response Data Format (1H)			
4	Additional Length (n)							
	Common Command Set Parameters							
5	Reserved (00H)							
6	Reserved (00H)							
7	Reserved (00H)							
8	Vendor Identification: ASCII 'C' (43H)							
9	Vendor Identification: ASCII 'D' (44H)							
10	Vendor Identification: ASCII 'C' (43H)							
11	Vendor Identification: ASCII blank (20H)							
12	Vendor Identification: ASCII blank (20H)							
13	Vendor Identification: ASCII blank (20H)							
14	Vendor Identification: ASCII blank (20H)							
15	Vendor Identification: ASCII blank (20H)							
16	Product Identification:							
17	Product Identification:							
18	Product Identification:							
19	Product Identification:							
20	Product Identification:							
21	Product Identification:							
22	Product Identification:							
23	Product Identification:							
24	Product Identification:							
25	Product Identification:							
26	Product Identification:							
27	Product Identification:							
28	Product Identification:							
29	Product Identification:							
30	Product Identification:							
31	Product Identification:							
32	Revision Level							
33	Revision Level							
34	Revision Level							
35	Revision Level							

Table 7-13. PERIPHERAL DEVICE TYPE

CODE	DESCRIPTION
00H	Direct-access device (e.g., magnetic disk)
01H	Sequential-access device (e.g., magnetic tape)
02H	Printer device
03H	Processor device
04H	Write-once read-multiple device (e.g., some optical disks)
05H	Read-only direct-access device (e.g., some optical disks)
06H--7EH	Reserved
7FH	Logical Unit not present
80H--FFH	Reserved

The Peripheral Device Type is shown in Table 7-13.

A Removable Medium (RMB) bit of zero indicates that the medium is not removable. A RMB bit of one indicates that the medium is removable.

The Device-Type Qualifier is a seven bit user specified code. This code may be set with switches or by some other means by the target or peripheral device. CDC products shall return all zero bits. This feature allows each user to assign unique codes to each specific type of peripheral device that is supported on the system being used. These codes may then be used by self-configuring software to determine what specific peripheral device is at each logical unit number. This is especially valuable for systems that support multiple types of removable medium.

The usage of nonzero code values in the ISO Version and ECMA Version fields is defined by the International Standards Organization and the European Computer Manufacturers Association, respectively. A zero code value in these fields shall indicate that the target does not claim compliance to the ISO or ECMA versions of SCSI. Note that it is possible to claim compliance to more than one of these SCSI standards.

The ANSI version is the implemented version of the ANSI SCSI standard and is defined as shown in Table 7-14.

TABLE 7-14. ANSI VERSION

CODE	DESCRIPTION
0H	Version is before ANSI standard is first approved.
1H	Complies with first release of ANSI SCSI standard.
2H--7H	Reserved

The Response Data Format indicates the format that additional INQUIRY data will be in. Codes are defined in Table 7-15.

TABLE 7-15. RESPONSE DATA FORMAT

CODE	DESCRIPTION
0H	Vendor Unique
1H	Common Command Set (CCS)
2H--FH	Reserved

The Additional Length shall specify the length in bytes of the vendor unique parameters. For CDC products this additional length will always be 31 decimal. If the Allocation Length of the command descriptor block is too small to transfer all of the vendor unique parameters, the additional length shall not be adjusted to reflect the truncation.

The Vendor Identification bytes for our company will be the ASCII characters for 'CDC' plus five ASCII blanks as shown in Table 7-12. Optical Storage International will use the ASCII characters for 'OSI' in bytes 8-10.

The Product Identification bytes will be the ASCII characters for the product identification codes and will be defined in individual Product Specifications.

The Revision Level is a product specific hardware and software revision level coded as four ASCII characters.

7.1.4 COPY Command (18H)

Peripheral Device Type: All
Operation Code Type: Optional (Mandatory for backup devices)

TABLE 7-17. COPY COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	1	1	0	0	0
1	Logical Unit Number			0	0	0	0	0
2	Parameter List Length (MSB)							
3	Parameter List Length							
4	Parameter List Length (LSB)							
5	0	0	0	0	0	0	Flag	Link

The COPY command (Table 7-17) provides a means to copy data from one logical unit to another or the same logical unit. The logical units may reside on the same SCSI device or different SCSI devices. CDC backup devices (i.e., devices with removable media) must support COPY to or from another SCSI device. All other COPY features are optional.

A CDC device that implements COPY command will only use commands listed as mandatory (in this specification) when communicating with other SCSI devices.

The Parameter List Length specifies the length in bytes of the parameters that shall be sent during the DATA OUT phase of the command. A Parameter List Length of zero indicates that no data shall be transferred. This condition shall not be considered as an error.

The COPY parameter list (Table 7-18) begins with a four-byte header that contains the COPY function code and priority. Following the header is one or more segment descriptors.

TABLE 7-18. COPY PARAMETER LIST

BIT / BYTE	7	6	5	4	3	2	1	0
0	COPY Function Code					Priority		
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
Segment Descriptor(s)								
0 - xx	Segment Descriptor 0 (See specific table for length.)							
	. . .							
0 - xx	Segment Descriptor n (See specific table for length.)							

The COPY function code defines a specific format for the segment descriptors. The COPY function codes are defined in Table 7-19.

The Priority field of the COPY parameter list establishes the relative priority of this COPY command to other commands being executed by the same target. All other commands are assumed to have a priority of 1. Priority 0 is the highest priority with increasing values indicating lower priorities.

The Segment Descriptor formats are determined by the COPY function code. The Segment Descriptor format used for write-once read-multiple devices and for read-only direct-access devices shall be the same as for direct-access devices. The Segment Descriptor format used for printer devices and for processor devices shall be the same as for sequential-access devices. Thus a COPY from a write-once read-multiple device to a printer device uses the same Segment Descriptor format as for a COPY from a direct-access device to a sequential-access device. (See Table 7-19.) The Segment Descriptor formats are described in Tables 7-20 through 7-22. A maximum of 256 segment descriptors are permitted. The segment descriptors are identified by ascending numbers beginning with zero.

TABLE 7-19. COPY FUNCTIONS

PERIPHERAL DEVICE TYPE		COPY FUNCTION CODE	SEGMENT DESCRIPTION TABLE	COMMENT
SOURCE	DESTINATION			
00H	01H	00H	Table 7-20	
00H	02H	00H	Table 7-20	
00H	03H	00H	Table 7-20	
04H	01H	00H	Table 7-20	Direct Access
04H	02H	00H	Table 7-20	to
04H	03H	00H	Table 7-20	Sequential Access
05H	01H	00H	Table 7-20	
05H	02H	00H	Table 7-20	
05H	03H	00H	Table 7-20	
01H	00H	01H	Table 7-20	Sequential Access
01H	04H	01H	Table 7-20	to
03H	00H	01H	Table 7-20	Direct Access
03H	04H	01H	Table 7-20	
00H	00H	02H	Table 7-21	
00H	04H	02H	Table 7-21	Direct Access
04H	00H	02H	Table 7-21	to
04H	04H	02H	Table 7-21	Direct Access
05H	00H	02H	Table 7-21	
05H	04H	02H	Table 7-21	
01H	01H	03H	Table 7-22	
01H	02H	03H	Table 7-22	Sequential Access
01H	03H	03H	Table 7-22	to
03H	01H	03H	Table 7-22	Sequential Access
03H	02H	03H	Table 7-22	
03H	03H	03H	Table 7-22	

Peripheral device type:
- 00H Direct-access device
- 01H Sequential-access device
- 02H Printer device
- 03H Processor device
- 04H Write-once read-multiple device
- 05H Read-only direct-access device

COPY function code:
- 00H Direct access to sequential access
- 01H Sequential access to direct access
- 02H Direct access to direct access
- 03H Sequential access to sequential access
- 04H--0FH Reserved
- 10H--1FH Reserved

7.1.4.1 Errors Detected by the Managing SCSI Device

Two classes of unusual conditions may occur during execution of a COPY command. The first class consists of those unusual conditions detected by the SCSI device that received the COPY command and is managing the execution of the command. These conditions include parity errors while transferring the COPY command and status byte, invalid parameters in the COPY command, invalid segment descriptors, and inability of the SCSI device controlling the COPY functions to continue operating. In the event of such an unusual condition, the SCSI device managing the COPY shall:

1. Terminate the COPY command with a CHECK CONDITION status.

2. Return the sense data in the extended sense format. The Valid bit shall be set to one. The Segment Number shall contain the number of the segment descriptor being processed at the time the unusual condition is detected. The Sense Key shall contain the sense key code describing the unusual condition. The information bytes shall contain the difference between the number of blocks field in the segment descriptor being processed at the time of the failure and the number of blocks successfully copied. This number is the residue of unprocessed blocks remaining for the segment descriptor.

7.1.4.2 Errors Detected by a Target

The second class of errors consists of unusual conditions detected by the SCSI device transferring data at the request of the SCSI device managing the transfer. The SCSI device managing the COPY command detects unusual conditions by receiving a CHECK CONDITION status from one of the SCSI devices it is managing. It then shall recover the sense data associated with the unusual condition.

The SCSI device managing the COPY command may also be the source or destination SCSI device (or both). It shall distinguish between a failure of the management of the COPY and a failure of the data transfer being requested. It shall then create the appropriate sense data internally. After recovering the sense data associated with the detected error, the SCSI device managing the COPY command shall:

1. Terminate the COPY command with a CHECK CONDITION status.

2. Return the sense data in the extended sense format. The Valid bit shall be set to one. The Segment Number shall contain the number of the Segment Descriptor being processed at the time the unusual condition is detected. The Sense Key shall be set to COPY ABORTED. The Information Bytes shall contain the difference between the number of blocks field in the segment descriptor being processed at the time of the failure and the number of blocks successfully copied. This number is the residue of unprocessed blocks remaining for the segment descriptor. The Additional Sense Length shall specify the number of additional sense bytes.

The first additional sense byte shall specify the byte number, relative to the first byte of sense data, of the beginning of the source logical unit's status byte and sense data. A zero value indicates that no status byte or sense data is being returned for the source logical unit. The first byte of the area pointed to by the first additional sense byte shall contain the status byte from the source logical unit. The subsequent bytes shall contain, unchanged, the sense data recovered from the source logical unit.

The second additional sense byte shall specify the byte number, relative to the first byte of sense data of the beginning of the destination logical unit's status byte and sense data. A zero value indicates that no status byte or sense data is being returned for the destination logical unit. The first byte of the area pointed to by the second additional sense byte shall contain the status byte from the destination logical unit. The subsequent bytes shall contain, unchanged, the sense data recovered from the destination logical unit.

7.1.4.3 COPY Function Code 00H and 01H

The format for the segment descriptors for COPY transfers between direct-access and sequential-access devices is specified in Table 7-20. This format is required for COPY function codes 00H or 01H. The segment descriptor may be repeated up to 256 times within the Parameter List Length specified in the command descriptor block.

TABLE 7-20. SEGMENT DESCRIPTOR FOR COPY FUNCTION CODES 00H AND 01H

BIT / BYTE	7	6	5	4	3	2	1	0
0	Source Address			0	0	Source LUN		
1	Destination Address			0	0	Destination LUN		
2	Sequential-Access Device Block-Length (MSB)							
3	Sequential-Access Device Block-Length (LSB)							
4	Direct-Access Device Number of Blocks (MSB)							
5	Direct-Access Device Number of Blocks							
6	Direct-Access Device Number of Blocks							
7	Direct-Access Device Number of Blocks (LSB)							
8	Direct-Access Device Logical Block Address (MSB)							
9	Direct-Access Device Logical Block Address							
10	Direct-Access Device Logical Block Address							
11	Direct-Access Device Logical Block Address (LSB)							

Source Address and Destination Address fields specify the SCSI devices and the Source LUN and Destination LUN fields specify the logical units to use for this segment of the COPY command. Some SCSI devices may not support "third-party" COPY in which the copying SCSI device is not the source or destination device. Some SCSI devices only support COPY within the SCSI device and not to other SCSI devices. If an unsupported COPY operation is requested, the command shall be terminated with a CHECK CONDITION status and the Sense Key shall be set to ILLEGAL REQUEST.

The Sequential-Access Device Block-Length field specifies the block-length to be used on the sequential-access logical unit during this segment of the COPY command. If this block-length is known by the SCSI device managing the COPY to be not supported, the command shall be terminated with a CHECK CONDITION status and the Sense Key shall be set to ILLEGAL REQUEST. If the block-length is found to be invalid while executing a read or write operation to the sequential-access device, the command shall be terminated with a CHECK CONDITION status and the Sense Key shall be set to COPY ABORTED.

The Direct-Access Device Number of Blocks field specifies the number of blocks in the current segment. A value of zero indicates that no blocks shall be transferred in this segment. The Direct-Access Device Logical Block Address specifies the starting logical block address on the logical unit for this segment.

7.1.4.4 COPY Function Code 02H

The format for the segment descriptors for COPY transfers among direct-access devices is specified by Table 7-21. This format is required for COPY function code 02H. The segment descriptor may be repeated up to 256 times within the parameter list length specified in the command descriptor block.

TABLE 7-21. SEGMENT DESCRIPTOR FOR COPY FUNCTION CODE 02H

BIT / BYTE	7	6	5	4	3	2	1	0
0	Source Address			0	0	Source LUN		
1	Destination Address			0	0	Destination LUN		
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	Source Number of Blocks (MSB)							
5	Source Number of Blocks							
6	Source Number of Blocks							
7	Source Number of Blocks (LSB)							
8	Source Logical Block Address (MSB)							
9	Source Logical Block Address							
10	Source Logical Block Address							
11	Source Logical Block Address (LSB)							
12	Destination Logical Block Address (MSB)							
13	Destination Logical Block Address							
14	Destination Logical Block Address							
15	Destination Logical Block Address (LSB)							

The Source Address and Destination Address fields specify the SCSI devices and the Source LUN and Destination LUN specify the logical units to use for this segment of the COPY command. Some SCSI devices may not support "third-party" COPY in which the copying SCSI device is not the source or destination device. Some SCSI devices only support COPY within the SCSI device and not to other SCSI devices. If an unsupported COPY operation is requested, the command shall be terminated with a CHECK CONDITION status and the sense key shall be set to ILLEGAL REQUEST.

The Source Number of Blocks field specifies the number of blocks to be transferred from the source device during command execution. The Source Logical Block Address field specifies the starting logical block address on the source device. The Destination Logical Block Address field specifies the starting logical block address on the destination device.

7.1.4.5 COPY Function Code 03H

The format for the segment descriptors for COPY transfers among sequential-access devices is specified by Table 7-22. This format is required for COPY function code 03H. The segment descriptor may be repeated up to 256 times within the parameter list length specified in the command descriptor block.

TABLE 7-22. SEGMENT DESCRIPTOR FOR COPY FUNCTION CODE 03H

BIT / BYTE	7	6	5	4	3	2	1	0
0	Source Address			0	0	Source LUN		
1	Destination Address			0	0	Destination LUN		
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	Source Block Length (MSB)							
5	Source Block Length (LSB)							
6	Destination Block Length (MSB)							
7	Destination Block Length (LSB)							
8	Source Number of Blocks (MSB)							
9	Source Number of Blocks							
10	Source Number of Blocks							
11	Source Number of Blocks (LSB)							

Source Address and Destination Address fields specify the SCSI devices and the Source LUN and Destination LUN fields specify the logical units to use for this segment of the COPY command. Some SCSI devices may not support "third-party" COPY in which the copying SCSI device is not the source or destination device. Some SCSI devices only support COPY within the SCSI device and not to other SCSI devices. If an unsupported COPY operation is requested, the command shall be terminated with a CHECK CONDITION status and the sense key shall be set to ILLEGAL REQUEST.

The Source Block-Length field specifies the block-length of the source device for this segment of the COPY. A zero in this field indicates variable block-length. For nonzero values, this field shall match the logical unit's actual block-length. If block-length mismatches are detected by the SCSI device managing the COPY, the command shall be terminated with a CHECK CONDITION status and the sense key shall be set to ILLEGAL REQUEST. If the mismatches are detected during the read operation by the COPY manager, the command shall be terminated with a CHECK CONDITION status and the Sense Key shall be set to COPY ABORTED.

The Destination Block-Length field specifies the block-length to be used on the destination logical unit during the COPY. Destination block-length mismatches are handled in the same manner as source block-length mismatches.

The Source Number of Blocks field specifies the number of blocks to be transferred from the source device during this segment. A value of zero indicates that no blocks shall be transferred.

7.1.5 RECEIVE DIAGNOSTIC RESULTS Command (1CH)

Peripheral Device Type: All
Operation Code Type: Optional

TABLE 7-23. RECEIVE DIAGNOSTIC RESULTS COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	1	1	1	0	0
1	Logical Unit Number			0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	Allocation Length (MSB)							
4	Allocation Length (LSB)							
5	0	0	0	0	0	0	Flag	Link

The RECEIVE DIAGNOSTIC RESULTS command (Table 7-23) requests analysis data be sent to the initiator after completion of a SEND DIAGNOSTIC command (see 7.1.6).

The Allocation Length shall specify the number of bytes that the initiator has allocated for returned diagnostic data. An Allocation Length of zero indicates that no diagnostic data shall be transferred. Any other value indicates the maximum number of bytes that shall be transferred. The target terminates the DATA IN phase when allocation length bytes have been transferred or when all available diagnostic data have been transferred to the initiator, whichever is less.

- The diagnostic data returned is vendor unique. CDC products will return bytes as defined in Table 7-24.

TABLE 7-24. CDC DIAGNOSTIC DATA BYTES

BYTE	DESCRIPTION
0	Additional Length (MSB)
1	Additional Length (LSB)
2	FRU Code (most probable)
3	FRU Code
4	FRU Code
5	FRU Code (least probable)
6	Error Code (MSB)
7	Error Code (LSB)
-	Optional product
n	unique bytes

Additional Length: This two byte value indicates the number of additional bytes included in the diagnostic data list. For example, if no product unique bytes were available, this value would be 0006H. A value of 0000H means that there are no additional bytes.

FRU Code: A Field Replacable Unit code is a byte that identifies an assembly that may have failed. The codes will be listed in probability order, with the most probable assembly listed first and the least probable listed last. A code of 00H indicates that there is no FRU information and a code of 01H indicates that the entire unit should be replaced. Other values have product unique meanings.

Error Code: This two byte value provides information about what part of a diagnostic operation has failed.

7.1.6 SEND DIAGNOSTIC Command (1DH)

Peripheral Device Type: All
Operation Code Type: Mandatory

TABLE 7-25. SEND DIAGNOSTIC COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	1	1	1	0	1
1	Logical Unit Number			0	0	SelfTst	DevOfL	UnitOfL
2	0	0	0	0	0	0	0	0
3	Parameter List Length (MSB)							
4	Parameter List Length (LSB)							
5	0	0	0	0	0	0	Flag	Link

The SEND DIAGNOSTIC command (Table 7-25) requests the target to perform diagnostic tests on itself, on the attached peripheral devices, or on both. CDC products shall support use of the SelfTs bit. Other SEND DIAGNOSTIC command features are optional.

The Parameter List Length specifies the length in bytes of the parameter list that shall be transferred during the DATA OUT phase. A Parameter List Length of zero indicates that no data shall be transferred. This condition shall not be considered as an error. The parameter list is vendor unique and reserved for future standardization by CDC.

A logical Unit Off-Line (UnitOfL) bit of one enables write operations on user medium or operations that affect user visible medium positioning. An SCSI Device Off-Line (DevOfL) bit of one enables diagnostic operations that may adversely affect operations to other logical units on the same target.

The Logical Unit Off-Line and SCSI Device Off-Line bits are generally set by operating system software, while the parameter list is prepared by diagnostic application software. Thus, by preventing operations that are not enabled by these bits, the target assists the operating system in protecting its resources.

A Self Test bit of one directs the target to complete its default self test. If the self test is requested, the parameter list length shall be set to zero and no data shall be transferred. If the self test successfully passes, the command shall be terminated with a GOOD status; otherwise, the command shall be terminated with a CHECK CONDITION status and, if extended sense is implemented, the Sense Key shall be set to HARDWARE ERROR.

7.2 Group 1 Commands for All Device Types

These commands shall be as listed in Table 7-26.

TABLE 7-26. GROUP 1 COMMANDS FOR ALL DEVICE TYPES

OPERATION CODE	TYPE	COMMAND NAME	SECTION
20H	R		
21H	R		
22H	R		
23H	R		
24H	R		
25H	*		
26H	R		
27H	R		
28H	*		
29H	R		
2AH	*		
2BH	R		
2CH	R		
2DH	R		
2EH	*		
2FH	*		
30H	*		
31H	*		
32H	*		
33H	*		
34H	R		
35H	R		
36H	R		
37H	R		
38H	R		
39H	O	COMPARE	7.2.1
3AH	O	COPY AND VERIFY	7.2.2
3BH	M	WRITE DATA BUFFER	7.2.3
3CH	M	READ DATA BUFFER	7.2.4
3DH	R		
3EH	R		
3FH	R		

Key: (Type definitions are defined in 6.1.2)
O = Command implementation is optional.
R = Operation code is reserved for future standardization.
* = These operation codes may have different meanings for spec types of peripheral devices. (See the appropriate section fo further information.)

7.2.1 COMPARE command (39H)

■ CDC products do not implement this command at this time.

7.2.2 COPY AND VERIFY command (3AH)

■ CDC products do not implement this command at this time.

■■ 7.2.3 WRITE DATA BUFFER Command (3BH)

Peripheral Device Type: All
Operation Code Type: Mandatory

TABLE 7-27. WRITE DATA BUFFER COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	1	1	1	0	1	1
1	Logical Unit Number				0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	Byte Transfer Length (MSB)							
8	Byte Transfer Length (LSB)							
9	0	0	0	0	0	0	Flag	link

The WRITE DATA BUFFER Command is used in conjunction with the READ BUFFER command as a diagnostic function for testing the target's data buffer memory and the SCSI bus integrity. The medium shall not be accessed during the execution of this command.

The Byte Transfer Length includes a four byte header and the WRITE DATA BUFFER data. Up to 65,535 bytes may be transferred, consisting of four bytes of header and up to 65,531 bytes of data. A transfer length of zero indicates that no data transfer shall take place. This condition shall not create the CHECK CONDITION status. If the transfer length is greater than the Available Length reported by the READ DATA BUFFER header, the target shall create the CHECK CONDITION status with the Sense Key of ILLEGAL REQUEST. In this case no data shall be transferred from the initiator.

It shall not be considered an error to request a transfer length less than the Available Length.

TABLE 7-28 WRITE DATA BUFFER HEADER

BIT / BYTE	7	6	5	4	3	2	1	0
0	Reserved							
1	Reserved							
2	Reserved							
3	Reserved							
4-n	Buffer Data Bytes							

CONDITION	SENSE KEY
Transfer length greater than buffer size.	ILLEGAL REQUEST
Target reset or medium change since last command from this initiator.	UNIT ATTENTION

7.2.4 READ DATA BUFFER Command (3CH)

Peripheral Device Type: All
Operation Code Type: Mandatory

TABLE 7-29. READ DATA BUFFER COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	0	0
1	Logical Unit Number				0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	Allocation Length (MSB)							
8	Allocation Length (LSB)							
9	0	0	0	0	0	0	Flag	Link

The READ DATA BUFFER Command is used in conjunction with the WRITE DATA BUFFER command as a diagnostic function for testing the target's data buffer memory and the SCSI bus integrity. The medium shall not be accessed during the execution of this command.

