Seagate

ST3655 Family:

ST3285N, ST3390N

ST3550N, ST3655N

SCSI Interface Drives

Product Manual

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1.0 Specifications summary

1.1 Formatted capacity

The capacities specified here do not include spare sectors and cylinders. The media contains one spare sector per cylinder and two spare cylinders per drive. You can change this allocation using the Format Device page (03_H) discussed in Appendix C.3.

	ST3285N	**ST3390N**
Formatted capacity (Mbytes*)	248.62	344.31
Bytes per sector	512	512
Total sectors	485,601	672,480

	ST3550N	**ST3655N**
Formatted capacity (Mbytes*)	456.48	545.29
Bytes per sector	512	512
Total sectors	891,574	1,065,036

***** One megabyte equals one million bytes.

1.2 Physical geometry

	ST3285N	**ST3390N**
Discs	2	2
Servo heads	1	1
Read/write heads	3	3
Cylinders	1,777	2,676

	ST3550N	**ST3655N**
Discs	3	3
Servo heads	1	1
Read/write heads	5	5
Cylinders	2,126	2,493

1.3 Functional specifications

Interface	Fast SCSI-2
Zone Bit Recording method	RLL (1,7)
External data transfer rate (Mbytes per sec, avg)	5.0 asynchronous 10.0 synchronous
Internal data transfer rate (Mbits per sec)	21.6 to 36.56
Spindle speed (RPM)	4,500 ± 0.5%
Multisegmented cache (Kbytes)	256
Track density (TPI)	3,000*
Recording density (BPI, max)	52,602

***** The track density of the ST3550N is 2,400 tracks per inch.

1.4 Physical dimensions

Height (max)	1.00 inch (25.4 mm)
Width (max)	4.02 inches (102.1 mm)
Depth (max)	5.77 inches (146.6 mm)
Weight (max)	1.5 lb (0.68 Kg)

1.5 Reliability

Read error rates are measured with automatic retries and data correction with ECC enabled and all flaws reallocated. MTBF is measured at nominal power at sea level and 40°C ambient temperature.

Nonrecoverable read errors	1 per 10^{13} bits transferred
Seek errors	1 per 10^{7} physical seeks
MTBF	250,000 power-on hours
Service life	5 years

1.6 Acoustics

Sound pressure is measured at idle from 1 meter above the drive top cover.

Sound pressure, typ	34 dBA
Sound pressure, max	38 dBA

1.7 Seek time

All seek time measurements are under nominal conditions of temperature and voltage with the drive mounted horizontally. In the table below:

- *Track-to-track* seek time is the average of all possible single-track seeks in both directions.
- *Average* seek time is a true statistical random average of at least 5,000 measurements of seeks in both directions between random cylinders, less overhead.
- *Full-stroke* seek time is one-half the time needed to seek from logical block address zero (LBA 0) to the maximum LBA and back to LBA 0.

Track-to-track seek time	Average seek time	Full-stroke seek time	Average latency
3.5 msec typ 4.0 msec max	12.0 msec typ 14.0 msec max	30.0 msec typ 32.0 msec max	6.67 msec

Note. Host overhead varies between systems and cannot be specified. Drive internal overhead is measured by issuing a no-motion seek. Drive overhead is typically less than 1.0 msec.

1.7.1 Read look-ahead and caching

The drive uses algorithms that improve seek performance by storing data in a buffer and processing it at a more convenient time. Three methods are employed: read look-ahead, read caching and write caching. These are described in Appendix C.5.

1.7.2 Thermal compensation

The thermal compensation feature compensates for position offset of the selected head due to variations in temperature. The drive automatically performs thermal compensation during startup and every 2 minutes thereafter.

You can pre-empt the automatic compensation by issuing a Rezero Unit command (01_H). The drive performs the thermal calibration and then sets a timer and waits 2 minutes before performing the calibration again.

Thermal compensation increases the execution time of the command during which it is performed by 100 msec (typ) to 350 msec (max).

1.8 Environmental

This section specifies acceptable environmental conditions for the drive. The operating specifications assume that the drive is powered up. The nonoperating specifications assume that the drive is packaged as it was shipped from the factory.

1.8.1 Ambient temperature

Operating	5°C to 55°C (41°F to 131°F)
Nonoperating	–40°C to 70°C (–40°F to 158°F)

1.8.2 Temperature gradient

Operating	20°C per hour (36°F per hour)
Nonoperating	30°C per hour (54°F per hour)

1.8.3 Relative humidity

Operating	8% to 80% noncondensing Maximum wet bulb 26°C (79°F)
Operating gradient, max	10% per hour
Nonoperating	5% to 95% noncondensing Maximum wet bulb 26°C (79°F)

1.8.4 Altitude

Operating	–1,000 ft to 10,000 ft (–305 m to 3,048 m)
Nonoperating	–1,000 ft to 40,000 ft (–305 m to 12,192 m)

1.9 Shock and vibration

All shock and vibration specifications assume that the drive is mounted in a recommended mounting configuration, as shown in Figure 9 on page 29. Inputs are measured at the drive mounting screws. Shock measurements are based on an 11 msec, half sine wave shock pulse, not to be repeated more than twice per second.

	Operating	**Nonoperating**
Shock	2 Gs	75 Gs
5–22 Hz vibration	0.020-inch displacement	0.020-inch displacement
22–500 Hz vibration	0.50 Gs	4.00 Gs

During operating shock and vibration, there is no physical damage to the drive or performance degradation. During nonoperating shock and vibration, the read/write heads are positioned in the shipping zone.

1.10 Start and stop time

If the motor start option is disabled, the drive becomes ready within 20 seconds after power is applied. If the motor start option is enabled, the drive becomes ready within 20 seconds after it receives the Motor Start command. The drive stops within 15 seconds, whether the drive is commanded to spin down or power is removed.

1.10.1 Power-up sequence

The following typical power-up sequence is provided to assist in evaluating drive performance. This information does not constitute a specification or a performance guarantee.

1. Power is applied to the disc drive.

2. When power is applied, the LED is on for about 5 seconds. Either of following two sequences can occur, depending on whether a jumper is installed on pins 3 and 4 of the options jumper block shown in Figure 7 on page 25.

   a. If a jumper is not installed on pins 3 and 4 of the options jumper block, the remote start option is not enabled. The drive begins to spin up as soon as power is applied.

b. If a jumper is installed on pins 3 and 4 of the options jumper block, the remote start option is enabled. The drive begins to spin up when the host commands the motor to start.

3. Within 250 msec after power is applied, the drive responds to the Test Unit Ready, Request Sense and Inquiry commands.

4. The drive begins to lock in speed control circuits.

5. The actuator-lock solenoid releases the actuator, producing an audible sound.

6. The spindle motor reaches operating speed in about 5 seconds. After 5 seconds, there are no speed variations.

7. The drive performs velocity adjustment seeks.

8. The drive loads RAM code from the disc. During RAM code loading, the LED flashes for approximately 1 second.

9. The drive seeks track 0 and becomes ready.

1.10.2 Power-down sequence

The following typical power-down sequence is provided to assist in evaluating drive performance. This information does not constitute a specification or a performance guarantee.

1. The power cable is unplugged from the drive, or the drive is commanded to spin down.

2. Within 3 seconds after the motor begins to spin down, the actuator lock engages, producing an audible sound.

3. The spindle stops within 15 seconds, whether the power cable is unplugged from the drive or the drive receives the power-down command.

1.10.3 Auto-park

Upon power-down, the read/write heads automatically move to the shipping zone. The heads park inside the maximum data cylinder. When power is applied, the heads recalibrate to track 0.

Caution. Do not move the drive until the spindle motor has come to a complete stop, otherwise you may damage the drive.

1.11 DC power

Except during the write procedure, you can apply power to the drive or remove power from the drive in any sequence without losing data or damaging the drive. If you remove the power from the drive during the write procedure, you may lose the data currently being written.

1.11.1 Input noise

	+5V	**+12V**
Voltage tolerance (including noise)	± 5%	± 5%
Input noise frequency (max)	25 MHz	25 MHz
Input noise (max, peak-to-peak)	100 mV	240 mV

1.11.2 Power management

The drive supports power-management modes that reduce its overall power consumption. The drive automatically changes from one mode to another based in response to interface activity. You do not need to change any parameters or send any special commands to make the drive change modes. The power-management modes are described below.

- **Spinup.** The spindle is coming up to operating speed. The power consumed in this mode is equivalent to the average power during the first 10 seconds after the drive begins to spin up. Refer to the startup current chart in Figure 1 on page 9 for a typical representation of power consumption during spinup.
- **Seeking.** The servo electronics are active and the read/write heads are moving to a specific location on the disc. The read/write electronics are powered-down. The power consumed in this mode is equivalent to the average power measured while executing random seeks with a 2-revolution (26.6 msec) dwell between seeks. The drive enters this mode from the Idle mode.
- **Read/write.** The drive is reading or writing. All electronics are active and the read/write heads are on track. The drive enters this mode from the Idle mode.

- **Idle.** The drive spindle motor is up to speed and the servo electronics are active. The heads are on track, ready to accept and execute any command without delay. The read/write electronics are powered down. The drive can enter this mode from any other mode (except the Standby mode).
- **Standby.** This mode is not implemented.

1.11.3 Power consumption

In the table below, the measurements are made at the drive power connector with an RMS DC ammeter. The terminating resistor packs are removed and terminator power is supplied through the SCSI connector. All values are measured 10 minutes after the drive spins up.

	Spinup	Seeking	Read/ Write	Idle
Current at +12V				
Amps peak	1.90	—	—	—
RMS amps typ	—	0.408	0.241	0.208
Watts typ	—	4.90	2.9	2.5
Current at +5V				
RMS amps typ	—	0.16	0.470	0.1
Watts typ	—	0.8	2.35	0.5
Power				
Total watts typ	7.00	5.70	5.25	3.0

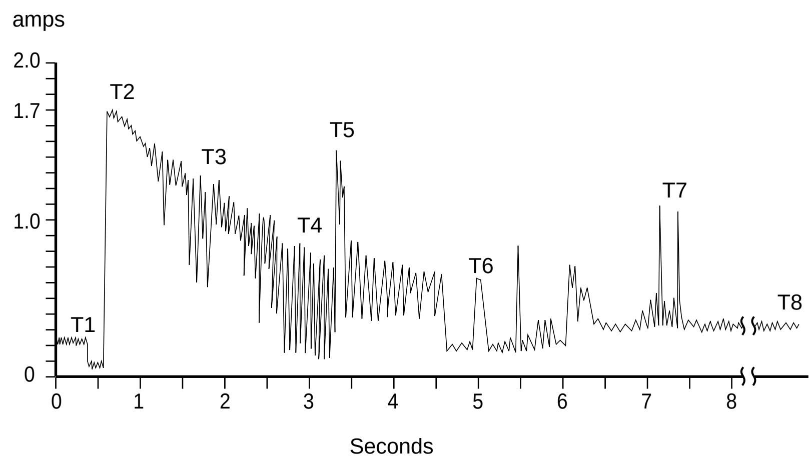


Figure 1. Typical startup current profile

T1	Voltage is applied to the drive.
T2	After a delay, the startup current is applied and the spindle begins to turn.
T3	The accelerating current is applied, causing the spindle speed to increase.
T4	The spindle speed is close to the final, correct value. The drive begins to lock in speed-control circuits.
T5	The actuator-lock solenoid releases the arm.
T6	The final speed-control lock is achieved.
T7	The servo is calibrated.
T8	The servo locks in on track 0 and the drive is ready.

1.12 Agency listings

This drive is listed by agencies as follows:

- Recognized in accordance with UL 478 and UL 1950
- Certified to CSA C22.2 No. 220-M1986 and CSA C22.2 No. 950
- Certified to VDE 0805/05.90 and EN 60950/1.88 as tested by VDE

1.13 FCC verification

ST3655 family drives are intended to be contained solely within a personal computer or similar enclosure (not attached to an external device). As such, a drive is considered to be a subassembly even when individually marketed to the customer. As a subassembly, no Federal Communications Commission authorization, verification or certification of the device is required.

Seagate Technology, Inc. has tested these drives in an enclosure as described above to ensure that the total assembly (enclosure, disc drive, motherboard, power supply, etc.) does comply with the limits for a Class B computing device, pursuant to Subpart J of Part 15 of the FCC rules. Operation with noncertified assemblies is likely to result in interference to radio and television reception.

Radio and television interference. This equipment generates and uses radio frequency energy and, if not installed and used in strict accordance with the manufacturer's instructions, may cause interference to radio and television reception.

This equipment is designed to provide reasonable protection against such interference in a residential installation. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause interference to radio or television, which can be determined by turning the equipment on and off, you are encouraged to try one or more of the following corrective measures:

- Reorient the receiving antenna.
- Move the device to one side or the other of the radio or TV.
- Move the device farther away from the radio or TV.
- Plug the equipment into a different outlet so that the receiver and computer are on different branch outlets.

If necessary, you should consult your dealer or an experienced radio/television technician for additional suggestions. You may find helpful the following booklet prepared by the Federal Communications Commission: *How to Identify and Resolve Radio-Television Interference Problems.* This booklet is available from the Superintendent of Documents, US Government Printing Office, Washington, DC 20402. Refer to publication number 004-000-00345-4.

Note. This digital apparatus does not exceed the Class B limits for radio noise emissions from computer equipment as set out in the radio interference regulations of the Canadian Department of communications.

Le présent appareil numérique n′émet pas de bruits radioélectriques dépassant les limites applicables aux appareils numériques de Classe B prescrites dans le règlement sur le brouillage radioélectrique édicté par le Ministère des Communications du Canada.

Sicherheitsanleitung

1. Das Gerrät ist ein Einbaugerät, das für eine maximale Umegebungstemperatur von 55°C vorgesehen ist.

2. Zur Befestigung des Laufwerks werden 3 Schrauben 6-32 UNC-2A benötigt. Bei seitlicher Befestigung darf die maximale Länge der Schrauben im Chassis nicht mehr als 3,3 mm und bei Befestigung an der Unterseite nicht mehr als 5,08 mm betragen.

3. Als Versorgungsspannugen werden benötigt:
+5V ± 5% 0,5A
+12V ± 5% 0,5A (1,9A fur ca. 30 Sek. fur ± 10%)

4. Die Versorgungsspannung muβ SELV entsprechen.

5. Alle Arbeiten dürfen nur von ausgebildetem Servicepersonal durchgeführt werden.

6. Der Einbaudes Drives muβ den Anforderungen gemäβ DIN IEC 950V DC 0805/05.90 entsprechen.

2.0 Hardware and interface

The SCSI-2 interface consists of a 9-bit bidirectional bus (8 data bits and 1 parity bit) plus 9 control signals supporting multiple initiators, disconnect and reconnect, and self-configuring host software. Logical block addressing is used.

The physical interface consists of single-ended drivers and receivers using asynchronous or synchronous communication protocols that support cable lengths of up to 6 meters (3 meters for Fast SCSI) and a bus interface transfer rate up to 5 Mbytes per second asynchronous and 10.0 Mbytes per second synchronous. The bus protocol supports multiple initiators, disconnect and reconnect, additional messages, and 6-byte and 10-byte command descriptor blocks.

2.1 SCSI-2 compatibility

The drive interface is described in the *Seagate Wren SCSI-2 Interface Product Manual*, publication number 77765466. The drive complies with the mandatory subset of the ANSI SCSI-2 interface. The Fast SCSI-2 interface is based on the ANSI Small Computer System Interface-2 (SCSI-2): document number ANSI X3.131-199*x* (X3T9.2/86-109 Rev. 10h).

2.2 Handling and static-discharge precautions

After you unpack the drive, and before you install it in a system, be careful not to damage it through mishandling. Observe the following standard handling and static-discharge precautions:

Caution:

- Keep the drive in its static-shielded bag until you are ready to complete the installation. Do not attach any cables to the drive while it is in its static-shielded bag.
- Before handling the drive, put on a grounded wrist strap, or ground yourself frequently by touching the metal chassis of a computer that is plugged into a grounded outlet. Wear a grounded wrist strap throughout the entire installation procedure.
- Handle the drive by its edges or frame only.
- The drive is extremely fragile—handle it with care. Do not press down on the drive top cover.
- Always rest the drive on a padded, antistatic surface until you mount it in the host system.

- Do not touch the connector pins or the printed circuit board. Do not touch the printed circuit cable between the circuit board and the head/disc assembly.
- Avoid wool or synthetic clothing, carpeting, plastics and Styrofoam; these items cause static discharge.
- Do not remove the factory-installed labels from the drive or cover them with additional labels. If you do, you may void the warranty. Some factory-installed labels contain information needed to service the drive. Others are used to seal out dirt and contamination.

2.3 Hot-plugging

If there is more than one SCSI device daisy-chained on the bus, you can connect and disconnect the drive I/O and power connector if the following conditions are met:

- The drive you are disconnecting (or connecting) is not the device supplying terminator power or terminating resistance to the bus.
- During hot-plugging, do not add or remove terminator power or resistors from the bus.
- During hot-plugging, do not use the bus for I/O transactions. If you are installing a drive on the bus, there must be no I/O transactions until the drive is connected and ready. If you are removing a drive from the bus, there must be no I/O transactions until the drive is completely disconnected.

To avoid damage to the disc and head, the spindle must be completely stopped and the heads must be parked before you remove the drive from the system. There are two ways to stop the spindle and park the heads:

- If the drive is not configured to use the remote start/stop feature, disconnect the DC power cable from the drive DC power connector and wait 30 seconds.
- If the drive is configured to use the remote start/stop feature, issue the SCSI stop command and wait 30 seconds.

2.4 SCSI connector

You can daisy-chain the drive with a maximum of seven other SCSI devices (including the host) that have single-ended drivers and receivers using a common cable. SCSI ID 7, by convention, is usually used for the host adapter. No drive can have the same SCSI ID as the host adapter.

All signals are common between all SCSI devices. The SCSI devices at both ends of the daisy-chain must be terminated; the intermediate SCSI devices should not be terminated.

The 50-conductor, nonshielded mating cable connector consists of two rows of 25 female contacts with adjacent contacts 0.100 inches apart. The recommended mating cable connector part numbers are shown in the table below. The mating cable is shown in Figure 2 on page 16.

The following table shows 3M™ connector part numbers for interface cable connectors compatible with the drive. These connectors do not have a center key; they are available with or without a strain relief.

	No strain relief No center key	**With strain relief No center key**
Closed end (for cable ends)	3M 3425-7000	3M 3425-7050
Open end (for daisy-chain)	3M 3425-6000	3M 3425-6050

The following table shows Molex™ connector part numbers for connectors that have a center key.

Closed end (for cable ends)	Molex 39-51-2504
Open end (for daisy-chain)	Molex 39-51-2501

Two strain reliefs, shown in the following table, are available for the connectors referred to in the previous table.

Molex strain relief, preferred version in Europe	Molex 90170-0050
Molex strain relief, preferred version in Japan	Molex 15-25-1503

In Figure 2, units are shown in inches (mm).

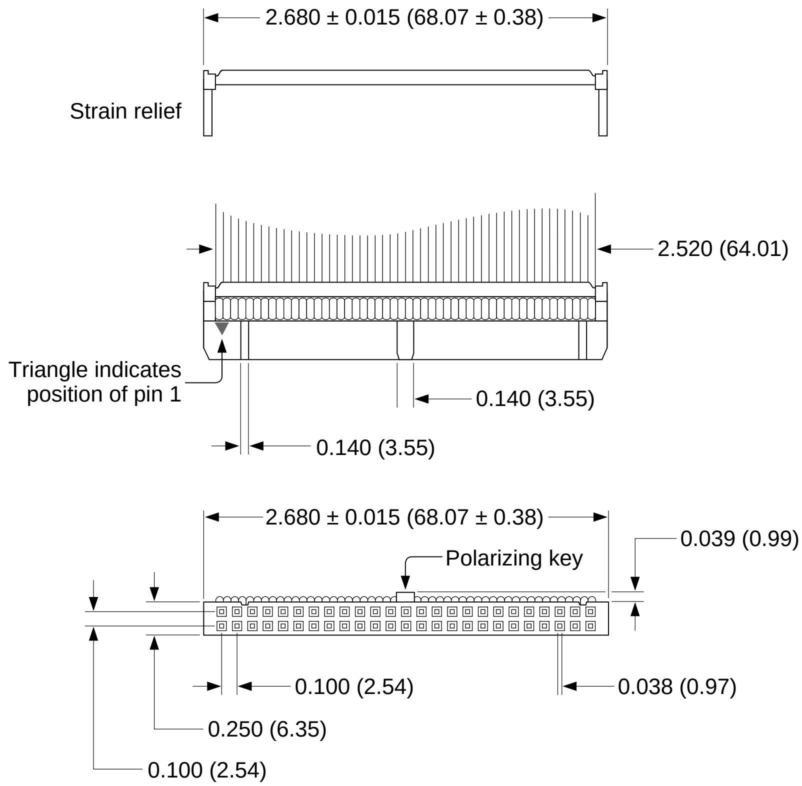


Figure 2. SCSI cable connector

The drive connector is a nonshielded, 50-pin connector consisting of two rows of 25 pins with adjacent pins 0.100 inches apart. The connector is keyed with a slot. The connector is shown in Figure 3.

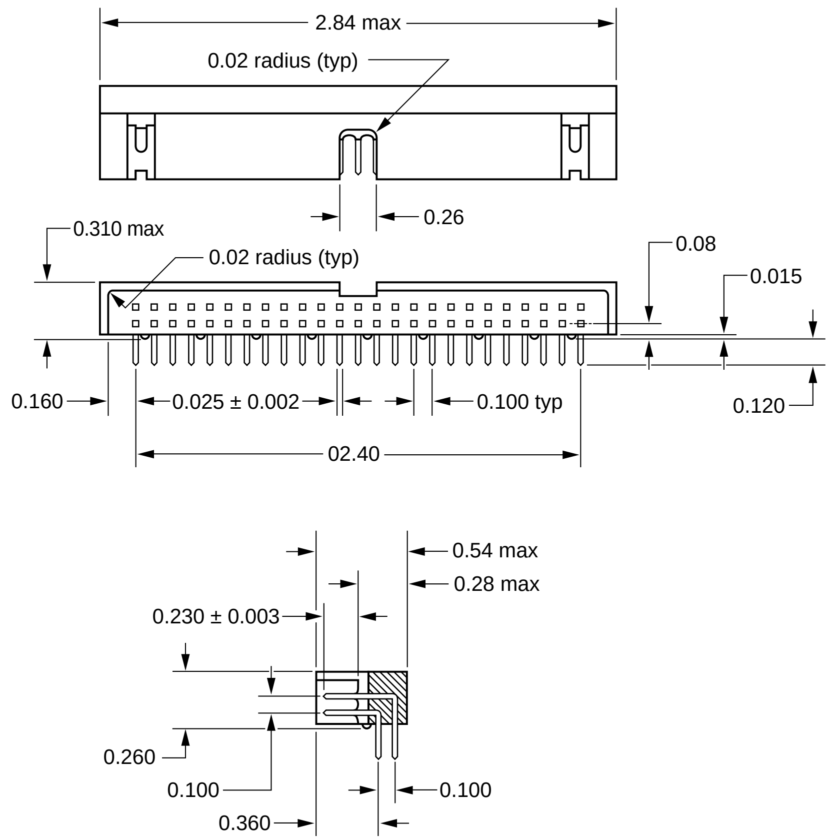


Figure 3. Drive connector

2.4.1 SCSI connector pin assignments

In the table below, a minus sign indicates active low.

Signal name	Signal pin number	Ground pin number
DB(0)–	2	1
DB(1)–	4	3
DB(2)–	6	5
DB(3)–	8	7
DB(4)–	10	9
DB(5)–	12	11
DB(6)–	14	13
DB(7)–	16	15
DB(P)–	18	17
Ground	19–22	—
Reserved	23–25	—
Terminator power	26	—
Reserved	27–28	—
Ground	29–30	—
ATN–	32	31
Ground	33–34	—
BSY–	36	35
ACK–	38	37
RST–	40	39
MSG–	42	41
SEL–	44	43
C/D–	46	45
REQ–	48	47
I/O–	50	49

Caution. Do not connect pin 25 to ground. If you plug in the connector upside down, the terminator power on pin 26 is shorted to ground. This can damage the drive.

2.5 Cable requirements

The characteristic impedance of the cable should be between 90 ohms and 140 ohms. However, most available cables have a somewhat lower characteristic impedance. To minimize discontinuities and signal reflections, do not use cables of different impedances in the bus.

Your design may require trade-offs in shielding effectiveness, the length of the interface cable, the number of loads, and the transfer rates. If your design uses both shielded and nonshielded cables within the same SCSI bus, you must allow for the effects of impedance mismatch.

To minimize noise effects, use a minimum conductor size of 28 AWG. Use only nonshielded cable connectors. Use a 50-conductor flat cable or 25-conductor twisted-pair cable. The recommended nonshielded flat cable part numbers are shown in the following table:

Part	Manufacturer
Flat Cable	3M-3365-50
Twisted Pair	Spectra Twist-N-Flat 455-248-50

2.6 Single-ended cable

The single-ended SCSI cable must meet the following requirements:

- The cable cannot be longer than 6.0 meters.
- A cable stub cannot be longer than 0.1 meter, from the mainline interconnection to any device. Stubs must be separated by at least 0.3 meter.

2.6.1 Fast synchronous data transfer

When using fast synchronous data transfer rates, the SCSI interface cable must meet the following additional requirements:

- The cable cannot be longer than 3.0 meters.
- A characteristic impedance of 90 ohms to 132 ohms is recommended for nonshielded flat cable or twisted-pair ribbon cable.
- The signal attenuation at 5 MHz must not be greater than 0.095 dB per meter.
- The DC resistance at 20°C must not exceed 0.230 ohms per meter.
- The propagation delay delta of a shielded, twisted-pair cable must not exceed 20 nsec per meter.

2.7 DC power connector

The drive is equipped with a 4-pin power connector as shown in Figure 7 on page 25.

2.8 Terminators

The interface is terminated with three SIP resistor modules that plug into sockets on the printed circuit board. You can order the drive in the active (default) or passive configuration, or without terminators, depending on your application. For terminator jumper configurations, see Section 2.9. When installing or removing terminators, follow these guidelines:

- If you are installing only one drive, and your system contains only one initiator (for example, a stand-alone host computer) leave the terminators installed on the drive.
- If you are installing multiple drives in a daisy-chain configuration, remove the terminators from all drives except the drives (or initiators) connected to the ends of the cable.
- If your application requires no terminators, remove the terminators from the drive circuit board. Removing the terminator power source selection jumper does not disconnect the terminator resistors from the circuit.
- If you use Fast SCSI transfer rates, you must use the active termination options. See Sections 2.8.1 and 2.9.5. If the transfer rate is 5.0 Mbytes per second or less, you can use either method of termination.

2.8.1 Active termination

All interface signals are single-ended and must be terminated at the drive with a 110-ohm resistor to +2.85V. This is the default. The Seagate® part number for the 110-ohm terminator is 502155-001.

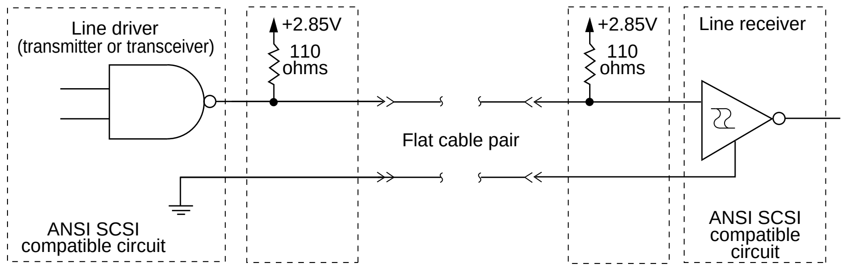


Figure 4. Active termination

2.8.2 Passive termination

All interface signals with the drive are single-ended and must be terminated with 220 ohms to +5V and 330 ohms to ground at each end of the cable. All signals use open-collector drivers or three-state drivers. The Seagate part number for the 220/330-ohm terminator is 75916526-9.

Single-ended SCSI devices providing termination power have the following characteristics:

Terminator voltage (V)	4.0 to 5.25
Source drive capability (mA, min)	800

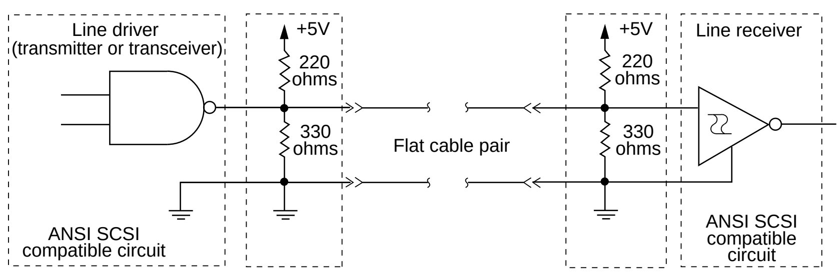


Figure 5. Passive termination

2.8.2.1 Single-ended drivers and receivers

The drive uses single-ended drivers and receivers. Schematic representations of the removable terminator resistor packs are shown in Figure 4 on page 21 and Figure 5 on page 21.

- **Transmitter characteristics.** The drive uses an ANSI SCSI-compatible, open-collector, single-ended driver. This driver is capable of sinking a current of 48 mA with a low-level output voltage of 0.4 volts.
- **Receiver characteristics.** The drive uses an ANSI SCSI single-ended receiver with hysteresis gate or equivalent as a line receiver.

The loss in the cable is defined as the difference between the voltages of the input and output signals, as shown below:

Logic level	Driver output (x)	Receiver input (x)
Asserted (1)	$0.0V \leq x \leq 0.4V$	$0.0V \leq x \leq 0.8V$
Negated (0)	$2.5V \leq x \leq 5.25V$	$2.0V \leq x \leq 5.25V$

2.9 Jumper configurations

The jumper blocks are shown in Figure 6 on page 24 and Figure 7 on page 25. The jumper applications and part numbers are listed below:

Jumper size	Part number	Application
2-mm	Seagate PN 13211-001 Du Pont PN 89133-001, Methode PN 8618-202-70, or equivalent	J5 and J8 only
0.1-inch	Seagate PN 10562-001 Du Pont PN 86214, Molex™ PN 87092-3013, or equivalent	All jumper blocks except J5 and J8

2.9.1 Parity enable option

When a jumper is installed on pins 1 and 2 of the options jumper block, the parity bit is used. This is the default. When a jumper is not installed on pins 1 and 2 of the options jumper block, the parity bit is not used.

2.9.2 Start/stop option

When a jumper is installed on pins 3 and 4 of the options jumper block, the drive waits for a Start/Stop Unit command from the host before starting or stopping the spindle motor.

2.9.3 SCSI address

Each device on the SCSI bus must have a unique SCSI ID. SCSI ID 7 is usually reserved for the SCSI host adapter. If you install only one drive, use SCSI ID 3 (the default). If you install a second drive, you can use any available ID. SCSI ID 2 is recommended.

When selecting the SCSI ID, you can install jumpers on either (not both) of the following jumper blocks:

- The SCSI ID jumper block
- The user-configuration jumper block (pins 1–6 only)

Note. If you install SCSI ID jumpers on both the SCSI ID jumper block and the user-configuration jumper block (pins 1–6), the drive may not function properly.

2.9.4 Terminator power source jumper block

To select the termination power source, install jumpers as follows:

- To provide terminator power to the SCSI connector and the drive terminator packs, install jumpers on pins 1 and 2 and pins 3 and 4 of the terminator power source jumper block. This is the default.
- To select the drive power connector as the termination power source for the resistor packs, install a jumper on pins 1 and 3 of the terminator power source jumper block.
- To select the SCSI connector as the termination power source for the resistor packs, install a jumper on pins 1 and 2 of the terminator power source jumper block.
- To provide terminator power to the SCSI connector from the drive power connector only, install a jumper on pins 3 and 4 of the terminator power source jumper block.

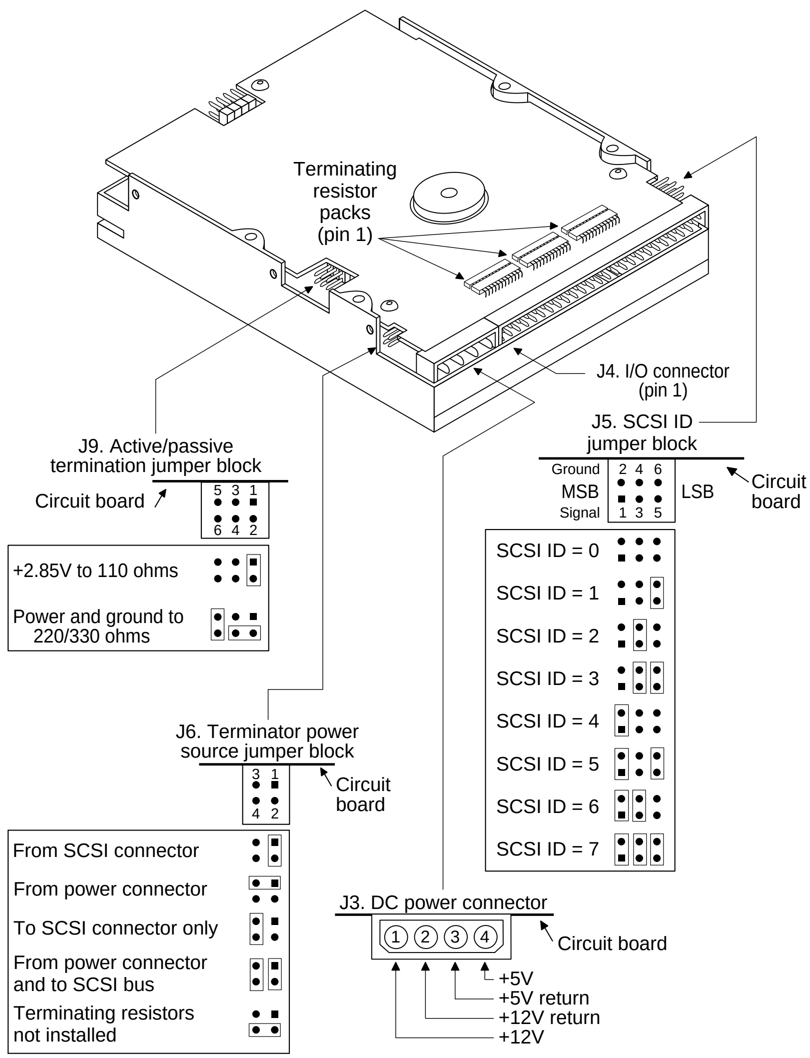
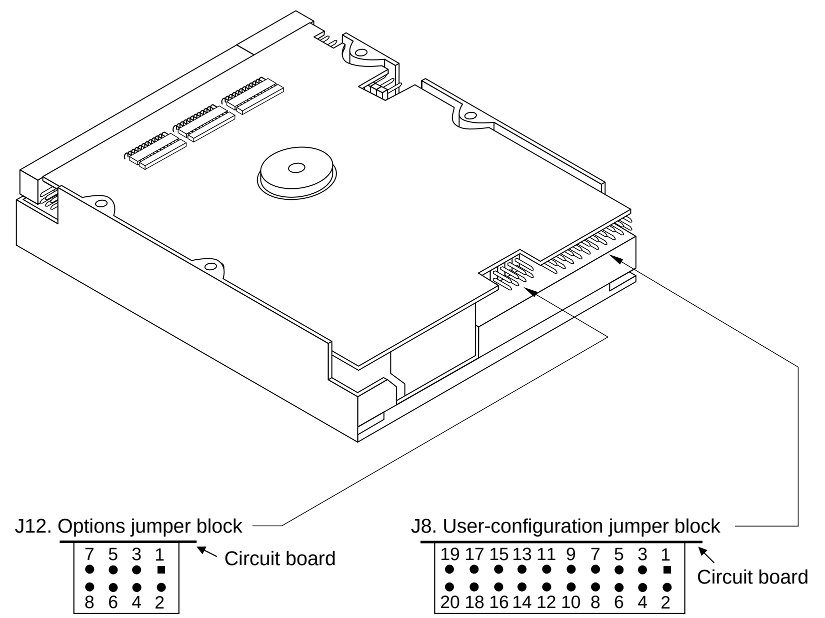


Figure 6. Configuration jumpers, back view



Pin	Function
1	Ground
2	Parity enable
3	Ground
4	Remote start enable
5	Clock ground
6	External spindle sync.
7	Remote LED –
8	Remote LED +

Pin	Function
1	SCSI ID bit 2 (MSB)
2	Ground
3	SCSI ID bit 1
4	Ground
5	SCSI ID bit 0 (LSB)
6	Ground
7	Ext. spindle sync.
8	Clock ground
9	Remote LED –
10	Remote LED +
11–20	Reserved. Do not use.

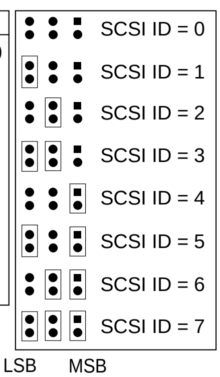


Figure 7. Configuration jumpers, front view

2.9.5 Active/passive termination jumper block

To select active termination (the default), install a jumper on pins 1 and 2 of the active/passive termination jumper block. To select passive termination, install jumpers on pins 5 and 6 and pins 2 and 4 of the active/passive termination jumper block, and change the terminating resistor packs.

Caution. When installing jumpers on the options jumper block and the user-configuration jumper block, be careful to install jumpers on the correct pins. Install jumpers only on pins 1 through 4 of the options jumper block and pins 1 through 6 of the user-configuration jumper block. If you install jumpers on pin pairs that are meant to accept only twisted pair connectors, the drive may not function properly.

2.10 Remote LED connection

Remote LED pins are located on two separate jumper blocks: the options jumper block and the user-configuration jumper block. Attach a two-pin remote LED connector to either jumper block, as follows:

- User-configuration jumper block, pins 9 and 10. Use any 2-pin, 2-mm connector and an LED from LiteOn™, part number LTL-3231A.
- Options jumper block, pins 7 and 8. Use any 2-pin, 0.1-inch connector and an LED from LiteOn™, part number LTL-3231A.

2.11 External spindle synchronization option

You can synchronize the spindle motors of an array of drives by connecting a twisted pair to each drive. The maximum cable length is 6 feet (1.8 meters).

Spindle synchronization pins are located on two separate jumper blocks: the options jumper block and the user-configuration jumper block. Use either jumper block to synchronize an array of drives, as follows:

- **User-configuration jumper block.** Use one strand of the twisted pair to connect together pin 7 of the user-configuration jumper block of each drive. Use the other strand to connect together pin 8 of the user-configuration jumper block of each drive.
- **Options jumper block.** Use one strand of the twisted pair to connect together pin 5 of the options jumper block of each drive. Use the other strand to connect together pin 6 of the options jumper block of each drive.

The spindle-synchronization characteristics can be controlled by the Mode Select command using the RPL bits in byte 17 of the Rigid Disc Geometry page.

In the default mode, all drives arbitrate during startup to see which drive will be the synchronized master. When the drives are calibrating their heads, they each check for a reference signal pulse. The drive that becomes ready first checks for the reference signal, and when it does not detect a pulse, it takes over as the master and begins sending reference pulses. All other drives synchronize their spindles to the reference signal as they in turn become ready.

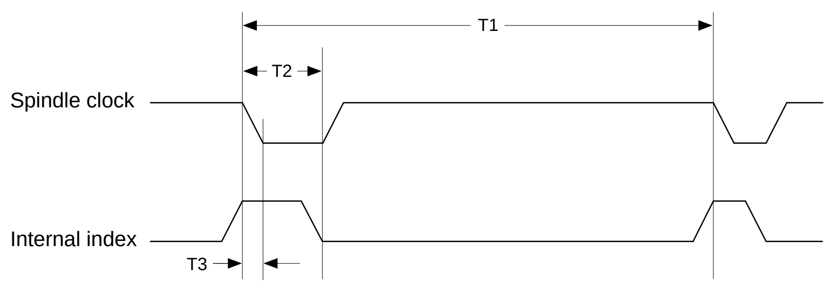


Figure 8. External spindle clock timing diagram

T1	Spindle clock period	13.34 msec ± 0.5%
T2	Duty cycle	0.5 µsec min 500 µsec max
T3	Spindle clock leading edge to index leading edge	0 µsec ± 250 µsec

2.12 Drive mounting

You can mount the drive in any orientation. Follow the guidelines below appropriate to the set of mounting holes you elect to use: either bottom mounting holes or side mounting holes. Refer to Figure 9 on page 29 for the recommended mounting orientations and note the choice of screw holes shown. Refer to Figure 10 on page 30 for drive dimensions.

Caution. Do not remove factory-installed labels from the drive or cover them with additional labels. If you do, you may void your warranty. Factory-installed labels contain information required when servicing the product.

2.12.1 Bottom mounting holes

Use 6-32 UNC screws in three of the four available bottom mounting holes as shown in Figure 9.

Caution. Do not insert the bottom mounting screws more than 0.20 inches (6 turns) into the drive frame. If you use a screw that is too long, you could damage the drive.

2.12.2 Side mounting holes

Use 6-32 UNC screws in three of the six available side mounting holes as shown in Figure 2 on page 12. Do not use all three mounting holes on the same side of the drive.

Caution. Do not insert side mounting screws more than 0.13 inches (4 turns) into the drive frame. If you use a screw that is too long, you could damage the drive.

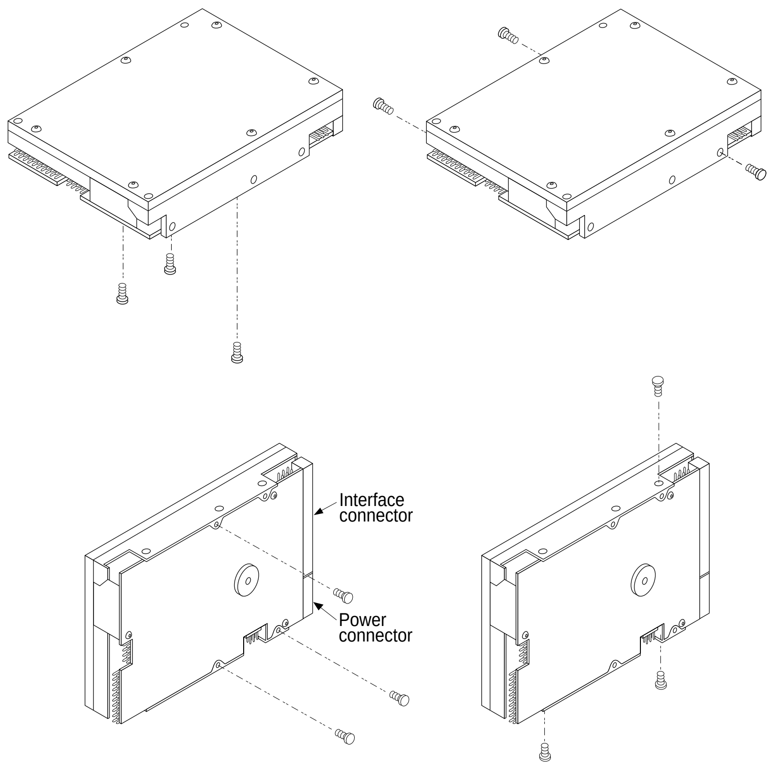


Figure 9. Drive mounting orientations

In the following figure, all dimensions are in inches (mm).

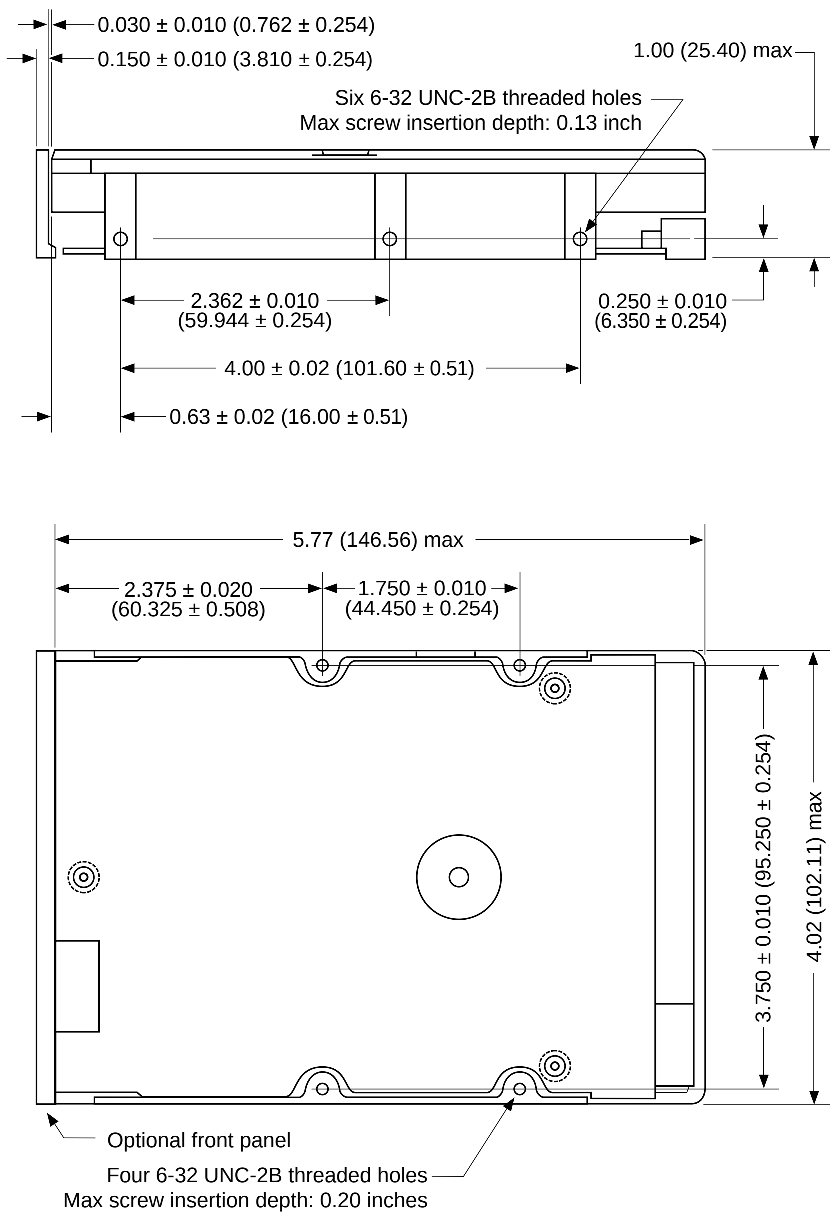


Figure 10. Drive mounting dimensions

3.0 Command set

The drive supports a subset of the Group 0 and Group 1 standard SCSI commands. The commands are described in this section.