The Allocation Length specifies the number of bytes that the initiator has allocated for returned READ DATA BUFFER data. An Allocation Length of zero indicates that no READ DATA BUFFER data shall be transferred. This condition shall not create the Check Condition status. Any other value indicates the maximum number of bytes to be transferred. This data is to be used by the initiator for comparison with the data pattern sent during the WRITE DATA BUFFER command. Up to 65,535 bytes may be requested to be transferred, consisting of four bytes of header and up to 65,531 bytes of data.

If the Allocation Length is greater than the Available Length (from READ DATA BUFFER Header), only the Available Length shall be transferred to the initiator.. It shall not be considered an error to request an Allocation Length less than the Available Length.

The target shall terminate the DATA IN phase when allocation length bytes have been transferred or when all available READ DATA BUFFER data have been transferred to the initiator, whichever is less.

The READ DATA BUFFER contains a four byte header, followed by the READ DATA BUFFER data.

TABLE 7-30. READ DATA BUFFER HEADER

BIT / BYTE	7	6	5	4	3	2	1	0
0	Reserved							
1	Reserved							
2	Available Length (MSB)							
3	Available Length (LSB)							
4-n	Buffer Data Bytes							

Some targets may optionally try to detect whether buffer data is changed between a WRITE DATA BUFFER and a READ DATA BUFFER command. If that target detects that buffer data was changed, the target shall create CHECK CONDITION status with a Sense Key of Miscompare. In this case no data shall be transferred to the initiator.

To avoid corruption of data, it is recommended that the initiator do one of the following:

1. issue the RESERVE UNIT command prior to the WRITE DATA BUFFER command and issue RELEASE UNIT command after the READ DATA BUFFER command.

2. select without allowing disconnection and link the WRITE DATA BUFFER and READ DATA BUFFER commands together.

The Available Length of data bytes returned by the target may be up to 65,531 bytes (64k bytes minus 4 byte header) or the target maximum buffer size, whichever is less. CDC products shall support an Available Length of one logical block or larger. If the Allocation Length of CDB is too small to transfer all of the Available Length, the Available Length shall not be adjusted to reflect the trunctation.

7.3 Group 2 Commands for All Device Types

The Group 2 commands (operation codes 40H through 5FH) are all reserved for future standardization.

7.4 Group 3 Commands for All Device Types

The Group 3 commands (operation codes 60H through 7FH) are all reserved for future standardization.

7.5 Group 4 Commands for All Device Types

The Group 4 commands (operation codes 80H through 9FH) are all reserved for future standardization.

7.6 Group 5 Commands for All Device Types

The Group 5 commands with operation codes A0H through BFH are reserved for future standardization.

7.7 Group 6 Commands for All Device Types

The Group 6 commands (operation codes C0H through DFH) are all reserve for proprietary CDC manufacturing usage. Customers should not attempt use these functions.

7.8 Group 7 Commands for All Device Types

The Group 7 commands (operation codes E0H through FFH) are all CDC reserved.

8.0 COMMAND DESCRIPTIONS FOR DIRECT-ACCESS DEVICES

8.1 Group 0 Commands for Direct-Access Devices

The Group 0 commands for direct-access devices shall be as shown in Table 8-1.

TABLE 8-1. GROUP 0 COMMANDS FOR DIRECT-ACCESS DEVICES

OPERATION CODE	TYPE	COMMAND NAME	SECTION
00H	M	TEST UNIT READY	7.1.1
01H	M	REZERO UNIT	8.1.1
02H	R		
03H	M	REQUEST SENSE	7.1.2
04H	M	FORMAT UNIT	8.1.2
05H	R		
06H	R		
07H	M	REASSIGN BLOCKS	8.1.3
08H	M	READ	8.1.4
09H	R		
0AH	M	WRITE	8.1.5
0BH	M	SEEK	8.1.6
0CH	R		
0DH	R		
0EH	R		
0FH	R		
10H	R		
11H	R		
12H	M	INQUIRY	7.1.3
13H	R		
14H	R		
15H	M	MODE SELECT	8.1.7
16H	M	RESERVE	8.1.8
17H	M	RELEASE	8.1.9
18H	O	COPY	7.1.4
19H	R		
1AH	M	MODE SENSE	8.1.10
1BH	O	START/STOP UNIT	8.1.11
1CH	O	RECEIVE DIAGNOSTIC RESULTS	7.1.5
1DH	M	SEND DIAGNOSTIC	7.1.6
1EH	O	PREVENT/ALLOW MEDIUM REMOVAL	8.1.12
1FH	R		

Key: (Type definitions are defined in 6.1.2)
M = Command implementation is mandatory.
O = Command implementation is optional.
R = Operation code is reserved for future standardization.

8.1.1 REZERO UNIT Command (01H)

Peripheral Device Type: Direct Access
Operation Code Type: Mandatory

TABLE 8-2. REZERO UNIT COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	1
1	Logical Unit Number			0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	Flag	Link

The REZERO UNIT command (Table 8-2) requests that the target set the logical unit to logical block address zero.

8.1.2 FORMAT UNIT Command (04H)

Peripheral Device Type: Direct Access
Operation Code Type: Mandatory

TABLE 8-3. FORMAT UNIT COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	0	0	1	0	0
1	Logical Unit Number			FmtData	CmpLst	Defect List Format		
2	0	0	0	0	0	0	0	0
3	Interleave (MSB)							
4	Interleave (LSB)							
5	0	0	0	0	0	0	0	0

The FORMAT UNIT command (Table 8-3) ensures that the medium is formatted so that all of the user addressable data blocks can be accessed. There is no guarantee that the medium has or has not been altered. In addition, the medium may be certified and control structures be created for the management of the medium and defects.

The FORMAT UNIT command shall be rejected with RESERVATION CONFLICT status if any extent (see 8.1.8.2) in the specified logical unit is reserved.

A Format Data (FmtData) bit of one indicates that format data is supplied during the DATA OUT phase. The defect list included with this data specifies the defects that shall be entered into the defect map. The format of the defect list is determined by Defect List Format field. A FmtData bit of zero indicates that the DATA OUT phase shall not occur (no defect data shall be supplied by the initiator).

A Complete List (CmpLst) bit of one indicates the data supplied is to be the complete list of Growth defects. Any previous Growth or Certification defect data shall be erased. The target may add to this list as it formats the medium. The result is to purge any previous Growth or Certification defect list and to build a new defect list. A CmpLst bit of zero indicates that the data supplied is in addition to existing Growth defect list.

The use of the P and C defect lists is controlled by byte 1 of the defect list header (See figure 8-5).

The Defect List Format field specifies additional information related to the defect list. (See Table 8-4 for further information.)

The Interleave field requests that the logical blocks be related in a specific fashion to the physical blocks to facilitate speed matching. An interleave value of zero requests that the target use its default interleave. An interleave value of one requests that consecutive logical blocks be placed in consecutive physical order. Values of two or greater indicate that one or more (respectively) physical blocks separate consecutive logical blocks.

The definitions listed below are needed to help in understanding the alternatives listed in Table 8-4.

P = Primary Defect List: The list of defects supplied by the original manufacturer of the disk (and stored within the peripheral).

C = Certification Defect List: The defects that are found by the target controller during a FORMAT UNIT command.

G = Growth Defect List: The defects detected after the disk has been used to store and retrieve data. These include defects automatically reallocated by the target, by a REASSIGN BLOCKS command, or by a Data Defect List of a previous FORMAT UNIT command.

D = Data Defect List: This list is supplied to the target by the initiator in the Data Out phase of a FORMAT UNIT command.

TABLE 8-4. FORMAT UNIT COMMAND VARIATIONS

BIT REFERENCE 4 Fmt Data	3 Cmp List	2 Defect Format	1 Defect Format	0 List Format	COMMAND TYPE	COMMENTS
0	X	X	X	X	Mandatory P+C	No Data Out phase (no defect list header, no defect descriptors). CDC products will use P and C defect types.
1	0	0	X	X	Mandatory with G	Defect List Length must be zero but four byte header is sent. See Note 1.
1	1	0	X	X	Mandatory erase G	
1	0	0	X	X	Not Supported	Non-zero Defect List Length is unsupported by CDC products.
1	1	0	X	X	Not Supported	
1	0	1	0	0	Optional G + D	Defect Descriptors in Bytes From Index Format (see Table 8-6). Defect List Length must be a multiple of 8. See Note 1.
1	1	1	0	0	Optional D	
1	0	1	0	1	Optional G + D	Defect Descriptors in Physical Sector Format (see Table 8-7). Defect List Length must be a multiple of 8. See Note 1.
1	1	1	0	1	Optional D	
1	0	1	1	0	Optional G + D	Defect Descriptors in Product Unique Format. See product specification. See Note 1.
1	1	1	1	0	Optional D	
1	X	1	1	1	Reserved	

X = Bit ignored by target. Recommend that the initiator send a zero.

NOTE 1: Byte 1 of the Defect List Header determines if the P and C defects are used or ignored.

NOTE 2: Each CDC product is required to support one of the three Defect List Format codes (Bytes From Index, Physical Sector, Vendor Unique) listed as optional in this Table.

The defect lists shown in Tables 8-6 and 8-7 contain a four-byte header followed by one or more defect descriptors. The length of the Defect Descriptors vary with the format of the defect list.

The Defect List Length in each table specifies the total length in bytes of the defect descriptors that follow. In Tables 8-6 and 8-7 the Defect List Length is equal to eight times the number of defect descriptors.

TABLE 8-5. DEFECT LIST HEADER (All List Types)

BIT / BYTE	7	6	5	4	3	2	1	0
Defect List Header								
0	Reserved							
1	FOV	DPRY	DCRT	STPF	Reserved			
2	Defect List Length (MSB)							
3	Defect List Length (LSB)							
Defect Descriptor(s)								
0-n	Defect Descriptor Bytes							

The Format Options Valid (FOV) bit, when set to one, enables the DPRY, DCRT, and STPF bits. The other bits are ignored when this bit is a zero. The CDC default when the FOV bit is zero is:

- DPRY bit equal to zero,
- DCRT bit equal to zero,
- STPF bit equal to zero.

The Disable Primary List (DPRY) bit, when set to one, asks that the flaws from the Primary defect list not be deallocated during formatting. When set to zero, the flaws from the Primary Defect List shall be deallocated during formatting. The Disable Certification (DCRT) bit, when set to one, asks that certification not be performed during formatting. When set to zero, certification is allowed during formatting. The Stop Format (STPF) bit, when set to one, requests that formatting be terminated if an error is encountered in accessing a defect list or if the target runs out of spare locations for defects. The target shall create Check Condition status with Medium Error Sense Key. When set to zero, formatting shall continue if an error in accessing a defect list is encountered or if the target runs out of spare locations for defects. After completion of formatting, the target shall create Check Condition status with Recovered Error Sense Key.

Support for FOV, DPRY and STPF bit functions is mandatory for CDC products. Support of the DCRT bit is required only if the product does certification during format.

TABLE 8-6. DEFECT LIST - BYTES FROM INDEX FORMAT

BIT / BYTE	7	6	5	4	3	2	1	0
	Defect List Header							
0	Reserved							
■ 1	FOV	DPRY	DCRT	STPF	Reserved			
2	Defect List Length (MSB)							
3	Defect List Length (LSB)							
	Defect Descriptor(s)							
0	Cylinder Number of Defect (MSB)							
1	Cylinder Number of Defect							
2	Cylinder Number of Defect (LSB)							
3	Head Number of Defect							
4	Defect Bytes from Index (MSB)							
5	Defect Bytes from Index							
6	Defect Bytes from Index							
7	Defect Bytes from Index (LSB)							

■ Byte 1 of header is described in Table 8-5. The Defect List Format
■ field must be 100 (binary) for this description to apply.

Each Defect Descriptor for the bytes from index format specifies the beginning of an eight-byte defect location on the medium. Each defect descriptor is comprised of the Cylinder Number of Defects, the Head Number of Defect, and the Defect Bytes from Index.

The Defect Descriptors shall be in ascending order. For determining ascending order, the Cylinder Number of Defect is considered the most sigificant part if the address and the Defect Bytes from Index is considered the least significant part of the address.

■ A value for Defect Bytes From Index of FFFFFFFFH is illegal for CDC products.

TABLE 8-7 DEFECT LIST - PHYSICAL SECTOR FORMAT

BIT / BYTE	7	6	5	4	3	2	1	0
	Defect List Header							
0	Reserved							
1	FOV	DPRY	DCRT	STPF	Reserved			
2	Defect List Length (MSB)							
3	Defect List Length (LSB)							
	Defect Descriptor(s)							
0	Cylinder Number of Defect (MSB)							
1	Cylinder Number of Defect							
2	Cylinder Number of Defect (LSB)							
3	Head Number of Defect							
4	Defect Sector Number (MSB)							
5	Defect Sector Number							
6	Defect Sector Number							
7	Defect Sector Number (LSB)							

■ Byte 1 of header is described in Table 8-5. The Defect List Format
■ field must be 101 (binary) for this description to apply.

Each Defect Descriptor for the physical sector format specifies a sector size defect location comprised of the Cylinder Number of Defect , the Head Number of Defect, and the Defect Sector Number. The Defect Descriptors shall be in ascending order. For determining ascending order, the Cylinder Number of defect is considered the most significant part of the address and the Defect Sector Number is considered the least significant part of the address.

■ A Defect Sector Number of FFFFFFFFH is illegal for CDC products.

8.1.3 REASSIGN BLOCKS Command (07H)

Peripheral Device Type: Direct Access and Write-Once Read-Multiple
Operation Code Type: Mandatory

TABLE 8-9. REASSIGN BLOCKS COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	0	0	1	1	1
1	Logical Unit Number			0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	Flag	Link

The REASSIGN BLOCKS command (Table 8-9) requests the target to reassign the defective logical blocks to an area on the logical unit reserved for this purpose.

The initiator transfers a defect list that contains the logical block addresses to be reassigned. The target shall reassign the physical medium used for each logical block address in the list. The data contained in the logical blocks specified in the defect list may or may not be preserved, but the data in all other logical blocks on the medium shall be preserved. It is recommended that the initiator recover the data from the logical block(s) to be reassigned before issuing this command. After completion of this command, the initiator can write the recovered data to the same Logical Block Address(es).

The effect of specifying a logical block to be reassigned that previously has been reassigned is to reassign the block again. Thus, over the life of the medium, a logical block can be assigned to multiple physical addresses (until no more spare locations remain on the medium).

The REASSIGN BLOCKS defect list (Table 8-10) contains a four-byte header followed by one or more Defect Descriptors. The length of each Defect Descriptor is four bytes.

The Defect List Length specifies the total length in bytes of the Defect Descriptors that follow. The Defect List Length is equal to four times the number of Defect Descriptors.

TABLE 8-10. REASSIGN BLOCKS DEFECT LIST

BYTE	DEFECT LIST HEADER
0	Reserved
1	Reserved
2	Defect List Length (MSB)
3	Defect List Length (LSB)
	Defect Descriptor(s)
0	Defect Logical Block Address (MSB)
1	Defect Logical Block Address
2	Defect Logical Block Address
3	Defect Logical Block Address (LSB)

The Defect Descriptor specifies a four-byte Defect Logical Block Address that contains the defect. The Defect Descriptors shall be in ascending order.

If the logical unit has insufficient capacity to reassign all of the defective logical blocks, the command shall terminate with a CHECK CONDITION status and the sense key shall be set to MEDIUM ERROR. The logical block address of the first logical block not reassigned shall be returned in the information bytes of the sense data.

8.1.4 READ Command (08H)

Peripheral Device Type: Direct Access
Operation Code Type: Mandatory

TABLE 8-11. READ COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0
1	Logical Unit Number			Logical Block Address (MSB)				
2	Logical Block Address							
3	Logical Block Address (LSB)							
4	Transfer Length							
5	0	0	0	0	0	0	Flag	Link

The READ command (Table 8-11) requests that the target transfer data to the initiator.

The Logical Block Address specifies the logical block at which the read operation shall begin.

The Transfer Length specifies the number of contiguous logical blocks of data to transferred. A Transfer Length of zero indicates that 256 logical blocks shall be transferred. Any other value indicates the number of logical blocks that shall be transferred.

The most recent data value written in the addressed logical block shall be returned.

This command shall be terminated with a RESERVATION CONFLICT status if any reservation access conflict (see 8.1.8) exists and no data shall be read.

If any of the following conditions occur, this command shall be terminated with a CHECK CONDITION status, and if extended sense is implemented, the Sense Key shall be set as indicated in the following table. This table does not provide an exhaustive enumeration of all conditions that may cause the CHECK CONDITION status.

CONDITION	SENSE KEY
Invalid Logical Block Address	ILLEGAL REQUEST (see note)
Target reset or medium change since last command from this initiator	UNIT ATTENTION
Unrecoverable read error	MEDIUM ERROR
Recovered read error	RECOVERED ERROR
Overrun or other error that might be resolved by repeating the command	ABORTED COMMAND

NOTE: The extended sense Information Bytes shall be set to the Logical Block Address of the first invalid address.

8.1.5 WRITE Command (0AH)

Peripheral Device Type: Direct Access
Operation Code Type: Mandatory

TABLE 8-12. WRITE COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	0
1	Logical Unit Number			Logical Block Address (MSB)				
2	Logical Block Address							
3	Logical Block Address (LSB)							
4	Transfer Length							
5	0	0	0	0	0	0	Flag	Link

The WRITE command (Table 8-12) requests that the target write the data transferred by the initiator to the medium.

The Logical Block Address specifies the logical block at which the write operation shall begin.

The Transfer Length specifies the number of contiguous logical blocks of data to transferred. A Transfer Length of zero indicates that 256 logical blocks shall be transferred. Any other value indicates the number of logical blocks that shall be transferred.

This command shall be terminated with a RESERVATION CONFLICT status if any reservation access conflict (see 8.1.8) exists and no data shall be written.

If any of the following conditions occur, this command shall be terminated with a CHECK CONDITION status, and if extended sense is implemented, the Sense Key shall be set as indicated in the following table. This table does not provide an exhaustive enumeration of all conditions that may cause the CHECK CONDITION status.

CONDITION	SENSE KEY
Invalid Logical Block Address	ILLEGAL REQUEST (see note)
Target reset or medium change since last command from this initiator	UNIT ATTENTION
Overrun or other error that might be resolved by repeating the command	ABORTED COMMAND

NOTE: The extended sense Information Bytes shall be set to the Logical Block Address of the first invalid address. In this case, no data shall be written on the logical unit.

8.1.6 SEEK Command (0BH)

Peripheral Device Type: Direct Access, Write-Once Read-Multiple, and Read-Only Direct Access

Operation Code Type: Mandatory

TABLE 8-13. SEEK COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	1
1	Logical Unit Number			Logical Block Address (MSB)				
2	Logical Block Address							
3	Logical Block Address (LSB)							
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	Flag	Link

The SEEK command (Table 8-13) requests that the logical unit seek to the specified Logical Block Address.

8.1.7 MODE SELECT Command (15H)

Peripheral Device Type: Direct Access
Operation Code Type: Mandatory

TABLE 8-14. MODE SELECT COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	1	0	1	0	1
1	Logical Unit Number			0	0	0	0	SMP
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	Parameter List Length							
5	0	0	0	0	0	0	Flag	Link

The MODE SELECT command (Table 8-14) provides a means for the initiator to specify medium, logical unit, or peripheral device parameters to the target.

The Save Mode Parameters (SMP) bit, when set to one, requests that the target save the saveable pages. Pages 3 and 4 may only be stored during FORMAT commands, so they cannot be saved via a MODE SELECT command. The target must update the Current mode values with parameters included with this command, save the Current values of the saveable parameters, and report GOOD status only after the save operation is completed. The Saved parameters shall not be changed if an error is detected during the MODE SELECT command. When the SMP bit is set to zero, the Saved parameter values will not be changed.

Support for Saved parameters is optional for CDC products. If the SMP bit is set and Saved parameters are not supported, the target shall return CHECK CONDITION status with ILLEGAL REQUEST Sense Key.

The Parameter List Length specifies the length in bytes of the MODE SELECT parameter list that shall be transferred during the DATA OUT phase. A Parameter List Length of zero indicates that no data shall be transferred. This condition shall not be considered as an error.

The MODE SELECT parameter list (Table 8-15) contains a four-byte header, followed by zero or one block descriptor, followed by the pages of MODE SELECT parameters.

TABLE 8-15. MODE SELECT PARAMETER LIST

BIT / BYTE	7	6	5	4	3	2	1	0
0	Reserved (all zeros)							
1	Medium Type							
2	Reserved (all zeros)							
3	Block Descriptor Length							
Block Descriptor(s)								
0	Density Code							
1	Number of Blocks (MSB)							
2	Number of Blocks							
3	Number of Blocks (LSB)							
4	Reserved (all zeros)							
5	Block Length (MSB)							
6	Block Length							
7	Block Length (LSB)							
Parameter Information								
0-n	Mode Select Page Headers and their parameters							

All CDC hard magnetic disk and optical disk products shall only support 00H in the Medium Type field.

The Block Descriptor Length specifies the length in bytes of the Block Descriptor. It is equal to the number of bytes in the Block Descriptor (either 0 or 8) and does not include the page headers and mode parameters, if any. A Block Descriptor Length of zero indicates that no block descriptor shall be included in the parameter list. This condition shall not be considered as an error. CDC products will support one Block Descriptor per LUN.

Each Block Descriptor specifies the medium characteristics for all or part of a logical unit. Each Block Descriptor contains a Density Code, a Number of Blocks, and a Block Length.

All CDC hard magnetic disk and optical disk products shall only support 00H in the Density Code field.

The Number of Blocks field specifies the number of logical blocks on the medium that meet the Density Code and Block Length in the block descriptor. A Number of Blocks of zero indicates that all of the remaining logical blocks of the logical unit shall have the medium characteristics specified by the Block Descriptor. If there is only one Block Descriptor, a Number of Blocks of zero means all logical blocks of the logical unit shall have the medium characteristics specified by the Block Descriptor.

The Block Length specifies the length in bytes of each logical block described by the Block Descriptor.

The rest of the MODE SELECT parameters are organized into pages that group the parameters by function. The parameter definitions are the same as those described in the MODE SENSE command (paragraph 8.1.10) and will not be repeated here.

TABLE 8-16 MODE SELECT PAGE DESCRIPTOR HEADER

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	Page Code					
1	Page Length							
2-n	Mode Parameters							

Each page of mode parameters begins with a two byte Page Descriptor Header. The Page Code identifies which page of mode parameters is being transferred. The Page Length indicates the number of additional bytes of mode parameters contained in this page. The number of additional bytes sent must always match the Page Length value.

If the initiator sends mode parameter bytes that are not supported by the target, the target will set CHECK CONDITION status with ILLEGAL REQUEST Sense Key. The initiator may only send mode parameters for pages if the target supports Changeable parameters within that page. The Page Length sent by the initiator must be the same as the Page Length value received from the target during a MODE SENSE command with PCF set to 01 (binary). CDC products may optionally support the following Page Codes:

Page Code	Description
00H	Product Unique. See individual product specifications.
01H	Error Recovery parameters.
02H	Disconnect/Reconnect Control parameters.
03H	Format parameters.
04H	Rigid Disk Drive Geometry Parameters.