3.1 Command descriptor block

The initiator makes a request to the drive by sending a command descriptor block (CDB) to the drive. Each CDB has the following common characteristics:

- Byte 0 always contains the operation code.
- The three most significant bits (bits 7–5) of byte 1 contain the logical unit number (LUN), which is always zero.
- If the link bit is zero, the flag bit must be zero; otherwise, the drive returns a check condition status. If the link bit is one and the drive completes the command without error, the flag bit specifies which message the drive returns to the initiator. If the flag bit is zero, the drive sends the *linked command complete* message. If the flag bit is one, the drive sends the *linked command complete with flag* message.

3.2 Status byte codes

After the drive terminates each command, the drive sends the status byte (shown below) to the initiator during the status phase, unless the command is terminated by one of the following methods:

- An abort message
- A bus device reset message
- A hard reset
- A catastrophic reset condition

<table>
<tr><th rowspan="2">Bytes</th><th colspan="8">Bits</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td rowspan="2">0</td><td colspan="2">Reserved</td><td colspan="5" rowspan="2">Status byte code</td><td>RSVD</td></tr>
<tr><td>0</td><td>0</td><td>0</td></tr>
</table>

The *status byte code* can be any of the following:

00_H **Good status.** The drive has successfully completed execution of a command.

02_H **Check condition status.** The drive detected an error, an exception, or an abnormal condition. In response, the initiator may issue a Request Sense command to determine the nature of the condition.

08_H **Busy status.** The drive is busy, and is, therefore, unable to accept a command from an initiator. The initiator retries the command later. The drive returns a busy status if the initiator has not sent the disconnect message and tries to queue a command or if the initiator rejects the disconnect message and the queue is not empty.

10_H **Intermediate status.** The drive successfully completed a command that was one of a series of linked commands without issuing a check condition status or reservation conflict status. (Had the drive not returned an intermediate status, the series of linked commands would have been terminated.)

18_H **Reservation conflict status.** A SCSI device tried to access the drive, but was unable to because the drive was already reserved by another SCSI device.

28_H **Queue full status.** The drive received a command, but rejected it because the queue was full. The drive only uses this status if tagged command queuing is implemented.

3.3 Supported commands

The drive supports the commands listed below.

Group 0 commands	Operation code
Test Unit Ready	00_H
Rezero Unit	01_H
Request Sense	03_H
Format Unit	04_H
Reassign Blocks	07_H
Read	08_H
Write	$0A_H$
Seek	$0B_H$
Inquiry	12_H
Mode Select	15_H
Reserve	16_H
Release	17_H
Mode Sense	$1A_H$
Start/Stop Unit	$1B_H$
Receive Diagnostic Results	$1C_H$
Send Diagnostic	$1D_H$

Group 1 commands	Operation code
Read Capacity	25_H
Read Extended	28_H
Write Extended	$2A_H$
Seek Extended	$2B_H$
Write and Verify	$2E_H$
Verify	$2F_H$
Read Defect Data	37_H
Write Data Buffer	$3B_H$
Read Data Buffer	$3C_H$
Read Long	$3E_H$
Write Long	$3F_H$

3.4 Group 0 commands

3.4.1 Test Unit Ready command (00_H)

The Test Unit Ready command verifies that the drive is ready; it is not a request for a self-test. If the drive accepts an appropriate media access command without encountering an error, it returns a good status.

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0
1	LUN			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

3.4.2 Rezero Unit command (01_H)

The Rezero Unit command requests that the drive set its logical block address to zero and return the read/write heads to the track (or cylinder) containing logical block 0.

This command is intended for systems that disable retries and the initiator performs error recovery. It is longer than a seek to logical block address 0 and should be used if seek errors are encountered.

When used with a host adapter that supports disconnection, the drive disconnects when this command is received.

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	1
1	LUN			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

3.4.3 Request Sense command (03_H)

The Request Sense command requests that the drive transfer sense data to the initiator in the additional sense data format. The additional sense format is described in Appendix C.

The sense data applies to the previous command on which a check condition status was returned. This sense data is saved for the initiator until:

- The initiator requests the sense data using the Request Sense command, or
- Another command is received from the initiator that issued the command, resulting in the check condition status.

If any of the following fatal errors occur during a Request Sense command, the drive sends a check condition status and the sense data may be invalid.

- The drive receives a nonzero reserved bit in the CDB.
- An unrecovered parity error occurs on the data bus.
- A malfunction prevents return of sense data.

If any other error occurs during the Request Sense command, the drive returns sense data with good status.

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	1	1
1	LUN			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

Byte 4 The *allocation length* specifies the maximum number of bytes the initiator has allocated for returned sense data. The drive returns up to, but no more than, 22 bytes of sense data. Therefore, if you want the initiator to receive all of the sense data, set the allocation length to 22 bytes or more. If you set the allocation length to zero, no sense data is returned.

3.4.4 Format Unit command (04_H)

The Format Unit command formats the disc so that all of the user-addressable data blocks can be accessed. In addition, the disc can be certified and control structures can be created for managing the disc and defects.

If the specified logical unit is reserved, the Format Unit command is rejected with a reservation conflict status. Extent reservations are not supported. See Section 3.4.11 for more information about reservations.

The initiator can specify (or not specify) sectors to be reallocated during the formatting process.

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	1	0	0
1	LUN			Fmt Data	Cmp lst	Defect list format		
2	0	0	0	0	0	0	0	0
3–4	Interleave							
5	0	0	0	0	0	0	Flag	Link

Byte 1 The *Fmt Data (format data)* bit, the *Cmp lst (complete list)* bit, and the *defect list format* field are described in Section 3.4.4.2.

Bytes 3–4 If the *interleave* field is not supported, it can contain any value. However, the drive always formats the disc with an interleave of 1:1.

3.4.4.1 Types of defects

The categories of flawed sectors are described below. This defect list is controlled by byte 1 of the defect list header described in Section 3.4.4.3.

- When the drive is manufactured, the *primary defect list (P-list)* is written to the disc in an area that is not directly accessible by the user. This list of permanent defects (sometimes called the ETF list) cannot be changed.
- The *data defect list (D-list)* is a list of sectors supplied to the drive by the initiator during a data-out phase of the current Format Unit command. The drive sends the D-list in the last bytes of the defect list described in Section 3.4.4.3.
- The *grown defect list (G-list)* is a list of sectors that contain media flaws. The drive reallocated these sectors during the last Reassign Blocks command, or they are data defects (D-list) reallocated during a previous Format Unit command, or they are defects that have been automatically reallocated by the drive. This G-list is recorded on the disc and can be referenced by current and subsequent Format Unit commands. The G-list does not include P-list defects.
- The *certification defect (C-list)* is a list of sectors that were incorrectly formatted by the drive during the Format Unit command. This list is created when the DCRT bit of the defect list header is set to zero.

3.4.4.2 Format Unit parameters

For each format listed below, except the default format, the initiator sends a defect list header. This header is described in Section 3.4.4.3. The bytes-from-index format is described in Section 3.4.4.4 and the physical sector format is described in Section 3.4.4.5. The block format is not discussed.

Byte 1 of CDB					Description
Bit 4	**Bit 3**	**Bit 2–Bit 0**			
Fmt Data	**Cmp Lst**	**Defect list format**			
0	0	X	X	X	*Default format*. The initiator does not send the defect list header or D-list to the drive. The drive reallocates all sectors in the P-list and erases the G-list.
1	0	0	X	X	*Extended format.* The initiator sends a defect list header, but no D-list. Before formatting, the reassigned LBAs are merged into the grown defect list (G-list). All sectors are then reallocated using the P-list and the current G-list. At the end of the format, the new G-list and defect tables are stored on a reserved area of the disc.
1	0	1	0	0	*Format option with the G-list and D-list.* The initiator does not send a D-list to the drive. The drive uses the existing G-list to find defects and adds new defects to the existing G-list in the bytes-from-index format.
1	0	1	0	1	*Format option with the G-list and D-list.* The initiator does not send a D-list to the drive. The drive uses the existing G-list to find defects and adds new defects to the existing G-list in the physical sector format.
1	1	0	X	X	*Format option without G-list or D-list* is selected, the initiator sends a defect list header, but no D-list. The drive erases any previous G-list.
1	1	1	0	0	*Format option with D-list*. The initiator sends the defect list header followed by a D-list in the bytes-from-index format. The drive erases any previous G-list.
1	1	1	0	1	*Format option with D-list and without G-list*. The initiator sends a defect list header followed by a D List of defects to be reallocated. The D list is in the physical sector format. Any previous G-list is erased.

3.4.4.3 Defect list header and defect list

The defect list, shown below, contains a 4-byte header, followed by one or more defect descriptors. Byte 1 of the defect list header determines whether the P and C defects are reallocated.

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0
1	FOV	DPRY	DCRT	STPF	0	0	0	0
2–3	Defect list length							
4–n	Defect descriptor							

Byte 1 If the *FOV* bit is 1, the DPRY, DCRT and STPF bits are interpreted. If the FOV bit is 0, the DPRY, DCRT and STPF bits are checked for zeros.

If the *DPRY* bit is 1, the defects described in the P-list are not reallocated during formatting. This means existing reallocations of the P-list are canceled and no new reallocations are made during formatting. The P-list is retained. If the DPRY bit is 0, the defects described in the P-list are reallocated during formatting. A check condition status is sent if the P-list cannot be found.

If the *DCRT* bit is 1, the drive does not verify the data written during the format. Therefore, no C-list for this format is created or reallocated. If the DCRT is 0, the drive verifies the data written during the format, creates a C-list and reallocates sectors that were incorrectly formatted.

If the *STPF* bit is 1, the drive stops formatting if it encounters an error while accessing either the P or G defect list. If the *STPF* bit is 0, the drive continues formatting even though it has encountered an error while accessing either the P or G defect list.

Bytes 2–3 The *defect list length* is the length, in bytes, of the defect list that follows the header. For each sector to be reallocated, the defect list contains 1 defect descriptor containing 8 bytes in either the bytes-from-index format or the physical sector format. These formats are explained in Sections 3.4.4.4 and 3.4.4.5, respectively.

Bytes 4–n The two types of defect descriptors are described in Sections 3.4.4.4 and 3.4.4.5.

3.4.4.4 Defect descriptor—bytes-from-index format

Defects are specified in the bytes-from-index format when the defect list format field is 100_{Binary}. See byte 1 of the Format Unit command in Section 3.4.4.

Each defect descriptor in the *bytes-from-index* format specifies the beginning of a single-byte defect location on the disc. Each defect descriptor is comprised of the cylinder number of the defect, the head number of the defect, and the number of bytes-from-index to the defect location. The defect descriptors are always listed in ascending order.

A value for defect bytes-from-index of $FFFFFFFF_H$ (which means reassign the entire track) is illegal.

The information in the following table is repeated for each defect.

Bit Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0–2	Cylinder number of defect							
3	Head number of defect							
4–7	Defect bytes-from-index							

3.4.4.5 Defect descriptor—physical sector format

Defects are specified in the physical sector format when the defect list format field is 101_{Binary}. See byte 1 of the Format Unit command in Section 3.4.4.

Each defect descriptor for the physical sector format specifies a sector size defect location comprised of the cylinder number of the defect, the head number of the defect, and the defect sector number. The defect descriptors must be in ascending order.

A defect sector number of $FFFFFFFF_H$ (which means reassign the entire track) is illegal.

Note. The initiator cannot use any previously defined C, G or D lists if the sector size (block length) has been changed by the Mode Select command. For more information on the Mode Select command, see Section 3.4.10.

The information in the following table is repeated for each defect.

Bit / Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0–2	Cylinder number of defect							
3	Head number of defect							
4–7	Defect sector number							

3.4.5 Reassign Blocks command (07_H)

When the drive receives the Reassign Blocks command, it reassigns defective logical blocks to available spare sectors. Use this command when the AWRE and ARRE bits are set to 0, which means that automatic reallocation is disabled. These bits are contained in byte 2 of the Error Recovery page, which is described in Appendix C.1.

If the system supports disconnection, the drive disconnects while executing this command. The initiator uses this command to immediately reallocate any block (sector) that requires the drive to recover data using ECC if the automatic reallocation feature is not enabled.

Note. Before sending this command, the initiator should recover the data from the logical blocks to be reassigned. After completing this command, the initiator can write the recovered data to the same logical block addresses.

After sending the Reassign Blocks command, the initiator transfers a defect list containing the logical block addresses to be reassigned. The drive reassigns the logical blocks. The data contained in the logical blocks is not preserved.

The drive can repeatedly assign a logical block to multiple physical addresses until there are no more spare locations available on the disc.

If the drive does not have enough spare sectors to reassign all of the defective logical blocks, the command terminates with a check condition status and the sense key is set to media error. The logical block address of the first logical block not reassigned is returned in the information bytes of the sense data.

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	1	1	1
1	LUN			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

3.4.5.1 Reassign blocks defect list

The Reassign Blocks defect list contains a four-byte header followed by one or more defect descriptors. The length of each defect descriptor is four bytes.

Bit Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0
2–3	Defect list length							
4–*n*	Defect descriptors							

Byte 1 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.

Bytes 4–*n* The *defect descriptor* contains the 4-byte logical block address of the defect. The defect descriptors are always in ascending order.

3.4.6 Read command (08_H)

When the drive receives the Read command, it transfers data to the initiator.

The Error Recovery page (01_H) determines how the drive handles errors during a Read command. The Error Recover page is discussed in Appendix C.1.

If there is a reservation access conflict, this command terminates with a reservation conflict status and no data is read. For more information about the reservation conflict status, see Section 3.2.

In systems that support disconnection, the drive disconnects when a valid Read command is received, unless the data is available in the cache buffer and the drive does not need to access the disc. The buffer full ratio byte of the Disconnect/Reconnect page determines when the drive reconnects. (The Disconnect/Reconnect page is discussed in Section C.2.) After the drive starts transferring data to the initiator, the drive does not disconnect unless an internal error recovery procedure is required or the data transfer to an initiator is interrupted for more than 1 millisecond.

Because the drive uses read look-ahead and caching functions, it may read more data into the buffer than specified by the transfer length in the CDB.

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0
1	LUN			Logical block address (MSB)				
2	Logical block address							
3	Logical block address (LSB)							
4	Transfer length							
5	Control byte (00_H)							

Bytes 1–3 The *logical block address* specifies the logical block where the read begins.

Byte 4 The *transfer length* specifies the number of contiguous logical blocks of data to be transferred. A transfer length of 0 indicates that 256 logical blocks are to be transferred. Any other value indicates the number of logical blocks to be transferred.

3.4.7 Write command ($0A_H$)

When the drive receives the Write command, it writes the data from the initiator to the disc. The drive receives all the write data before seeking or disconnecting.

The AWRE bit of the Error Recovery page (01_H) determines how the drive handles bad sectors during a Write command. The Error Recover page is discussed in Appendix C.1.

If the system supports disconnection, the drive can disconnect and reconnect while executing this command. The drive disconnects when any of the following conditions arise:

- An internal error recovery procedure is required.
- The data transfer with the initiator is interrupted for more than 1 msec.
- The drive’s internal data buffer is full.

The buffer empty ratio in the Disconnect/Reconnect page determines when the drive reconnects. Section C.2 documents the Disconnect/Reconnect page.

The initiator must continue sending write data to the drive until the drive sends a command complete status or until the initiator resets or aborts the command.

If there is a reservation access conflict, this command terminates with a reservation conflict status and no data is written. For more information about the reservation conflict status, see Section 3.2.

Bit Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	0	0	0	0	1	0	1	0
1	LUN			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

Bytes 1–3 The *logical block address* specifies the logical block where the write operation begins.

Byte 4 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 are to be transferred. Any other value indicates the number of logical blocks to be transferred.

3.4.8 Seek command ($0B_H$)

When the drive receives the Seek command, it seeks the specified logical block address. This command is seldom used because all commands that access the disc contain implied seeks. In systems that support disconnection, the drive disconnects when it receives a valid Seek command.

Bit / Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	0	0	0	0	1	0	1	1
1	LUN			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

Bytes 1–3 The *logical block address* specifies the logical block the head seeks. For the maximum *logical block address* that may be specified for a Seek command, see Section 3.5.1.

3.4.9 Inquiry command (12_H)

When the drive receives the inquiry command, it asserts the data-in phase and sends 68 bytes of inquiry data to the initiator. When the requested inquiry data cannot be returned, a check condition status is reported. After the data has been transferred to the initiator, the drive deasserts the data-in phase.

If an Inquiry command is received from an initiator with a pending unit-attention condition (before the drive reports a check condition status), the drive performs the Inquiry command and the Unit Attention condition is not cleared.

The initiator should allocate 36_H bytes for inquiry data. The inquiry data returned to the initiator is summarized in Appendix D.

<table>
<tr><th>Bit
Byte</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">1</td><td colspan="3">LUN</td><td colspan="4" rowspan="2">Reserved</td><td>EVPD</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td rowspan="2">2</td><td colspan="8">Page code</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>4</td><td colspan="8">Allocation length, in bytes</td></tr>
<tr><td>5</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>Flag</td><td>Link</td></tr>
</table>

Byte 1 If the *EVDP* (Enable Vital Product Data) bit is zero, the drive returns the standard inquiry data. If the EVDP bit is one, the drive returns the optional vital product data specified in byte 2.

Byte 2 The page code field specifies which page of the vital product information the drive returns.

Byte 4 The *allocation length* specifies the number of bytes the initiator has allocated for returned inquiry data. An allocation length of 0 indicates that no inquiry data is transferred. This condition is not considered an error. Any other value indicates the maximum number of bytes to be transferred. The allocation length should be at least 36_H to allow the initiator to receive all of the inquiry data.

3.4.10 Mode Select command (15_H)

The Mode Select command allows the initiator to change parameters stored in the mode pages. The mode pages are described in Appendix C. The drive stores four copies of each mode page:

- **Current values copy.** This copy contains the parameter values the drive is using to control its operation. After a power-on reset, hard reset or bus device reset, the current values are equal to the saved values if the saved values can be retrieved, or the default values if the saved values cannot be retrieved.
- **Changeable values copy.** This copy does not actually contain any parameters. Instead, it contains a map of each mode page indicating which parameter values are changeable by the initiator. If a bit contains a 1, the corresponding value in the mode page is changeable. If a bit contains a 0, the corresponding value in the mode page is not changeable. The changeability values for each bit of each mode page are listed in Appendix C with the default values.
- **Default values copy.** This copy contains the parameter values the drive used as its current values when it was manufactured. The drive defaults to these values after a reset condition, unless valid saved values are available. The default values are listed in Appendix C.
- **Saved values copy.** The saved values are the values the drive stores on the disc. If the parameter is changeable, these values can be set using a Mode Select command. If the parameter is not changeable, the default values are always used.

The drive has one set of mode parameters for each initiator on the SCSI bus. If the initiator that issued the Mode Select command changes a parameter that applies to another initiator, the drive generates a sense key of *unit attention* with an additional sense of *mode parameters changed* (26_H) for all the other initiators. The sense keys and additional sense codes are discussed in Appendix B.

Before sending any Mode Select commands, the initiator should send a Mode Sense command requesting that the drive return all pages with changeable values. The initiator uses this information to determine which pages are supported, the proper length for those pages, and which parameters in those pages can be changed for that logical unit.

When the drive receives the Mode Select command, it updates the savable parameters with the current values included in the Mode Select command. After the drive saves the parameters, the drive reports a good status. The drive verifies only mode select data that is defined as changeable.

If the drive detects invalid parameter data during the Mode Select command, the drive sends a sense key of *illegal request* with an additional sense code of *invalid field in parameter list* and no parameters are changed.

Bit / Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	0	0	0	1	0	1	0	1
1	LUN			PF = 1	0	0	0	SP
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

Byte 1 The *page format (PF)* bit is always one. This means that the data sent by the initiator after the mode select header and block descriptors complies with the page format.

When the *SP (save mode parameters)* bit is 1, the drive saves the savable pages in RAM and on the disc. When the *SP (save mode parameters)* bit is 0, the drive saves the savable pages in RAM only, which means that the parameters are lost when the drive is powered down. When the drive executes the Mode Select command, it does not save the Format Device page (03_H) and the Rigid Disc Geometry page (04_H); it saves these pages during the Format Unit command.

Byte 4 The *parameter list length* specifies the length, in bytes, of the header and mode page transferred to the drive. A parameter list length of 0 means that no data is transferred. To calculate the parameter list length for any given mode page, add the parameter list header (4 bytes), the block descriptor (if any, 8 bytes), the 2-byte mode page header and the length of the mode page. For the lengths of the mode pages, refer to Appendix C.

3.4.10.1 Mode Select parameter list

The Mode Select parameter list contains a 4-byte header, followed by a 1-block descriptor (if any), followed by the pages of Mode Select parameters.

Each block descriptor specifies the media characteristics for all or part of a logical unit. The rest of the Mode Select parameters are grouped by function and organized into mode pages. The mode pages are described in Appendix A.

Bit Byte	7	6	5	4	3	2	1	0
	Parameter list header							
0 (default)	Reserved (00_H)							
1 (default)	Medium type (00_H)							
2 (default)	Reserved (00_H)							
3 (default)	Block descriptor length (00_H or 08_H)							
	Block descriptor data							
4 (default)	Density code (00_H)							
5–7	Number of blocks							
8 (default)	Reserved (00_H)							
9–11	Block length							
	Parameter information							
12–*n*	Mode pages							

Byte 1 The *medium type* field is always 00_H, which means that the drive is a direct access device.

Byte 3 If the *block descriptor length* is 8 bytes, a block descriptor is sent to the drive. If the *block descriptor length* is 0 bytes, no block descriptor is sent to the drive.

Byte 4 The *density code* is always 00_H and cannot be changed.

Bytes 5–7 The *number of blocks* is equal to the guaranteed sectors, which is listed in the formatted capacity section of the appropriate product manual.

Bytes 9–11 The *block length* is always 512 and cannot be changed.

3.4.11 Reserve command (16_H)

When the initiator issues a Reserve command, it requests that the drive be reserved for exclusive use by the initiator until the reservation is:

- Superseded by another Reserve command from the initiator that made the reservation. An initiator that has already reserved the drive can modify that reservation by issuing another Reserve command. When the drive receives the superseding Reserve command, the previous reservation is canceled.
- Released by a Release command from the same initiator. See the Release command in Section 3.4.12.
- Released by a bus device reset message from any initiator
- Released by a hard reset

After the drive honors the reservation from one initiator, it accepts only Request Sense and Inquiry commands from other initiators; the drive rejects all other commands with a reservation conflict status.

Bit Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	0	0	0	1	0	1	1	0
1	LUN			3rd pty	3rd party device ID			Extent
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

Byte 1 If the *3rd pty* bit is 0, the initiator reserves the drive for itself. If the 3rd pty bit is 1, the initiator reserves the drive for another initiator. The SCSI ID of the third-party initiator is specified in the *3rd party device ID* field.

The *extent* bit must always be 0. The drive does not support extent reservations. If the Extent bit is 1, the drive generates a check condition status.

3.4.12 Release command (17_H)

When an initiator that had reserved the drive using the Reserve command issues the Release command, it cancels the reservation. If the drive is not currently reserved and it receives a Release command, the drive returns a good status.

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	1	0	1	1	1
1	LUN			3rd pty	3rd party device ID			Extent
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

Byte 1 If the *3rd pty* bit is 0, the initiator releases its own reservation. If the 3rd pty bit is 1, the initiator releases the drive for another initiator. An initiator can only release a third party reservation that it made. The SCSI ID of the third-party initiator is specified in the *3rd party device ID* field.

The *extent* bit must always be 0. The drive does not support extent reservations. If the extent bit is 1, the drive generates a check condition status.

3.4.13 Mode Sense command ($1A_H$)

When the initiator sends this command to the drive, it returns mode page parameters to the initiator. This command is used in conjunction with the Mode Select command.

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	1	1	0	1	0
1	LUN			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

Byte 2 The *PCF (page control field)* determines the content of Mode Parameter bytes. Regardless of the value of the PCF, the block descriptor always contains the current values.

PCF bit 7	PCF bit 6	Effect
0	0	Return current values.
0	1	Return changeable values.
1	0	Return default values.
1	1	Return saved values.

The *page code* is the designator that is unique to each page. The page codes are listed in Section 3.4.13.1.

Byte 4 The *allocation length* specifies the number of bytes that the initiator has allocated for returned Mode Sense data. An allocation length of 0 means that no Mode Sense data is to be transferred. This condition is not considered an error. Any other value represents the number of bytes to be transferred. For a description of the allocation length, see Section 3.4.13.1.

3.4.13.1 Page code and allocation length

The Mode Sense command descriptor block contains a page code (byte 2, bits 5–0) and an allocation length (byte 4). These parameters are described in the following table. You can transfer mode pages to the initiator either of two ways:

- Transfer all mode pages at once by using page code $3F_H$, as described in the last row of this table, or
- Transfer one mode page at a time by using the page code and allocation length of the mode page.

Page code	Allocation length	Mode Sense data returned
01_H	18_H	4 bytes of Mode Sense header 8 bytes of block descriptor 2 bytes of mode page header 10 bytes of Error Recovery parameters
02_H	18_H	4 bytes of Mode Sense header 8 bytes of block descriptor 2 bytes of mode page header 12 bytes of Disconnect/Reconnect parameters
03_H	24_H	4 bytes of Mode Sense header 8 bytes of block descriptor 2 bytes of mode page header 24 bytes of Format Device parameters
04_H	20_H	4 bytes of Mode Sense header 8 bytes of Block descriptor 2 bytes of mode page header 20 bytes of Rigid Disc Geometry parameters
08_H	20H	4 bytes of Mode Sense header 8 bytes of block descriptor 2 bytes of mode page header 20 bytes of Caching parameters
$0C_H$	24_H	4 bytes of Mode Sense header 8 bytes of block descriptor 2 bytes of mode page header 24 bytes of Notch and Partition parameters
$0D_H$	18_H	4 bytes of Mode Sense header 8 bytes of block descriptor 2 bytes of mode page header 12 bytes of Power Condition parameters

Page code	Allocation length	Mode Sense data returned
38_H	$1C_H$	4 bytes of Mode Sense header 8 bytes of block descriptor 2 bytes of mode page header 16 bytes of Cache Control parameters
$3C_H$	0FH	4 bytes of Mode Sense header 8 bytes of block descriptor 2 bytes of mode page header 3 bytes of Soft ID parameters
00_H	10_H	4 bytes of Mode Sense header 8 bytes of block descriptor 2 bytes of mode page header 4 bytes of Operating parameters
$3F_H$	143 or 144	4 bytes of Mode Sense header 8 bytes of block descriptor 2 bytes of mode page header 143 or 144 bytes of mode parameters, including all mode pages

* The allocation length depends on whether the Operating page has 2 or 3 bytes. The Operating page is described in Section C.10.

3.4.13.2 Mode sense data

The Mode Sense parameter list contains a 4-byte header followed by a 8-byte block descriptor (if any), followed by the mode pages. The header and block descriptor are shown below. The mode pages are described in Appendix C.

Bit / Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Mode sense data length							
1 (default)	Medium type (00_H)							
2	WP=0	Reserved						
3 (default)	Block descriptor length (08_H)							
Block descriptor								
4 (default)	Density code (00_H)							
5–7	Number of blocks							
8 (default)	Reserved (00_H)							
9–11	Block length							
Mode pages								
12–*n*	Mode pages							

Byte 0 The *mode sense data length* specifies the number of bytes minus 1 of the Mode Sense data to be transferred to the initiator.

Byte 1 The *medium type* is always 0.

Byte 2 The *WP (write protect)* bit is always 0, which means the media is write-enabled.

Byte 3 The *block descriptor length* is the number of bytes in the block descriptor. This value does not include the page headers and mode pages that follow the block descriptor, if any.

Byte 4 The *density code* is not supported.

Bytes 5–7 The *number of blocks* field contains the total number of blocks available to the user, which is specified on page 1.

Byte 8 Reserved.

Bytes 9–11 The *block length* is specifies the number of bytes contained in each logical block described by the block descriptor.

3.4.14 Start/Stop Unit command ($1B_H$)

When the drive receives the Start/Stop Unit command, the drive either spins up or spins down, depending on the setting of the start bit in byte 4.

If the host adapter supports disconnection, the drive disconnects when it receives the Start/Stop Unit command and reconnects when it is up to speed and ready.

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	1	1	0	1	1
1	LUN = 0			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

Byte 1 If the *immed* bit is 0, the drive returns the status after it completes the command. If the immed bit is 1, the drive returns the status when it receives the command.

Byte 4 If the *start* bit is 1, the drive spins up. If the *start* bit is 0, the drive spins down.

3.4.15 Receive Diagnostic Results command ($1C_H$)

When the drive receives the Receive Diagnostics command, it sends eight diagnostic data bytes to the initiator. The initiator sends the Receive Diagnostic Results command after the drive completes the Send Diagnostic command, which is discussed in Section 3.4.16.

Bit / Byte	7	6	5	4	3	2	1	0
0	0	0	0	1	1	1	0	0
1	LUN = 0			0	0	0	0	0
2	0	0	0	0	0	0	0	0
3–4	Allocation length							
5	0	0	0	0	0	0	Flag	Link

Bytes 3–4 The *allocation length* specifies the number of bytes the initiator has allocated for returned diagnostic result data. An allocation length of 0 means that no diagnostic data is transferred. Any other value indicates the maximum number of bytes to be transferred. The allocation length should be at least 8 bytes to accommodate all the diagnostic data.

3.4.15.1 Diagnostic data format

Bit / Byte	7	6	5	4	3	2	1	0
0–1 (default)	Additional length (0006_H)							
2–5	FRU code							
6	Diagnostic error code							
7	Vendor-unique error code							

Byte 0–1 The *additional length* indicates the number of additional bytes included in the diagnostic data list. A value of 0000_H means that there are no additional bytes. A value of 0006_H means that no product-unique bytes are available.

Bytes 2–5 If the *FRU (field replaceable unit) code* is 00_H, there is no FRU information. If the FRU code is 01_H, replace the drive. Other values are drive-unique.

Byte 6 The *diagnostic error code* is not supported.

Byte 7 The *vendor-unique error codes* are listed in Section 3.4.15.2.

3.4.15.2 Diagnostic error codes

The following diagnostic error codes are reported in byte 7 of the diagnostic data format in Section 3.4.15.1.

Error code	Description
01_H	Format diagnostic error
02_H	Microprocessor RAM diagnostic error
04_H	No drive ready
08_H	No sector or index detected
09_H	Fatal hardware error during drive diagnostics
$0C_H$	No drive command complete
10_H	Unable to set drive sector size
14_H	Unable to clear drive attention
18_H	Unable to start spindle motor
20_H	Unable to recall drive
30_H	Unable to send write current data to drive
34_H	Unable to issue the Seek command
40_H	Unable to read user table from drive
41_H	No more spare sectors during drive diagnostics
42_H	Unable to read reallocation table
43_H	Unable to read ETF log
60_H	Thermal calibration failure
70_H	Microprocessor internal timer error
80_H	Buffer controller diagnostic error
81_H	Buffer RAM diagnostic error
$C1_H$	Data miscompare during drive diagnostics

3.4.16 Send Diagnostic command ($1D_H$)

When the drive receives this command, it performs diagnostic tests on itself. In systems that support disconnection, the drive disconnects while executing this command.

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	1	1	1	0	1
1	LUN = 0			0	0	Self Test	Dev OfL	Unit OfL
2	0	0	0	0	0	0	0	0
3–4 (default)	Parameter list length (00_H)							
5	0	0	0	0	0	0	Flag	Link

Byte 1 When the *self test* bit is 1, the drive performs the buffer RAM diagnostics, which is the default self test. If the default self test is requested, the parameter list length is 0 and no data is transferred. If the self test passes successfully, the command terminates with a good status. If the self test fails, the command terminates with a check condition status and the sense key is hardware error.

The *Dev OfL (device off line)* bit is not supported.

The *UnitOfL (unit off line)* bit is not supported.

Bytes 3–4 The *parameter list length* is always zero. This byte is not supported.

3.5 Group 1 commands

3.5.1 Read Capacity command (25_H)

The initiator uses the Read Capacity command to determine the capacity of the drive. When the drive receives the Read Capacity command, it sends the initiator read capacity data, which is described in Section 3.5.1.1.

Bit / Byte	7	6	5	4	3	2	1	0
0	0	0	1	0	0	1	0	1
1	LUN			0	0	0	0	Rel Adr
2–5	Logical block address							
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

Bytes 2–5 The *logical block address* specified in the CDB cannot be greater than the logical block address reported by the drive in the read capacity data.

Byte 8 If the *partial medium indicator (PMI)* bit is zero, the logical block address in the CDB is also zero. The read capacity data returned by the drive contains the logical block address and block length of the last logical block of the drive.

If the PMI bit is one, the drive returns the read capacity data, which contains the logical block address and block length of the last logical block address, after which a substantial delay (approximately 1 msec) in data transfer occurs. This logical block address must be greater than or equal to the logical block address specified in the command descriptor block. This reported logical block address is a cylinder boundary.

3.5.1.1 Read Capacity data

The Read Capacity data is shown below.

Bit Byte	7	6	5	4	3	2	1	0
0–3	Logical block address							
4–7	Block length (00000200_H)							

Bytes 0–3 The logical block address is determined by the PMI bit in the CDB of the Read Capacity command. The PMI bit is described in Section 3.5.1.

Bytes 4–7 The block length is always 512.

3.5.2 Read Extended command (28_H)

When the drive receives the Read Extended command, it transfers data to the initiator. This command is the same as the Read command discussed in Section 3.4.6, except that in the CDB for the Read Extended command, a 4-byte logical block address and a 2-byte transfer length can be specified.

If there is a reservation access conflict, this command terminates with a reservation conflict status and no data is read. For more information about the reservation conflict status, see Section 3.2.

Bit Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	0	0	1	0	1	0	0	0
1	LUN			DPO	FUA	0	0	Rel Adr
2–5	Logical block address							
6	0	0	0	0	0	0	0	0
7–8	Transfer length							
9	0	0	0	0	0	0	Flag	Link

Byte 1 If the *DPO (disable page out)* bit is one, the cached data that the drive receives during this command has the lowest priority for being retained in the cache. If DPO is zero, the cached data has the highest priority for being retained in the cache.

If the *FUA (forced unit access)* bit is one, the drive must access the disc to get the data requested by the initiator, even if the data is available in the cache. If the FUA bit is zero, the drive can get the data from the cache or the disc.

If the *REL ADR* bit is one, the logical block address field specifies the first logical block of the range of logical blocks to be written and verified by the drive. If the REL ADR bit is one, the logical block address field is a two’s complement displacement. This displacement is added to the logical block address last accessed on the drive to determine the logical block address for this command. The REL ADR bit should only be one if linked commands are used.

Bytes 2–5 The *logical block address* specifies the logical block where the read operation begins.

Bytes 7–8 The *transfer length* specifies the number of contiguous logical blocks of data to be transferred. A transfer length of 0 means that no logical blocks are to be transferred. This condition is not considered an error. Any other value indicates the number of logical blocks to be transferred.

3.5.3 Write Extended command ($2A_H$)

When the drive receives the Write Extended command, the drive writes the data from the initiator to the disc. This command is like the Write command, except that the command descriptor block for this command contains a 4-byte logical block address and a 2-byte transfer length. For more information about the Write command, see Section 3.4.7.

If there is a reservation access conflict, this command terminates with a reservation conflict status and no data is written. For more information about the reservation conflict status, see Section 3.2.

Bit Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	0	0	1	0	1	0	1	0
1	LUN			DPO	FUA	0	0	Rel Adr
2–5	Logical block address							
6	0	0	0	0	0	0	0	0
7–8	Transfer length							
9	0	0	0	0	0	0	Flag	Link

Byte 1 If the *DPO (disable page out)* bit is one, the cached data that the drive receives during this command has the lowest priority for being retained in the cache. If DPO is zero, the cached data has the highest priority for being retained in the cache.

If the *FUA (forced unit access)* bit is one, the drive must access the disc to write the data sent by the initiator, even if the data could be stored in the cache. If the FUA bit is zero, the drive can write the data to the cache or the disc.

If the *REL ADR* bit is one, the logical block address field specifies the first logical block of the range of logical blocks to be written and verified by the drive. If the REL ADR bit is one, the logical block address field is a two’s complement displacement. This displacement is added to the logical block address last accessed on the drive to determine the logical block address for this command. The REL ADR bit should only be one if linked commands are used.

Bytes 2–5 The *logical block address* specifies the logical block where the write operation begins.

Bytes 7–8 The *transfer length* specifies the number of contiguous logical blocks of data to be transferred. A transfer length of zero means that no logical blocks are to be transferred. Any other value indicates the number of logical blocks to be transferred.

3.5.4 Seek Extended command ($2B_H$)

The Seek Extended command requests that the drive seek to the specified logical block address. This command is the same as the Seek command, except that the CDB includes a 4-byte logical block address. The Seek command is described in Section 3.4.8.

Bit Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	0	0	1	0	1	0	1	1
1	LUN			0	0	0	0	0
2–5	Logical block address							
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

3.5.5 Write and Verify command ($2E_H$)

When the drive receives the Write and Verify command, it writes the data sent by the initiator to the media and then verifies that the data is correctly written.

If the host adapter supports disconnection, the drive disconnects while it is executing this command.

Bit / Byte	7	6	5	4	3	2	1	0
0	0	0	1	0	1	1	1	0
1	LUN			0	0	0	BYT CHK	REL ADR
2–5	Logical block address							
6	0	0	0	0	0	0	0	0
7–8	Transfer length							
9	0	0	0	0	0	0	Flag	Link

Byte 1 If the *BYT CHK (byte check)* bit is zero, the drive verifies the media without performing a byte-by-byte comparison of the data stored there. If the BYT CHK bit is one, the drive verifies the media and performs a byte-by-byte comparison of the data stored there.

If the *REL ADR* bit is one, the logical block address field specifies the first logical block of the range of logical blocks to be written and verified by the drive. If the REL ADR bit is one, the logical block address field is a two's complement displacement. This displacement is added to the logical block address last accessed on the drive to determine the logical block address for this command. The REL ADR bit should only be one if linked commands are used.

Bytes 2–5 The *logical block address* field specifies the logical block where the drive begins writing and verifying the data.

Bytes 7–8 The *transfer length* field specifies the number of contiguous logical blocks to be transferred. If the transfer length is zero, the initiator does not transfer any data and the drive does not write or verify any data. This condition is not considered an error.

3.5.6 Verify command ($2F_H$)

When the drive receives the Verify command, it verifies the data on the disc. If the host adapter supports disconnection, the drive disconnects while it is executing this command.

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	1	0	1	1	1	1
1	LUN			0	0	0	BYT CHK	REL ADR
2–5	Logical block address							
6	0	0	0	0	0	0	0	0
7–8	Verification Length							
9	0	0	0	0	0	0	Flag	Link

Byte 1 If the *BYT CHK (byte check)* bit is zero, the drive verifies the media without performing a byte-by-byte comparison of the stored data. If the BYT CHK bit is one, the drive verifies the media and performs a byte-by-byte comparison of the stored data.

A *REL ADR* bit of zero means that the logical block address field specifies the first logical block of the range of logical blocks to be written by the drive. If the REL ADR bit is one, the logical block address field is a two's complement displacement. This displacement is added to the logical block address last accessed on the drive to determine the logical block address for this command. The REL ADR bit should only be one if linked commands are used.

Bytes 2–5 The *logical block address* field specifies the logical block where the drive begins verifying the data.

Bytes 7–8 The *verification length* field specifies the number of contiguous logical blocks to be verified. If the verification length is zero, the drive does not verify any logical blocks although an implied seek is still performed. This condition is not considered an error.

3.5.7 Read Defect Data command (37_H)

When the drive receives this command, it reads the defect data off its reserved cylinders and transfers the defect data to the initiator.

The initiator can use this command to do a Format Unit command. It reads the defect lists off the reserved cylinders and resends the lists as defect data without changing them.

The Read Defect Data command can be used to access two types of defect lists, the P-list and the G-list. These lists are described in Section 3.4.4.1.

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	1	1	0	1	1	1
1	LUN			0	0	0	0	0
2	0	0	0	P-list	G-list	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
7–8	Allocation length							
9	0	0	0	0	0	0	Flag	Link

Byte 2 If the *P-list* bit is 1, the drive sends the primary defect list. If the P-list bit is 0, the drive does not send the primary defect list. If the *G-list* bit is 1, the drive sends the grown defect list. If the G-list bit is 0, the drive does not send the grown defect list. If both the P-list and G-list bits are zero, the drive returns the defect list header only.

If the *defect list format* field contains 100, the drive returns the defect data in the bytes-from-index format. If the defect list format field contains 101, the drive returns the defect data in the physical sector format. If the *defect list format* field contains 000, the drive returns the defect data in the default format, which is the physical sector format, and generates a check condition status.

Bytes 7–8 The *allocation length* specifies the number of bytes the initiator has allocated for the returned defect data. An allocation length of 0 indicates that no defect data is transferred. Any other value indicates the maximum number of bytes to be transferred. The data in phase ends when the allocation length bytes have been transferred or when all available defect data has been transferred to the initiator, whichever is less.

3.5.7.1 Defect list header

The defect data always begins with a 4-byte header, followed by a 6-byte descriptor for each defect. The defect list header format is described below.

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0
1	0	0	0	P-list	G-list	Defect list format		
2–3	Defect list length							

Byte 1 If the *P-list* bit is 1, the defect data contains the primary defect list. If the P-list bit is 0, the defect data does not contain the primary defect list.

If the *G-list* bit is 1, the defect data contains the grown defect list. If the G-list bit is 0, the defect data does not contain the grown defect list.

The *defect list format* field is described in Section 3.5.7.

Bytes 2–3 The *defect list length* specifies the length of the defect data. If the P-list and G-list bits are 0, no defect descriptor bytes are sent to the initiator and the defect list length is 0. If the allocation length (in the CDB) is not large enough to accommodate all the defect descriptors, the defect list length contains the same value as the allocation length.

3.5.8 Write Buffer command ($3B_H$)

In conjunction with the Read Buffer command, the Write Buffer command can be used in the following ways:

- To diagnose problems in the drive's data buffer.
- To test the integrity of the SCSI bus.

The Write Buffer command can also be used to download microcode to the buffer and save it on the disc.

Note. This command treats the buffer as a single segment, regardless of the number of segments specified in Mode Page 08_H. (Mode Page 08_H is described in Section C.5.)

Bit / Byte	7	6	5	4	3	2	1	0
0	0	0	1	1	1	0	1	1
1	LUN			0	0	Mode		
2	Buffer ID (00_H)							
3–5	Buffer offset							
6–8	Parameter list length							
9	0	0	0	0	0	0	Flag	Link

Byte 1 If the *mode* bits contain 000, the initiator transfers data to the drive buffer with a 4-byte header that contains all zeros. This mode is called *write combined header and data*.

If the *mode* bits contain 010, the initiator transfers data to the drive buffer without the header. This mode is called *write data*.

If the *mode* bits contain 101, the initiator downloads microcode to the drive buffer, and the drive saves the microcode in reserved cylinders. The drive uses the new microcode for all future operations. This mode is called *download microcode and save*.

Note. If the mode bits contain 101, the flag and link bits must be 0.

After the microcode has been successfully downloaded, the drive generates a unit attention condition of *microcode has been downloaded* for all initiators except the one that issued the current Write Buffer command.

All other settings for the mode bits are reserved.

Byte 2 The *buffer ID* is not supported and must always be zero.

Byte 3–5 The *buffer offset* is added to the starting address of the buffer to determine the destination of the first data byte. The bytes that follow are placed in sequential addresses. If the sum of the buffer offset and the transfer length exceeds the buffer size reported by the Read Buffer command (see Section 3.5.9), the drive generates a check condition status and the initiator does not transfer any data.

Bytes 6–8 The *parameter list length* field specifies the maximum number of bytes the initiator transfers. If it transfers the 4-byte header, the transfer length includes the header. If the transfer length is zero, no data is transferred to the drive buffer. This is not considered an error.

3.5.9 Read Buffer command ($3C_H$)

In conjunction with the Write Buffer command, the Read Buffer command can be used in the following ways:

- To diagnose problems in the drive's data buffer.
- To test the integrity of the SCSI bus.

Note. This command treats the buffer as a single segment, regardless of the number of segments specified in Mode Page 08_H. (Mode Page 08_H is described in Section C.5.)

<table>
<tr><th>Bit
Byte</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td colspan="3">LUN</td><td>0</td><td>0</td><td colspan="3">Mode</td></tr>
<tr><td>2</td><td colspan="8">Buffer ID (00_H)</td></tr>
<tr><td>3–5</td><td colspan="8">Buffer offset</td></tr>
<tr><td>6–8</td><td colspan="8">Allocation length</td></tr>
<tr><td>9</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>Flag</td><td>Link</td></tr>
</table>

Byte 1 If the *mode* bits contain 000, the initiator reads data from the drive buffer. The data is preceded by a 4-byte header. This mode is called *read combined header and data*.

If the *mode* bits contain 010, the initiator reads data from the drive buffer without a header. This mode is called *read data*.

All other settings for the mode bits are reserved.

Byte 2 The *buffer ID* is not supported and must always be zero.

Byte 3–5 The *buffer offset* is added to the starting address of the buffer to determine the source of the first data byte. The bytes that follow are read from sequential addresses. If the sum of the buffer offset and the transfer length exceeds the available length reported in the Read Buffer header (see Section 3.5.9.1), the drive transfers all the data contained in the buffer.

Bytes 6–8 The *allocation length* field specifies the maximum number of bytes read by the initiator. If the 4-byte header is transferred, the transfer length includes the header. If the transfer length is zero, no data is read. This is not considered an error.

3.5.9.1 Read Buffer header

Bit / Byte	7	6	5	4	3	2	1	0
0	0							
1–3	Buffer capacity							

Bytes 1–3 The *buffer capacity* field specifies the size of the drive buffer.

3.5.10 Read Long command ($3E_H$)

When the drive receives the Read Long command, it transfers data to the initiator.

Bit / Byte	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	1	0
1	LUN			0	0	0	0	0
2–5	Logical block address							
6	0	0	0	0	0	0	0	0
7–8	Byte transfer length							
9	0	0	0	0	0	0	Flag	Link

Bytes 2–5 The *logical block address* specifies the LBA where the drive begins reading data.

Bytes 7–8 The *byte transfer length* specifies the number of bytes transferred to the initiator. The drive transfers either the byte transfer length or the logical block size plus six, whichever is less. If the byte transfer length is zero, the drive does not transfer any data to the initiator. This condition is not considered an error.

3.5.11 Write Long command ($3F_H$)

When the drive receives the Write Long command, it writes one logical block of data and six bytes of error correction code (ECC) to the disc. During this command, the drive does not perform any ECC verification.

Bit / Byte	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	1	1
1	LUN			0	0	0	0	0
2–5	Logical block address							
6	0	0	0	0	0	0	0	0
7–8	Byte transfer length							
9	0	0	0	0	0	0	Flag	Link

Bytes 2–5 The *logical block address* specifies the LBA where the drive begins writing data.