The initiator shall issue a MODE SENSE command requesting the target to return all pages with Changeable values (see PCF field description for MODE SENSE command) prior to issuing any MODE SELECT commands. This allows the initiator to correctly determine which pages are supported, the proper length for those pages, and which parameters in those pages may be changed for that Logical Unit Number.

8.1.8 RESERVE Command (16H)

Peripheral Device Type: Direct Access, Write-Once Read-Multiple, and Read-Only Direct Access

Operation Code Type: Mandatory

TABLE 8-17. RESERVE COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	1	0	1	1	0
1	Logical Unit Number			3rdPty	Third Party Device ID			Extent
2	Reservation Identification							
3	Extent List Length (MSB)							
4	Extent List Length (LSB)							
5	0	0	0	0	0	0	Flag	Link

The RESERVE command (Table 8-17) is used to reserve logical units or, if the extent reservation option is implemented, extents within logical units for the use of the initiator. If the third party reservation option is implemented, the logical units or extents may be reserved for another specified SCSI device. The RESERVE and RELEASE commands provide the basic mechanism for contention resolution in multiple-initiator systems.

8.1.8.1 Logical Unit Reservation

If the Extent bit is zero, this command shall request that the entire logical unit be reserved for exclusive use of the initiator until the reservation is superceded by another valid RESERVE command from the initiator that made the reservation, released by a RELEASE command from the same initiator, by a BUS DEVICE RESET message from any initiator, or by a "hard" RESET condition. A logical unit reservation shall not be granted if any extent or logical unit is reserved by another initiator or if any extent with a read shared reservation type is reserved by this initiator. It shall be permissible for an initiator to reserve a logical unit that is currently reserved by that initiator. If the Extent bit is zero, the Reservation Identification and the Extent List Length shall be ignored.

If the logical unit, or any extent within the logical unit is reserved for another initiator, the target shall respond by either:

1. Returning a RESERVATION CONFLICT status.

2. Queuing the reservation request and then disconnecting until all previously queued reservations have been released and the logical unit is available, then reconnecting to perform the reservation.

If, after honoring the reservation, any other initiator then subsequently attempts to perform any command on the reserved logical unit other than a RESERVE command, which may be queued, or a RELEASE command, which shall be ignored, then the command shall be rejected with RESERVATION CONFLICT status.

8.1.8.2 Extent Reservation

CDC products will not support Extent reservations. This bit must always be zero. Since the Reservation Identification byte and the Extent List Length are only valid for extent reservations, CDC products will ignore these fields.

8.1.8.3 Third Party Reservation

All CDC products will support the third party reservation option. The third-party reservation option for the RESERVE command allows an initiator to reserve a logical unit or extents within a logical unit for another SCSI device. This option is intended for use in multiple-initiator systems that use the COPY command. Any target that implements the third-party reservation option shall also implement the third-party release option (see 8.1.9.3).

If the third-party (3rdPty) bit is zero, then the third-party reservation option is not requested. If the 3rdPty bit is one and the third-party reservation option is implemented, then the RESERVE command shall reserve the specified logical unit or extents for the SCSI device specified in the third-party device ID field. The target shall preserve the reservation until it is superceded by another valid RESERVE command from the initiator that made the reservation or until it is released by the same initiator, by a BUS DEVICE RESET message from any initiator, or a "hard" RESET condition. The target shall ignore any attempt to release the reservation made by any other initiator.

8.1.8.4 Superceding Reservations

An initiator that holds a current reservation may modify that reservation by issuing another RESERVE command to the same logical unit and, if the extent bit is one, using the same reservation identification. The superceding RESERVE command shall release the previous reservation state when the new reservation request is granted. The previous reservation shall not be modified if the new reservation request cannot be granted. If the superceding reservation cannot be granted because of conflicts with a previous active reservation (other than the reservation being superceded) then the target shall either:

(1) return RESERVATION CONFLICT status

(2) queue the reservation request and disconnect until it is allowed to be active. The reservation request shall be made active when it is free from conflict with all resrvations. A superceding reservation takes place over any previously queued reservation request.

IMPLEMENTORS NOTE: Superceding reservations are principally intended to allow the SCSI device ID to be changed on a reservation using third-party reservation option. This capability is necessary for certain situations when using the COPY command.

8.1.9 RELEASE Command (17H)

Peripheral Device Type: Direct Access, Write-Once Read-Multiple, and Read-Only Direct Access

Operation Code Type: Mandatory

TABLE 8-18. RELEASE COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	1	0	1	1	1
1	Logical Unit Number			3rdPty	Third Party Device ID			Extent
2	Reservation Identification							
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	Flag	Link

The RELEASE command (Table 8-18) is used to release previously reserved logical units, or, if the extent release option is implemented, previously reserved extents within logical units. It is not an error for an initiator to attempt to release a reservation that is not currently active. In this case, the target returns GOOD status without altering any other reservation.

8.1.9.1 Logical Unit Release

If the extent bit is zero, the RELEASE command shall cause the target to terminate all logical unit and extent reservations that are active from the initiator to the specified logical unit.

8.1.9.2 Extent Release

CDC products will not support extent reservations. This bit must always be zero. Since the Reservation Identification byte is only valid for extent reservations, CDC products will ignore this byte.

8.1.9.3 Third Party Release

All CDC products will support the third party release option. The third-party release option for the RELEASE command allows an initiator to release a logical unit or extents within a logical unit that were previously reserved using the third-party reservation option (see 8.1.8.3). This option shall be implementated if the third-party reservation option is implemented. This option is intended for use in multiple-initiator systems that use the COPY command.

If the third-party (3rdPty) bit is zero, then the third-party release option is not requested. If the 3rdPty bit is one and the target implements the third-party release option, then the target shall release the specified logical unit or extents, but only if the reservation was made using the third-party reservation option by the initiator that is requesting the release and for the same SCSI device as specified in the third-party ID field.

8.1.10 MODE SENSE Command (1AH)

Peripheral Device Type: Direct Access
Operation Code Type: Mandatory

TABLE 8-19. MODE SENSE COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	1	1	0	1	0
1	Logical Unit Number			0	0	0	0	0
2	PCF		Page Code					
3	0	0	0	0	0	0	0	0
4	Allocation Length							
5	0	0	0	0	0	0	Flag	Link

The MODE SENSE command (Table 8-19) provides a means for a target to report its medium, logical unit, or peripheral device parameters to the initiator. It is a complementary command to the MODE SELECT command for support of medium that may contain multiple block lengths or densities.

The Page Control Field (PCF) defines the type of mode parameter values to be returned. The target shall return the same Page Length for each supported page regardless of the value in the PCF. The field is defined as follows:

Bit 7	Bit 6	
0	0	Return Current values. The Current values are the values currently being used by the target to control its operation. After a Power On Reset, a hard RESET, or a BUS DEVICE RESET message the Current values will be equal to the Saved values (if Saved values are supported and can be retrieved) or the Default values (if Saved values aren't supported or cannot be retrieved). The Current value of a parameter is updated whenever a MODE Select command that changes that parameter ends with GOOD status being returned.
0	1	Return Changeable values. The changeable values of any page is a mask that indicates which parameters may be changed via a MODE SELECT command and which parameters may not. Each returned parameter byte shall contain ones where a field or bit may be changed and zeros where a field or bit may not be changed.
1	0	Return Default values. The Default values are the values a target will set the Current values to after a reset condition unless valid Saved values are available.
1	1	Return Saved values. The Saved values are the values a target stores in non-volatile memory. The Saved values of any changeable parameter can be set via a MODE SELECT command. For nonchangeable parameters, the Default value will be used. Support for Saved parameter values is optional for CDC products.

The Block Descriptor will contain its normal values regardless of the value of the PCF. Unsupported firlds or bits within a page will be returned as zeros for all PCF values.

The Page Code allows the initiator to select one or all of the pages of Mode parameters supported by the target. Page Codes which may be supported by CDC products are listed here:

Page Code	Description
00H	Product Unique. See individual product specifications.
01H	Error Recovery parameters.
02H	Disconnect/Reconnect Control parameters.
03H	Format parameters.
04H	Rigid Disk Drive Geometry parameters.
3FH	Return all supported pages.

The Allocation Length specifies the number of bytes that the initiator has allocated for returned MODE SENSE data. An Allocation Length of zero indicates that no MODE SENSE data shall be transferred. This condition shall not be considered as an error. Any other value indicates the maximum number of bytes that shall be transferred. The target shall terminate the DATA IN phase when allocation length bytes have been transferred or when all available MODE SENSE data has been transferred to the initiator, whichever is less.

The MODE SENSE data (Table 8-20) will always include a four-byte header, followed by one eight-byte block descriptor, followed by the requested page or pages of MODE SENSE parameters.

TABLE 8-20. MODE SENSE DATA

BIT / BYTE	7	6	5	4	3	2	1	0
0	Sense Data Length							
1	Medium Type							
2	WP	Reserved (all zeros)						
3	Block Descriptor Length							
	Block Descriptor(s)							
0	Density Code							
1	Number of Blocks (MSB)							
2	Number of Blocks							
3	Number of Blocks (LSB)							
4	Reserved (all zeros)							
5	Block Length (MSB)							
6	Block Length							
7	Block Length (LSB)							
	Parameter Information							
0-n	Mode Select Page Headers and their parameters							

The Sense Data Length specifies the length in bytes of the following MODE SENSE data that is available to be transferred during the DATA IN phase. The Sense Data Length does not include itself.

All CDC hard magnetic disk and optical disk products shall only support 00H in the Medium Type field.

A Write Protected (WP) bit of zero indicates that the medium is write enabled. A WP bit of one indicates that the medium is write protected.

The Block Descriptor Length specifies the length in bytes of the Block Descriptor. It is equal to the number of bytes in the Block Descriptor (8) and does not include the page headers and mode parameters, if any. CDC products will send one Block Descriptor per LUN.

Each Block Descriptor specifies the medium characteristics for all or part of a logical unit. Each Block Descriptor contains a Density Code, a Number of Blocks, and a Block Length.

All CDC hard magnetic disk and optical disk products shall only support 00H in the Density Code field.

The Number of Blocks field specifies the number of logical blocks of the medium that meets the Density Code and Block Length in the Block Descriptor. A Number of Blocks of zero indicates that all of the remaining logical blocks of the logical unit have the medium characteristics specified by the Block Descriptor.

The Block Length specifies the length in bytes of each logical block described by the Block Descriptor.

TABLE 8-21 MODE SENSE PAGE DESCRIPTOR HEADER

BIT / BYTE	7	6	5	4	3	2	1	0
0	PS	0	Page Code					
1	Page Length							
2-n	Mode Parameters							

Each page of mode parameters (for the MODE SENSE command) begins with a two byte Page Descriptor Header. The Page Code identifies which page of mode parameters is being transferred. The Page Length indicates the number of additional bytes of mode parameters being sent by this target. Multiple pages of mode parameters may be transferred in one MODE SENSE data in phase (using page code 3FH).

The Parameters Saveable (PS) bit, when set to one, indicates that the page contains Saved parameters. Since the support of Saved values is optional, refer to individual product specifications to see which parameters are saved. When the PS bit is set to zero, none of the parameters within the page are saved. Since the parameters within pages 3 and 4 will always be saved during FORMAT commands (but not via a MODE SELECT command with the SMP bit set to one), these pages will return a one for the PS bit if these pages are supported.

Since support for mode parameters is optional, some CDC products will return a Page Length that is shorter than the number of bytes defined in this specification.

TABLE 8-22 ERROR RECOVERY PAGE

BIT / BYTE	7	6	5	4	3	2	1	0
0	PS	0	0	0	0	0	0	1
1	Page Length							
2	AWRE	ARRE	TB	RC	EEC	PER	DTE	DCR
3	Retry Count							
4	Correction Span							
5-7	Reserved							

The Automatic Write Reallocation of defective data blocks Enabled (AWRE) bit, when set to one, allows the target to automatically relocate bad blocks detected during write operations. This function doesn't apply to the FORMAT UNIT command. When set to zero, the target shall not perform automatic reallocation but shall create the CHECK CONDITION Status with Sense Key of MEDIUM ERROR instead.

The Automatic Read Reallocation of defective data blocks Enabled (ARRE) bit, when set to one, allows the target to automatically relocate bad blocks detected during read operations. When set to zero, the target shall not perform automatic reallocation but shall create the CHECK CONDITION Status with Sense Key of MEDIUM ERROR instead.

The Transfer Block (TB) bit, when set to one, indicates that the failing data block shall be transferred to the initiator. When set to zero, the failing data block shall not be transferred.

The Read Continuous (RC) bit, when set to one, requests the target to transfer the requested data length without adding delays (for retries or ECC correction) that may be required to ensure data integrity. The target may send data that is erroneous in order to maintain the continuous flow of data. This bit shall override the DTE bit if it is set. When set to zero, recovery actions during data transfer are allowed.

The Enable Early Correction (EEC) bit, when set to one, allows the target to apply ECC correction as soon as possible, before the retry count is exhausted. Seek error retries are not affected by this bit. When this bit is set, the DCR bit must be zero. When the EEC bit is set to zero, the target shall exhaust the retry count before applying ECC correction.

The Post Error (PER) bit, when set to one, indicates that the target will report CHECK CONDITION status and appropriate Sense Key for any recovered errors encountered. Reporting of unrecoverable errors will have priority over Reporting of recoverable errors. When set to zero, any errors recovered within the limits established by the other Error Recovery Flags will not be reported. Any unrecoverable errors will still be reported.

The Disable Transfer on Error (DTE) bit is only valid when the PER bit is also set to one. When the DTE bit is set to one, it indicates that the target will terminate data transfer even for recoverable errors. The setting of the TB bit determines whether the block in error will be transferred. When DTE is set to zero, data transfer will continue if recoverable errors are encountered. If the PER bit is one and the DTE bit is zero, recoverable errors will be reported after all data has been transferred.

The Disable Correction (DCR) bit, when set to one, indicates that ECC correction shall not be applied to the data even if correction is possible. When set to zero, ECC correction shall be applied if correction is possible.

The Retry Count is the maximum number of times that the target should attempt its read recovery algorithm.

The Correction Span is the size of the largest read data error, in bits, on which ECC correction may be attempted. Data errors longer than this span will be reported as unrecoverable errors.

TABLE 8-23 DISCONNECT/RECONNECT CONTROL PARAMETERS

BIT / BYTE	7	6	5	4	3	2	1	0
0	PS	0	0	0	0	0	1	0
1	Page Length							
2	Buffer Full Ratio							
3	Buffer Empty Ratio							
4	Bus Inactivity Limit (MSB)							
5	Bus Inactivity Limit (LSB)							
6	Disconnect Time Limit (MSB)							
7	Disconnect Time Limit (LSB)							
8	Reserved (always zeros)							
9	Reserved (always zeros)							

Both the ratio parameters are the numerator of a fractional multiplier that has 256 as its denominator.

The Buffer Full Ratio indicates, on READ commands, how full the target's buffer shall be prior to reconnecting. Targets that include a larger granular buffer block size shall round down to the nearest whole buffer block.

The Buffer Empty Ratio indicates, on WRITE commands, how empty the target's buffer shall be prior to reconnecting to fetch more data. Targets that include a larger granular buffer block size shall round up to the nearest whole buffer block.

The Bus Inactivity Limit field (bytes 4 and 5) indicates the time, in 100 microsecond increments, that the target is allowed to assert the BUSY signal without handshakes until it shall disconnect. The target may round down to its nearest capable value. A value of zero indicates that the target is allowed to maintain the bus busy indefinitely without handshakes.

The Disconnect Time Limit field (bytes 6 and 7) indicates the minimum time, in 100 microsecond increments, that the target shall remain disconnected until it shall attempt to reconnect. The target may round down to its nearest capable value. A value of zero indicates that the target is allowed to reconnect immediately.

■■ TABLE 8-24 FORMAT PARAMETERS

BIT / BYTE	7	6	5	4	3	2	1	0
0	PS	0	0	0	0	0	1	1
1	Page Length							
2	Tracks per Zone (MSB)							
3	Tracks per Zone (LSB)							
4	Alternate Sectors per Zone (MSB)							
5	Alternate Sectors per Zone (LSB)							
6	Alternate Tracks per Zone (MSB)							
7	Alternate Tracks per Zone (LSB)							
8	Alternate Tracks per volume (MSB)							
9	Alternate Tracks per volume (LSB)							
10	Sectors per Track (MSB)							
11	Sectors per Track (LSB)							
12	Bytes per Physical Sector (MSB)							
13	Bytes per Physical Sector (LSB)							
14	Interleave (MSB)							
15	Interleave (LSB)							
16	Track Skew Factor (MSB)							
17	Track Skew Factor (LSB)							
18	Cylinder Skew Factor (MSB)							
19	Cylinder Skew Factor (LSB)							
20	SSEC	HSEC	RMB	SURF	INS	Reserved (always zero)		
21	Reserved (always zero)							
22	Reserved (always zero)							

■ This page of parameters may only be sent immediately prior to sending a FORMAT UNIT command to the target. The Current parameters for this page will be updated immediately but any changes between these Current parameters and the existing media format will not be in effect until after the FORMAT UNIT command is completed.

■ The Tracks per Zone field indicates the number of tracks that the target will allocate to each defect management zone. Spare sectors or tracks will be placed at the end of each defect management zone. A value of zero indicates that the entire unit will be taken as one defect management zone.

■ The Alternate Sectors per Zone field indicates the number of spare sectors that is to be reserved at the end of each defect management zone. A value of zero indicates that no sectors are to be reserved for defect management. This is to accommodate hosts that want to manage the defects themselves.

■ The Alternate Tracks per Zone field indicates the number of spare tracks that is to be reserved at the end of each defect management zone. A value of zero indicates that no spare tracks are to be reserved in each zone for defect management.

The Alternate Tracks per Volume field indicates the number of spare tracks that is to be reserved at the end of the logical unit. The target may use these locations for replacing defective tracks or sectors depending upon the target defect management scheme. A value of zero indicates that no spare tracks are to be reserved at the end of the unit for defect management.

The Sectors per Track field indicates the number of physical sectors that the target shall allocate per disk track. A value of zero indicates that the number of sectors per track may be variable or the target is to determine the best value.

The Bytes per Physical Sector field indicates the number of data bytes that the target shall allocate per physical sector. The target may assign multiple physical sectors to a logical block if this value is smaller than the logical block size. This value may not be larger than the logical block size.

The Interleave field is the interleave value sent to the target during the last FORMAT UNIT command. This field is only valid for MODE SENSE commands. The Target shall ignore this field during MODE SELECT commands.

The Track Skew Factor field indicates the number of physical sectors between the last logical block on one track and the first logical block on the next sequential track of the same cylinder. A value of zero indicates no skew.

The Cylinder Skew Factor field indicates the number of physical sectors between the last logical block of one cylinder and the first logical block of the next cylinder. A value of zero indicates no skew.

The Soft Sectoring (SSEC) bit, when set to one, indicates that the target shall use soft sector formatting.

The Hard Sectoring (HSEC) bit, when set to one, indicates that the target shall use hard sector formatting. The SSEC and HSEC bits cannot both be set to one in MODE SELECT commands.

The Removable Media (RMB) bit, when set to one, indicates that the logical unit contains removable media. This same bit is also returned in the INQUIRY parameters (see section 7.1.3).

The Surface Map (SURF) bit, when set to one, indicates that the target shall allocate successive logical blocks to all sectors on a surface prior to allocating logical blocks to the next surface. When SURF is set to zero, the target shall allocate successive logical blocks to all sectors within a cylinder prior to allocating logical blocks to the next cylinder.

- The Inhibit Save (INS) bit, when set to one, indicates that the target shall inhibit the saving of any parameters other than those contained in pages 3 or 4 during the next FORMAT command. The preexisting values of any saveable parameters will be maintained. When INS is set to zero, any saveable parameters shall be updated per their Current values and saved during the next FORMAT command.

TABLE 8-25 RIGID DISK DRIVE GEOMETRY PARAMETERS

BIT / BYTE	7	6	5	4	3	2	1	0
0	PS	0	0	0	0	1	0	0
1	Page Length							
2	Number or Cylinders (MSB)							
3	Number or Cylinders							
4	Number or Cylinders (LSB)							
5	Number of Heads							
6	Reserved							
7	Reserved							
8	Reserved							
9	Reserved							
10	Reserved							
11	Reserved							
12	Drive Step Rate (MSB)							
13	Drive Step Rate (LSB)							
14	Reserved							
15	Reserved							
16	Reserved							

This page of parameters may only be sent immediately prior to sending a FORMAT UNIT command to the target. The Current parameters for this page will be updated immediately but any changes between these Current parameters and the existing media format will not be in effect until after the FORMAT UNIT command is completed.

The Number of Cylinders field indicates the maximum number of cylinders that is to be formatted by the target. The target may use some of the allowed cylinders for storing target parameters, defect lists, or diagnostic purposes.

The Number of Heads field indicates the maximum number of heads that is to be formatted by the target.

The Drive Step Rate field is the minimum time, in 100 nanosecond increments, between step pulses. The target shall use the lowest step rate, greater than or equal to this number, that it is capable of implementing. A value of zero allows the drive to determine its own step rate.

For Page Code 3FH, all pages supported by the target will be returned. Some page codes may be supported for one PCF value (for example, Default) but may not be supported for another PCF VALUE (for example, Changeable). However, a Default value and a Current value is required for all supported parameters.

8.1.11 START/STOP UNIT Command (1BH)

Peripheral Device Type: Direct Access, Write-Once Read-Multiple, and Read-Only Direct Access
Operation Code Type: Optional

TABLE 8-26. START/STOP UNIT COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	1	1	0	1	1
1	Logical Unit Number			0	0	0	0	Immed
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	Start
5	0	0	0	0	0	0	Flag	Link

The START/STOP UNIT Command (Table 8-26) requests that the target enable or disable the logical unit for further operations.

An Immediate (Immed) bit of one indicates that the status shall be returned as soon as the operation is initiated. An Immed bit of zero indicates that status shall be returned after the operation is completed.

A Start bit of one requests the logical unit be made ready for use. A Start bit of zero requests that the logical unit be stopped.

8.1.12 PREVENT/ALLOW MEDIUM REMOVAL Command (1EH)

Peripheral Device Type: Direct Access, Write Once Read Multiple, and Read-Only Direct Access
Operation Code Type: Optional

TABLE 8-27. PREVENT/ALLOW MEDIUM REMOVAL COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	1	1	1	1	0
1	Logical Unit Number			0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	Prevent
5	0	0	0	0	0	0	Flag	Link

The PREVENT/ALLOW MEDIUM REMOVAL command (Table 8-27) requests that the target enable or disable the removal of the medium in the logical unit.

A Prevent bit of one shall inhibit mechanisms that normally allow removal of the medium. A Prevent bit of zero shall allow removal of the medium.

This prevention of medium removal condition shall terminate upon receipt of a PREVENT/ALLOW MEDIIM command with the Prevent bit set to zero, or by the receipt of a BUS DEVICE RESET message from any initiator or by a "hard" RESET condition.

8.2 Group 1 Commands for Direct-Access Devices

The Group 1 commands for direct-access devices shall be as shown in Table 8-28.