Bytes 7–8 The *byte transfer length* specifies the number of bytes transferred by the initiator to the drive. If the transfer length does not equal the sum of the logical block size plus six, the command is terminated with a check condition status. If the byte transfer length is zero, the initiator does not transfer any data to the drive; this condition is not considered an error.

3.6 Group 2, 3 and 4 commands

Group 2, 3 and 4 commands are 10-byte commands. Group 2 commands are are not implemented. Group 3 and 4 commands are reserved. If the drive receives one of these commands, it returns a check condition status.

Note. Do not use Group 3 and 4 commands. If you do, you may destroy data on the disc.

3.7 Group 5 and 6 commands

Group 5 and 6 commands are 12-byte commands. Group 5 commands are not implemented. If the drive receives a Group 5 command, it returns a check condition status. Group 6 commands are reserved for Seagate use.

Note. Do not use Group 6 commands. If you do, you may destroy data on the disc.

3.8 Group 7 commands

Group 7 commands are 10-byte commands. These commands are not implemented. If the drive receives one of these commands, it returns a check condition status.

Appendix A. Supported messages

A.1 Single-byte messages

The implemented single-byte messages are listed below.

Code	Message name	Direction	Must negate ATN before last ACK?
06_H	Abort	O	Yes
$0D_H$	Abort tag	O	Yes
$0C_H$	Bus device reset	O	Yes
$0E_H$	Clear queue	O	Yes
00_H	Command complete	I	—
04_H	Disconnect	I	—
80_H	Identify	I/O	No
23_H	Ignore wide residue	I	—
$0F_H$	Initiate recovery	I/O	Yes
05_H	Initiator detected error	O	Yes
$0A_H$	Linked command complete	I	—
$0B_H$	Linked command complete (with flag)	I	—
09_H	Message parity error	O	Yes
07_H	Message reject	I/O	Yes
08_H	No operation	O	Yes
21_H	Head of queue tag	O	No
22_H	Ordered queue tag	O	No
20_H	Simple queue tag	O	No
10_H	Release recovery	O	Yes
03_H	Restore pointers	I	—
02_H	Save data pointer	I	—
11_H	Terminate I/O process	O	Yes

A.2 Synchronous data transfer request message (01_H)

The synchronous data transfer message is the only extended message supported by the drive.

Depending on the value contained in the SSM bit (contained in byte 2 of the Operating page in Section C.10), the drive or the initiator can negotiate for synchronous data transfer after a reset. If any problem precludes the successful exchange of synchronous data transfer request messages, the initiator and drive default to asynchronous data transfers. This exchange of messages establishes the transfer period and the REQ/ACK offset.

Bit Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Extended message (01_H)							
1	Extended message length (03_H)							
2	Identifier code (01_H)							
3	Minimum transfer period divided by 4							
4	REQ/ACK offset							

Byte 0 This byte identifies the message as an extended message.

Byte 1 This byte reports the length of the message.

Byte 2 This byte identifies the message as a synchronous data transfer request message.

Byte 3 The value contained in this byte is in nanoseconds. It is equal to the minimum time between leading edges of successive REQ and ACK pulses divided by four. In byte 3, the minimum value supported by the drive is 25, which is equivalent to a transfer period of 100 nanoseconds, or an external transfer rate of 10 Mbytes per second. A value of 50 is equivalent to a transfer period of 200 nanoseconds, or an external transfer rate of 5 Mbytes per second.

Byte 4 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 of zero indicates asynchronous mode. The drive supports a maximum REQ/ACK offset of six.

Appendix B. Sense data

The appendix contains the descriptions for sense data returned by the Request Sense command. For more information on the Request Sense command, see Section 3.4.3.

B.1 Additional sense data

When the initiator issues a Request Sense command, the drive returns the following additional sense data.

Bit / Byte	7	6	5	4	3	2	1	0
0	Valid	Error code						
		1	1	1	0	0	0	X
1	Segment number (00_H)							
2	0	0	ILI	0	Sense key			
3–6	Information bytes							
7	Additional sense length							
8–11	Command specific data							
12	Additional sense code							
13	Additional sense code qualifier							
14	FRU code							
15	SKSV	Sense key specific						
16–17								
18–22	Product-unique sense data (00_H)							

Byte 0 If the *valid* bit is one, the information bytes (bytes 3 through 6) are valid. If the validity bit is zero, the information bytes are not valid.

If the *error code* contains a value of 70_H, the error occurred on the command that is currently pending. If the error code contains a value of 71_H, the error occurred during the execution of a previous command for which a good status has already been returned.

Byte 1 The *segment number* is always zero.

Byte 2 If the *incorrect length indicator (ILI)* bit is zero, the requested block of data from the previous command did not match the logical block length of the data on the disc. If the ILI bit is one, the request block of data from the previous command matched the logical block length of the data on the disc.

The *sense key* indicates one of nine general error categories. These error categories are listed in Appendix B.2.

Bytes 3–6 When the *valid* bit is 1, the *information bytes* contain the logical block address of the current logical block associated with the sense key. For example, if the sense key is media error, the information bytes contain the logical block address of the offending block.

Byte 7 The *additional sense length* is limited to a maximum of $0E_H$ additional bytes. If the allocation length of the command descriptor block is too small to accommodate all of the additional sense bytes, the additional sense length is not adjusted to reflect the truncation.

Bytes 8–11 These bytes contain command specific data.

Bytes 12–13 The *additional sense code* and *additional sense code qualifier* provide additional details about errors. See Appendix B.3.

Byte 14 The *field replaceable unit (FRU) code* is used by field service personnel only.

Bytes 15–22 These bytes are not used.

B.2 Sense key

The sense keys in the lower-order bits of byte 2 of the sense data returned by the Request Sense command are described in the following table. You can find a more detailed description of the error by checking the additional sense code and the additional sense code qualifier in Section B.3.

Sense key	Description
0_H	**No Sense.** In the case of a successful command, no specific sense key information needs to be reported for the drive.
1_H	**Recovered error.** The drive completed the last command successfully with some recovery action. When many recovered errors occur during one command, the drive determines which error it will report.
2_H	**Not ready.** The addressed logical unit cannot be accessed. Operator intervention may be required to correct this condition.
3_H	**Medium error.** The command was terminated with a nonrecoverable error condition, probably caused by a flaw in the media or an error in the recorded data.
4_H	**Hardware error.** The drive detected a nonrecoverable hardware failure while performing the command or during a self-test. This includes, for example, SCSI interface parity errors, controller failures and device failures.
5_H	**Illegal request.** An illegal parameter in the command descriptor block or in the additional parameters supplied as data for some commands (for example, the Format Unit command, the Mode Select command and others). If the drive detects an invalid parameter in the command descriptor block, it terminates the command without altering the media. If the drive detects an invalid parameter in the additional parameters supplied as data, the drive may have already altered the media.
6_H	**Unit attention.** The drive may have been reset. See the *Seagate SCSI-2 Interface Manual*, publication number 77765466, for more details about the Unit Attention condition.
B_H	**Aborted command.** The drive aborted the command. The initiator may be able to recover by retrying.
E_H	**Miscompare.** The source data did not match the data read from the media.

B.3 Additional sense code and additional sense code qualifier

The additional sense code and additional sense code qualifiers returned in byte 12 and byte 13, respectively, of the Sense Data Format of the Request Sense command are listed in the following table.

Error code (hex)		Description
Byte 12	**Byte 13**	
00	00	No additional information is supplied.
01	00	There is no index/sector signal.
02	00	There is no seek complete signal.
03	00	A write fault occurred.
04	00	The drive is not ready and the cause is not reportable.
04	01	The drive is not ready, but it is in the process of becoming ready.
04	02	The drive is not ready; it is waiting for the initializing command.
04	03	The drive is not ready; human intervention is required.
04	04	The drive is not ready; the format routine is in process.
05	00	The drive does not respond when it is selected.
06	00	Track 0 was not found.
07	00	More than one drive is selected at a time.
08	00	There was a drive communication failure.
08	01	A drive communication time-out occurred.
08	02	A drive communication parity error occurred.
09	00	A track following error occurred.
0A	00	An error log overflow occurred.
0C	01	A write error occurred, but the error was recovered using auto-reallocation.
0C	02	A write error occurred. Auto-reallocation was attempted, but it failed.
10	00	An ID CRC or ECC error occurred.

Error code (hex)		Description
Byte 12	Byte 13	
11	00	An unrecovered read error occurred.
11	01	The read retries were exhausted.
11	02	The error was too long to correct.
11	03	There were multiple read errors.
11	04	A read error occurred. Auto-reallocation was attempted, but it failed.
12	00	The address mark was not found in the ID field.
13	00	The address mark was not found in the data field.
14	00	No record was found.
14	01	No record was found.
15	00	A seek positioning error occurred.
15	01	A mechanical positioning error occurred.
15	02	A positioning error was detected by reading the media.
16	00	A data synchronization mark error occurred.
17	00	The data was recovered without applying error correction or retrying.
17	01	The data was recovered with retries.
17	02	The data was recovered with positive head offset.
17	03	The data was recovered with negative head offset.
17	05	The data was recovered using the previous sector ID.
17	06	The data was recovered without ECC. The drive uses data auto-reallocation.
18	00	The data was recovered with ECC.
18	01	The data was recovered with ECC and retries.
18	02	The data was recovered with ECC, retries, and auto-reallocation.
19	00	There is an error in the defect list.

Error code (hex)		Description
Byte 12	**Byte 13**	
19	01	The defect list is not available.
19	02	There is an error in the primary defect list.
19	03	There is an error in the grown defect list.
1A	00	A parameter overrun occurred.
1B	00	A synchronous transfer error occurred.
1C	00	The defect list could not be found.
1C	01	The primary defect list could not be found.
1C	02	The grown defect list could not be found.
1D	00	During a verify operation, a compare error occurred: the source data did not match the data read from the media.
1E	00	An ID error was recovered.
20	00	The drive received an invalid command operation code.
21	00	The logical block address was not within the acceptable range.
22	00	The drive received a CDB that contains an invalid bit. (This error code applies to direct-access devices.)
24	00	The drive received a CDB that contains an invalid bit. (This error code applies to all SCSI devices.)
25	00	The drive received a CDB that contains an invalid LUN.
26	00	The drive received a CDB that contains an invalid field.
26	01	The drive received a CDB containing a parameter that is not supported.
26	02	The drive received a CDB containing an invalid parameter.
26	03	The drive received a CDB containing a threshold parameter that is not supported.
29	00	A power-on reset or a bus device reset occurred.

Error code (hex)		Description
Byte 12	Byte 13	
2A	00	Some parameters were changed by another initiator.
2A	01	The Mode Select parameters were changed by another initiator.
2B	00	The microcode was downloaded.
2F	00	The tagged commands were cleared by another initiator.
30	01	The media cannot be read because the format is not recognized.
30	02	The media cannot be read because the format is incompatible with certain parameters.
31	00	The media format is corrupted.
31	01	The format command failed.
32	00	There are no spare defect locations available.
32	01	An error occurred when the defect list was being updated.
37	00	A rounded parameter caused an error.
3D	00	The identify message contains invalid bits.
3F	00	The target operation command was changed.
3F	01	The microcode was changed.
3F	02	The drive was operating as a SCSI drive and is now operating as a SCSI-2 drive, or vice versa.
3F	03	The inquiry data was changed.
40	00	The RAM failed.
40	8*x*	A correctable ECC error occurred; *x* equals the length of the error.
40	90	A configuration error occurred.
40	A0	The self-test routine discovered an error in a ROM.
40	A1	The self-test routine discovered an error in the processor RAM.
40	A2	The self-test routine discovered an error in the buffer RAM.

Error code (hex)		Description
Byte 12	Byte 13	
40	A3	The self-test routine discovered a SCSI protocol error.
40	A4	The self-test routine discovered a DMA error.
40	A5	The self-test routine discovered an error in the disc sequencer.
40	A6	The self-test routine discovered an error in the disc sequencer RAM.
40	A7	A self-test error occurred.
40	A8	The EEPROM cannot be read or written.
40	A9	The EEPROM directory cannot be read, or it is corrupted.
40	AA	The EEPROM contains an incompatible version number.
40	AB	The EEPROM contains an incompatible revision number.
40	AC	An EEPROM checksum error occurred.
40	AD	The EEPROM contains invalid parameters.
40	AE	The EEPROM is incompatible with the HDA and the circuit board. The EEPROM must be reconfigured.
40	B0	The servo command timed out.
40	B1	The servo command failed.
40	B2	The servo command was rejected.
40	B3	The servo interface does not work.
40	B4	The servo either failed to lock on track during spinup, or has wandered off track.
40	B5	An internal servo error occurred.
40	B6	During spinup, a servo error occurred.
40	B7	The servo pattern is inconsistent.
40	B8	A seek recovery error occurred.
40	B9	The actuator did not achieve high-speed calibration.
40	C0	The defect list is full.

Error code (hex)		Description
Byte 12	**Byte 13**	
40	C1	A failure occurred while the grown defect list was being written.
40	C2	The write life-cycle of the EEPROM has been exceeded.
40	C3	There was an attempt to add an illegal entry to the grown defect list.
40	C4	There was an attempt to add a duplicate entry to the grown defect list.
41	00	A data path diagnostic failed.
42	00	A power-on or self-test failure occurred.
43	00	A message reject error occurred.
44	00	An internal controller error occurred.
45	00	An error occurred during a selection or a reselection.
47	00	A SCSI interface bus parity error occurred.
48	00	The initiator has detected an error.
49	00	The initiator received an invalid message from the drive.
4C	00	Drive failed to self-configure.
4E	00	The drive attempted to perform overlapped commands.
5B	00	There was a log exception.
5B	01	A threshold condition was met.
5B	02	The log counter has reached its maximum value.
5B	03	All the log list codes have been used.
5C	00	There was a change in the RPL status. The drive lost synchronization.

Appendix C. Mode pages

Mode pages are groups of parameters stored by the drive. These parameters can be read using the Mode Sense command and changed using the Mode Select command. These commands are described in Sections 3.4.10 and 3.4.13.

This appendix contains the default parameters and the changeable parameters for the mode pages. The current parameters and the saved parameters are not shown.

Note. The default values contained in this appendix may differ from the default values actually contained in your drive. To determine the default values, use the Mode Sense command.

Mode page	Page code	Bytes	Contains changeable parameters
Error Recovery page	01_H	10	Yes
Disconnect/Reconnect page	02_H	14	Yes
Format Device page	03_H	22	Yes
Rigid Disc Geometry page	04_H	22	Yes
Caching page (SCSI-3)	08_H	18	Yes
Control Mode page	$0A_H$	10	Yes
Notch page	$0C_H$	22	No
Cache Control page	38_H	14	No
Soft ID page	$3C_H$	1	Yes
Operating page	00_H	2 or 3	Yes

For all mode pages:

- If the changeable value is 0, the initiator *cannot* change the bit directly. If the changeable value is 1, the initiator *can* change the bit directly.

  For example, in the header below, the changeable value for the page code bits is 0, which means that the page code cannot be changed; the changeable value of the PS bit is one, which means that the PS bit can be changed.

- During the Mode Sense command, the PS (parameter savable) bit is 1, which means the mode page is saved on the disc. During the Mode Select command, you must set the PS bit to 0.
- An X means that the value of the bit cannot be specified. For example, the default value of bit 0 of byte 1 of page 00_H (the Operating Page) cannot be specified because the bit can be either 1 or 0.

All mode pages contain a 2-byte header that contains the page code and the page length for that particular page. The header is shown below.

Bit **Byte**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS	Page code						
changeable	1	0	0	0	0	0	0	0
1	Page length							
changeable	00_H							

Byte 0 During the Mode Sense command, the *PS* (parameter savable) bit is 1, which means the mode page is saved on the disc. During the Mode Select command, you must set the PS bit to 0.

The *page code* is the unique code that identifies the page.

Byte 1 The *page length* is the length, in bytes, of the page.

C.1 Error Recovery page (01_H)

The Error Recovery page is shown below. This table summarizes the function, the default value, and the changeability of each bit.

Bit / Byte	7	6	5	4	3	2	1	0
0	PS (1)	Page code (01_H)						
1	Page length ($0A_H$)							
2	AWRE	ARRE	TB	RC	EER	PER	DTE	DCR
default	0	0	0	0	0	0	0	0
changeable	1	1	1	1	1	1	1	1
3 (default)	Read retry count (20_H)							
changeable	FF_H							
4 (default)	Correction span (16_H)							
changeable	00_H							
5 (default)	Head offset count (00_H)							
changeable	00_H							
6 (default)	Data strobe offset count (00_H)							
changeable	00_H							
7 (default)	Reserved (00_H)							
changeable	00_H							
8 (default)	Write retry count (20_H)							
changeable	00_H							
9 (default)	Reserved (00_H)							
changeable	00_H							
10–11 (default)	Recovery time limit ($FFFF_H$)							
changeable	0000_H							

Byte 2 When the *Automatic Write Reallocation Enabled (AWRE)* bit is 1, the drive automatically reallocates bad blocks detected while writing to the disc. When the AWRE bit is 0, the drive does not perform automatic reallocation; instead, the drive reports a check condition status with a sense key of media error.

Note. The AWRE bit does not apply during the Format command.

Byte 2 continued

When the *Automatic Read Reallocation Enabled (ARRE)* bit is 1, the drive automatically reallocates bad blocks detected while reading from the disc. When the ARRE bit is 0, the drive does not automatically reallocate bad blocks. Instead, a check condition status is reported with a sense key of media error.

When the *Transfer Block (TB)* bit is 1, the failing data block is transferred to the initiator. When the TB bit is 0, the failing data block is not transferred.

When the *Read Continuous (RC)* bit is 1, the drive sends all data without doing any corrections. This function supersedes other bits in this byte. When the RC bit is 0, the correction is performed according to the other bits in this byte.

When the *Enable Early Recovery (EER)* bit is 1, the drive retries the command before applying ECC. When the EER bit is 0, the drive applies ECC immediately. This bit applies to data error recovery only; it does not affect positioning retries and message system error recovery procedures.

When the *Post Error (PER)* bit is 1, the drive reports the check condition status and the appropriate sense key for any recovered errors encountered. When the PER bit is 0, any errors recovered within the limits established by the other error recovery flags are not reported. Any nonrecoverable errors are reported.

The *Disable Transfer on Error (DTE)* bit is valid only when the PER bit is set to 1. When the DTE bit is 1, the drive terminates data transfer if a recoverable error occurs. When the DTE bit is 0, the drive continues transferring data if recoverable errors are encountered.

When the *Disable Correction (DCR)* bit is 1, the drive does not apply ECC to the data even if correction is possible.

Byte 3

The *read retry count* field is the maximum number of times the drive attempts its recovery algorithms. If the *EER* bit is 1, the number of retries specified by read retry count (up to a maximum of nine retries) is performed before ECC is applied. The read retry count field has a range of 0 through 20_H. A read retry count of 0 means that no retries are performed.

Byte 4

The *correction span* is the size of the largest read data error, in bits, on which ECC correction is attempted. Longer errors are reported as nonrecoverable.

Byte 5 The *head offset count* is not implemented. Head offsets are performed as part of the drive's retry algorithms.

Byte 6 The *data strobe offset count* is not implemented.

Byte 7 Reserved.

Byte 8 The *write retry count* field contains the maximum number of times the drive attempts its recovery algorithms. If the EER bit is set, the number of retries specified by the retry count, up to a maximum of nine retries, is performed before ECC is applied. The write retry count field has a range of 0 through 20_H. A write retry count of 0 means that no retries are performed.

Byte 9 Reserved.

Bytes 10–11 The *recovery time limit* field always has a value of $FFFF_H$, which means that the recovery time is unlimited.

C.2 Disconnect/Reconnect page (02_H)

The Disconnect/Reconnect page is shown below. This table summarizes the function, the default value, and the changeability of each bit.

Bit Byte	7	6	5	4	3	2	1	0
0	PS (1)	Page code (02_H)						
1	Page length ($0E_H$)							
2 (default)	Buffer full ratio ($F0_H$)							
changeable	FF_H							
3 (default)	Buffer empty ratio (10_H)							
changeable	FF_H							
4–5 (default)	Bus inactivity limit ($000A_H$)							
changeable	0000_H							
6–7 (default)	Disconnect time limit (0000_H)							
changeable	0000_H							
8–9 (default)	Connect time limit (0000_H)							
changeable	0000_H							
10–11 (default)	Maximum burst size (0000_H)							
changeable	0000_H							
12–15 (default)	Reserved (00000000_H)							
changeable	0000_H							

Byte 2 The *buffer full ratio* field indicates, on Read commands, how full the drive's buffer is before reconnecting. The drive rounds up to the nearest whole logical block. This parameter is the numerator of a fraction that has 256 as its denominator.

Byte 3 The *buffer empty ratio* field indicates, on Write commands, how empty the drive's buffer is before reconnecting to fetch more data. The drive rounds up to the nearest whole logical block. This parameter is the numerator of a fraction that has 256 as its denominator.

Bytes 4–5 The *bus inactivity limit* field indicates the time, in 100-µsec increments, that the drive can assert the Busy signal without handshakes until it disconnects. The drive may round down to its nearest capable value. The default value of $000A_H$ allows the drive to maintain the BSY– signal for 1 msec without handshakes.

Bytes 6–7 The *disconnect time limit* field indicates the minimum time, in 100-µsec increments, the drive remains disconnected until it attempts to reconnect. A value of 0 indicates that the drive is allowed to reconnect immediately.

Bytes 8–9 The *connect time limit* field indicates the maximum time, in 100-µsec increments, that the drive should remain connected until it attempts to disconnect. The drive may round to its nearest capable value. A value of 0 means that the drive can remain connected indefinitely until it tries to disconnect.

Bytes 10–11 The *maximum burst size* field limits the amount of data that can be transferred during the data phase before the drive disconnects from the host. The value, multiplied by 512, indicates the maximum number of bytes that can be contained in a single burst. A value of 0 means that there is no limit to how many bytes can be transferred during a single burst.

Bytes 12–15 Reserved.

C.3 Format Device page (03_H)

The Format Device page is shown below. This table summarizes the function, the default value, and the changeability of each bit.

This page is sent only before the Format Unit command is sent. The drive parameters are updated immediately, but any changes between these current parameters and the existing media format do not take effect until after the Format Unit command is completed.

Bit Byte	7	6	5	4	3	2	1	0
0	PS (1)	Page code (03_H)						
1	Page length (16_H)							
2–3	Tracks per zone							
default	ST3285N and ST3390N = 0003_H ST3550N and ST3655N = 0005_H							
changeable	$FFFF_H$							
4–5 (default)	Alternate sectors per zone (0001_H)							
changeable	$FFFF_H$							
6–7 (default)	Alternate tracks per zone (0000_H)							
changeable	0000_H							
8–9	Alternate tracks per volume							
default	ST3285N and ST3390N = 0006_H ST3550N and ST3655N = $000A_H$							
changeable	$FFFF_H$							
10–11 (default)	Sectors per track (0052_H)							
changeable	0000_H							
12–13 (default)	Data bytes per physical sector (0200_H)							
changeable	0000_H							
14–15 (default)	Interleave (0001_H)							
changeable	0000_H							
16–17 (default)	Track skew factor (0002_H)							
changeable	$FFFF_H$							
18–19 (default)	Cylinder skew factor (0009_H)							
changeable	$FFFF_H$							

continued

continued from previous page

Bit Byte	7	6	5	4	3	2	1	0
20	SSEC	HSEC	RMB	SURF	Reserved			
default	1	0	0	0				
changeable	0	0	0	0	0	0	0	0
21–23 (default)	Reserved (000000_H)							
changeable	000000_H							

Bytes 2–3 The *tracks per zone* field indicates the number of tracks the drive allocates to each defect-management zone. Spare sectors or tracks are placed at the end of each defect management zone. If each zone is treated as containing one track, the valid value for tracks per zone is 1. If each zone is treated as containing one cylinder, the valid value is equal to the number of read/write heads.