TABLE 8-28. GROUP 1 COMMANDS FOR DIRECT-ACCESS DEVICES

	OPERATION CODE	TYPE	COMMAND NAME	SECTION
	20H	R		
	21H	R		
	22H	R		
	23H	R		
	24H	R		
■	25H	M	READ CAPACITY	8.2.1
	26H	R		
	27H	R		
■	28H	M	READ EXTENTED	8.2.2
	29H	R		
■	2AH	M	WRITE EXTENDED	8.2.3
■	2BH	M	SEEK EXTENDED	8.2.4
	2CH	R		
	2DH	R		
	2EH	O	WRITE AND VERIFY	8.2.5
	2FH	O	VERIFY	8.2.6
■	30H	R		
■	31H	R		
■	32H	R		
■	33H	R		
	34H	R		
	35H	R		
	36H	R		
■	37H	M	READ DEFECT DATA	8.2.9
	38H	R		
■	39H	R		
■	3AH	R		
■	3BH	M	WRITE DATA BUFFER	7.2.3
■	3CH	M	READ DATA BUFFER	7.2.4
	3DH	R		
	3EH	R		
	3FH	R		

key: (Type definitions are defined in 6.1.2).
M = Command implementation is mandatory.
O = Command implementation is optional.
R = Operation code is reversed for future standardization.

8.2.1 READ CAPACITY Command (25H)

Peripheral Device Type: Direct Access, Write-Once Read-Multiple, and Read-Only Direct Access

■ Operation Code Type: Mandatory

TABLE 8-29. READ CAPACITY COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	1	0	0	1	0	1
1	Logical Unit Number			0	0	0	0	0
2	Logical Block Address (MSB)							
3	Logical Block Address							
4	Logical Block Address							
5	Logical Block Address (LSB)							
6	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	PMI
9	0	0	0	0	0	0	Flag	Link

The READ CAPACITY command (Table 8-29) provides a means for the initiator to request information regarding the capacity of the logical unit.

A Partial Medium Indicator (PMI) bit of zero indicates that the information returned in the READ CAPACITY data shall be the Logical Block Address and Block Length (in bytes) of the last logical block of the logical unit. The Logical Block Address in the Command Descriptor Block shall be to set zero for this option.

A PMI bit of one indicates that the information returned shall be the Logical Block Address and Block Length (in bytes) of the last logical block address after which a substantial delay in data transfer will be encountered. This Logical Block Address shall be greater than or equal to the Logical Block Address specified in the Command Descriptor Block.

■ Support for the PMI function is mandatory for CDC products.

The eight bytes of READ CAPACITY data shown in Table 8-30 shall be sent during the DATA IN phase of the command.

TABLE 8-30. READ CAPACITY DATA

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

8.2.2 READ EXTENDED Command (28H)

Peripheral Device Type: Direct Access
Operation Code Type: Mandatory

TABLE 8-31. READ EXTENDED COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	1	0	1	0	0	0
1	Logical Unit Number			0	0	0	0	0
2	Logical Block Address (MSB)							
3	Logical Block Address							
4	Logical Block Address							
5	Logical Block Address (LSB)							
6	0	0	0	0	0	0	0	0
7	Transfer Length (MSB)							
8	Transfer Length (LSB)							
9	0	0	0	0	0	0	Flag	Link

The READ command (Table 8-31) requests that the target transfer data to the initiator.

The Logical Block Address specifies the logical block at which the read operation shall begin.

The Transfer Length specifies the number of contiguous logical blocks of data that shall be transferred. A Transfer Length of zero indicates that no logical blocks shall be transferred. This condition shall not be considered as an error. Any other value indicates the number of logical blocks that shall be transferred.

The most recent data value written in the addressed logical block shall be returned.

This command shall be terminated with a RESERVATION CONFLICT status if any reservation access conflict (see 8.1.8) exists and no data shall be read.

If any of the following conditions occur, this command shall return a CHECK CONDITION status and the sense key shall be set as indicated in the following table. This table does not provide an exhaustive enumeration of all conditions that may cause the CHECK CONDITION status.

CONDITION	SENSE KEY
Invalid Logical Block Address	ILLEGAL REQUEST (see note)
Target reset or medium change since last command from this initiator	UNIT ATTENTION
Unrecovered read error	MEDIUM ERROR
Recoverable read error	RECOVERED ERROR
Overrun or other error that might be resolved by repeating the command	ABORTED COMMAND

NOTE: The extended sense information bytes shall be set to the Logical Block Address of the first invalid address.

8.2.3 WRITE EXTENDED Command (2AH)

Peripheral Device Type: Direct Access
Operation Code Type: Mandatory

TABLE 8-32. WRITE EXTENDED COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	1	0	1	0	1	0
1	Logical Unit Number			0	0	0	0	0
2	Logical Block Address (MSB)							
3	Logical Block Address							
4	Logical Block Address							
5	Logical Block Address (LSB)							
6	0	0	0	0	0	0	0	0
7	Transfer Length (MSB)							
8	Transfer Length (LSB)							
9	0	0	0	0	0	0	Flag	Link

The WRITE command (Table 8-32) requests that the target write the data transferred by the initiator to the medium.

The Logical Block Address specifies the logical block at which the write operation shall begin.

The Transfer Length specifies the number of contiguous logical blocks of data that shall be transferred. A Transfer Length of zero indicates that no logical blocks shall be transferred. This condition shall not be considered as an error and no data shall be written. Any other value indicates the number of logical blocks that shall be transferred.

This command shall be terminated with a RESERVATION CONFLICT status if any reservation access conflict (see 8.1.8) exists and no data shall be written.

If any of the following conditions occur, this command shall be terminated with a CHECK CONDITION status and the sense key shall be set as indicated in the following table. This table does not provide an exhaustive enumeration of all conditions that may cause the CHECK CONDITION status.

CONDITION	SENSE KEY
Invalid Logical Block Address	ILLEGAL REQUEST (see note)
Target reset or medium change since the last command from this initiator	UNIT ATTENTION
Overrun or other error that might be resolved by repeating the command	ABORTED COMMAND

NOTE: The extended sense information bytes shall be set to the Logical Block Address of the first invalid address. In this case, no data shall be written on the logical unit.

8.2.4 SEEK EXTENDED Command (2BH)

Peripheral Device Type: Direct Access, Write-Once Read-Multiple, and Read-Only Direct Access

Operation Code Type: Mandatory

TABLE 8-33. SEEK EXTENDED COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	1	0	1	0	1	1
1	Logical Unit Number			0	0	0	0	0
2	Logical Block Address (MSB)							
3	Logical Block Address							
4	Logical Block Address							
5	Logical Block Address (LSB)							
6	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	Flag	Link

The SEEK EXTENDED command (Table 8-33) requests that the logical unit seek to the specified Logical Block Address.

8.2.5 WRITE AND VERIFY Command (2EH)

Peripheral Device Type: Direct Access
Operation Code Type: Optional

TABLE 8-34. WRITE AND VERIFY COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	1	0	1	1	1	0
1	Logical Unit Number			0	0	0	BytChk	0
2	Logical Block Address (MSB)							
3	Logical Block Address							
4	Logical Block Address							
5	Logical Block Address (LSB)							
6	0	0	0	0	0	0	0	0
7	Transfer Length (MSB)							
8	Transfer Length (LSB)							
9	0	0	0	0	0	0	Flag	Link

The WRITE AND VERIFY command (Table 8-34) requests that the target write the data transferred from the initiator to the medium and then verify that the data is correctly written.

A Byte Check (BytChk) bit of zero causes the verification to be simply a medium verification (CRC, ECC, etc). A BytChk bit of one causes a byte-by-byte compare of data written on the peripheral device and the data transferred from the initiator. If the compare is unsuccessful, the command shall be terminated with a CHECK CONDITION status and the sense key shall be set to MISCOMPARE.

The Logical Block Address specifies the logical block at which the write operation shall begin.

The Transfer Length specifies the number of contiguous logical blocks of data that shall be transferred. A Transfer Length of zero indicates that no logical blocks shall be transferred. This condition shall not be considered as an error and no data shall be written. Any other value indicates the number of logical blocks that shall be transferred.

8.2.6 VERIFY Command (2FH)

Peripheral Device Type: Direct Access
Operation Code Type: Optional

TABLE 8-35. VERIFY COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	1	0	1	0	0	0
1	Logical Unit Number			0	0	0	BytChk	0
2	Logical Block Address (MSB)							
3	Logical Block Address							
4	Logical Block Address							
5	Logical Block Address (LSB)							
6	0	0	0	0	0	0	0	0
7	Verification Length (MSB)							
8	Verification Length (LSB)							
9	0	0	0	0	0	0	Flag	Link

The VERIFY command (Table 8-35) requests that the target verify the data written on the medium.

A Byte Check (BytChk) bit of zero causes the verification to be simply a medium verification (CRC, ECC, etc). A BytChk bit of one causes a byte-by-byte compare of data on the medium and the data transferred from the initiator. If the compare is unsuccessful, the command shall be terminated with a CHECK CONDITION status and the sense key shall be set to MISCOMPARE.

The Logical Block Address specifies the logical block at which the verify operation shall begin.

The Verification Length specifies the number of contiguous logical blocks of data that shall be verified. A Verification Length of zero indicates that no logical blocks shall be verified. This condition shall not be considered as an error. Any other value indicates the number of logical blocks that shall be verified.

8.2.7 SEARCH DATA Commands (30H, 31H, or 32H)

■ CDC products do not implement these commands at this time.

8.2.8 SET LIMITS Command (33H)

■ CDC products do not implement this command at this time.

8.2.9 READ DEFECT DATA Command (37H)

Peripheral Device Type: Direct Access
Operation Code Type: Mandatory

TABLE 8-36. READ DEFECT DATA COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	1	1	0	1	1	1
1	Logical Unit Number			0	0	0	0	0
2	0	0	0	P	G	Defect List Format		
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	Allocation Length (MSB)							
8	Allocation Length (LSB)							
9	0	0	0	0	0	0	Flag	Link

The READ DEFECT DATA command requests that the target transfers the medium defect data to the initiator.

The Defect List Format field indicates the defect data format preferred by the initiator. The meaning is the same as the Defect List Format field in the Format command (indicated in Table 8-4). The Defect List Format field is intended for those targets capable of returning various formats. If not, the target may return its default format and create the CHECK CONDITION status with RECOVERED ERROR Sense Key at the end of the READ DEFECT DATA data transfer.

The P and G bits indicate the defect data types preferred by the initiator. The P and G bits are defined as follows:

BIT P	BIT G	
0	0	Return Defect List Header only.
0	1	Return the Growth list and Certification list. (Optional)
1	0	Return the Primary list only.
1	1	Return all lists (Primary, Growth, and Certification).

The Allocation Length specifies the number of bytes that the initiator has allocated for the returned defect data. An Allocation Length of zero indicates that no READ DEFECT DATA shall be transferred. Any other value indicates the maximum number of bytes to be transferred. The target shall terminate the DATA IN phase when the Allocation Length bytes have been transferred or when all available defect data has been transferred to the initiator, whichever is less.

Defect List Header

BIT / BYTE	7	6	5	4	3	2	1	0
0	Reserved							
1	Reserved			P	G	Defect List Format		
2	Defect List Length (MSB)							
3	Defect List Length (LSB)							
4-n	Defect Descriptor Bytes							

The first 4 bytes returned are the Defect List Header. The P bit, G bit, and Defect List Format fields indicate the defect format that is actually returned by the target. The definitions are the same as for byte 2 of the READ DEFECT DATA Command Descriptor Block. These codes are not required to be the same as the ones sent by the initiator if the target doesn't support those options.

The Defect List Length specifies the total length in bytes of all the defect descriptors available from the target. If the Allocation Length of the CDB is too small to transfer all of the defect descriptors, the Defect List Length is not adjusted to reflect the truncation. The Defect Descriptors do not have to be in ascending order.

9.0 GROUP 0 COMMAND DESCRIPTIONS FOR SEQUENTIAL ACCESS DEVICES

The Group 0 commands for sequential-access devices shall be as shown in Table 9-1.

TABLE 9-1. GROUP 0 COMMANDS FOR SEQUENTIAL-ACCESS DEVICES

OPERATION CODE	TYPE	COMMAND NAME	SECTION
00H	M	TEST UNIT READY	7.1.1
01H	M	REWIND	9.1
02H	R		
03H	M	REQUEST SENSE	7.1.2
04H	R		
05H	M	READ BLOCK LIMITS	9.2
06H	R		
07H	R		
08H	M	READ	9.3
09H	R		
0AH	M	WRITE	9.4
0BH	O	TRACK SELECT	9.5
0CH	R		
0DH	R		
0EH	R		
0FH	O	READ REVERSE	9.6
10H	M	WRITE FILEMARKS	9.7
11H	O	SPACE	9.8
12H	M	INQUIRY	7.1.3
13H	O	VERIFY	9.9
14H	O	RECOVER BUFFERED DATA	9.10
15H	M	MODE SELECT	9.11
16H	M	RESERVE UNIT	9.12.1
17H	M	RELEASE UNIT	9.12.2
18H	M	COPY	7.1.4
19H	O	ERASE	9.13
1AH	M	MODE SENSE	9.14
1BH	O	LOAD/UNLOAD	9.15
1CH	O	RECEIVE DIAGNOSTIC RESULTS	7.1.5
1DH	M	SEND DIAGNOSTIC	7.1.6
1EH	O	PREVENT/ALLOW MEDIUM REMOVAL	9.16
1FH	R		

Key: (Type definitions are defined in 6.1.2).
M = Command implementation is mandatory.
O = Command implementation is optional.
R = Operation code is reserved for future standardization.

9.1 REWIND Command (01H)

Peripheral Device Type: Sequential Access
Operation Code Type: Mandatory

TABLE 9-2. REWIND COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	1
1	Logical Unit Number			0	0	0	0	Immed
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	Flag	Link

The REWIND command (Table 9-2) requests that the target rewind the logical unit to the beginning-of-medium or load-point.

An Immediate (Immed) bit of one indicates that status shall be returned as soon as the operation is initiated. An Immed bit of zero indicates that status shall be returned after the operation is completed.

9.2 READ BLOCK LIMITS Command (05H)

Peripheral Device Type: Sequential Access
Operation Code Type: Mandatory

TABLE 9-3. READ BLOCK LIMITS COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	0	0	1	0	1
1	Logical Unit Number			0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	Flag	Link

The READ BLOCK LIMITS command (Table 9-3) requests that the target's capability for block length limits be returned for the logical unit. The READ BLOCK LIMITS data shown in Table 9-4 shall be sent during the DATA IN phase of the command.

TABLE 9-4. READ BLOCK LIMITS DATA

BYTE	DESCRIPTION
0	Reserved (all zeros)
1	Maximum Block Length (MSB)
2	Maximum Block Length
3	Maximum Block Length (LSB)
4	Minimum Block Length (MSB)
5	Minimum Block Length (LSB)

If the Maximum Block Length equals the Minimum Block Length, fixed-length blocks of the length indicated are supported. Otherwise, variable-length blocks are supported. For variable-length blocks, if the Maximum Block Length equals zero, no upper limit is specified.

9.3 READ Command (08H)

Peripheral Device Type: Sequential Access
Operation Code Type: Mandatory

TABLE 9-5. READ COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0
1	Logical Unit Number			0	0	0	0	Fixed
2	Transfer Length (MSB)							
3	Transfer Length							
4	Transfer Length (LSB)							
5	0	0	0	0	0	0	Flag	Link

The READ command (Table 9-5) transfers one or more block(s) to the initiator beginning with the next block on the logical unit. The Fixed bit specifies both the meaning of the Transfer Length field and whether fixed-length or variable-length block(s) are to be transferred.

If the Fixed bit is zero, a single block shall be transferred with the Transfer Length specifying the maximum number of bytes the initiator has allocated for the returned data. If the actual block length is different from the specified transfer length, a CHECK CONDITION status shall be sent to the initiator and the incorrect length indicator (ILI) bit and Valid bit in extended sense shall be set to one. The Information Bytes in extended sense shall be set to the difference (residue) between the requested Transfer Length and the actual Block Length. Targets that do not support negative residues shall set the ILI bit to one and the residue to zero when the actual Block Length is larger than the Transfer Length. In any case, no more than Transfer Length bytes shall be transferred to the initiator and the medium shall be positioned after the block (end-of-medium side).

If the Fixed bit is one, the Transfer Length specifies the number of blocks to be transferred to the initiator. This form of the READ command is valid only if the logical unit is currently operating in fixed block mode. A logical unit is in fixed block mode when either of the following conditions are true:

1. The logical unit reports the same value for Minimum Block Length and Maximum Block Length in response to the READ BLOCK LIMITS command. In this case, the current Block Length is the value returned.

2. The logical unit has been instructed to use fixed-length blocks with the MODE SELECT command. In this case, the current Block Length is the Block Length defined in the MODE SELECT command.

Otherwise, the logical unit is in variable block mode. The target may implement fixed block mode, variable block mode, or both modes. If the Fixed bit does not match the current mode, or the mode indicated by the Fixed bit is not implemented, the target shall reject the command by returning a CHECK CONDITION status and by setting the sense key to ILLEGAL REQUEST.

A successful READ command with the Fixed bit equal to one shall transfer the current Block Length times the Transfer Length bytes of data to the initiator. Upon termination of the READ command, the medium shall be positioned after the last block transferred (end-of-medium side).

If the Fixed bit is one and if a block is read that is larger or smaller than the current Block Length, a CHECK CONDITION status shall be returned to the initiator. The ILI bit and the Valid bit in extended sense shall be set to one. The Information Bytes shall be set to the difference (residue) between the requested Transfer Length and the actual number of blocks read (not including the incorrect length block). Upon termination, the medium shall be positioned after the incorrect length block (end-of-medium side).

If a logical unit reads a filemark during a READ command, it shall send a CHECK CONDITION status to the initiator and shall set the Filemark bit in extended sense. Upon termination, the medium shall be positioned after the filemark (end-of-medium side). If the Fixed bit is one, the target shall set the Valid bit to one and the Information Bytes shall be set to the difference (residue) between the requested Transfer Length and the actual number of blocks read (not including the filemark).

If a logical unit encounters the physical end-of-medium during a READ command, the target shall return a CHECK CONDITION status to the initiator and shall set the End-Of-Medium (EOM) bit to one in extended sense. The Sense Key shall be set to MEDIUM ERROR. If the Fixed bit is one, the target shall set the Valid bit to one and the Information Bytes to the difference (residue) between the requested Transfer Length and the actual number of blocks successfully read. The medium position following this condition is not defined.

When the Transfer Length is zero, no data shall be transferred and the current position on the logical unit shall not be changed. This condition shall not be considered as an error.

9.4 WRITE Command (0AH)

Peripheral Device Type: Sequential Access
Operation Code Type: Mandatory

TABLE 9-6. WRITE COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	0
1	Logical Unit Number			0	0	0	0	Fixed
2	Transfer Length (MSB)							
3	Transfer Length							
4	Transfer Length (LSB)							
5	0	0	0	0	0	0	Flag	Link

The WRITE command (Table 9-6) transfers one or more block(s) from the initiator to the current position on the logical unit. The Fixed bit specifies both the meaning of the Transfer Length field and whether fixed-length or variable-length block(s) are to be transferred.

If the Fixed bit is zero, a single block shall be transferred from the initiator and shall be written to the logical unit beginning at the current medium position. The Transfer Length specifies the length of the block to be written (in bytes). The requested block length shall be within the minimum and maximum block length range (returned by the READ BLOCK LIMITS command, Section 9.2). If this condition is not met, a CHECK CONDITION status shall be returned and the Sense Key shall be set to ILLEGAL REQUEST and no data shall be written. Upon successful termination, the medium shall be positioned after the block written by this command (end-of-medium side).

If the Fixed bit is one, the Transfer Length field specifies the number of block(s) to be transferred to the logical unit beginning at the current medium position. This form of the WRITE command is valid only if the logical unit is currently operating in fixed block mode (see 9.3). Upon termination, the medium shall be positioned after the block(s) written by this command (end-of-medium side).

The target may implement fixed block mode, variable block mode, or both modes. If the Fixed bit does not match the current mode, or the mode indicated by the Fixed bit is not implemented, the target shall reject the command by returning a CHECK CONDITION status and by setting the Sense Key to ILLEGAL REQUEST.

If the early warning end-of-medium condition is encountered while writing, an attempt to finish writing any buffered data may be made. The command shall terminate with a CHECK CONDITION status and the EOM bit in extended sense shall be set to one. If any data remains in the target's buffer, then the sense key shall be set to VOLUME OVERFLOW. If the Fixed bit is one and the logical unit is not buffered (buffered mode of the MODE SENSE command is zero), then the Valid bit in extended sense shall be set to one and the Information Bytes shall be set to the difference (residue) between the requested Transfer Length and the actual number of blocks written to the medium. If the Fixed bit is one and the logical unit is buffered (buffered mode of the MODE SENSE command is one), then the Valid bit shall be set to one and the Information Bytes shall be set to the total number of blocks not written (the number of blocks not transferred from the initiator plus the number of blocks remaining in the target's buffer). Note that in this case it is possible for the value in the Information Bytes to exceed the Transfer Length.

When the Transfer Length is zero, no data shall be transferred and the current position on the logical unit shall not be changed. This condition shall not be considered as an error.

9.5 TRACK SELECT Command (0BH)

Peripheral Device Type: Sequential Access
Operation Code Type: Optional

TABLE 9-7. TRACK SELECT COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	1
1	Logical Unit Number			0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	Track Value							
5	0	0	0	0	0	0	Flag	Link

The TRACK SELECT command (Table 9-7) requests that the track specified in the Track Value field be selected.

9.6 READ REVERSE Command (0FH)

Peripheral Device Type: Sequential Access
Operation Code Type: Optional

TABLE 9-8. READ REVERSE COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	0	1	1	1	1
1	Logical Unit Number			0	0	0	0	Fixed
2	Transfer Length (MSB)							
3	Transfer Length							
4	Transfer Length (LSB)							
5	0	0	0	0	0	0	Flag	Link

The READ REVERSE command (Table 9-8) functions identically to the READ command except that medium motion is in the reverse direction. Thus, the block(s) and bytes within the block(s) are transferred in the reverse order and the medium position upon termination is before the last block read (beginning-of-medium side). This command shall terminate with a CHECK CONDITION status and the EOM bit in extended sense shall be set to one if beginning-of-medium or load-point is encountered. The Sense Key shall be set to NO SENSE. If the Fixed bit is one, then the Valid bit shall be set to one and the Information Bytes shall contain the difference (residue) of the requested Transfer Length and the actual number of blocks transferred before beginning-of-medium or load-point was encountered.

Filemark handling is the same as in the READ command except that the medium position upon command termination shall be before the filemark (beginning-of-medium side).

If the Transfer Length is zero, no data shall be transferred and the current position on the logical unit shall not be changed. This condition shall not be considered as an error.

The target may implement fixed block mode, variable block mode, or both modes. If the Fixed bit does not match the current mode, or the mode indicated by the Fixed bit is not implemented, the target shall reject the command by returning a CHECK CONDITION status and by setting the Sense Key to ILLEGAL REQUEST.

9.7 WRITE FILEMARKS Command (10H)

Peripheral Device Type: Sequential Access
Operation Code Type: Mandatory

TABLE 9-9. WRITE FILEMARKS COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	1	0	0	0	0
1	Logical Unit Number			0	0	0	0	Immed
2	Number of Filemarks (MSB)							
3	Number of Filemarks							
4	Number of Filemarks (LSB)							
5	0	0	0	0	0	0	Flag	Link

The WRITE FILEMARKS command (Table 9-9) causes the specified Number of Filemarks to be written beginning at the current medium position on the logical unit. A zero in this field indicates that no filemarks are to be written.