Bytes 4–5 The *alternate sectors per zone* field indicates the number of spare sectors to be reserved at the end of each defect-management zone. The drive defaults to one spare sector per zone. If each zone is treated as containing one track, the valid value for alternate sectors per zone is 1. If each zone is treated as containing one cylinder, the valid values are 1 through 3.

Bytes 6–7 The *alternate tracks per zon*e field indicates the number of spare tracks the drive reserves at the end of each defect-management zone. A value of 0 indicates that no spare tracks are reserved at the end of each zone for defect management.

Bytes 8–9 The *alternate tracks per volume* field indicates the number of spare tracks to be reserved at the end of the drive for defect management.

For the ST3285N and ST3390N, the value must be a multiple of 3 and can range from 3 through 255. For the ST3550N and ST3655N, the value must be a multiple of 5 and can range from 5 through 255.

The default is equal to twice the number of read/write heads.

Bytes 10–11 The *sectors per track* field indicates the number of physical sectors the drive allocates per track. The drive reports the average number of physical sectors per track since the number of sectors per track varies between the outer and inner tracks.

Bytes 12–13 The *data bytes per physical sector* field indicates the number of data bytes allocated per physical sector.

Bytes 14–15 The *interleave* field is the interleave value sent to the drive during the last Format Unit command. This field is valid only for Mode Sense commands. The drive ignores this field during Mode Select commands. The interleave is always 1:1.

Bytes 16–17 The *track skew factor* field indicates the number of physical sectors on the media between the last logical block of one track and the first logical block of the next sequential track of the same cylinder. The actual track skew factor being used by the drive is different for every zone. The default value is 0002_H which is the track skew factor for the first zone. This default value is only used when tracks per zone and alternate sectors per zone are set to 1.

If the initiator attempts to change the value of the track skew factor, the drive responds with a good status. However, the initiator cannot directly change the track skew factor.

Bytes 18–19 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. The actual cylinder skew factor that the drive uses depends on the zone. The default value is 0009_H, which is the cylinder skew factor for the first zone.

If the initiator attempts to change the value of the cylinder skew factor, the drive responds with a good status. However, the initiator cannot directly change the cylinder skew factor.

Byte 20 The *drive type* field bits are defined as follows:

The *Soft Sectoring (SSEC)* bit is set to 1. This bit is reported as not changeable. Although it can be set to satisfy system requirements, it does not affect drive performance.

The *Hard Sectoring (HSEC)* bit is set to 0. This bit is reported as not changeable. Although it can be set to satisfy system requirements, it does not affect drive performance.

The *Removable Media (RMB)* bit is always set to 0, indicating that the drive does not support removable media. This same bit is also returned in the Inquiry parameters.

The *Surface Map (SURF)* bit is set to 0, indicating that the drive allocates successive logical blocks to all sectors within a cylinder before allocating logical blocks to the next cylinder.

Bytes 21–23 Reserved.

C.4 Rigid Disc Geometry page (04_H)

The Rigid Disc Geometry page is shown below. This table summarizes the function, the default value, and the changeability of each bit.

Bit / Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS (1)	Page code (04_H)						
1	Page length (16_H)							
2–4	Number of cylinders							
changeable	000000_H							
5	Number of heads							
changeable	00_H							
6–8	Starting cylinder for write precompensation							
default	000000_H							
changeable	000000_H							
9–11	Starting cylinder for reduced write current							
default	000000_H							
changeable	000000_H							
12–13 (default)	Drive step rate (0000_H)							
changeable	0000_H							
14–16 (default)	Loading zone cylinder (000000_H)							
changeable	000000_H							
17	Reserved						RPL	
default							0	0
changeable	0	0	0	0	0	0	1	1
18 (default)	Rotational offset (00_H)							
changeable	FF_H							
19 (default)	Reserved (00_H)							
changeable	00_H							
20–21	Media rotation rate							
default	1194_H							
changeable	0000_H							
22–23 (default)	Reserved (0000_H)							
changeable	0000_H							

Bytes 2–4 The *number of cylinders* field specifies the number of user-accessible cylinders, including two spare cylinders set aside for defects. The drive uses the additional cylinders for storing parameters and defect lists, or for diagnostic purposes. The number of cylinders is specified on page 1.

Byte 5 The *number of heads* field specifies the number of read/write heads on the drive. The number of heads is specified on page 1.

Bytes 6–16 The *starting cylinder for reduced write current*, *starting cylinder for reduced read current, drive step rate*, and *loading zone cylinder* bytes are not used by the drive.

Byte 17 When the *Rotational Position Locking (RPL)* bits are 00_{Binary}, the rotational position locking is changeable. When the *RPL* bits are 01_{Binary}, the drive automatically synchronizes its spindle with the synchronized master. When the *RPL* bits are 10_{Binary} or 11_{Binary}, the drive is the synchronized-spindle master.

For more information about external spindle-clock synchronization, see Section 2.11.

Byte 18 The *rotational offset* is the rotational skew the drive uses when synchronized. The rotational skew is applied in the retarded direction (lagging the sync spindle master). A value of zero means no rotational offset is used.

Byte 19 Reserved.

Bytes 20–21 The medium rotation rate is the spindle speed, which is specified on page 1.

Bytes 22–23 Reserved.

C.5 Caching page (08_H)

The drive uses read look-ahead, read caching and write caching to improve seek times and performance.

C.5.1 Read look-ahead and read caching

The drive uses an algorithm that improves seek performance by reading the next logical sectors after the last requested sector. These unrequested sectors are read into a buffer and are ready to be transmitted to the host before they are requested. Because these sectors are read before they are requested, access read time for the sectors is virtually eliminated. This process is called either read look-ahead or read caching.

Read look-ahead and caching are similar algorithms. Read look-ahead occurs when a Read command requests more data than can be contained in one buffer segment. Caching occurs when a Read command requests less data than can be contained in one buffer segment.

The buffer used for read look-ahead and caching can be divided into segments as shown in the following table. To change the number of segments, use byte 13 of the Caching page, which is described in Appendix C.5.3. The default is one, 256-Kbyte segment.

Number of segments	Size of segment (in Kbytes)
1	256
2	128
4	64
8	32
16	16

When the buffer is divided into multiple segments, each segment functions as an independent buffer, causing dramatically increased performance in multitasking and multiuser environments.

C.5.2 Write caching and write merging

Write caching. The drive uses the write segment to store write commands and data. After the drive caches the commands and data, it is immediately ready to process new commands. The drive writes the data to the disc at its next convenient opportunity.

Write merging. The drive accepts contiguous write commands and executes them sequentially as one command.

C.5.3 Caching page description

The Caching page is shown below. This table summarizes the function, the default value and the changeability of each bit.

<table>
<tr><th>Bit
Byte</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td>PS (1)</td><td colspan="7">Page code (08_H)</td></tr>
<tr><td>1</td><td colspan="8">Page length (12_H)</td></tr>
<tr><td>2</td><td>IC</td><td>ABPF</td><td>CAP</td><td>DISC</td><td>SIZE</td><td>WCE</td><td>MF</td><td>RCD</td></tr>
<tr><td>default</td><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>changeable</td><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>3</td><td colspan="4">Demand read retention priority</td><td colspan="4">Write retention priority</td></tr>
<tr><td>default</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>changeable</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>4–5 (default)</td><td colspan="8">Disable prefetch transfer length ($FFFF_H$)</td></tr>
<tr><td>changeable</td><td colspan="8">0000_H</td></tr>
<tr><td>6–7 (default)</td><td colspan="8">Minimum prefetch (0000_H)</td></tr>
<tr><td>changeable</td><td colspan="8">0000_H</td></tr>
<tr><td>8–9 (default)</td><td colspan="8">Maximum prefetch ($FFFF_H$)</td></tr>
<tr><td>changeable</td><td colspan="8">$FFFF_H$</td></tr>
<tr><td>10–11 (default)</td><td colspan="8">Maximum prefetch ceiling ($FFFF_H$)</td></tr>
<tr><td>changeable</td><td colspan="8">$FFFF_H$</td></tr>
<tr><td>12</td><td>FSW</td><td>Rsrvd</td><td>DRA</td><td colspan="5">Reserved</td></tr>
<tr><td>default</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>changeable</td><td>1</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
</table>

Bit Byte	7	6	5	4	3	2	1	0
13	Number of cache segments							
default	0	0	0	0	0	0	0	1
changeable	1	1	1	1	1	1	1	1
14–15 (default)	Cache segment size (0000_H)							
changeable	0000_H							
16 (default)	Reserved (00_H)							
changeable	00_H							
17–19 (default)	Noncache segment size (000000_H)							
changeable	000000_H							

Byte 2 When the *Initiator Control (IC)* bit is 1, the drive uses either the number of cache segments field or the cache segment size field, as determined by the SIZE bit (bit 3), to control the caching algorithm. When the IC bit is 0, the drive uses its own algorithm to control caching.

When the *Abort Prefetch (ABPF)* bit is 0, the drive controls completion of prefetch. See the description for the DISC bit, below. This is the default value and it is not changeable.

When the *Caching Analysis Permitted (CAP)* bit is 0, caching analysis is disabled to reduce overhead time or to prevent operations that are not pertinent from impacting tuning values. When the CAP bit is 1, caching analysis is enabled.

When the *Discontinuity (DISC)* bit is 1, the drive may prefetch across cylinder boundaries, where head seeks consume additional processing time. This is the default value and it is not changeable.

When the *Size Enable (SIZE)* bit is 0, the drive uses the number of cache segments field to control caching segmentation. When the SIZE bit is 1, the drive uses the cache segment size field to control caching segmentation.

When the *Write Cache Enable (WCE)* bit is 0, the drive returns a good status for a Write command after successfully writing all the data to the media. When the WCE bit is 1, the drive returns a good status for a Write command after successfully receiving the data and before writing it to the media.

Byte 2 continued When the *Multiplication Factor (MF)* bit is 0, the drive interprets the *minimum prefetch* and *maximum prefetch* fields as the number of logical blocks to be prefetched. When the MF bit is 1, the drive interprets the minimum prefetch and maximum prefetch fields in terms of a number which, when multiplied by the transfer length of the current command, yields the number of logical blocks to be prefetched.

When the *Read Cache Disable (RCD)* bit is 0, the drive may return data requested by a Read command by accessing either the cache or the media. If the RCD bit is 1, the cache is not used.

Byte 3 The *demand read retention priority* field is not used. The initiator cannot assign any special retention priority to the drive.

The *write retention priority* field is not used. The initiator cannot assign any special retention priority to the drive.

Bytes 4–5 The *disable prefetch transfer length* always has a value of $FFFF_H$, which means that the drive attempts an anticipatory prefetch for all Read commands.

Bytes 6–7 The *minimum prefetch* field specifies the minimum number of blocks the drive prefetches, regardless of the delays it may cause in executing subsequent pending commands. When the minimum prefetch field contains 0, the drive terminates prefetching whenever another command is ready to be executed. If the minimum prefetch equals the maximum prefetch, the drive prefetches the same number of blocks regardless of whether there are commands pending.

Bytes 8–9 The *maximum prefetch* field specifies the maximum number of blocks the drive prefetches during a Read command if there are no other commands pending. The maximum prefetch field represents the maximum amount of data to prefetch into the cache for any single Read command.

Bytes 10–11 The *maximum prefetch ceiling* field should be equal to the maximum prefetch field. The maximum prefetch ceiling and maximum prefetch fields are the same if the MF bit is 0.

Byte 12 When the *Force Sequential Write (FSW)* bit is 1, the drive writes blocks of data to the media sequentially, from lowest to highest logical block address. When the FSW bit is 0, the drive changes the sequence in which it writes logical blocks to speed processing.

When the *Disable Read-Ahead (DRA)* bit is 1, the drive does not read into the buffer any logical blocks beyond the addressed logical blocks. When the DRA bit equals 0, the drive can continue reading logical blocks into the buffer beyond the addressed logical blocks.

Byte 13 The *number of cache segments* field determines how many segments into which the cache should be divided. Valid values are 1, 2, 4, 8, 16 and 32.

Bytes 14–15 The *cache segment size* field indicates the segment size in bytes. The cache segment size field is valid only when the SIZE bit is 1.

Byte 16 Reserved.

Bytes 17–19 The *noncache segment size* field always contains zeros. This means that the entire buffer is available for caching.

C.6 Control Mode page ($0A_H$)

The Control Mode page is shown below. This table summarizes the function, the default value, and the changeability of each bit.

Bit Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS (1)	Page code ($0A_H$)						
1	Page length ($0A_H$)							
2	Reserved							RLEC
default	0	0	0	0	0	0	0	0
changeable	0	0	0	0	0	0	0	1
3	Queue algorithm modifier				Reserved		QErr	DQue
default	0	0	0	0	0	0	0	0
changeable	00_H							
4	EECA	Reserved				RAENP	UAAENP	EAENP
default	0	0	0	0	0	0	0	0
changeable	00_H							
5 (default)	Reserved (00_H)							
changeable	00_H							
6–7 (default)	Ready AEN hold-off period (0000_H)							
changeable	0000_H							
8–9 (default)	Busy timeout period ($FFFF_H$)							
changeable	0000_H							
10–11 (default)	Reserved (0000_H)							
changeable	0000_H							

Byte 2 The *RLEC* bit is not implemented.

Byte 3 The *queue algorithm modifier* field contains zero, which means the drive arranges the execution sequence of the commands using a simple queue tag.

The *disable queuing (DQue)* bit is zero, which means that tagged command queuing is enabled.

Byte 4 Not implemented.

Byte 5 Reserved.

Bytes 6–7 Not implemented.

Bytes 8–9 The *busy timeout period* field contains the maximum possible value, which means that the drive can remain busy an unlimited amount of time.

Bytes 10–11 Reserved.

C.7 Notch page ($0C_H$)

The Notch page contains parameters that describe the notches. The table below summarizes the function, default value, and the changeability of each bit.

The drive uses zone bit recording, which means that the outer cylinders of the disc contain more logical blocks than the inner cylinders. The cylinders are organized into groups, called zones or notches. Every logical block is part of a notch. Notches do not overlap.

Bit Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS (1)	Page code ($0C_H$)						
1	Page length (16_H)							
2	ND	LPN	Reserved					
default	1	0	0	0	0	0	0	0
changeable	0	0	0	0	0	0	0	0
3 (default)	Reserved (00_H)							
changeable	(00_H)							
4–5	Maximum number of notches							
default	ST3285N, ST3390N, ST3550N = 13_H ST3655N = 12_H							
changeable	0000_H							
6–7 (default)	Active notch (0000_H)							
changeable	0	0	0	1	1	1	1	1
8–11 (default)	Starting boundary (00000000_H)							
changeable	00000000_H							
12–15	Ending boundary							
default	ST3285N, ST3390N, ST3550N = $000A7602_H$ ST3655N = $0009BC04_H$							
changeable	00000000_H							
16–23 (default)	Pages notched (0000000000000008_H)							
changeable	0000000000000000_H							

Byte 2 The *notched drive (ND)* bit is always 1, which means the disc contains notches of different recording densities. For each supported active notch value, this page defines the starting and ending boundaries of the notch.

The *logical or physical notch (LPN)* bit is 0, which means the notch boundaries are based on the physical parameters of the logical unit. The cylinder is most significant; the head is least significant.

Byte 3 Reserved.

Bytes 4–5 The *maximum number of notches* field indicates the maximum number of notches supported by the drive.

Bytes 6–7 The *active notch* field identifies the notch to which this, and all future Mode Select and Mode Sense commands refer, until the active notch is changed by a later Mode Select command. The value of the active notch field must be greater than or equal to 0 and less than or equal to the maximum number of notches. An active notch value of 0 means that current and future Mode Select and Mode Sense commands refer to the parameters that apply for all notches.

Bytes 8–11 The *starting boundary* field indicates the beginning of the active notch, if the active notch is not 0, or the starting boundary of the logical unit, if the active notch is 0. This field is ignored by the Mode Select command.

When the LPN bit is 0, the three most significant bytes represent the cylinder number and the least significant byte represents the head number.

Bytes 12–15 The *ending boundary* field indicates the end of the active notch, if the active notch is not 0, or the end of the logical unit, if the active notch is 0. The default is equal to the end of zone 1.

When the LPN bit is 0, the three most significant bytes represent the cylinder number and the least significant byte represents the head number.

Bytes 16–23 The *pages notched* field contains a bit map of the mode page codes that indicates which pages may contain different parameters for each notch. When a bit is 1, the corresponding mode page can contain different parameters for each notch. When a bit is 0, the corresponding mode page contains the same parameters for all the notches. The most significant bit of this field corresponds to page code $3F_H$ and the least significant bit corresponds to page code 00_H.

C.8 Cache Control page (38_H)

The Cache Control page is shown below. This table summarizes the function, the default value and the changeability of each bit.

Bit Byte	7	6	5	4	3	2	1	0
0	PS (1)	Page code (38_H)						
1	Page length ($0E_H$)							
2	Rsrvd	WIE	Rsrvd	CE	Cache table size			
default	0	X	0	X	X	X	X	X
changeable	(00_H)							
3 (default)	Prefetch threshold (00_H)							
changeable	00_H							
4 (default)	Maximum prefetch (FF_H)							
changeable	00_H							
5 (default)	Maximum prefetch multiplier (00_H)							
changeable	00_H							
6 (default)	Minimum prefetch (00_H)							
changeable	00_H							
7 (default)	Minimum prefetch multiplier (00_H)							
changeable	00_H							
8–15 (default)	Reserved (0000000000000000_H)							
changeable	0000000000000000_H							

Byte 2 The *cache enable (CE)* bit is always the inverse of the *RCD* bit in Mode Page 08_H.

The *write index enable (WIE)* bit controls the creation of cache data on Write commands. If bit 6 is 0, the next command treats the cache area as empty.

The *cache table size* field contains the same values as Mode Page 08_H, byte 13, bits 3 through 0.

Byte 3 The *prefetch threshold* is not implemented. The drive reads until the buffer is full upon receipt of a Read command.

Byte 4 The *maximum prefetch* field always contains the same value as byte 9 of the Caching page. The initiator cannot directly change this byte.

Byte 5 The *maximum prefetch multiplier* field always contains the same value as byte 9 of the Caching page. The initiator cannot directly change this byte.

Byte 6 The *minimum prefetch* field always contains the same value as byte 7 of the Caching page. The initiator cannot directly change this byte.

Byte 7 The *minimum prefetch multiplier* field always contains the same value as byte 7 of the Caching page. The initiator cannot directly change this byte.

Byte 8–15 Reserved.

C.9 Soft ID Page (EEPROM) ($3C_H$)

The Soft ID page is shown below. This table summarizes the function, the default value and the changeability of each bit. This page is saved in an EEPROM that has a life span of 10,000 writes.

Note. The write life span is 10,000 writes. To preserve the write life span of the EEPROM, the page is not saved to the EEPROM during a Mode Select command if the new parameters are the same as the current contents in the EEPROM. When the write life cycle limit is exceeded, the drive sets the sense key to hardware error and the additional sense error code to $C2_H$. The additional sense error codes are described in Appendix B.3.

Bit / Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS (1)	Page code ($3C_H$)						
1	Page length (01_H)							
2	Soft ID	Soft Parity	Param enable	Soft remote	Remote S/S	ID 2	ID 1	ID 0
default	0	0	0	0	0	0	0	0
changeable	1	1	1	1	1	1	1	1

Byte 2 When the *soft ID* bit is 0, the drive ignores ID0, ID1 and ID2 and uses the SCSI ID jumpers to determine the SCSI ID. When the soft ID bit is 1, the drive ignores the SCSI ID jumpers and uses ID0, ID1 and ID2 to determine the SCSI ID. See Figure 7 on page 25 for jumper settings.

When the *soft parity* bit is 0, the drive uses the parity jumper settings to determine whether the drive uses parity. When the soft parity bit is 1, the drive ignores the parity jumper settings.

When the *soft remote* bit is 0, the drive uses the remote start jumper setting to determine whether remote start is implemented. When the soft remote bit is 1, the drive ignores the jumpers and uses the remote S/S bit to determine whether remote start is implemented.

When the *remote S/S* bit is 0, the drive spins up after a delay specified by the spinup delay field (byte 4 of the Operating page, 00_H). When the remote S/S bit is 1, the drive spins up when it receives the Start Unit command. This bit is only valid if the soft remote bit is 1.

The *ID0*, *ID1* and *ID2* bits are the SCSI ID bits. These bits are only valid when the soft ID bit is 1.

When the *param enable* bit is 0, the drive does not check parity. When the param enable bit is 1, the drive checks parity. This bit is only valid if the soft parity bit is 1.

C.10 Operating page (EEPROM) (00_H)

The Operating page is shown in the table below. This table shows the function, the default value, and the changeability of each bit.

The drive accepts an Operating page of two lengths: two bytes or three bytes. If the length is two bytes, then byte 4, the *spinup delay* field, is not written and is assumed to be unchanged.

In addition to being saved on the media, this vendor-unique page is saved in an EEPROM that has a life span of 10,000 writes.

Note. The write life span is 10,000 writes. To preserve the write life span of the EEPROM, the page is not saved to the EEPROM during a Mode Select command if the new parameters are the same as the current contents in the EEPROM. When the write life cycle limit is exceeded, the drive sets the sense key to hardware error and the additional sense error code to $C2_H$. The additional sense error codes are described in Appendix B.3.

Bit Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS (1)	Page code (00_H)						
1 (default)	Page length (02_H or 03_H)							
default	0	0	0	0	0	0	1	X
changeable	0	0	0	0	0	0	0	1
2	Usage	SSM	RSVD	ATOFF	Reserved			
default	1	0	0	0	0	0	0	0
changeable	1	1	0	1	0	0	0	0
3	Rsrvd	Device type qualifier (00_H)						
default	0	0	0	0	0	0	0	0
changeable	0	1	1	1	1	1	1	1
4 (default)	Spinup delay (00_H)							
changeable	FF_H							

Byte 2 When the *usage* bit is 1, a warning message is enabled. When the write life span of the EEPROM is exceeded, a warning message is generated. See additional sense error code C2 in

Appendix B.3. When the usage bit is 0, the warning message is disabled. If requested, the EEPROM data and the write counter is updated even after the write life span is exceeded, but the integrity of the data cannot be assured.

Byte 2 When the *synchronous select mode (SSM)* bit is 0, the drive does not send a synchronous data transfer message unless the initiator has already issued a synchronous data transfer message. When the *SSM* bit is 1, the drive can send a synchronous data transfer message, even when the initiator has not sent a synchronous data transfer message.

When the *disable unit attention (ATOFF)* bit is 0, the drive generates a unit attention condition during power up. When the *disable unit attention (ATOFF)* bit is 1, the drive does not generate a unit attention condition during power up.

Byte 3 The *device type qualifier* field can have a value from 00_H through $7F_H$. This field can be read back by the host in Inquiry data, byte 1. The Inquiry data is discussed in Appendix D.

Byte 4 The *spinup delay* field controls the drive when it is not in the remote mode. When the value is 00_H, the drive spins up without delay. When the value is FF_H, the drive delays spinup after a duration, in seconds, equal to the drive's SCSI bus ID number times 5. When the value is 01_H through FE_H, the drive delays spinup for the corresponding duration, in seconds.