This command is also used to force any buffered data (see buffered mode in the MODE SENSE command, Section 9.14) to be written. If the logical unit is not buffered (Buffered Mode of the MODE SENSE command is zero) or the Immediate (Immed) bit is zero, then this command shall not return a GOOD status unless all buffered data blocks and the filemarks (if any) are correctly written on the medium. If the logical unit is buffered (Buffered Mode of the MODE SENSE command is one) and the Immed bit is one, then status shall be returned immediately after the operation is initiated. Errors and exception conditions on the logical unit that are detected after status is returned shall be reported on a subsequent command from the same initiator.

If the early warning end-of-medium condition is encountered while writing, an attempt to finish writing any buffered data may be made. The command (or subsequent command) shall terminate with a CHECK CONDITION status and the EOM bit in extended sense shall be set to one. If any blocks or filemarks remain to be written, then the Sense Key shall be set to VOLUME OVERFLOW. If the logical unit is not buffered (buffered mode of the MODE SENSE command is zero), then the Valid bit in extended sense shall be set to one and the Information Bytes shall be set to the number of unwritten filemarks. If the logical unit is buffered (buffered mode of the MODE SENSE command is one), then the Valid bit shall be set to one and the Information Bytes shall be set to the total number of blocks not written (the number of unwritten filemarks plus the number of blocks remaining in the target's buffer). Note that in this case it is possible for the value in the Information Bytes to exceed the Transfer Length.

9.8 SPACE Command (11H)

Peripheral Device Type: Sequential Access
Operation Code Type: Optional

TABLE 9-10. SPACE COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	1	0	0	0	1
1	Logical Unit Number			0	0	0	Code	
2	Count (MSB)							
3	Count							
4	Count (LSB)							
5	0	0	0	0	0	0	Flag	Link

The SPACE command (Table 9-10) provides a variety of positioning functions that are determined by the Code and Count. Both forward (toward end-of-medium) and reverse (toward beginning-of-medium) positioning are provided, although some SCSI devices may only support a subset of this command. Such SCSI devices shall return a CHECK CONDITION status and set the Sense Key to ILLEGAL REQUEST in response to any attempt to invoke a function that is not supported.

The Code field is defined as follows:

DB(1)	DB(0)	DESCRIPTION
0	0	Blocks
0	1	Filemarks
1	0	Sequential Filemarks
1	1	Physical End-of-Data

When spacing over blocks or filemarks, the Count field specifies the number of blocks or filemarks to be spaced over. A positive value N in the count field shall cause forward medium movement over N blocks or filemarks ending on the end-of-medium side of the last block or filemark. A zero value in the Count field shall cause no medium movement. A negative value -N (2's complement notation) in the count field shall cause reverse medium movement over N blocks or filemarks ending on the beginning-of-medium side of the last block or filemark.

If a filemark is encountered while spacing over blocks, medium movement shall be stopped. The medium shall be positioned on the end-of-medium side of the filemark if movement was in the forward direction and on the beginning-of-medium side of the filemark if movement was in the reverse direction. A CHECK CONDITION status shall be sent to the initiator and the Filemark and Valid bits in extended sense shall be set to one. The Information Bytes shall be set to the difference (residue) in the requested Count and the actual number of blocks spaced over (not including the filemark).

If the physical end-of-medium is encountered while spacing forward over blocks or filemarks, the target shall return a CHECK CONDITION status to the initiator and shall set the End-Of-Medium (EOM) bit in extended sense to one. The Sense Key shall be set to MEDIUM ERROR. The target shall set the Valid bit to one and the Information Bytes to the difference (residue) between the requested Count and the actual number of blocks or filemarks spaced over.

If beginning-of-medium or load-point is encountered while spacing over blocks or filemarks in the reverse direction, the target shall return a CHECK CONDITION status to the initiator and shall set the End-Of-Medium (EOM) bit in extended sense to one. The Sense Key shall be set to NO SENSE. The target shall set the Valid bit to one and the Information Bytes to the difference (residue) between the requested Count and the actual number of blocks or filemarks spaced over.

When spacing over sequential filemarks, the Count field is interpreted as follows:

1. A positive value N shall cause forward medium movement to the first occurrence of N or more consecutive filemarks stopping after the Nth filemark.

2. A zero value shall cause no medium movement.

3. A negative value -N (2's complement notation) shall cause reverse medium movement to the first occurrence of N or more consecutive filemarks stopping on the beginning-of-medium side of the Nth filemark.

When spacing to physical end-of-data, the Count field is ignored. Forward medium movement shall occur until the logical unit encounters physical end-of-data as defined by the sequential-access device. Some sequential-access devices define physical end-of-data as an erased area on the medium; however, other definitions are not precluded. Targets that implement this function shall leave the medium positioned such that a subsequent WRITE command would append data to the last recorded information on the medium.

9.9 VERIFY Command (13H)

Peripheral Device Type: Sequential Access
Operation Code Type: Optional

TABLE 9-11. VERIFY COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	1	0	0	1	1
1	Logical Unit Number			0	0	Immed	BytCmp	Fixed
2	Verification Length (MSB)							
3	Verification Length							
4	Verification Length (LSB)							
5	0	0	0	0	0	0	Flag	Link

The VERIFY command (Table 9-11) verifies one or more block(s) beginning with the next block on the logical unit. The Fixed bit specifies both the meaning of the Verification Length field and whether fixed-length or variable-length block(s) are to be verified.

If the logical unit is not buffered (Buffered Mode of the MODE SENSE command is zero) or the Immediate (Immed) bit is zero, then this command shall not return a GOOD status unless all specified bytes or blocks have been successfully verified. If the logical unit is buffered (Buffered Mode of the MODE SENSE command is one) and the Immed bit is one, then the status shall be returned immediately after the operation is initiated (but after the data transfer, if any). Errors and exception conditions on the logical unit that are detected after the status is returned shall be reported on the next VERIFY command from the same initiator. In order to insure that no errors are lost, the initiator should set the Immed bit to zero on the last VERIFY command when issuing a series of VERIFY commands.

A Byte Compare (BytCmp) bit of zero indicates that the verification shall be simply a medium verification (CRC, ECC, etc). No data shall be transferred between the initiator and target. A Byte Compare bit of one indicates that a byte-by-byte compare of the data on the medium, and the data transferred from the initiator shall be performed by the target. Data shall be transferred from the initiator to the target as in a WRITE command.

A Fixed bit of zero requests that the next block of the logical unit be verified. The Verification Length specifies the number of bytes to verify. A Fixed bit of one requests Verification Length blocks be verified beginning with the next logical block on the logical unit. This form of the VERIFY command is only valid if the logical unit is currently in fixed block mode as defined in the READ command. If the data does not compare (byte compare bit equals one), the command (or the next VERIFY command, if the Immediate bit is one and the logical unit is in Buffered Mode) shall terminate with a CHECK CONDITION status and the Sense Key shall be set to MISCOMPARE. If the Fixed bit is one, the Valid bit shall be set to one and the Information Bytes shall be set to the difference (residue) between the Verification Length and the actual number of blocks successfully verified. This number may be larger than the requested Verification Length if the error occurred on a previous VERIFY command with an Immediate bit of one. The medium shall be positioned after the block containing the miscompare (end-of-medium side).

The target may implement fixed block mode, variable block mode, or both modes. If the Fixed bit does not match the current mode, or the mode indicated by the Fixed bit is not implemented, the target shall reject the command by returning a CHECK CONDITION status and by setting the Sense Key to ILLEGAL REQUEST.

The VERIFY command shall terminate when the Verification Length has been satisfied, when a filemark is encountered, or when physical end-of-medium is encountered. The status and sense data for each of these conditions are handled the same as in the READ command, except that the status and sense may be reported on the next VERIFY command if the Immediate bit is one and the logical unit is in Buffered Mode. In this case, the residue reported in the extended sense may exceed the requested verification length. Upon completion of the VERIFY command, the medium shall be positioned after the last block from which data was verified or after the filemark, if encountered.

When the Verification Length is zero, no data shall be verified and the current position on the logical unit shall not be changed. This condition shall not be considered as an error.

9.10 RECOVER BUFFERED DATA Command (14H)

Peripheral Device Type: Sequential Access
Operation Code Type: Optional

TABLE 9-12. RECOVER BUFFERED DATA COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	1	0	1	0	0
1	Logical Unit Number			0	0	0	0	Fixed
2	Transfer Length (MSB)							
3	Transfer Length							
4	Transfer Length (LSB)							
5	0	0	0	0	0	0	Flag	Link

The RECOVER BUFFERED DATA command (Table 9-12) is used to read data that has been transferred to an SCSI device buffer but has not been written on the medium. It is normally only used to recover from error or exception conditions that make it impossible to write the buffered data on the medium.

This command functions similarly to the READ command except that the data is transferred from the SCSI device buffer instead of the medium. The order in which block(s) are transferred is the same as if they would have been transferred to the medium. One or more RECOVER BUFFERED DATA commands may be used to read the unwritten buffered data.

The target may implement fixed block mode, variable block mode, or both modes. If the Fixed bit does not match the current mode, or the mode indicated by the Fixed bit is not implemented, the target shall reject the command by returning a CHECK CONDITION status and by setting the Sense Key to ILLEGAL REQUEST.

If an attempt is made to recover more logical blocks of data than are contained in the SCSI device buffer, the command shall be terminated with a CHECK CONDITION status. The EOM bit in extended sense shall be set to one. If the Fixed bit is one, the Valid bit shall be set to one and the Information Bytes shall be set to the difference (residue) between the requested Transfer Length and the actual number of blocks transferred.

The Transfer Length specifies the number of contiguous logical blocks of data to be transferred. A Transfer Length of zero indicates that no data shall be transferred. This condition shall not be considered as an error.

9.11 MODE SELECT Command (15H)

Peripheral Device Type: Sequential Access
Operation Code Type: Mandatory

TABLE 9-13. MODE SELECT COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	1	0	1	0	1
1	Logical Unit Number			0	0	0	0	SMP
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	Parameter List Length							
5	0	0	0	0	0	0	Flag	Link

The MODE SELECT command (Table 9-13) provides a means for the initiator to specify medium, logical unit, or peripheral device parameters to the target.

The Save Mode Parameters (SMP) bit, when set to one, requests that the target save the saveable pages. The target must update the Current mode values with parameters included with this command, save the Current values of the saveable parameters, and report GOOD status only after the save operation is completed. The Saved parameters shall not be changed if an error is detected during the MODE SELECT command. When the SMP bit is set to zero, the Saved parameter values will not be changed.

Support for Saved parameters is optional for CDC products. If the SMP bit is set and Saved parameters are not supported, the target shall return CHECK CONDITION status with ILLEGAL REQUEST Sense Key.

The Parameter List Length specifies the length in bytes of the MODE SELECT parameter list that shall be transferred during the DATA OUT phase. A zero Parameter List Length indicates that no data shall be transferred. This condition shall not be considered as an error.

The MODE SELECT parameter list (Table 9-14) contains a four-byte header, followed by zero or one block descriptor, followed by the pages of MODE SELECT parameters.

TABLE 9-14. MODE SELECT PARAMETER LIST

BIT / BYTE	7	6	5	4	3	2	1	0
0	Reserved (all zeros)							
1	Reserved (all zeros)							
2	0	Buffered Mode			Speed			
3	Block Descriptor Length							
	Block Descriptor(s)							
0	Density Code							
1	Number of Blocks (MSB)							
2	Number of Blocks							
3	Number of Blocks (LSB)							
4	Reserved							
5	Block Length (MSB)							
6	Block Length							
7	Block Length (LSB)							
	Parameter Information							
0-n	Mode Select Page Headers and their parameters							

A Buffered Mode of zero indicates that the target shall not report a GOOD status on WRITE commands until the data blocks are actually written on the medium. A Buffered Mode of one indicates that the target may report a GOOD status on WRITE commands as soon as the data block has been transferred to the SCSI device buffer. One or more blocks may be buffered prior to writing the block(s) to the medium. Buffered Modes of 2H through 7H are reserved.

Code values for the Speed field shall be assigned as follows:

0H	Default (Use the peripheral device's default speed).
1H	Use the peripheral device's lowest speed.
2H--FH	Use increasing peripheral device speeds.

The Block Descriptor Length specifies the length in bytes of all the block descriptors. It is equal to the number of block descriptors times eight and does not include the pages of MODE SELECT parameters. A Block Descriptor Length of zero indicates that no block descriptors are included in the parameter list. This condition shall not be considered as an error.

Each Block Descriptor specifies the medium characteristics for all or part of a logical unit. Each Block Descriptor contains a Density Code, a Number of Blocks, and a Block Length.

Code values for the Density Code field are defined in Table 9-15.

TABLE 9-15 SEQUENTIAL-ACCESS DENSITY CODES

Code Value	Density
00H	Default (peripheral device's default or only density)

Magnetic Tapes

	Width mm (inch)	Tracks	Density BPMM (BPI)	Code	Type	Standard	Note
01H	12.7 (.5)	9	32 (800)	NRZI	R	X3.22-1983	3
02H	12.7 (.5)	9	63 (1600)	PE	R	X3.39-1973	3
03H	12.7 (.5)	9	246 (6250)	GCR	R	X3.54-1976	3
04H	6.3 (.25)	4/9	315 (8000)	GCR	C		2,4
05H	6.3 (.25)	4/9	315 (8000)	GCR	C	X3.136-198X	2
06H	12.7 (.5)	9	126 (3200)	PE	R	X3B5/85-98	1,3
07H	6.3 (.25)	4	252 (6400)	IMFM	C	X3.116-198X	2
08H	3.81 (.15)	4	315 (8000)	GCR	CS	X3B5/85-77	1,2
09H	12.7 (.5)	18			C	X3B5/85-76	1,3
0AH	6.3 (.25)	12	394 (10000)	GCR	C	X3B5/85-82	2
0BH	6.3(0.25)	4	63 (1600)	PE	C	X3.56-198X	2
0CH	12.7 (0.5)	24	500 (12690)	GCR	C		2
0DH	12.7 (0.5)	24	999 (25380)	GCR	C		2
8CH-FFH	Vendor Unique						

All others Reserved

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	MC

NOTES:

1. Working Draft. X3B5 assigns a new document number to each revision of their documents. Please contact the Chairman of X3B5 for the latest document number.
2. Serially Recorded
3. Parallel Recorded
4. Old format known as QIC-11

The Number of Blocks field specifies the number of logical blocks on the medium that meet the Density Code and Block Length in the block descriptor. A Number of Blocks of zero indicates that all of the remaining logical blocks of the logical unit shall have the medium characteristics specified by the Block Descriptor.

The Block Length specifies the length in bytes of each logical block described by the Block Descriptor. A block length of zero indicates that the length shall be variable.

The rest of the MODE SELECT parameters are organized into pages that group the parameters by function. The parameter definitions are the same as those described in the MODE SENSE command (paragraph 9.14) and will not be repeated here.

TABLE 9-16 MODE SELECT PAGE DESCRIPTOR HEADER

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	Page Code					
1	Page Length							
2-n	Mode Parameters							

Each page of mode parameters begins with a two byte Page Descriptor Header. The Page Code identifies which page of mode parameters is being transferred. The Page Length indicates the number of additional bytes of mode parameters contained in this page. The number of additional bytes sent must always match the Page Length value.

If the initiator sends mode parameter bytes that are not supported by the target, the target will set CHECK CONDITION status with ILLEGAL REQUEST Sense Key. The initiator may only send mode parameters for pages if the target supports Changeable parameters within that page. The Page Length sent by the initiator must be the same as the Page Length value received from the target during a MODE SENSE command with PCF set to 01 (binary). CDC products may optionally support the following Page Codes:

Page Code	Description
00H	Product Unique. See individual product specifications.
01H	Tape Control parameters.
02H	Disconnect/Reconnect Control parameters.

The initiator shall issue a MODE SENSE command requesting the target to return all pages with Changeable values (see PCF field description for MODE SENSE command) prior to issuing any MODE SELECT commands. This allows the initiator to correctly determine which pages are supported, the proper length for those pages, and which parameters in those pages may be changed for that Logical Unit Number.

9.12 RESERVE UNIT and RELEASE UNIT Commands (16H and 17H, respectively)

Peripheral Device Type: Sequential Access
Operation Code Type: Mandatory

TABLE 9-18. RESERVE UNIT AND RELEASE UNIT COMMANDS

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	1	0	1	1	X
1	Logical Unit Number			3rdPty	Third Party Device ID			0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	Flag	Link

The RESERVE UNIT and RELEASE UNIT commands both use the Command Descriptor Block shown in Table 9-18.

9.12.1 RESERVE UNIT Command (16H)

The RESERVE UNIT command shall reserve the specified logical unit for the exclusive use by the requesting initiator or, if third-party reservation option is implementated, to another specified SCSI device.

The reservation shall remain in effect until superceded by another RESERVE UNIT command from the same initiator that made the reservation or until released by a RELEASE UNIT command from the same initiator, or a BUS DEVICE RESET message is received from any initiator, or a "hard" RESET condition. The occurrence of the last two conditions is indicated by a Sense Key of UNIT ATTENTION on the next command following the condition. It is not an error to issue this command to a logical unit that is currently reserved to the requesting initiator.

If the logical unit is previously reserved for another initiator, then the target shall either:

1. return a RESERVATION CONFLICT status

2. queue the reservation request and then disconnect until all previously queued reservations have been released. When the logical unit is available, the target shall reconnect to perform the reservation.

If, after honoring the reservation, any other initiator then subsequently attempts to perform any command on the reserved logical unit other than a RESERVE UNIT command, which may be queued, or a RELEASE UNIT command, which shall be ignored, then the command shall be rejected with a RESERVATION CONFLICT status.

The third-party reservation option for the RESERVE UNIT command allows an initiator to reserve a logical unit for another SCSI device. This option is intended for use in multiple-initiator systems that use the COPY command. Any target that implements the third-party reservation option shall also implement the third-party release option (see 9.12.2).

If the third-party (3rdPty) bit is zero, then the third-party reservation option is not requested. If the 3rdPty bit is one and the third-party reservation option is implemented, then the RESERVE UNIT command shall reserve the specified logical unit for the SCSI device specified in the third-party device ID field. The target shall preserve the reservation until superceded by another RESERVE UNIT command from the same initiator, or by a BUS DEVICE RESET message from any initiator, or by a "hard" RESET condition. The target shall ignore (i.e., return GOOD status) any attempt made by any other initiator to release the reservation.

- CDC products will support the third-party reservation option.

An initiator that holds a current reservation may modify that reservation (e.g., switch third-parties) by issing another RESERVE UNIT command to the same Logical Unit. The superceding RESERVE UNIT command shall release the previous reservation state only when the new reservation is granted. A superceding reservation takes priority over any previously queued reservation request.

9.12.2 RELEASE UNIT Command (17H)

The RELEASE UNIT command shall release the logical unit if it is currently reserved by the requesting initiator.

It is not an error to attempt to release a logical unit that is not currently reserved to the requesting initiator. However, it shall not be released if it is reserved by another initiator.

The third-party release option for the RELEASE UNIT command allows an initiator to release a logical unit that was previously reserved using the third-party reservation option (see 9.12.1). This option shall be implemented if the third-party reservation option is implemented. This option is intended for use in multiple-initiator systems that use the COPY command.

If the third-party (3rdPty) bit is zero, then the third-party release option is not requested. If the 3rdPty bit is one and the target implements the third-party release option, then the target shall release the specified logical unit, but only if the reservation was made using the third-party reservation option by the same initiator that is requesting the release and for the same SCSI device as specified in the third-party device ID field.

- CDC products will support the third-party release option.

9.13 ERASE Command (19H)

Peripheral Device Type: Sequential Access
Operation Code Type: Optional

TABLE 9-19. ERASE COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	1	1	0	0	1
1	Logical Unit Number			0	0	0	0	Long
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	Flag	Link

The ERASE command (Table 9-19) causes part or all of the remaining medium to be erased beginning from the current medium position. As used here, "erased" means either the medium shall be erased or a pattern shall be written on the medium that appears as gap to the target.

The distance to be erased is controlled by the Long bit. A Long bit of one indicates that all remaining medium on the logical unit shall be erased. A Long bit of zero indicates that a peripheral device specified portion of the medium shall be erased. Normally, short erases are used to create an extended gap for software controlled error recovery or for support of "update in place" functions. The medium position following an ERASE command with a Long bit of one is not defined by this specification.

NOTE: Some targets may reject ERASE commands with the Long bit set to one if the medium is not positioned at the beginning-of-medium.

9.14 MODE SENSE Command (1AH)

Peripheral Device Type: Sequential Access
Operation Code Type: Mandatory

TABLE 9-20. MODE SENSE COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	1	1	0	1	0
1	Logical Unit Number			0	0	0	0	0
2	PCF		Page Code					
3	0	0	0	0	0	0	0	0
4	Allocation Length							
5	0	0	0	0	0	0	Flag	Link

The MODE SENSE command (Table 9-20) provides a means for a target to report its medium, logical unit, or peripheral device parameters to the initiator. It is a complementary command to the MODE SELECT command (see 9.11) for support of a medium that may contain different densities, such as half-inch tapes.

The Page Control Field (PCF) defines the type of mode parameter values to be returned. The target shall return the same Page Length for each supported page regardless of the value in the PCF. The field is defined as follows:

Bit 7 Bit 6

0 0 Return Current values. The Current values are the values currently being used by the target to control its operation. After a Power On Reset, a hard RESET, or a BUS DEVICE RESET message the Current values will be equal to the Saved values (if Saved values are supported and can be retrieved) or the Default values (if Saved values aren't supported or cannot be retrieved). The Current value of a parameter is updated whenever a MODE Select command that changes that parameter ends with GOOD status being returned.

0 1 Return Changeable values. The changeable values of any page is a mask that indicates which parameters may be changed via a MODE SELECT command and which parameters may not. Each returned parameter byte shall contain ones where a field or bit may be changed and zeros where a field or bit may not be changed.

Bit 7	Bit 6	
1	0	Return Default values. The Default values are the values a target will set the Current values to after a reset condition unless valid Saved values are available.
1	1	Return Saved values. The Saved values are the values a target stores in non-volatile memory. The Saved values of any changeable parameter can be set via a MODE SELECT command. For nonchangeable parameters, the Default value will be used. Support for Saved parameter values is optional for CDC products.

The Block Descriptor will contain its normal values regardless of the value of the PCF. Unsupported firlds or bits within a page will be returned as zeros for all PCF values.

The Page Code allows the initiator to select one or all of the pages of Mode parameters supported by the target. Page Codes which may be supported by CDC products are listed here:

Page Code	Description
00H	Product Unique. See individual products specification.
01H	Tape Control parameters.
02H	Disconnect/Reconnect Control parameters.
3FH	Return all supported pages.

The Allocation Length specifies the number of bytes that the initiator has allocated for returned MODE SENSE data. An Allocation Length of zero indicates that no MODE SENSE data shall be transferred. This condition shall not be considered as an error. Any other value indicates the maximum number of bytes that shall be transferred. The target shall terminate the DATA IN phase when Allocation Length bytes have been transferred or when all available MODE SENSE data have been transferred to the initiator, whichever is less.

The MODE SENSE data (Table 9-21) will always include a four-byte header, followed by one eight-byte block descriptor, followed by the requested page or pages of MODE SENSE parameters.