Appendix D. Inquiry data

When the initiator issues an Inquiry command, the drive returns either of the following two types of data, depending on the value in the EVPD bit in byte 1 of the Inquiry command descriptor block:

- Inquiry data
- Vital product data

Both types of data are discussed in this appendix. The Inquiry command is described in Section 3.4.9.

D.1 Inquiry data

When the initiator issues an Inquiry command, and the EVDP bit in byte 1 of the Inquiry command descriptor block is 0, the drive returns the following data. If the EVDP bit in byte 1 of the Inquiry command descriptor block is 1, see Appendix D.2.

Bit Byte	7	6	5	4	3	2	1	0
0	Peripheral qualifier			Peripheral device type				
	0	0	0	0	0	0	0	0
1	RMB	Device type qualifier						
	0	0	0	0	0	0	0	0
2	ISO version		ECMA version			ANSI version		
	0	0	0	0	0	0	1	0
3	AENC	TrmIOP	Reserved		Response data format			
	0	0			0	0	1	0
4	Additional length ($8F_H$)							
5–6	Reserved (00_H)							
7	Rel Adr	Wbus32	Wbus16	Sync	Linked	0	CmdQue	Sft Re
8–15	Vendor identification							
16–31	Product identification							
32–35	Product revision level							
36–43	Drive serial number							
44–95	Reserved							
96–143	Copyright notice							
144–147	Servo PROM part number							

Byte 0 The *peripheral qualifier* field contains zero, which means that the drive is currently connected to the logical unit that is issuing the Inquiry command.

The *peripheral device type* field contains zero, which means that the drive is a direct access device.

Byte 1 The *RMB* bit is 0, which means the discs are not removable.

The *device type modifier* is not used.

Byte 2 The *ISO version* field contains zero, which means that we do not claim compliance with ISO 9316.

The *EMCA version* field contains zero, which means that we do not claim compliance with EMCA-111.

The *ANSI version* field contains two, which means that the drive complies with ANSI SCSI-2 standard X3.131-199x.

Byte 3 The *asynchronous event notification (AENC)* bit is zero, which means that the drive does not support asynchronous event notification.

The *terminate I/O process (TRMIOP)* bit is zero, which means that the drive does not support the terminate I/O process message.

The *response data format* field contains two, which means that the inquiry data is in standard SCSI-2 format.

Byte 4 The *additional length* field contains 143, which is the number of bytes contained in the inquiry data beyond byte 4. This value represents a total inquiry data length of 148 bytes. If the allocation length in the CDB of the Inquiry command is less than 148, the inquiry data is truncated, but the additional length does not change.

Bytes 5–6 Reserved

Byte 7 The *RelAdr* bit is one, which means that the drive supports the relative addressing mode.

The *WBUS32* bit is zero, which means that the drive does not support 32-bit data transfers.

The *WBUS16* bit is zero, which means that the drive does not support 16-bit data transfers.

The *SYNC* bit is one, which means that the drive supports synchronous data transfer.

The *Linked* bit is one, which means that the drive supports linked commands.

The *CmdQue* bit is one, which means that the drive supports tagged command queuing.

The *Soft Re* bit is zero, which means that the drive responds to a reset with a hard reset.

Bytes 8–15 The *vendor identification* field contains “Seagate” in ASCII text.

Bytes 16–31 The *product identification* field contains the model number of the drive in ASCII text.

Bytes 32–35 The *product revision level* field contains the last four digits of the firmware release number in ASCII.

Bytes 36–43 The *drive serial number* field contains the serial number of the drive in ASCII.

Bytes 44–95 Reserved. These bytes contain only zeros.

Bytes 96–143 The *copyright notice* field contains the following ASCII string: “ Copyright (c) 1990 Seagate All rights reserved .”

Bytes 144–147 The *servo PROM part number* field contains the part number of the PROM in ASCII.

D.2 Vital product data pages

When the initiator issues an Inquiry command, and the EVPD bit in byte 1 of the Inquiry command descriptor block is 1, the drive returns vital product data pages. If the EVDP bit in byte 1 of the Inquiry command descriptor block is 0, see Appendix D.1.

All vital product data pages contain a 4-byte header, shown below.

Bit / Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Peripheral qualifier			Peripheral device type				
1	Page code							
2	Reserved (00_H)							
3	Page length							

Byte 0 The *peripheral qualifier* field contains zero, which means that the drive is currently connected to the logical unit issuing the Inquiry command.

The *peripheral device type* field contains zero, which means that the drive is a direct access device.

Byte 1 The *page code* field contains the same value contained in the page code field in byte 2 of the Inquiry command descriptor block.

If the page code field contains any of the page codes shown in the table below, the drive returns the corresponding page. The available page codes are:

Page code	**Description**
00_H	Supported vital product data pages
80_H	Unit serial number page
81_H	Implemented operating definitions page
$C0_H$	Firmware numbers page (vendor-unique)
$C1_H$	Data code page (vendor-unique)
$C2_H$	Jumper settings page (vendor-unique)

Byte 2 Reserved

Byte 3 The *page length* field contains the length of the supported page list.

D.2.1 Unit Serial Number page (80_H)

The Unit Serial Number page is shown below. The table summarizes the function and the default value of each bit.

Bit / Byte	7	6	5	4	3	2	1	0
0	Peripheral qualifier			Peripheral device type				
1	Page code (80_H)							
2	Reserved (00_H)							
3	Page length ($0E_H$)							
4–17	Product serial number							

Bytes 4–17 The product serial number field contains the serial number for the drive in ASCII. If the drive does not return the serial number, it returns spaces (20_H).

D.2.2 Implemented Operating Definition page (81_H)

The Implemented Operating Definition page is shown below. The table summarizes the function and the default value of each bit.

Bit Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Peripheral qualifier			Peripheral device type				
1	Page code (81_H)							
2	Reserved (00_H)							
3	Page length (05_H)							
4	SAVIMP 0	Current operating definition						
5	SAVIMP 0	Default operating definition						
6–8	SAVIMP 0	Supported operating definition						

Byte 4 The current operating definition field contains the value of the current operating definition.

Byte 5 The SAVIMP bit is always zero; therefore, the current operating definition parameter cannot be saved. If the SAVIMP bit is one, the current operating parameter can be saved.

The default operating definition field contains the value of the default operating definition. If no operating definition is saved, the drive uses the default operating definition.

Bytes 6–8 If the SAVIMP bit is zero, the default definition parameter cannot be saved. If the SAVIMP bit is one, the default definition parameter can be saved.

The supported operating definition field contains the value of the supported operating definition. If no supported operating definition is saved, the drive uses the default operating definition.

D.2.3 Firmware Numbers page ($C0_H$)

The Firmware Numbers page is shown below. The table summarizes the function, and default value of each bit.

Bit Byte	7	6	5	4	3	2	1	0
0	Peripheral qualifier			Peripheral device type				
1	Page code ($C0_H$)							
2	Reserved (00_H)							
3	Page length (10_H)							
4–7	Download firmware number							
8–11	Controller PROM number							
12–15	Servo PROM number							
16–19	EEPROM image number							

Bytes 4–8 The *download firmware number* field contains the firmware number in ASCII.

Bytes 9–11 The *controller PROM number* field contains the controller PROM number in ASCII.

Bytes 12–15 The *servo PROM number* field contains the servo PROM in ASCII.

Bytes 16–19 The *EEPROM image number* field contains the EEPROM image number in ASCII.

D.2.4 Date Code page ($C1_H$)

The Date Code page is shown below. The table summarizes the function and the default value of each bit.

Bit / Byte	7	6	5	4	3	2	1	0
0	Peripheral qualifier			Peripheral device type				
1	Page code ($C1_H$)							
2	Reserved (00_H)							
3	Page length (03_H)							
4	Year							
5–6	Week							

Bytes 4 The *year* field contains the year, in ASCII, that the firmware was released.

Bytes 5–6 The *week* field contains the week, in ASCII, that the firmware was released.

D.2.5 Jumper Settings page ($C2_H$)

The Jumper Settings page is shown below. The table summarizes the function and the default value of each bit.

Bit / Byte	7	6	5	4	3	2	1	0
0	Peripheral qualifier			Peripheral device type				
1	Page code ($C2_H$)							
2	Reserved (00_H)							
3	Page length (01_H)							
4	Reserved			MS	PE	SCSI ID		

Byte 4 If the Motor Start (MS) bit is 1, the remote start enable jumper is installed on pins 3 and 4 of the options jumper block. If the MS bit is 0, the remote start enable jumper is not installed.

If the Parity Enable (PE) bit is 1, the parity enable jumper is installed on pins 1 and 2 of the options jumper block. If the PE bit is 0, the parity enable jumper is not installed.

SCSI ID is the SCSI ID of the drive.

Appendix E. Timing diagrams

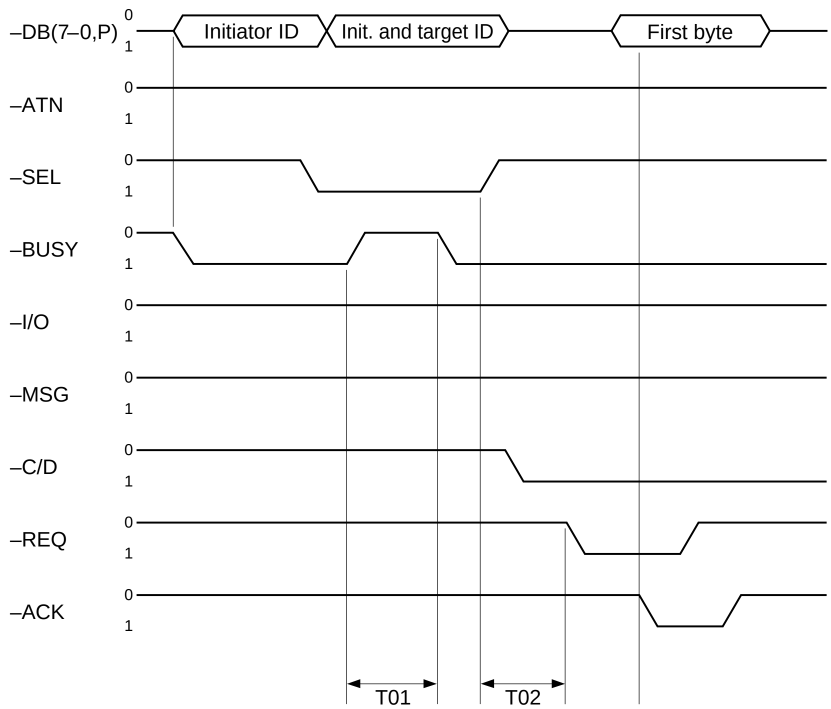


Figure 11. Arbitration, selection (without ATN) and command

Description	Symbol	Typical	Max
Target select time (without arbitration)	T00	<80 µsec	<250 msec
Target select time (with arbitration)	T01	<90 µsec	<250 msec
Target select to command	T02	<150 µsec	—

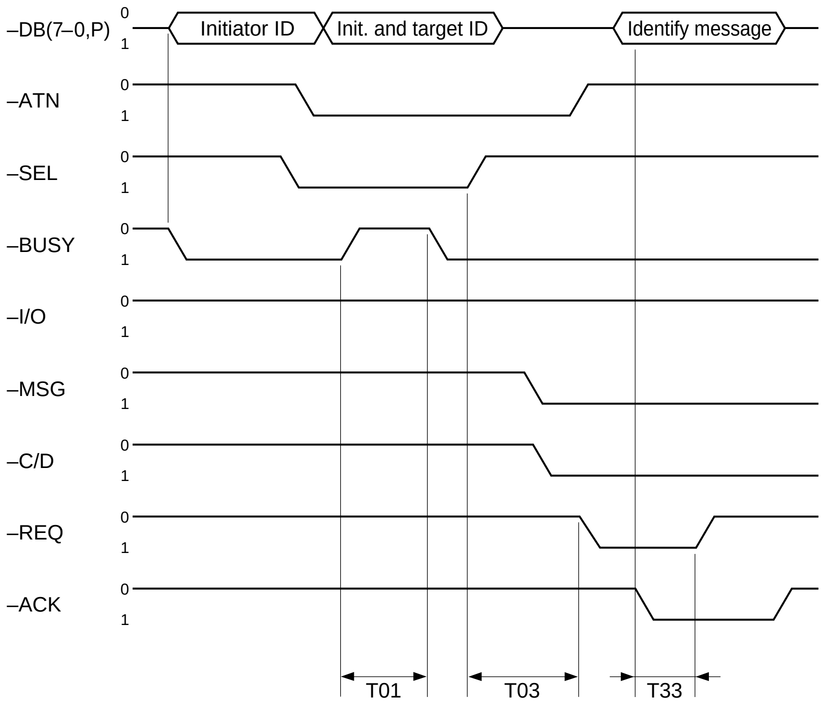


Figure 12. Arbitration, selection (with ATN) and message out

Description	Symbol	Typical	Max
Target select time (without arbitration)	T00	<1.0 µsec	<250 µsec
Target select time (with arbitration)	T01	<55 µsec	<250 µsec
Target select to message out	T03	<125 µsec	—
Message out byte transfer	T33	<0.1 µsec	0.15 µsec

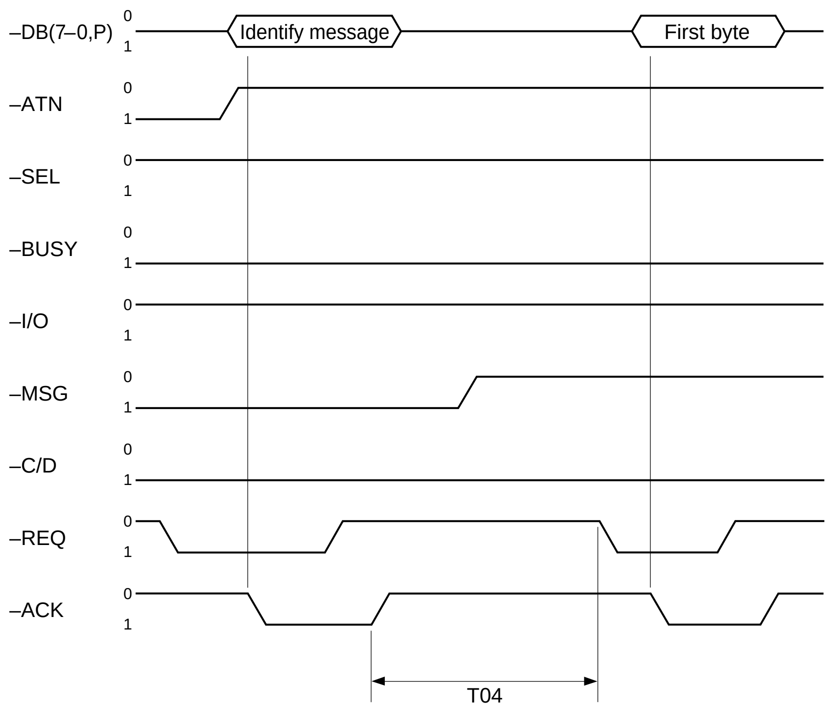


Figure 13. Identify message out to command

Description	Symbol	Typical
Identify message to command	T04	<150 μsec

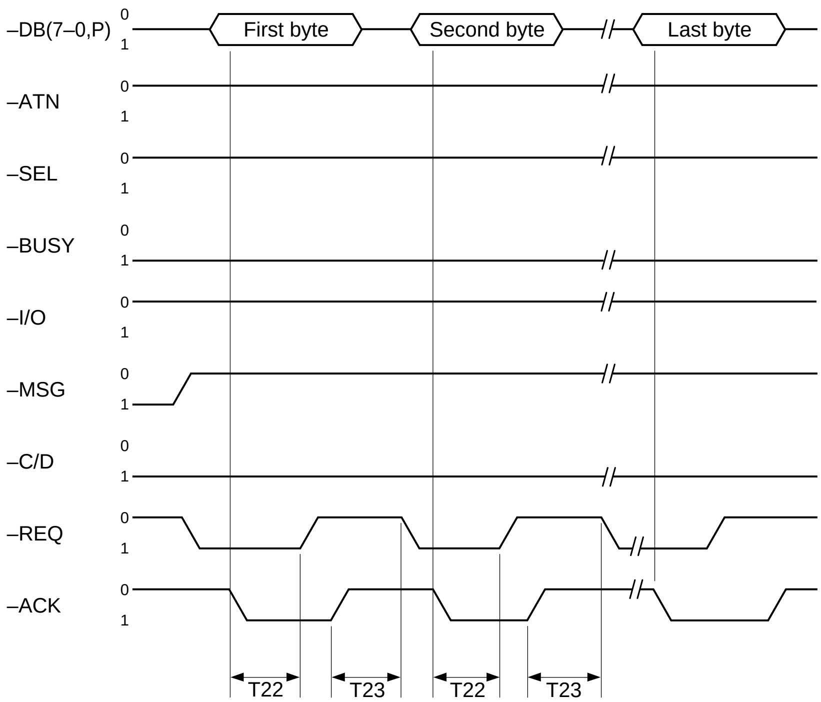


Figure 14. Command descriptor block transfer

Description	Symbol	Typical	Max
Command byte transfer	T22	<0.08 µsec	0.15 µsec
Next command byte access *	T23	<6.5 µsec	1.0 µsec

***** T23 is used, except for byte 7 of a 10-byte CDB. A 6-byte CDB requires less than 5 µsec for five T23 occurrences. A 10-byte CDB requires less than 110 µsec for 9 occurrences.

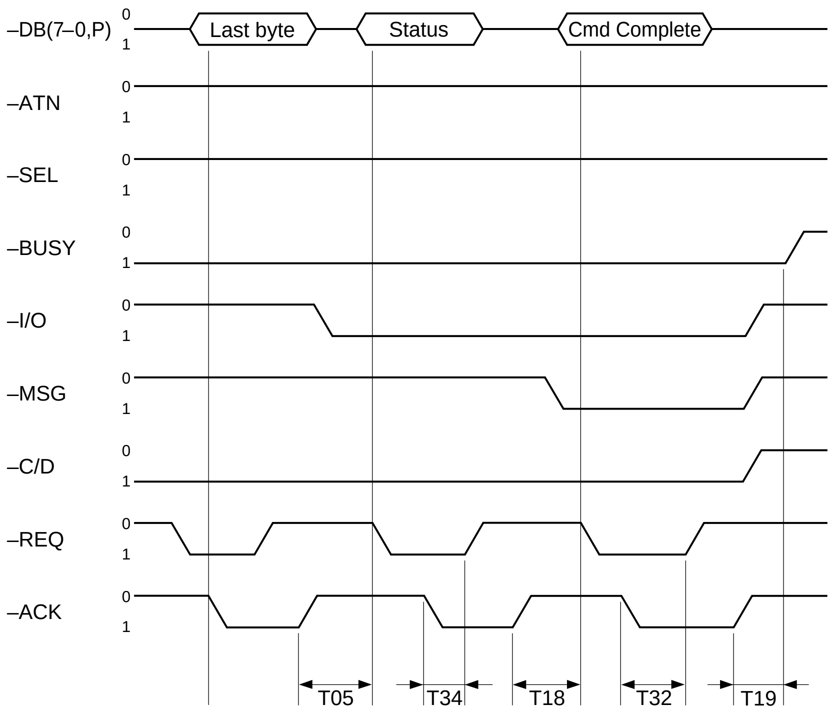


Figure 15. Command, status, command complete message and bus free

Description	Symbol	Typical	Max
Command to status	T05	Command dependent	
Status to command complete message	T18	<150 µsec	—
Command complete message to bus free	T19	<100 µsec	—
Message in byte transfer	T32	<0.1 µsec	0.15 µsec
Status byte transfer	T34	<0.1 µsec	0.15 µsec

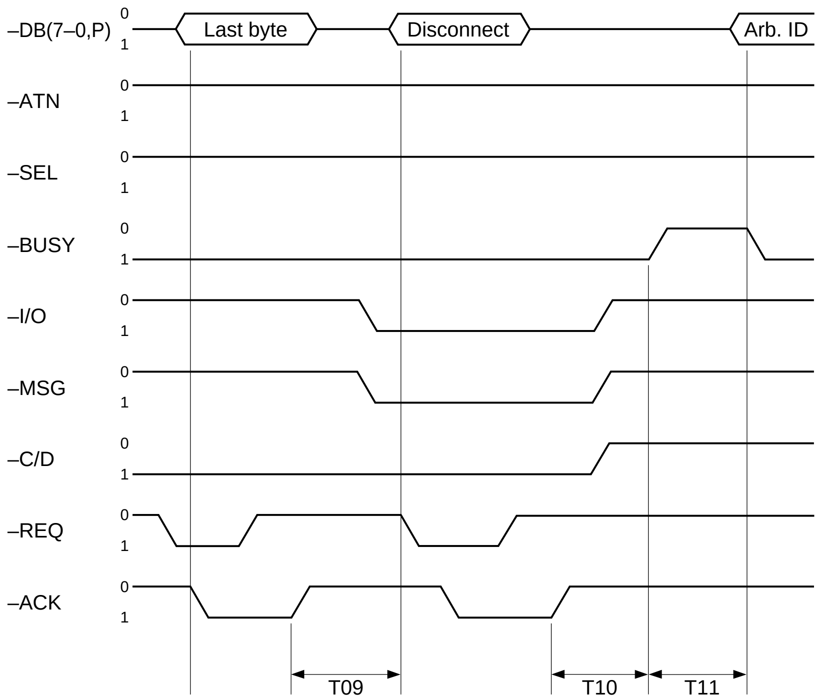


Figure 16. Last command byte, disconnect message, bus free and reselection

Description	Symbol	Typical	Max
Command to disconnect message	T09	Command dependent	
Disconnect message to bus free	T10	<100 µsec	—
Disconnect to arbitration (for reselect). Measures disconnected command overhead.	T11 *	Command dependent	

***** When measuring T11, no other device can be contending for the SCSI bus.

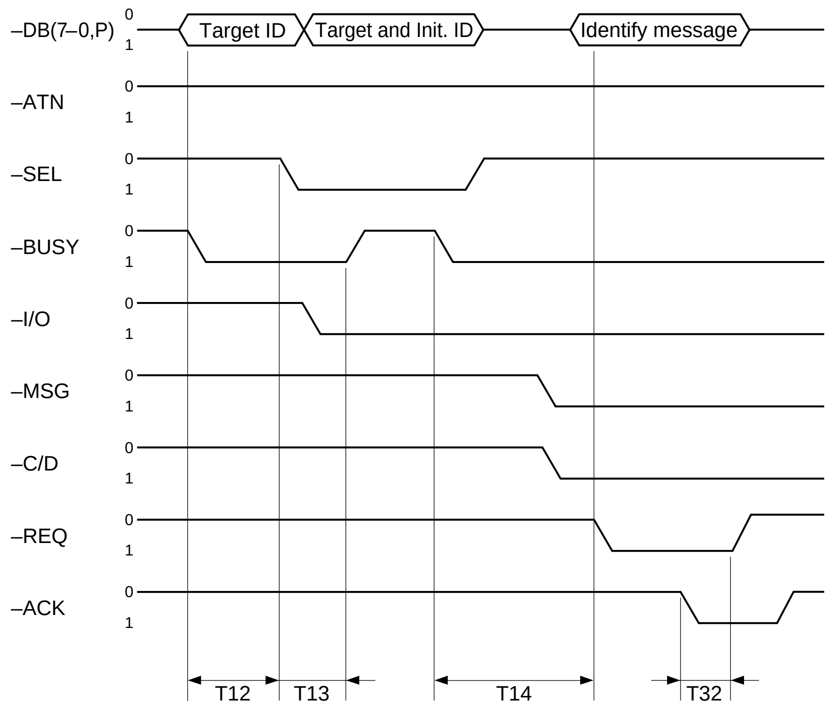


Figure 17. Arbitration, reselection and message in

Description	Symbol	Typical	Max
Target wins arbitration (for reselect)	T12	<6 µsec	—
Arbitration to reselect	T13	<5 µsec	—
Reselect to identify message in	T14	<150 µsec	—
Message in byte transfer	T32	<0.1 µsec	0.15 µsec