TABLE 9-21. MODE SENSE DATA

BIT / BYTE	7	6	5	4	3	2	1	0
0	Sense Data Length							
1	Medium Type							
2	WP	Buffered Mode			Speed			
3	Block Descriptor Length							
	Block Descriptor(s)							
0	Density Code							
1	Number of Blocks (MSB)							
2	Number of Blocks							
3	Number of Blocks (LSB)							
4	Reserved							
5	Block Length (MSB)							
6	Block Length							
7	Block Length (LSB)							
	Parameter Information							
0-n	Mode Select Page Headers and their parameters							

The Sense Data Length specifies the length in bytes of the following mode sense data that is available to be transferred during the DATA IN phase. The Sense Data Length does not include itself.

Code values for the Medium Type field shall be assigned as follows:

00H	Default (Only one medium type supported)
01H--7FH	Reserved
80H--FFH	Reserved

A Write Protected (WP) bit of zero indicates that the medium is write enabled. A Write Protected bit of one indicates that the medium is write protected.

A Buffered Mode of zero indicates that the target does not report a GOOD status on WRITE commands until the data blocks are actually written on the medium. A Buffered Mode of one indicates that the target may report a GOOD status on WRITE commands as soon as the data block has been transferred to the SCSI device buffer. One or more blocks may be buffered prior to writing the block(s) to the medium. Buffered Modes of 2H through 7H are reserved.

Code values for the Speed field shall be assigned as follows:

0H	Default (only one speed supported)
1H	Lowest peripheral device speed
2H--FH	Increasing peripheral device speeds

The Block Descriptor Length specifies the length in bytes of the Block Descriptor. It is equal to the number of bytes in the Block Descriptor (8) and does not include the page headers and mode parameters, if any. CDC products will send one Block Descriptor per LUN.

Each Block Descriptor specifies the medium characteristics for all or part of a logical unit. Each Block Descriptor contains a Density Code, a Number of Blocks, and a Block Length.

Code values for the Density Code field are defined in Table 9-14.1.

The Number of Blocks field specifies the number of logical blocks on the medium that meet the Density Code and Block Length in the block descriptor. A Number of Blocks of zero indicates that all of the remaining logical blocks of the logical unit have the medium characteristics specified by the Block Descriptor.

The Block Length specifies the length in bytes of each logical block described by the Block Descriptor. A Block Length of zero indicates that the length is variable.

TABLE 9-22. MODE SENSE PAGE DESCRIPTOR HEADER

BIT / BYTE	7	6	5	4	3	2	1	0
0	PS	0	Page Code					
1	Page Length							
2-n	Mode Parameters							

Each page of mode parameters (for the MODE SENSE command) begins with a two byte Page Descriptor Header. The Page Code identifies which page of mode parameters is being transferred. The Page Length indicates the number of additional bytes of mode parameters being sent by this target. Multiple pages of mode parameters may be transferred in one MODE SENSE data in phase (using page code 3FH).

The Parameters Saveable (PS) bit, when set to one, indicates that the page contains Saved parameters. Since the support of Saved values is optional, refer to individual product specifications to see which parameters are saved. When the PS bit is set to zero, none of the parameters within the page are saved.

Since support for most mode parameters is optional, some CDC products will return a Page Length that is shorter than the number of bytes defined in this specification.

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PAGE 1 MODE PARAMETER DESCRIPTION.

TABLE 9-23 DISCONNECT/RECONNECT CONTROL PARAMETERS

BIT / BYTE	7	6	5	4	3	2	1	0
0	PS	0	0	0	0	0	1	0
1	Page Length							
2	Buffer Full Ratio							
3	Buffer Empty Ratio							
4	Bus Inactivity Limit (MSB)							
5	Bus Inactivity Limit (LSB)							
6	Disconnect Time Limit (MSB)							
7	Disconnect Time Limit (LSB)							
8	Reserved (always zeros)							
9	Reserved (always zeros)							

Both the ratio parameters are the numerator of a fractional multiplier that has 256 as its denominator.

The Buffer Full Ratio indicates, on READ commands, how full the target's buffer shall be prior to reconnecting. Targets that include a larger granular buffer block size shall round down to the nearest whole buffer block.

The Buffer Empty Ratio indicates, on WRITE commands, how empty the target's buffer shall be prior to reconnecting to fetch more data. Targets that include a larger granular buffer block size shall round up to the nearest whole buffer block.

The Bus Inactivity Limit field (bytes 4 and 5) indicates the time, in 100 microsecond increments, that the target is allowed to assert the BUSY signal without handshakes until it shall disconnect. The target may round down to its nearest capable value. A value of zero indicates that the target is allowed to maintain the bus busy indefinitely without handshakes.

The Disconnect Time Limit field (bytes 6 and 7) indicates the minimum time, in 100 microsecond increments, that the target shall remain disconnected until it shall attempt to reconnect. The target may round down to its nearest capable value. A value of zero indicates that the target is allowed to reconnect immediately.

For Page Code 3FH, all pages supported by the target will be returned. Some page codes may be supported for one PCF value (for example, Default) but may not be supported for another PCF VALUE (for example, Changeable). However, a Default value and a Current value is required for all supported parameters.

9.15 LOAD/UNLOAD Command (1BH)

Peripheral Device Type: Sequential Access
Operation Code Type: Optional

TABLE 9-26. LOAD/UNLOAD COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	1	1	0	1	1
1	Logical Unit Number			0	0	0	0	Immed
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	Re-Ten	Load
5	0	0	0	0	0	0	Flag	Link

The LOAD/UNLOAD command (Table 9-26) requests that the target enable or disable the logical unit for further operations. This command may also be used to request the re-tension function on peripheral devices that support this function.

A Load bit of one indicates that the medium on the logical unit shall be loaded and positioned to the beginning-of-medium or load-point as determined by the peripheral device. A Load bit of zero indicates that the medium on the logical unit shall be positioned for removal from the peripheral device.

Status shall be returned after the medium is positioned unless the Immediate (Immed) bit is one. If the Immed bit is one, status may be returned as soon as the command has been accepted.

A Re-Tension (Re-Ten) bit of one indicates that the medium on the addressed logical unit shall be correctly tensioned before the LOAD/UNLOAD command is completed. This is an optional function intended for use by those peripheral devices that support the re-tension function.

9.16 PREVENT/ALLOW MEDIUM REMOVAL Command (1EH)

Peripheral Device Type: Sequential Access
Operation Code Type: Optional

TABLE 9-27. PREVENT/ALLOW MEDIUM REMOVAL COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	1	1	1	1	0
1	Logical Unit Number			0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	Prevent
5	0	0	0	0	0	0	Flag	Link

The PREVENT/ALLOW MEDIUM REMOVAL command (Table 9-27) requests that the target enable or disable the removal of the medium in the logical unit.

A Prevent bit of one shall inhibit mechanisms that normally allow removal of the medium. A Prevent bit of zero shall allow removal of the medium.

This prevention of medium removal condition shall terminate upon receipt of a PREVENT/ALLOW MEDIUM REMOVAL command with the prevent bit set to zero, or by the receipt of a BUS DEVICE RESET message from any initiator or by a "hard" RESET condition.

10.0 GROUP 0 COMMAND DESCRIPTIONS FOR PRINTER DEVICES

- CDC doesn't plan to offer SCSI products of this type.

11.0 GROUP 0 COMMAND DESCRIPTIONS FOR PROCESSOR DEVICES

- CDC doesn't plan to offer SCSI products of this type.

12.0 COMMAND DESCRIPTIONS FOR WRITE-ONCE READ-MULTIPLE DEVICES

12.1 Group 0 Commands for Write-Once Read-Multiple Devices

The Group 0 commands for write-once read-multiple devices shall be as shown in Table 12-1.

TABLE 12-1. GROUP 0 COMMANDS FOR WRITE-ONCE READ-MULTIPLE DEVICES

OPERATION CODE	TYPE	COMMAND NAME	SECTION
00H	M	TEST UNIT READY	7.1.1
01H	M	REZERO UNIT	8.1.1
02H	R		
03H	M	REQUEST SENSE	7.1.2
04H	R		
05H	R		
06H	R		
07H	M	REASSIGN BLOCKS	8.1.3
08H	M	READ	12.1.1
09H	R		
0AH	M	WRITE	12.1.2
0BH	M	SEEK	8.1.6
0CH	R		
0DH	R		
0EH	R		
0FH	R		
10H	R		
11H	R		
12H	M	INQUIRY	7.1.3
13H	R		
14H	R		
15H	M	MODE SELECT	12.1.3
16H	M	RESERVE	8.1.8
17H	M	RELEASE	8.1.9
18H	M	COPY	7.1.4
19H	R		
1AH	M	MODE SENSE	12.1.4
1BH	O	START/STOP UNIT	8.1.11
1CH	O	RECEIVE DIAGNOSTIC RESULTS	7.1.5
1DH	M	SEND DIAGNOSTIC	7.1.6
1EH	O	PREVENT/ALLOW MEDIUM REMOVAL	8.1.12
1FH	R		

key: (Type definitions are defined in 6.1.2).
M = Command implementation is mandatory.
O = Command implementation is optional.
R = Operation code is reversed for future standardization.

12.1.1 READ Command (08H)

Peripheral Device Type: Write-Once Read-Multiple and Read-Only Direct Access
Operation Code Type: Mandatory

TABLE 12-2. READ COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0
1	Logical Unit Number			Logical Block Address (MSB)				
2	Logical Block Address							
3	Logical Block Address (LSB)							
4	Transfer Length							
5	0	0	0	0	0	0	Flag	Link

The READ command (Table 12-2) requests that the target transfer data to the initiator.

The Logical Block Address specifies the logical block at which the read operation shall begin. Leading zeros will be assumed (ahead of the 21 bit address) if the device requires an address larger than 21 bits.

The Transfer Length specifies the number of contiguous logical blocks of data to be transferred. A Transfer Length of zero indicates that 256 logical blocks shall be transferred. Any other value indicates the number of logical blocks that shall be transferred.

This command shall be terminated with a status of RESERVATION CONFLICT if any reservation access conflict (see 8.1.8) exists and no data shall be transferred.

If any of the following conditions occur, this command shall be terminated with a CHECK CONDITION status, and if extended sense is implemented, the Sense Key shall be set as indicated in the following table. This table does not provide an exhaustive enumeration of all conditions that may cause the CHECK CONDITION status.

CONDITION	SENSE KEY
Invalid Logical Block Address	ILLEGAL REQUEST (see note 1)
Target reset or medium change since the last command from this initiator	UNIT ATTENTION
Unrecoverable read error	MEDIUM ERROR
Overrun or other error that might be resolved by repeating the command	ABORTED COMMAND
Attempt to read a blank or previously unwritten block	BLANK CHECK (see note 2)

NOTES:
1. The extended sense Information Bytes shall be set to the Logical Block Address of the first invalid address.

2. The extended sense Information Bytes shall be set to the Logical Block Address of the first blank block encountered. The data read up to that block shall be transferred.

12.1.2 WRITE Command (0AH)

Peripheral Device Type: Write-Once Read-Multiple
Operation Code Type: Mandatory

TABLE 12-3. WRITE COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	0
1	Logical Unit Number			Logical Block Address (MSB)				
2	Logical Block Address							
3	Logical Block Address (LSB)							
4	Transfer Length							
5	0	0	0	0	0	0	Flag	Link

The WRITE command (Table 12-3) requests that the target write the data transferred from the initiator to the medium.

The Logical Block Address specifies the logical block at which the write operation shall begin. Leading zeros will be assumed (ahead of the 21 bit address) if the device requires an address larger than 21 bits.

The Transfer Length specifies the number of contiguous logical blocks of data that shall be written. A Transfer Length of zero indicates that 256 logical blocks shall be written. Any other value indicates the number of logical blocks that shall be written.

This command shall be terminated with a status of RESERVATION CONFLICT if any reservation access conflict (see 8.1.8) exists and no data shall be written.

If any of the following conditions occur, this command shall be terminated with a CHECK CONDITION status, and if extended sense is implemented, the Sense Key shall be set as indicated in the following table. This table does not provide an exhaustive enumeration of all conditions that may cause the CHECK CONDITION status.

CONDITION	SENSE KEY
Invalid Logical Block Address	ILLEGAL REQUEST (see note 1)
Target reset or medium change since the last command from this initiator	UNIT ATTENTION
Overrun or other error that might be resolved by repeating the command	ABORTED COMMAND
Attempt to write a previously written block and blank checking is enabled (see 12.1.3)	BLANK CHECK (see note 2)

NOTES:

1. The extended sense Information Bytes shall be set to the Logical Block Address of the first invalid address.

2. The extended sense Information Bytes shall be set to the Logical Block Address of the first non-blank block encountered.

12.1.3 MODE SELECT Command (15H)

Peripheral Device Type: Write-Once Read-Multiple and Read-Only Direct Access

Operation Code Type: Mandatory

TABLE 12-4. MODE SELECT COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	1	0	1	0	1
1	Logical Unit Number			0	0	0	0	SMP
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	Parameter List Length							
5	0	0	0	0	0	0	Flag	Link

The MODE SELECT command (Table 12-4) provides a means for the initiator to specify medium, logical unit, or peripheral device parameters to the target.

The Save Mode Parameters (SMP) bit, when set to one, requests that the target save the saveable pages. The target must update the Current mode values with parameters included with this command, save the Current values of the saveable parameters, and report GOOD status only after the save operation is completed. The Saved parameters shall not be changed if an error is detected during the MODE SELECT command. When the SMP bit is set to zero, the Saved parameter values will not be changed.

Support for Saved parameters is optional for CDC products. If the SMP bit is set and Saved parameters are not supported, the target shall return CHECK CONDITION status with ILLEGAL REQUEST Sense Key.

The Parameter List Length specifies the length in bytes of the MODE SELECT parameter list that shall be transferred from the initiator to the target. A Parameter List Length of zero indicates that no data shall be transferred. This condition shall not be considered as an error.

The MODE SELECT parameter list (Table 12-5) contains a four-byte header, followed by zero or one eight-byte block descriptors, followed by the pages of MODE SELECT parameters.

TABLE 12-5. MODE SELECT PARAMETER LIST

BIT / BYTE	7	6	5	4	3	2	1	0
0	Reserved							
1	Reserved							
2	Reserved							EBC
3	Block Descriptor Length							
	Block Descriptor(s)							
0	Reserved							
1	Number of Blocks (MSB)							
2	Number of Blocks							
3	Number of Blocks (LSB)							
4	Reserved							
5	Block Length (MSB)							
6	Block Length							
7	Block Length (LSB)							
	Parameter Information							
0-n	Mode Select Page Headers and their parameters							

An Enable Blank Check (EBC) bit of zero disables blank checking of the medium during write operations. An EBC bit of one enables blank checking. If a non-blank block is found during a write operation, the command shall be terminated with a CHECK CONDITION status and the sense key shall be set to BLANK CHECK. For read-only direct-access devices, the EBC bit is reserved.

The Block Descriptor Length specifies the length in bytes of the Block Descriptor. It is equal to the number of bytes in the Block Descriptor (either 0 or 8) and does not include the page headers and mode parameters, if any. A Block Descriptor Length of zero indicates that no block descriptor shall be included in the parameter list. This condition shall not be considered as an error. CDC products will support one Block Descriptor per LUN.

Each Block Descriptor specifies the medium characteristics for all or part of a logical unit. Each Block Descriptor contains a Number of Blocks and a Block Length. The Number of Blocks field specifies the number of logical blocks to be formatted with the Block Length specified in the Block Descriptor. The Block Length field specifies the length in bytes of the logical block to be formatted.

The rest of the MODE SELECT parameters are organized into pages that group the parameters by function. The parameter definitions are the same as those described in the MODE SENSE command (paragraph 12.1.4) and will not be repeated here.

TABLE 12-6. MODE SELECT PAGE DESCRIPTOR HEADER

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	Page Code					
1	Page Length							
2-n	Mode Parameters							

Each page of mode parameters begins with a two byte Page Descriptor Header. The Page Code identifies which page of mode parameters is being transferred. The Page Length indicates the number of additional bytes of mode parameters contained in this page. The number of additional bytes sent must always match the Page Length value.

If the initiator sends mode parameter bytes that are not supported by the target, the target will set CHECK CONDITION status with ILLEGAL REQUEST Sense Key. The initiator may only send mode parameters for pages if the target supports Changeable parameters within that page. The Page Length sent by the initiator must be the same as the Page Length value received from the target during a MODE SENSE command with PCF set to 01 (binary). CDC products may optionally support the following Page Codes:

Page Code	Description
00H	Product Unique. See individual product specifications.
01H	Error Recovery parameters.
02H	Disconnect/Reconnect Control parameters.

The initiator shall issue a MODE SENSE command requesting the target to return all pages with Changeable values (see PCF field description for MODE SENSE command) prior to issuing any MODE SELECT commands. This allows the initiator to correctly determine which pages are supported, the proper length for those pages, and which parameters in those pages may be changed for that Logical Unit Number.

12.1.4 MODE SENSE Command (1AH)

Peripheral Device Type: Write-Once Read-Multiple and Read-Only Direct Access

■ Operation Code Type: Mandatory

TABLE 12-7. MODE SENSE COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	1	1	0	1	0
1	Logical Unit Number			0	0	0	0	0
■ 2	PCF		Page Code					
3	0	0	0	0	0	0	0	0
4	Allocation Length							
5	0	0	0	0	0	0	Flag	Link

The MODE SENSE command (Table 12-7) provides a means for a target to report its medium, logical unit, or peripheral device parameters to the initiator. It is a complementary command to the MODE SELECT command for support of medium that may contain multiple block lengths.

■ The Page Control Field (PCF) defines the type of mode parameter values to be returned. The target shall return the same Page Length for each supported page regardless of the value in the PCF. The field is defined as follows:

■ Bit 7 Bit 6

0 0 Return Current values. The Current values are the values currently being used by the target to control its operation. After a Power On Reset, a hard RESET, or a BUS DEVICE RESET message the Current values will be equal to the Saved values (if Saved values are supported and can be retrieved) or the Default values (if Saved values aren't supported or cannot be retrieved). The Current value of a parameter is updated whenever a MODE Select command that changes that parameter ends with GOOD status being returned.

0 1 Return Changeable values. The changeable values of any page is a mask that indicates which parameters may be changed via a MODE SELECT command and which parameters may not. Each returned parameter byte shall contain ones where a field or bit may be changed and zeros where a field or bit may not be changed.

Bit 7	Bit 6	
1	0	Return Default values. The Default values are the values a target will set the Current values to after a reset condition unless valid Saved values are available.
1	1	Return Saved values. The Saved values are the values a target stores in non-volatile memory. The Saved values of any changeable parameter can be set via a MODE SELECT command. For nonchangeable parameters, the Default value will be used. Support for Saved parameter values is optional for CDC products.

The Block Descriptor will contain its normal values regardless of the value of the PCF. Unsupported fields or bits within a page will be returned as zeros for all PCF values.

The Page Code allows the initiator to select one or all of the pages of Mode parameters supported by the target. Page Codes which may be supported by CDC products are listed here:

Page Code	Description
00H	Product Unique. See individual products specification.
01H	Error Recovery parameters.
02H	Disconnect/Reconnect Control parameters.
3FH	Return all supported pages.

The Allocation Length specifies the number of bytes that the initiator has allocated for returned MODE SENSE Data. An Allocation Length of zero indicates that no MODE SENSE data shall be transferred. This condition shall not be considered as an error. Any other value indicates the maximum number of bytes that shall be transferred. The target shall terminate the DATA IN phase when Allocation Length bytes have been transferred or when all available MODE SENSE data have been transferred to the initiator, whichever is less.

The MODE SENSE data (Table 12-8) will always include a four-byte header, followed by one eight-byte block descriptor, followed by the requested page or pages of MODE SENSE parameters.

TABLE 12-8. MODE SENSE DATA

BIT / BYTE	7	6	5	4	3	2	1	0
0	Sense Data Length							
1	Medium Type							
2	WP	Reserved						EBC
3	Block Descriptor Length							
Block Descriptor(s)								
0	Reserved							
1	Number of Blocks (MSB)							
2	Number of Blocks							
3	Number of Blocks (LSB)							
4	Reserved							
5	Block Length (MSB)							
6	Block Length							
7	Block Length (LSB)							
Parameter Information								
0-n	Mode Select Page Headers and their parameters							

The Sense Data Length specifies the length in bytes of the following MODE SENSE data that is available to be transferred during the DATA IN phase. The Sense Data Length does not include itself.

Code values for the Medium Type field shall be assigned as follows:

00H	Default (only one medium type supported)
01H--7FH	Reserved
80H--FFH	Reserved

An Enable Blank Check (EBC) bit of zero indicates that blank checking of the medium during write operations is disabled. An EBC bit of one indicates that blank checking during write operations is enabled. For read-only direct-access devices, the EBC bit is reserved.

A Write Protected (WP) bit of zero indicates that the medium is write enabled. A WP bit of one indicates that the medium is write protected. For read-only direct-access devices, the WP bit is reserved.

The Block Descriptor Length specifies the length in bytes of the Block Descriptor. It is equal to the number of bytes in the Block Descriptor (8) and does not include the page headers and mode parameters, if any. CDC products will send one Block Descriptor per LUN.

Each Block Descriptor specifies the medium characteristics for all or part of a logical unit. Each Block Descriptor contains a Number of Blocks and a Block Length.

The Number of Blocks field indicates the number of logical blocks that have the block length specified in the Block Descriptor. The Block Length field indicates the length in bytes of each logical block.

TABLE 12-9. MODE SENSE PAGE DESCRIPTOR HEADER

BIT / BYTE	7	6	5	4	3	2	1	0
0	PS	0	Page Code					
1	Page Length							
2-n	Mode Parameters							

Each page of mode parameters (for the MODE SENSE command) begins with a two byte Page Descriptor Header. The Page Code identifies which page of mode parameters is being transferred. The Page Length indicates the number of additional bytes of mode parameters being sent by this target. Multiple pages of mode parameters may be transferred in one MODE SENSE data in phase (using page code 3FH).

The Parameters Saveable (PS) bit, when set to one, indicates that the page contains Saved parameters. Since the support of Saved values is optional, refer to individual product specifications to see which parameters are saved. When the PS bit is set to zero, none of the parameters within the page are saved.

Since support for most mode parameters is optional, some CDC products will return a Page Length that is shorter than the number of bytes defined in this specification.

■■ TABLE 12-10 ERROR RECOVERY PAGE

BIT / BYTE	7	6	5	4	3	2	1	0
0	PS	0	0	0	0	0	0	1
1	Page Length							
2	AWRE	ARRE	TB	RC	EEC	PER	DTE	DCR
3	Retry Count							
4	Correction Span							
5-7	Reserved							

■ The Automatic Write Reallocation of defective data blocks Enabled (AWRE) bit, when set to one, allows the target to automatically relocate bad blocks detected during write operations. This function doesn't apply to the FORMAT UNIT command. When set to zero, the target shall not perform automatic reallocation but shall create the CHECK CONDITION Status with Sense Key of MEDIUM ERROR instead.

■ The Automatic Read Reallocation of defective data blocks Enabled (ARRE) bit, when set to one, allows the target to automatically relocate bad blocks detected during read operations. When set to zero, the target shall not perform automatic reallocation but shall create the CHECK CONDITION Status with Sense Key of MEDIUM ERROR instead.

■ The Transfer Block (TB) bit, when set to one, indicates that the failing data block shall be transferred to the initiator. When set to zero, the failing data block shall not be transferred.