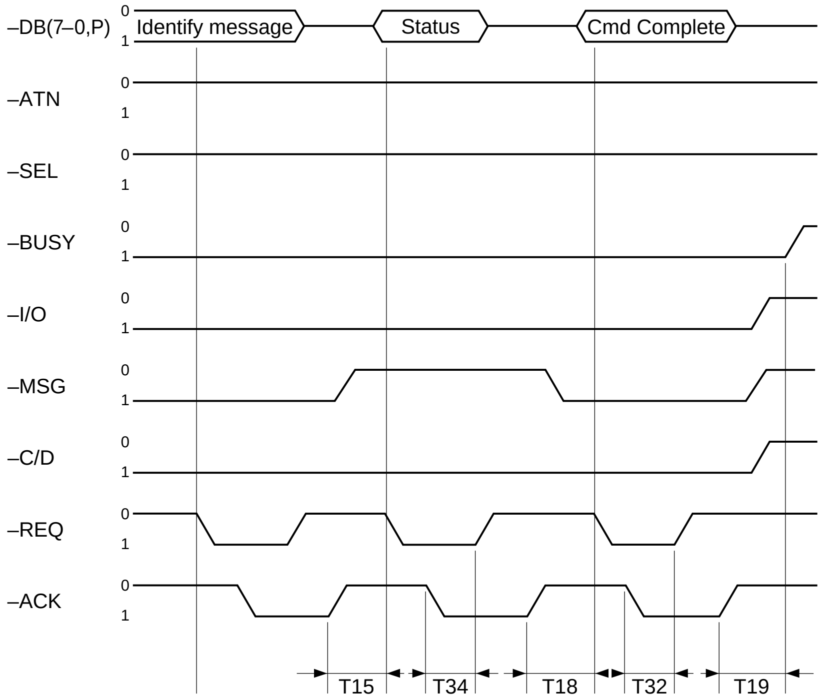


Figure 18. Reselection, status, command complete and bus free

Description	Symbol	Typical	Max
Reselect identify message to status	T15	<150 µsec	—
Status to command complete message	T18	<150 µsec	—
Command complete message to bus free	T19	<100 µsec	—
Message in byte transfer	T32	<0.1 µsec	0.15 µsec
Status byte transfer	T34	<0.1 µsec	0.15 µsec

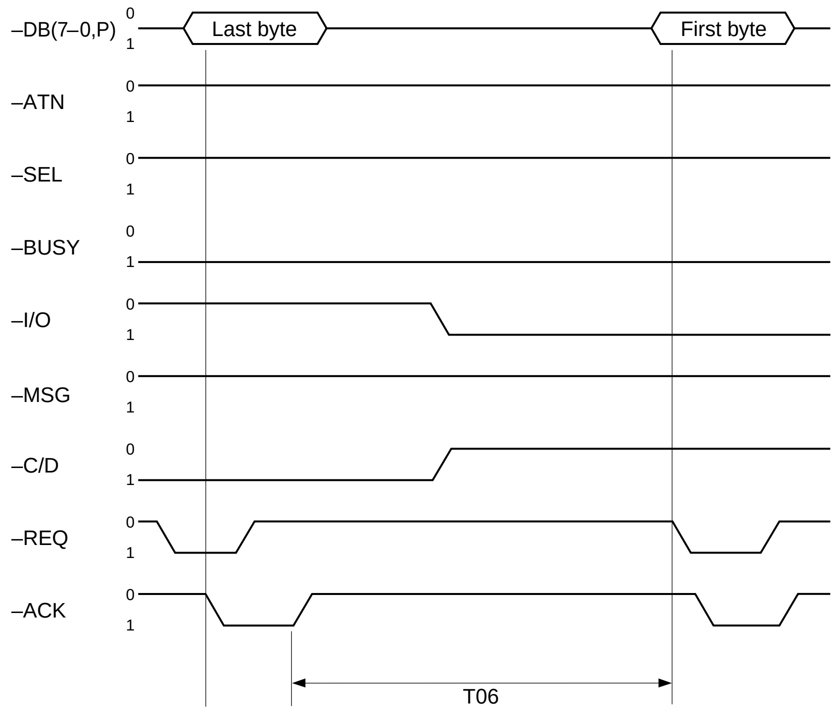


Figure 19. Last command byte to data in

Description	Symbol	Typical	Max
Command to data in or parameter in	T06	Command dependent	

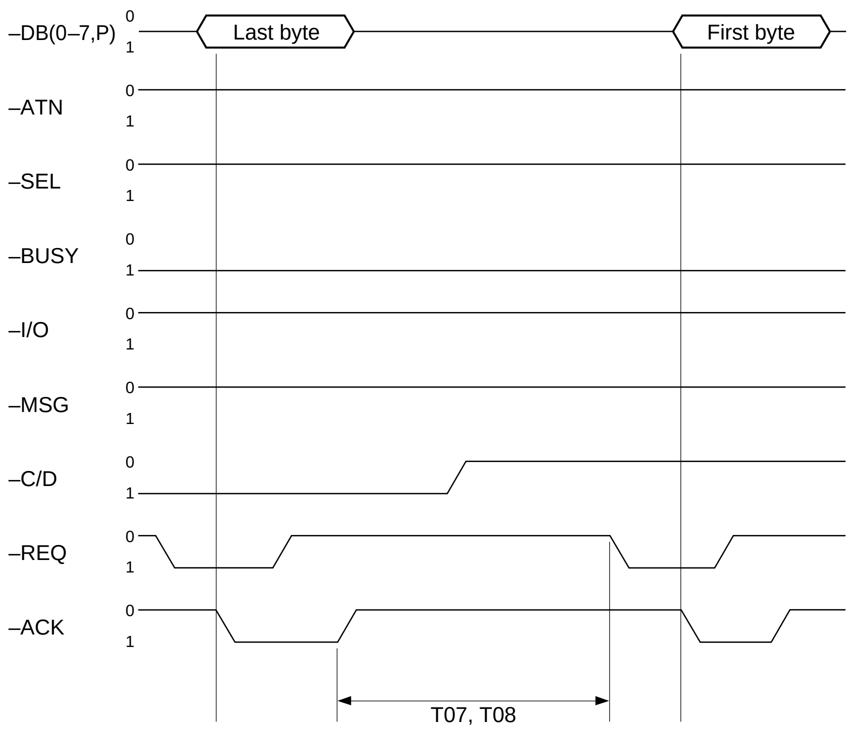


Figure 20. Last command byte to data out

Description	Symbol	Typical	Max
Command to data out or parameter out	T07	Command dependent	
Command to data (write to data buffer)	T08	<500 µsec	1025 µsec

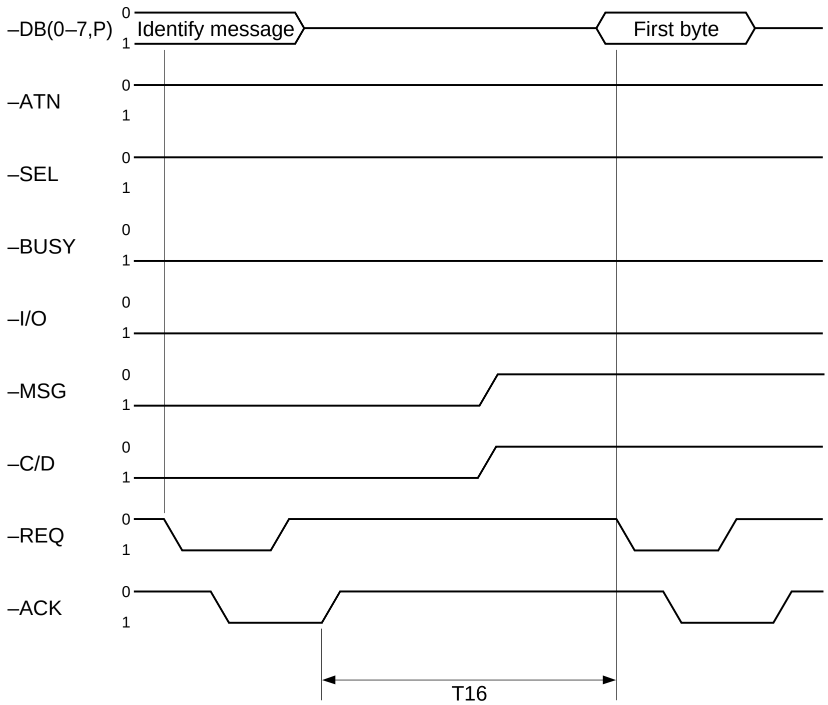


Figure 21. Reselect identify message to data in

Description	Symbol	Typical	Max
Reselect identify message to data (media)	T16	Command dependent	

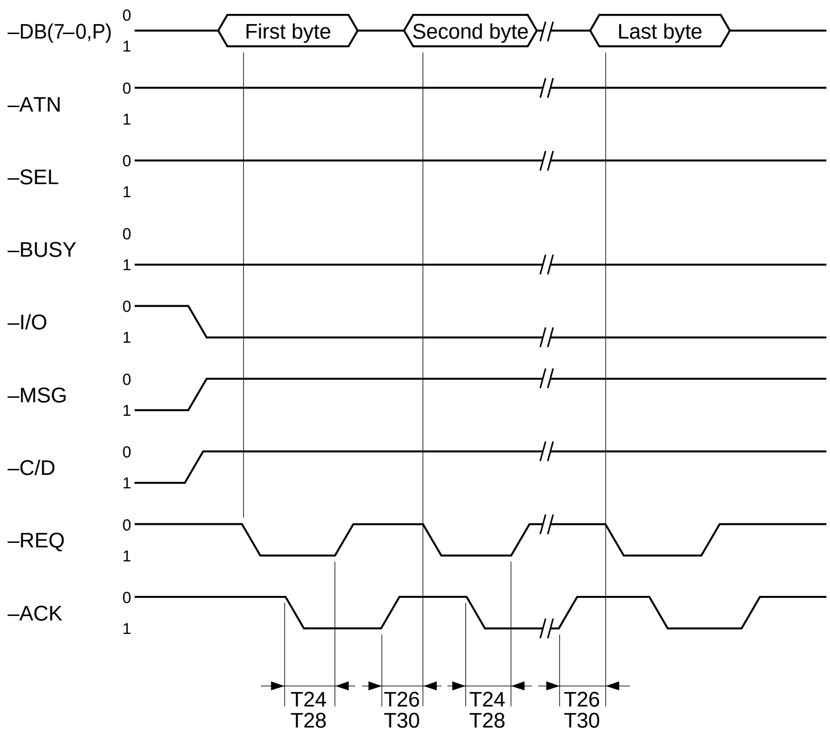


Figure 22. Data in block transfer

Description	Symbol	Typical	Max
Data in block transfer (ASYNC)	T24	<0.1 µsec	0.2 µsec
Next data in byte access (ASYNC)	T26	<0.8 µsec	1.5 µsec
Data in byte transfer (SYNC)	T28	<60 nsec	100 nsec
Next data in byte access (SYNC)	T30	<600 nsec	1.2 µsec

The maximum SCSI asynchronous interface transfer rate is 5 Mbytes per second. Therefore, the minimum time between two leading edges of a request is 200 nsec.

The maximum SCSI synchronous interface transfer rate is 10.0 Mbytes per second. Therefore, the minimum time between two leading edges of a request is 100 nsec.

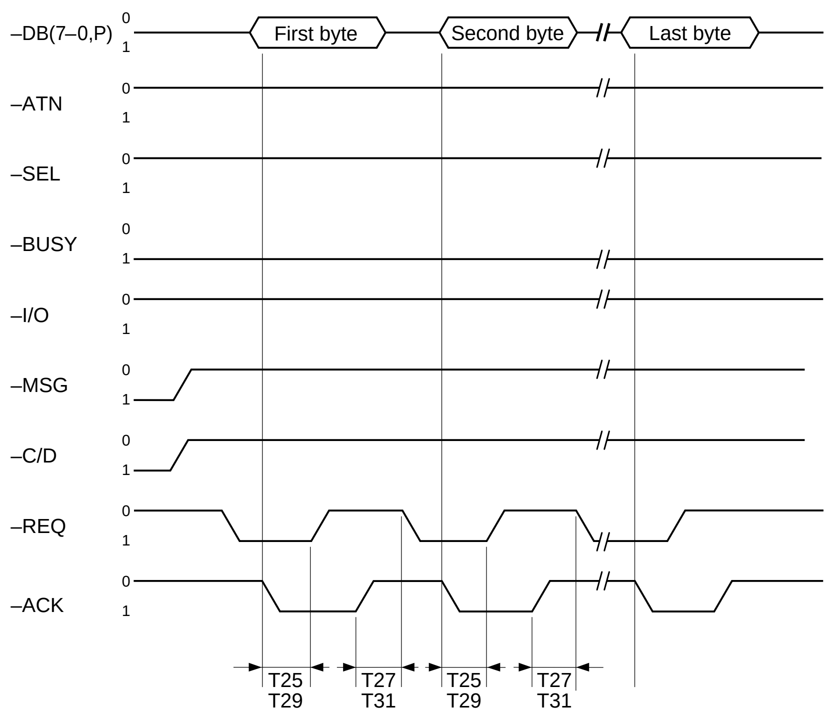


Figure 23. Data out block transfer

Description	Symbol	Typical	Max
Data out block transfer (ASYNC)	T25	<0.1 µsec	0.2 µsec
Next data out byte access (ASYNC)	T27	<0.8 µsec	1.5 µsec
Data out byte transfer (SYNC)	T29	<60 nsec	100 nsec
Next data out byte access (SYNC)	T31	<600 nsec	1.2 µsec

The maximum SCSI asynchronous interface transfer rate is 5 Mbytes per second. Therefore, the minimum time between two leading edges of a request is 200 nsec.

The maximum SCSI synchronous interface transfer rate is 10.0 Mbytes per second. Therefore, the minimum time between two leading edges of a request is 100 nsec.

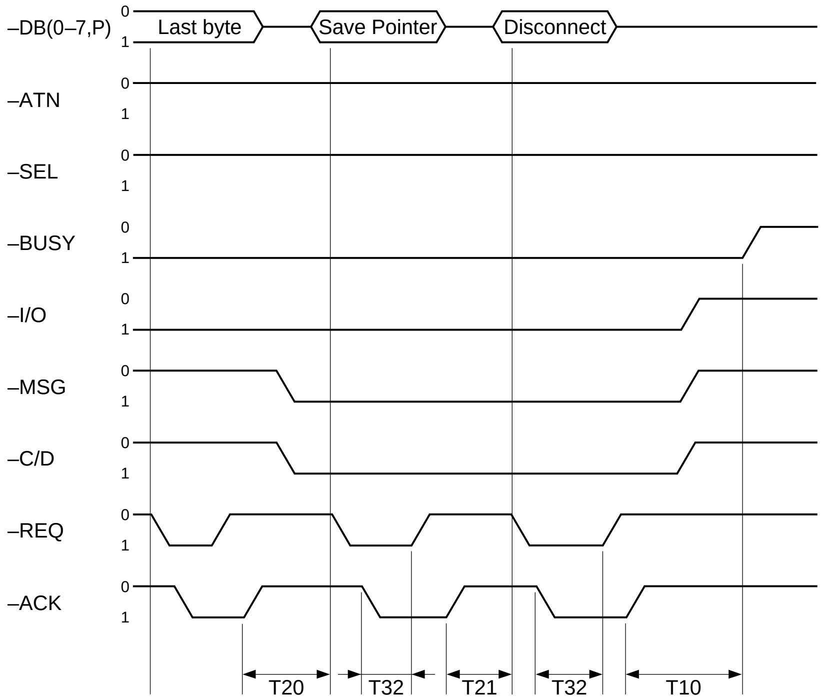


Figure 24. Last data byte, save pointer message and disconnect message

Description	Symbol	Typical	Max
Disconnect message to bus free	T10	<100 µsec	—
Data to save data pointer message	T20	<175 µsec	—
Save data pointer message to disconnect message	T21	<175 µsec	—
Message in byte transfer	T32	<0.1 µsec	0.15 µsec

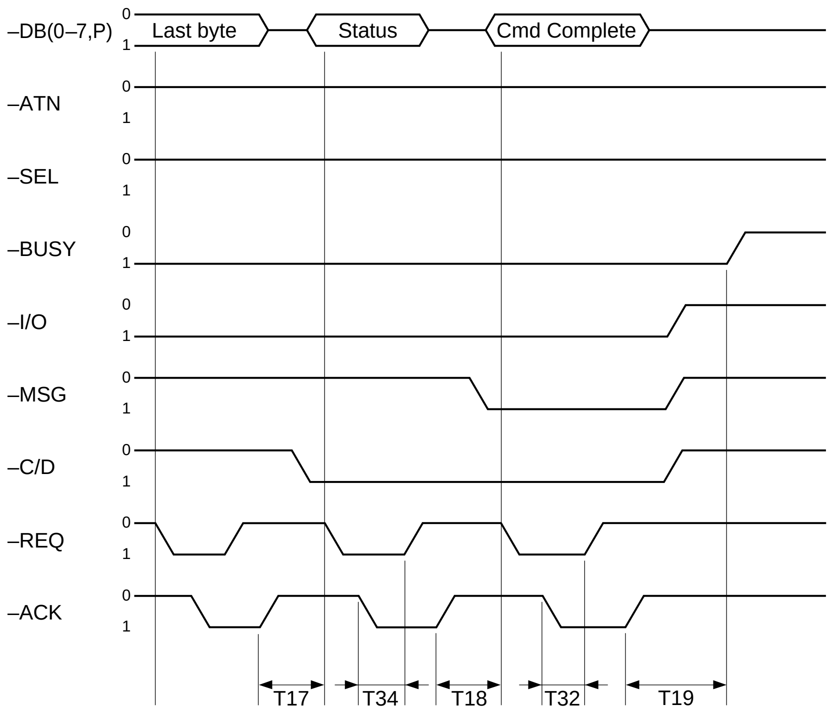


Figure 25. Data in, status, command complete message and bus free

Description	Symbol	Typical	Max
Data to status	T17	Command dependent	
Status to command complete message	T18	<150 µsec	—
Command complete message to bus free	T19	<100 µsec	—
Message in byte transfer	T32	<0.1 µsec	0.15 µsec
Status byte transfer	T34	<0.1 µsec	0.15 µsec

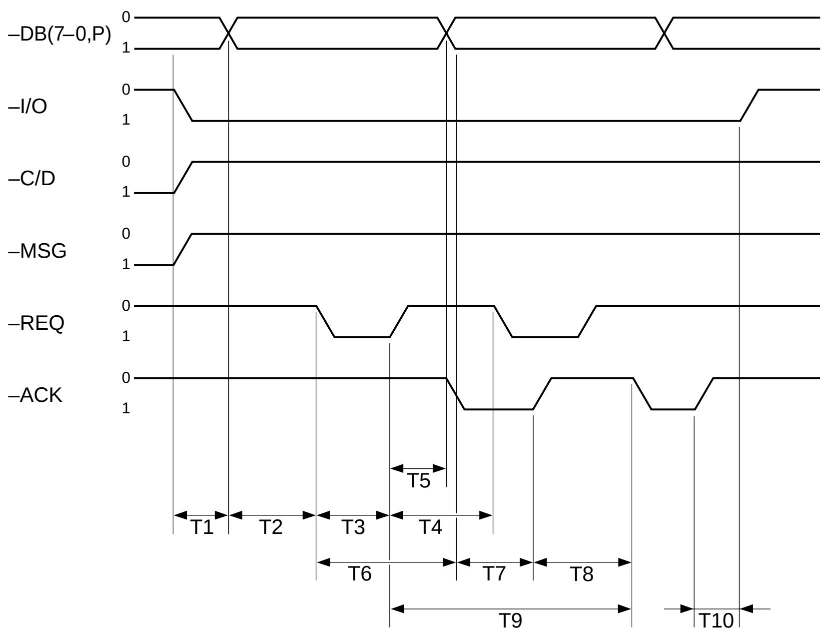


Figure 26. Synchronous read timing

Description	Symbol	Min
I/O low to data bus enable	T1	400 nsec
Data bus valid to REQ– low	T2	57.5 nsec
REQ– assertion period	T3	30.0 nsec
REQ– deassertion period	T4	30.0 nsec
REQ– high to data hold	T5	—
REQ– low ACK– low	T6	10 nsec
ACK– assertion period	T7	30.0 nsec
ACK– deassertion period	T8	30.0 nsec
ACK– period	T9	100 nsec
Last ACK– pulse high to phase change	T10	125 nsec

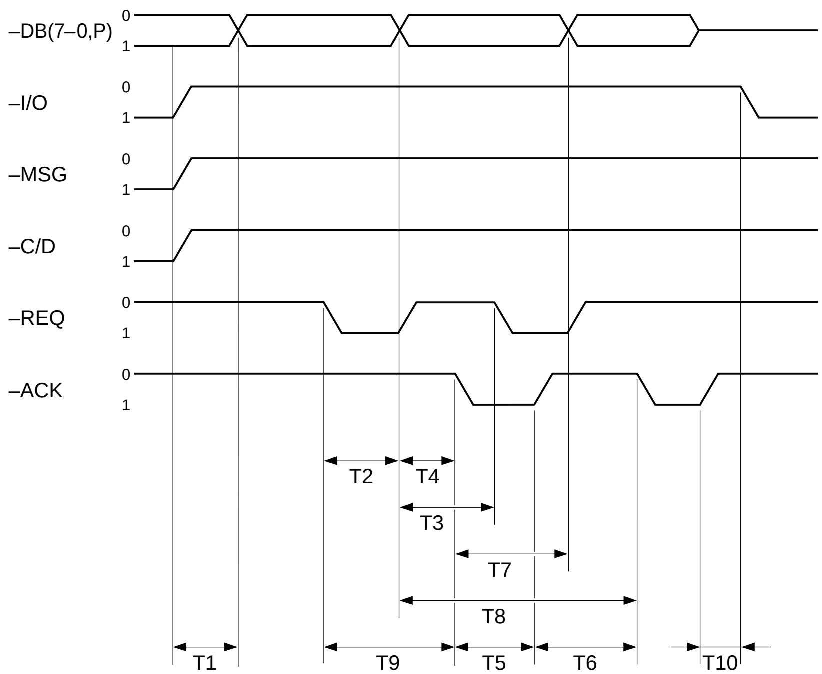


Figure 27. Synchronous write timing

Description	Symbol	Min	Max
I/O high to data bus disable	T1	—	50 nsec
REQ– assertion period	T2	30.0 nsec	—
REQ– deassertion period	T3	30.0 nsec	—
Data valid to ACK– low	T4	—	—
ACK– assertion period	T5	30.0 nsec	—
ACK– deassertion period	T6	30.0 nsec	—
ACK– low to data hold	T7	10 nsec	—
ACK– period	T8	100 nsec	—
REQ– low to ACK– low	T9	10 nsec	—
Last ACK– pulse high to phase change	T10	125 nsec	—

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