■ The Read Continuous (RC) bit, when set to one, requests the target to transfer the requested data length without adding delays (for retries or ECC correction) that may be required to ensure data integrity. The target may send data that is erroneous in order to maintain the continuous flow of data. This bit shall override the DTE bit if it is set. When set to zero, recovery actions during data transfer are allowed.

■ The Enable Early Correction (EEC) bit, when set to one, allows the target to apply ECC correction as soon as possible, before the retry count is exhausted. Seek error retries are not affected by this bit. When this bit is set, the DCR bit must be zero. When the EEC bit is set to zero, the target shall exhaust the retry count before applying ECC correction.

■ The Post Error (PER) bit, when set to one, indicates that the target will report CHECK CONDITION status and appropriate Sense Key for any recovered errors encountered. Reporting of unrecoverable errors will have priority over Reporting of recoverable errors. When set to zero, any errors recovered within the limits established by the other Error Recovery Flags will not be reported. Any unrecoverable errors will still be reported.

The Disable Transfer on Error (DTE) bit is only valid when the PER bit is also set to one. When the DTE bit is set to one, it indicates that the target will terminate data transfer even for recoverable errors. The setting of the TB bit determines whether the block in error will be transferred. When DTE is set to zero, data transfer will continue if recoverable errors are encountered. If the PER bit is one and the DTE bit is zero, recoverable errors will be reported after all data has been transferred.

The Disable Correction (DCR) bit, when set to one, indicates that ECC correction shall not be applied to the data even if correction is possible. When set to zero, ECC correction shall be applied if correction is possible.

The Retry Count is the maximum number of times that the target should attempt its read recovery algorithm.

The Correction Span is the size of the largest read data error, in bits, on which ECC correction may be attempted. Data errors longer than this span will be reported as unrecoverable errors.

TABLE 12-11 DISCONNECT/RECONNECT CONTROL PARAMETERS

BIT / BYTE	7	6	5	4	3	2	1	0
0	PS	0	0	0	0	0	1	0
1	Page Length							
2	Buffer Full Ratio							
3	Buffer Empty Ratio							
4	Bus Inactivity Limit (MSB)							
5	Bus Inactivity Limit (LSB)							
6	Disconnect Time Limit (MSB)							
7	Disconnect Time Limit (LSB)							
8	Reserved (always zeros)							
9	Reserved (always zeros)							

Both the ratio parameters are the numerator of a fractional multiplier that has 256 as its denominator.

The Buffer Full Ratio indicates, on READ commands, how full the target's buffer shall be prior to reconnecting. Targets that include a larger granular buffer block size shall round down to the nearest whole buffer block.

The Buffer Empty Ratio indicates, on WRITE commands, how empty the target's buffer shall be prior to reconnecting to fetch more data. Targets that include a larger granular buffer block size shall round up to the nearest whole buffer block.

The Bus Inactivity Limit field (bytes 4 and 5) indicates the time, in 100 microsecond increments, that the target is allowed to assert the BUSY signal without handshakes until it shall disconnect. The target may round down to its nearest capable value. A value of zero indicates that the target is allowed to maintain the bus busy indefinitely without handshakes.

The Disconnect Time Limit field (bytes 6 and 7) indicates the time, in 100 microsecond increments, that the target shall remain disconnected until it shall attempt to reconnect. The target may round down to its nearest capable value. A value of zero indicates that the target is allowed to reconnect immediately.

For Page Code 3FH, all pages supported by the target will be returned. Some page codes may be supported for one PCF value (for example, Default) but may not be supported for another PCF VALUE (for example, Changeable). However, a Default value and a Current value is required for all supported parameters.

12.2 Group 1 Commands for Write-Once Read-Multiple Devices

The Group 1 commands for write-once read-multiple devices shall be as shown in Table 12-13.

TABLE 12-13. GROUP 1 COMMANDS FOR WRITE-ONCE READ-MULTIPLE DEVICES

	OPERATION CODE	TYPE	COMMAND NAME	SECTION
	20H	R		
	21H	R		
	22H	R		
	23H	R		
	24H	R		
■	25H	M	READ CAPACITY	8.2.1
	26H	R		
	27H	R		
	28H	M	READ EXTENDED	12.2.1
	29H	R		
	2AH	M	WRITE EXTENDED	12.2.2
■	2BH	M	SEEK EXTENDED	8.2.4
	2CH	R		
	2DH	R		
	2EH	O	WRITE AND VERIFY	12.2.3
	2FH	O	VERIFY	12.2.4
	30H	O	SEARCH DATA HIGH	12.2.5.1
	31H	O	SEARCH DATA EQUAL	12.2.5.2
	32H	O	SEARCH DATA LOW	12.2.5.3
■	33H	R		
	34H	R		
	35H	R		
	36H	R		
	37H	R		
	38H	R		
	39H	O	COMPARE	12.2.5
	3AH	O	COPY AND VERIFY	12.2.6
■	3BH	M	WRITE DATA BUFFER	7.2.3
■	3CH	M	READ DATA BUFFER	7.2.4
	3DH	R		
	3EH	R		
	3FH	R		

key: (Type definitions are defined in 6.1.2).
M = Command implementation is mandatory.
O = Command implementation is optional.
R = Operation code is reversed for future standardization.

12.2.1 READ EXTENDED Command (28H)

Peripheral Device Type: Write-Once Read-Multiple and Read-Only Direct Access
Operation Code Type: Mandatory

TABLE 12-14. READ COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	1	0	1	0	0	0
1	Logical Unit Number			0	0	0	0	0
2	Logical Block Address (MSB)							
3	Logical Block Address							
4	Logical Block Address							
5	Logical Block Address (LSB)							
6	0	0	0	0	0	0	0	0
7	Transfer Length (MSB)							
8	Transfer Length (LSB)							
9	0	0	0	0	0	0	Flag	Link

The READ command (Table 12-14) requests that the target transfer data to the initiator from the medium.

The Logical Block Address specifies the logical block at which the read operation shall begin.

The Transfer Length specifies the number of contiguous logical blocks of data that shall be transferred. A Transfer Length of zero indicates that no data shall be transferred. This condition shall not be considered as an error. Any other value indicates the number of logical blocks that shall be transferred.

This command shall be terminated with a status of RESERVATION CONFLICT if any reservation access conflict (see 8.1.8) exists and no data shall be transferred.

If any of the following conditions occur, this command shall be terminated with a CHECK CONDITION status and, if extended sense is implemented, the Sense Key shall be set as indicated in the following table. This table does not provide an exhaustive enumeration of all conditions that may cause the CHECK CONDITION status.

CONDITION	SENSE KEY
Invalid Logical Block Address	ILLEGAL REQUEST (see note 1)
Target reset or medium change since the last command from this initiator	UNIT ATTENTION
Overrun or other error that might be resolved by repeating the command	ABORTED COMMAND
Attempt to read a blank or previously unwritten block	BLANK CHECK (see note 2)

NOTES:

1. The extended sense Information Bytes shall be set to the Logical Block Address of the first invalid address.

2. The extended sense Information Bytes shall be set to the Logical Block Address of the first blank block encountered. The data read up to that block shall be transferred.

12.2.2 WRITE EXTENDED Command (2AH)

Peripheral Device Type: Write-Once Read-Multiple
Operation Code Type: Mandatory

TABLE 12-15. WRITE EXTENDED COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	1	0	1	0	1	0
1	Logical Unit Number			0	0	0	0	0
2	Logical Block Address (MSB)							
3	Logical Block Address							
4	Logical Block Address							
5	Logical Block Address (LSB)							
6	0	0	0	0	0	0	0	0
7	Transfer Length (MSB)							
8	Transfer Length (LSB)							
9	0	0	0	0	0	0	Flag	Link

The WRITE command (Table 12-15) requests that the target write the data transferred from the initiator to the medium.

The Logical Block Address specifies the logical block at which the write operation shall begin.

The Transfer Length specifies the number of contiguous logical blocks of data that shall be transferred. A Transfer Length of zero indicates that no data shall be transferred. This condition shall not be considered as an error and no data shall be written. Any other value indicates the number of logical blocks that shall be transferred.

This command shall be terminated with a status of RESERVATION CONFLICT if any reservation access conflict (see 8.1.8) exists and no data shall be written.

If any of the following conditions occur, this command shall be terminated with a CHECK CONDITION status and, if extended sense is implemented, the Sense Key shall be set as indicated in the following table. This table does not provide an exhaustive enumeration of all conditions that may cause the CHECK CONDITION status.

CONDITION	SENSE KEY
Invalid Logical Block Address	ILLEGAL REQUEST (see note 1)
Target reset or medium change since the last command from this initiator	UNIT ATTENTION
Overrun or other error that might be resolved by repeating the command	ABORTED COMMAND
Attempt to write a previously written block and blank checking is enabled (see 12.1.3)	BLANK CHECK (see note 2)

NOTES:

1. The extended sense Information Bytes shall be set to the Logical Block Address of the first invalid address.

2. The extended sense Information Bytes shall be set to the Logical Block Address of the first non-blank block encountered.

12.2.3 WRITE AND VERIFY Command (2EH)

Peripheral Device Type: Write-Once Read-Multiple
Operation Code Type: Optional

TABLE 12-16. WRITE AND VERIFY COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	1	0	1	1	1	0
1	Logical Unit Number			0	0	0	BytChk	0
2	Logical Block Address (MSB)							
3	Logical Block Address							
4	Logical Block Address							
5	Logical Block Address (LSB)							
6	0	0	0	0	0	0	0	0
7	Transfer Length (MSB)							
8	Transfer Length (LSB)							
9	0	0	0	0	0	0	Flag	Link

The WRITE AND VERIFY command (Table 12-16) requests that the target write the data transferred from the initiator to the medium and then verify that the data is correctly written.

A Byte Check (BytChk) bit of zero causes the verification to be simply a medium verification (CRC, ECC, etc). A BytChk bit of one causes a byte-by-byte compare of data written to the peripheral device and the data transferred from the initiator. If the compare is unsuccessful, the command shall be terminated with a CHECK CONDITION status and the Sense Key shall be set to MISCOMPARE.

The Logical Block Address specifies the logical block at which the write operation shall begin.

The Transfer Length specifies the number of contiguous logical blocks of data that shall be transferred. A Transfer Length of zero indicates that no logical blocks shall be transferred. This condition shall not be considered as an error and no data shall be written. Any other value indicates the number of logical blocks that shall be transferred.

12.2.4 VERIFY Command (2FH)

Peripheral Device Type: Write-Once Read-Multiple and Read-Only Direct Access
Operation Code Type: Optional

TABLE 12-17. VERIFY COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	1	0	1	1	1	1
1	Logical Unit Number			0	0	BlkVfy	BytChk	0
2	Logical Block Address (MSB)							
3	Logical Block Address							
4	Logical Block Address							
5	Logical Block Address (LSB)							
6	0	0	0	0	0	0	0	0
7	Verification Length (MSB)							
8	Verification Length (LSB)							
9	0	0	0	0	0	0	Flag	Link

The VERIFY command (Table 12-17) requests that the target verify the data on the medium.

A Byte Check (BytChk) bit of zero causes the verification to be simply a medium verification (CRC, ECC, etc). A BytChk bit of one causes a byte-by-byte compare of the data on the medium and the data transferred from the initiator. The data shall be transferred as it would be for a WRITE command. If the compare is unsuccessful, the command shall be terminated with a CHECK CONDITION status and the Sense Key shall be set to MISCOMPARE.

A Blank Verify (BlkVfy) bit of one causes a verification that the blocks are blank.

The Logical Block Address specifies the logical block at which the verify operation shall begin.

The Verification Length specifies the number of contiguous logical blocks of data or blanks that shall be verified. A Verification Length of zero indicates that no logical blocks shall be verified. This condition shall not be considered as an error. Any other value indicates the number of logical blocks that shall be verified.

12.2.5 SEARCH DATA Commands (30H, 31H or 32H)

Peripheral Device Type: Direct Access, Write-Once Read-Multiple, and Read-Only Direct Access
Operation Code Type: Optional

TABLE 12-18. SEARCH DATA COMMANDS

Bit / Byte	7	6	5	4	3	2	1	0
0	0	0	1	1	0	0	X	X
1	Logical Unit Number			Invert	0	0	SpnDat	0
2	Logical Block Address (MSB)							
3	Logical Block Address							
4	Logical Block Address							
5	Logical Block Address (LSB)							
6	0	0	0	0	0	0	0	0
7	Transfer Length (MSB)							
8	Transfer Length (LSB)							
9	0	0	0	0	0	0	Flag	Link

The SEARCH DATA commands (Table 12-18) search one or more logical blocks for equality or inequality to a data pattern. The concept of records within a logical block is used to allow multiple records within a logical block to be searched.

An Invert bit of one indicates that the search condition is to be inverted. See 12.2.5.1 through 12.2.5.3 for a description of the search conditions for the individual SEARCH DATA commands.

A Spanned Data (SpnDat) bit of zero indicates that each record shall be wholly contained within a single block. Any space at the end of a block that is smaller than the record length is ignored by the SEARCH DATA commands. A SpnDat bit of one indicates that records span block boundaries. Thus, a record may start in one block and end in the next or a subsequent block.

A Transfer Length of zero indicates that no data shall be searched. This condition shall be treated the same as an unsatisfied search.

A Link bit of zero indicates a nonlinked command and if the search is satisfied, the command shall be terminated with a CONDITION MET status. A REQUEST SENSE command can then be issued to determine the Logical Block Address and record offset of the matching record. If the search is not satisfied and no error occurs, the command shall be terminated with GOOD status.

A Link bit of one indicates a command is linked to the SEARCH DATA command and if the search is satisfied, CONDITION MET status is returned and the next command is executed. If the RelAdr bit in the next command is one, the logical block address of the next command is used as a displacement from the Logical Block Address at which the search was satisfied. If a linked search is not satisfied, the command is terminated with a CHECK CONDITION status. A REQUEST SENSE command may then be issued.

A REQUEST SENSE command following a satisfied SEARCH DATA command shall:

(1) Return a Sense Key of EQUAL if the search was satisfied by an exact match. If the search was satisfied by an inequality then a Sense Key of NO SENSE shall be returned.

(2) Return the Valid bit set to one.

(3) Return the Logical Block Address of the logical block containing the first matching record in the Information Bytes.

(4) Return the record offset of the matching record in the first four bytes of additional sense bytes.

A REQUEST SENSE command following an unsatisfied SEARCH DATA command shall:

(1) Return a Sense Key of NO SENSE, if no errors occurred during the command execution.

(2) Return the Valid bit set to zero.

The SEARCH DATA parameter list (Table 12-14) contains a fourteen-byte header, followed by one or more search argument descriptors.

TABLE 12-19. SEARCH DATA PARAMETER LIST

Byte	Parameter List Header
0	Logical Record Length (MSB)
1	Logical Record Length
2	Logical Record Length
3	Logical Record Length (LSB)
4	First Record Offset (MSB)
5	First Record Offset
6	First Record Offset
7	First Record Offset (LSB)
8	Number of Records (MSB)
9	Number of Records
10	Number of Records
11	Number of Records (LSB)
12	Search Argument Length (MSB)
13	Search Argument Length (LSB)
	Search Argument Descriptor(s)
0	Displacement (MSB)
1	Displacement
2	Displacement
3	Displacement (LSB)
4	Pattern Length (MSB)
5	Pattern Length (LSB)
6-n	Pattern

The Logical Record Length field specifies the record length in bytes.

The First Record Offset field specifies the number of bytes that shall be ignored in the first logical block before the search begins. The value in the First Record Offset field shall not exceed the length of the logical block. Subsequent logical blocks shall be searched beginning with the first byte in the logical block. This permits one or more records to be skipped initially.

The Number of Records field specifies the maximum number of records that shall be searched by this command. An unsatisfied search shall terminate when the Number of Records or the number of blocks (from the Command Descriptor Block) have been exhausted.

The Search Argument Length specifies the length in bytes of all the Search Argument Descriptors that follow. Since the Pattern Length can vary, there is no fixed multiple of the Search Argument Descriptor to determine the Search Argument Length.

The Search Argument Descriptors specify one or more search conditions to execute within a single record in order to satisfy the search. Each Search Argument Descriptor is made up of a Displacement, a Pattern Length, and a Pattern.

The Displacement field specifies the displacement in bytes of the first byte of the data to be compared from the start of the logical record.

The Pattern Length field specifies the length in bytes of the pattern that follows.

The Pattern specifies the data to compare to the logical record.

12.2.5.1 SEARCH DATA HIGH Command (30H)

The SEARCH DATA HIGH command shall be satisfied by the first logical record searched that contains data that satisfies all of the Search Argument Descriptor(s). If the Invert bit in the Command Descriptor Block is zero, the Search Argument Descriptor(s) shall be satisfied by data in the logical record being greater than the data in the pattern. If the Invert bit is one, the Search Argument Descriptor(s) shall be satisfied by data in the logical record being less than or equal to the data in the pattern. (See 12.2.5).

12.2.5.2 SEARCH DATA EQUAL Command (31H)

The SEARCH DATA EQUAL command shall be satisfied by the first logical record searched that contains data that satisfies all of the Search Argument Descriptor(s). If the Invert bit in the Command Descriptor Block is zero, the Search Argument Descriptor(s) shall be satisfied by data in the logical record being equal to the data in the pattern. If the Invert bit is one, the Search Argument Descriptor(s) shall be satisfied by data in the logical record being not equal to the data in the pattern. (See 12.2.5).

12.2.5.3 SEARCH DATA LOW Command (32H)

The SEARCH DATA LOW command shall be satisfied by the first logical record searched that contains data that satisfies all of the Search Argument Descriptor(s). If the Invert bit in the Command Descriptor Block is zero, the Search Argument Descriptor(s) shall be satisfied by data in the logical record being less than the data in the pattern. If the Invert bit is one, the Search Argument Descriptor(s) shall be satisfied by data in the logical record being greater than or equal to the data in the pattern. (See 12.2.5).

12.2.6 COMPARE Command (39H)

Peripheral Device Type: All
Operation Code Type: Optional

TABLE 12-20. COMPARE COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	1	1	1	0	0	1
1	Logical Unit Number			0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	Parameter List Length (MSB)							
4	Parameter List Length							
5	Parameter List Length (LSB)							
6	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	Flag	Link

The COMPARE command (Table 12-20) provides the means to compare data from one logical unit with another or the same logical unit in a manner similar to the COPY command.

This command functions in the same manner as the COPY command, except that the data from the source is compared on a byte-by-byte basis with the data from the destination. The parameter list transferred to the target is the same as for the COPY command. This parameter list contains the information to identify the logical units involved in the comparison and the length of the comparison. (See 7.1.4 for additional information about the COPY command.)

If the comparison is unsuccessful, the command shall be terminated with a CHECK CONDITION status and the Sense Key shall be set to MISCOMPARE. The remaining fields in the extended sense shall be set as documented in the COPY command.

12.2.7 COPY AND VERIFY Command (3AH)

Peripheral Device Type: All
Operation Code Type: Optional

TABLE 12-21. COPY AND VERIFY COMMAND

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	1	1	1	0	1	0
1	Logical Unit Number			0	0	0	BytChk	0
2	0	0	0	0	0	0	0	0
3	Parameter List Length (MSB)							
4	Parameter List Length							
5	Parameter List Length (LSB)							
6	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	Flag	Link

The COPY AND VERIFY command (Table 12-21) performs the same function as the COPY command, except that a verification of the data written to the destination logical unit is performed after the data is written. The parameter list transferred to the target is the same as for the COPY command. This parameter list contains the information to identify the logical units involved in the copy and the length of the copy. (See 7.1.4 for additional information about the COPY command.)

A Byte Check (BytChk) bit of zero causes the verification to be simply a medium verification (CRC, ECC, etc). A BytChk bit of one causes a byte-by-byte comparison of data written to the destination logical unit and the data read from the source logical unit.

If the comparison is unsuccessful, the command shall be terminated with a CHECK CONDITION status and the Sense Key shall be set to MISCOMPARE. The remaining fields in the extended sense shall be set as documented in the COPY command.

13.0 COMMAND DESCRIPTIONS FOR READ-ONLY DIRECT-ACCESS DEVICES

13.1 Group 0 Commands for Read-Only Direct-Access Devices

The Group 0 commands for read-only direct-access devices shall be as shown in Table 13-1.

TABLE 13-1. GROUP 0 COMMANDS FOR READ-ONLY DIRECT-ACCESS DEVICES

OPERATION CODE	TYPE	COMMAND NAME	SECTION
00H	M	TEST UNIT READY	7.1.1
01H	M	REZERO UNIT	8.1.1
02H	R		
03H	M	REQUEST SENSE	7.1.2
04H	R		
05H	R		
06H	R		
07H	R		
08H	M	READ	12.1.1
09H	R		
0AH	R		
0BH	M	SEEK	8.1.6
0CH	R		
0DH	R		
0EH	R		
0FH	R		
10H	R		
11H	R		
12H	M	INQUIRY	7.1.3
13H	R		
14H	R		
15H	M	MODE SELECT	12.1.3
16H	M	RESERVE	8.1.8
17H	M	RELEASE	8.1.9
18H	M	COPY	7.1.4
19H	R		
1AH	M	MODE SENSE	12.1.4
1BH	O	START/STOP UNIT	8.1.11
1CH	O	RECEIVE DIAGNOSTIC RESULTS	7.1.5
1DH	M	SEND DIAGNOSTIC	7.1.6
1EH	O	PREVENT/ALLOW MEDIUM REMOVAL	8.1.12
1FH	R		

key: (Type definitions are defined in 6.1.2).
M = Command implementation is mandatory.
O = Command implementation is optional.
R = Operation code is reversed for future standardization.

13.2 Group 1 Commands for Read-Only Direct-Access Devices

The Group 1 commands for read-only direct-access devices shall be as shown in Table 13-2.

Table 13-2. GROUP 1 COMMANDS FOR READ-ONLY DIRECT-ACCESS DEVICES

OPERATION CODE	TYPE	COMMAND NAME	SECTION
20H	R		
21H	R		
22H	R		
23H	R		
24H	R		
25H	M	READ CAPACITY	8.2.1
26H	R		
27H	R		
28H	M	READ EXTENDED	12.2.1
29H	R		
2AH	R		
2BH	M	SEEK EXTENDED	8.2.4
2CH	R		
2DH	R		
2EH	R		
2FH	O	VERIFY	12.2.4
30H	O	SEARCH DATA HIGH	12.2.5.1
31H	O	SEARCH DATA EQUAL	12.2.5.2
32H	O	SEARCH DATA LOW	12.2.5.3
33H	R		
34H	R		
35H	R		
36H	R		
37H	R		
38H	R		
39H	O	COMPARE	12.2.6
3AH	O	COPY AND COMPARE	12.2.7
3BH	M	WRITE DATA BUFFER	7.2.3
3CH	M	READ DATA BUFFER	7.2.4
3DH	R		
3EH	R		
3FH	R		

key: (Type definitions are defined in 6.1.2).
M = Command implementation is mandatory.
O = Command implementation is optional.
R = Operation code is reversed for future standardization.

14.0 STATUS

A status byte shall be sent from the target to the initiator during the STATUS phase at the termination of each command as specified in Tables 14-1 and 14-2 unless the command is cleared by an ABORT message, by a BUS DEVICE RESET message, by a "hard" RESET condition, or by a catastrophic reset condition.

TABLE 14-1. STATUS BYTE

BIT / BYTE	7	6	5	4	3	2	1	0
0	0	0	0	Status Byte Code				0

TABLE 14-2. STATUS BYTE CODE BIT VALUES

Bits of Status Byte								
7	6	5	4	3	2	1	0	Status(es) Represented
R	0	0	0	0	0	0	0	GOOD
R	0	0	0	0	0	1	0	CHECK CONDITION
R	0	0	0	0	1	0	0	CONDITION MET/GOOD
R	0	0	0	0	1	1	0	Reserved
R	0	0	0	1	0	0	0	BUSY
R	0	0	0	1	0	1	0	Reserved
R	0	0	0	1	1	0	0	Reserved
R	0	0	0	1	1	1	0	Reserved
R	0	0	1	0	0	0	0	INTERMEDIATE/GOOD
R	0	0	1	0	0	1	0	Reserved
R	0	0	1	0	1	0	0	INTERMEDIATE/CONDITION MET/GOOD
R	0	0	1	0	1	1	0	Reserved
R	0	0	1	1	0	0	0	RESERVATION CONFLICT
R	0	0	1	1	0	1	0	Reserved
R	0	0	1	1	1	0	0	Reserved
R	0	0	1	1	1	1	0	Reserved

Key: R - Reserved bit (always zero).

A description of the status byte codes is given below:

GOOD - This status indicates that the target has successfully completed the command.

CHECK CONDITION - Any error, exception, or abnormal condition that causes sense data to be set, shall cause a CHECK CONDITION status. The REQUEST SENSE command should be issued following a CHECK CONDITION status, to determine the nature of the condition.

CONDITION MET - The SEARCH DATA commands shall return this status whenever a search condition is satisfied. This status does not break a chain of linked commands. The logical block address of the logical block that satisfies the search may be determined with a REQUEST SENSE command.

BUSY - The target is busy. This status shall be sent whenever a target is unable to accept a command from an initiator. The normal initiator recovery action is to issue the command again at a later time.

INTERMEDIATE - This status shall be returned for every command in a series of linked commands (except the last command), unless an error, exception, or abnormal condition causes a CHECK CONDITION status or a RESERVATION CONFLICT status to be set. If this status is not returned, the chain of linked commands is broken; no further commands in the series are executed.

RESERVATION CONFLICT - This status shall be returned whenever an SCSI device attempts to access a logical unit or an extent within a logical unit that is reserved for that type of access to another SCSI device.

APPENDIX A

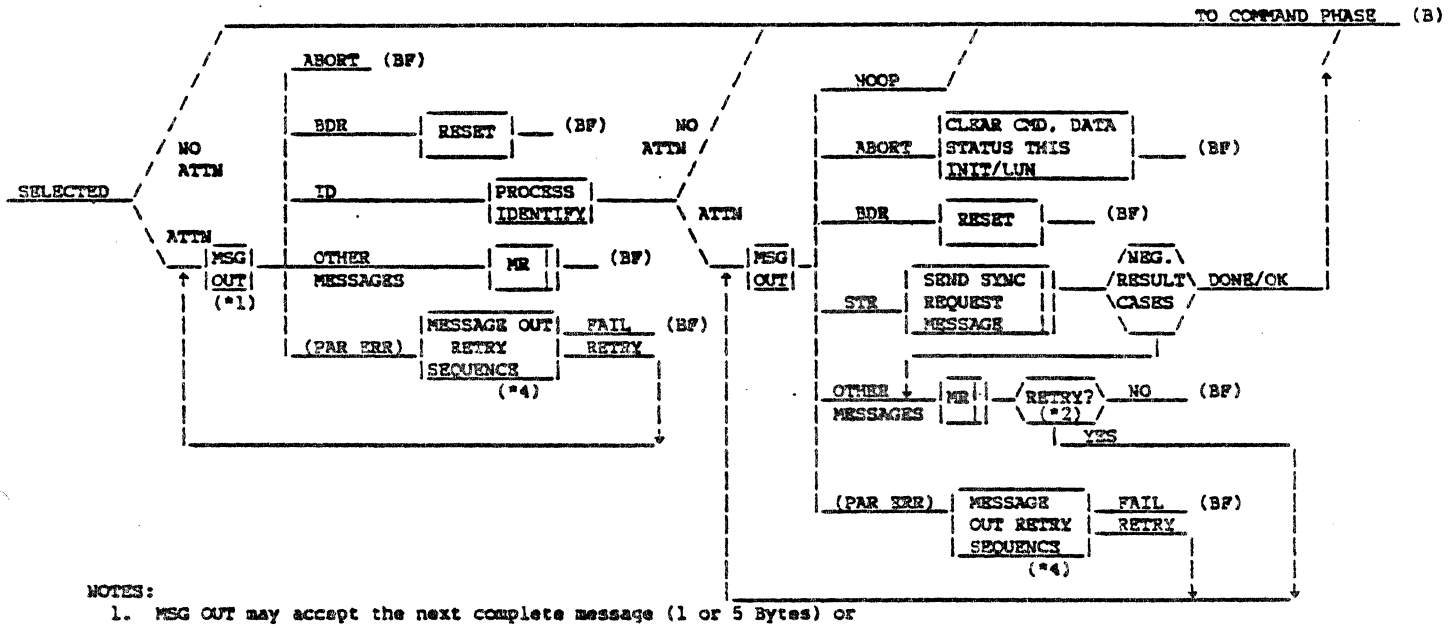
SCSI PROTOCOL ERROR HANDLING FLOW CHARTS

Glossary of Flowchart Abbreviations

ATTN	-	ATTENTION signal on SCSI bus
BDR	-	BUS DEVICE RESET message
BF	-	BUS FREE phase
CMD	-	Command
DISCON	-	DISCONNECT message
ERR CD	-	Error Code in Request Sense byte 12
HDWE ERR	-	HARDWARE ERROR Sense Key
ID	-	IDENTIFY message
IDE	-	INITIATOR DETECTED ERROR message
LUN	-	Logical Unit Number
MPE	-	MESSAGE PARITY ERROR message
MR	-	MESSAGE REJECT message
MSG	-	Message
NOOP	-	NO OPERATION message
PAR ERR	-	Parity Error was detected during MESSAGE OUT phase
RES	-	Any Reserved or unimplemented message code (extended or non-extended)
RP	-	RESET POINTERS message
SDP	-	SAVE DATA POINTER message
STR	-	SYNCHRONOUS DATA TRANSFER RREQUEST message
U.A.	-	Unit Attention condition

3127-1 0221D

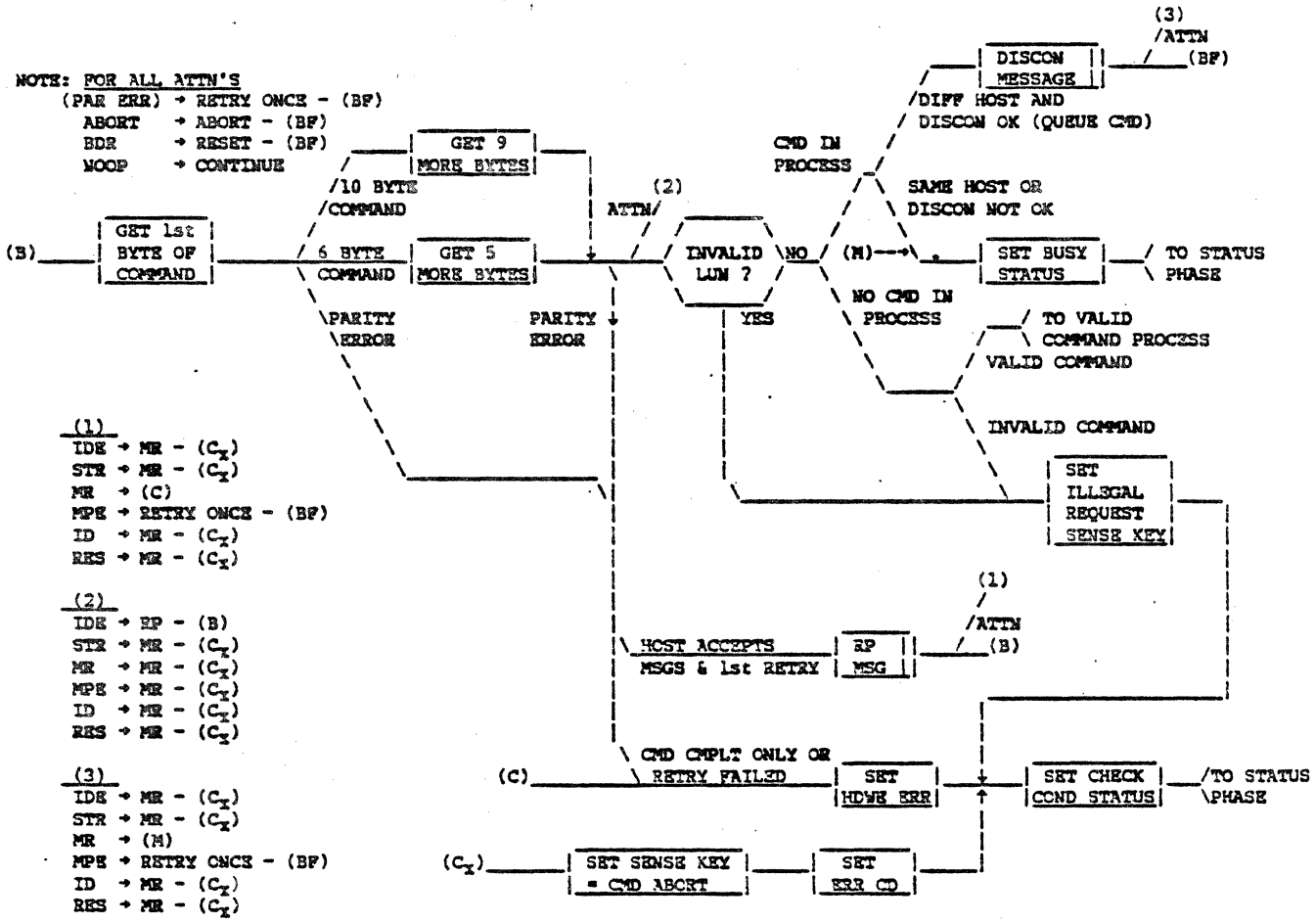
FLOWCHART 1. SELECTION MESSAGES



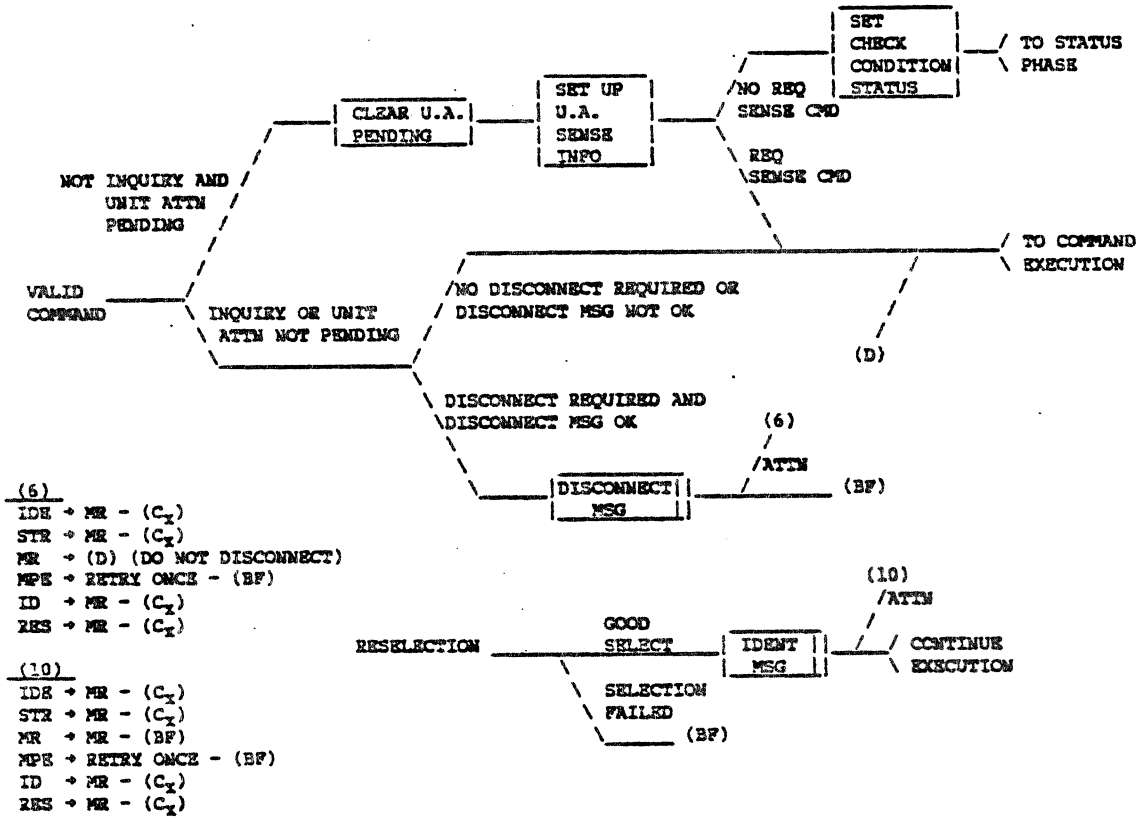
NOTES:

1. MSG OUT may accept the next complete message (1 or 5 Bytes) or may accept and buffer all message bytes available while ATN is asserted.
2. Retry is optional in these cases. If messages are buffered; discard.
3. The MSG OUT retry sequence will insure that any buffered messages are diccarded and that ATTN is false.
4. Indicates a transmission to the Host.

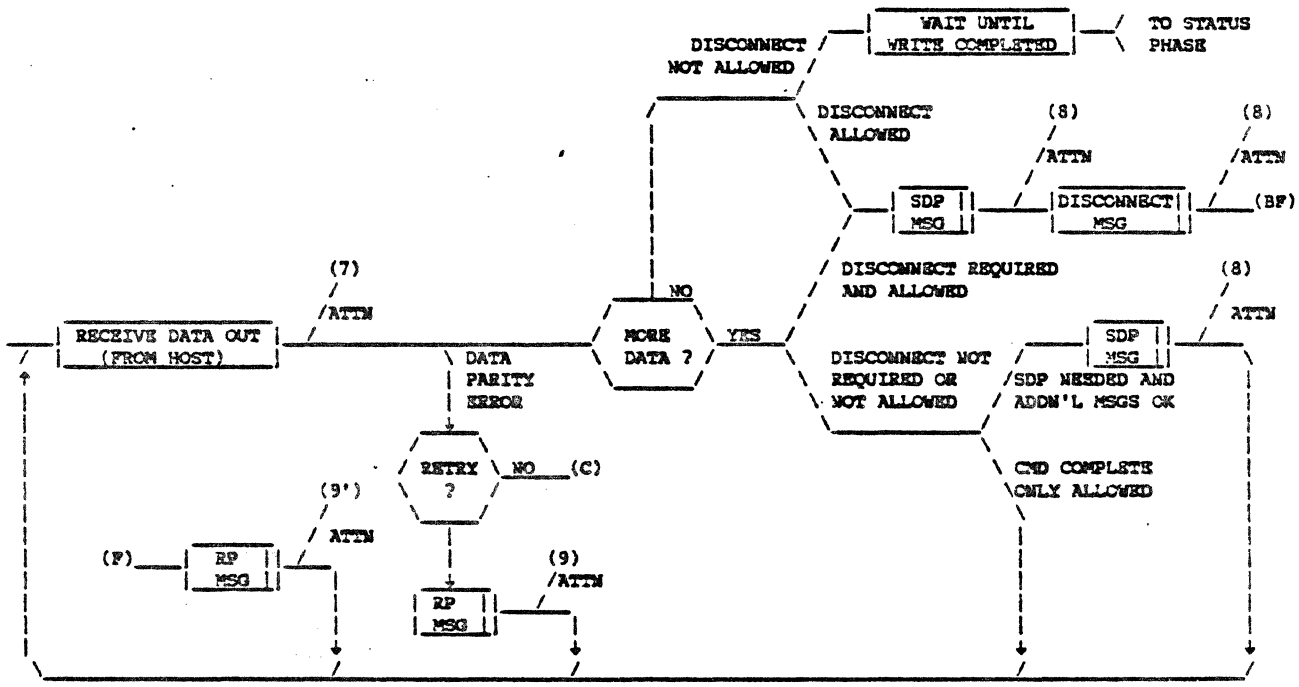
FLOWCHART 2. COMMAND PHASE



FLOWCHART 3. VALID COMMAND PROCESS



FLOWCHART 4. DATA OUT PHASE

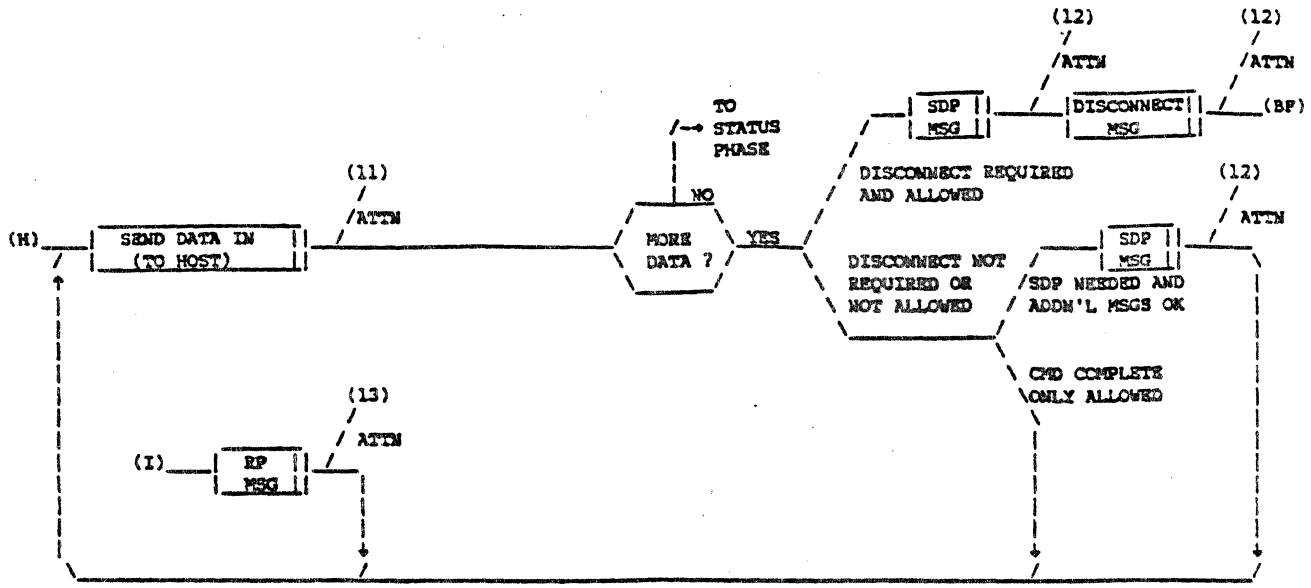


(7)
IDE → (F)
STR → MR - (C_X)
MR → MR - (C_X)
MPE → MR - (C_X)
ID → MR - (C_X)
RES → MR - (C_X)

(9 & 9')
IDE → MR - (C_X)
STR → MR - (C_X)
MR → (C_X) OR (C_X')
MPE → RETRY ONCE - (BF)
ID → MR - (C_X)
RES → MR - (C_X)

(8)
IDE → MR - (C_X)
STR → MR - (C_X)
MR → CONTINUE
MPE → RETRY ONCE - (BF)
ID → MR - (C_X)
RES → MR - (C_X)

FLOWCHART 5. DATA IN PHASE

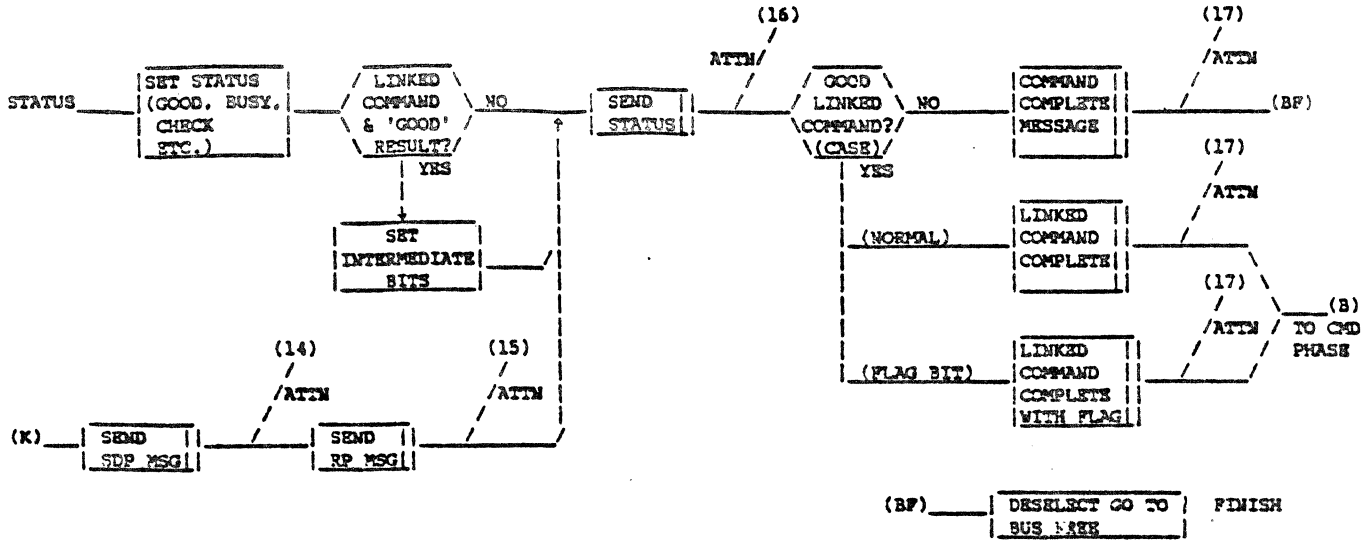


(11)
IDE → (I)
STR → MR - (C_X)
MR → MR - (C_X)
MPE → MR - (C_X)
ID → MR - (C_X)
RES → MR - (C_X)

(13)
IDE → MR - (C_X)
STR → MR - (C_X)
MR → (C_X)
MPE → RETRY ONCE - (BF)
ID → MR - (C_X)
RES → MR - (C_X)

(12)
IDE → MR - (C_X)
STR → MR - (C_X)
MR → (H)
MPE → RETRY ONCE - (BF)
ID → MR - (C_X)
RES → MR - (C_X)

FLOWCHART 6. STATUS PHASE



(14)
IDE → MR - CONTINUE
STR → MR - CONTINUE
MR → CONTINUE
MPE → RETRY ONCE - (BF)
ID → MR - CONTINUE
RES → MR - CONTINUE

(15)
IDE → MR - CONTINUE
STR → MR - CONTINUE
MR → CONTINUE
MPE → RETRY ONCE - (BF)
ID → MR - CONTINUE
RES → MR - CONTINUE

(16)
IDE → (K) IF 1ST TRY
STR → MR - CONTINUE
MR → CONTINUE
MPE → MR - CONTINUE
ID → MR - CONTINUE
RES → MR - CONTINUE

(17)
IDE → MR - (BF)
STR → MR - (BF)
MR → (BF)
MPE → RETRY ONCE - (BF)
ID → MR - (BF)
RES → MR - (BF)