

---

## Chapter 12 Storage

---

---

**IMPORTANT:** The requirements in this guide provide instructions for designing PC systems that will result in an optimal user experience with typical Windows-based applications running under either the Microsoft Windows Millennium Edition or Windows 2000 Professional or later operating systems. These design requirements are not the basic system requirements for running any version of Windows operating systems.

---

This chapter presents requirements for storage devices and related technologies.

Unless this chapter defines a specific requirement or exception, all requirements for storage devices apply as presented in Chapter 3, “PC System,” and Chapter 6, “Buses and Interfaces.”

### Storage Basic Requirements

This section presents the requirements for storage and related peripherals, including DVD devices.

For specific information about implementation details related to storage devices under the Windows Me and Windows 2000 operating systems, see the Storage Technology Web page, listed in “Storage References.”

#### **STOR–0341. Storage components and optical devices support bus master capabilities**

Hard disk and optical devices (such as CD and DVD devices) must support bus mastering, and bus mastering must be enabled on the host by default. When correctly implemented, bus master support improves performance and Windows-compatible device driver support.

Bus master capabilities must meet the related specification for the particular controller. For example, the programming register set for PCI IDE bus master DMA is defined in the *AT Attachment with Packet Interface – 5* (ATA/ATAPI-5), standard. Bus master support is required of optical devices in order to adequately support video playing for DVD and CD-ROM devices.

A DVD drive and controller must support word-aligned, multisegment, bus master DMA transfers. DMA must be enabled by default.

If attached by way of an ATA interface, ATAPI DVD drives and ATA systemboard implementations must support DMA as specified in the ATA/ATAPI-5 standard or *ATAPI Removable Rewritable Media Devices* (INF-8070i).

#### **STOR–0342. Removable media devices support media status notification**

The following list shows the required specifications for implementing media status notification, depending on device type.

##### **Media Status Notification Requirements**

<b>Device type</b>	<b>Media status notification implementation</b>
CD and DVD devices	Comply with <i>SCSI Multimedia Commands–2 (MMC-2)</i> standard for Media Status Event Notification.
ATAPI floppy/optical direct access drives	Comply with either MMC-2 standard or INF-8070i version 1.2.
IEEE 1394 storage devices	Comply with <i>Reduced Block Commands (RBC)</i> standard (T10/97-260r0).
ATA and non-ATAPI storage devices	Comply with <i>Media Status Notification Support Specification, Version 1.03</i> .
Other ATA/ATAPI-5 or later devices, including tape drives	If implemented, comply with <i>Media Status Notification Support Specification, Version 1.03</i> , or INF-8070i.
Other types of SCSI removable devices	If implemented, support based on the RBC standard.

#### **STOR–0343. USB storage devices comply with the USB mass storage class specification**

All USB storage devices must meet the requirements of the *Universal Serial Bus Mass Storage Class Specification Overview, V1.0 Revision*. This includes all USB Mass Storage class documents, including Bulk Only, Control/Bulk/Interrupt, Bootability, and UFI Command specifications.

## SCSI Storage

This section presents requirements for SCSI storage. See also “SCSI” in Chapter 6, “Buses and Interfaces.”

#### **SCSI–0109. Differential devices support DIFFSENS as defined in SPI-3 or later standard**

Without DIFFSENS, the differential bus drivers, a single-ended device, or both could be damaged if a single-ended device is connected to a differential bus. The standard for DIFFSENS is defined in Section 5.4.2 of the SPI-3 or later standard.

**STOR–0345. External devices use automatic termination or an accessible termination switch**

An external SCSI peripheral device must provide automatic termination. At a minimum, a mechanical means must be provided for setting termination and the switch must be accessible to the user without opening the device chassis.

**STOR–0346. Devices supports the STOP/START UNIT command as defined in the SBC standard**

SCSI peripherals must be able to fully recover from a software-initiated spin down without rebooting the system or cycling power. To properly support power management on SCSI drives and to see that the operating system responds to appropriate driver calls, the STOP/START UNIT command must be implemented as defined in the *SCSI-3 Block Commands (SBC)* standard.

## ATA and ATAPI Storage

This section defines the requirements for all ATAPI storage devices. See also “ATA and ATAPI” in Chapter 6, “Buses and Interfaces.” Discrete ATA/ATAPI-5 controllers in docked mobile PCs must comply with ATA–0122, “Discrete PCI ATA controllers in mobile docking stations implement in PCI Native-Mode ATA” in Chapter 6.

**STOR–0347. Peripherals comply with ATA/ATAPI-5**

The ATA/ATAPI-5 standard defines hardware and software design requirements for ATAPI devices.

**STOR–0348. ATAPI devices support DEVICE RESET command**

ATAPI devices must respond to the DEVICE RESET command as defined in the ATA/ATAPI-5 standard, regardless of their internal state. The controller can be reset when the computer is turned on (requests cleared, signature present), but any nondefault mode values must be left in their current state with the device driver (DRV) bit unchanged.

Devices such as hard disk drives that do not implement the PACKET command feature set must not implement the DEVICE RESET command.

**STOR–0349. ATA device supports ATA STANDBY command**

ATA drives must implement the ATA STANDBY command, as defined in the ATA/ATAPI-5 standard. Information on system power states and transitions can be found in *Storage Device Class Power Management Reference Specification, Version 1.0*.

**STOR-0350. ATA devices support Ultra DMA**

All ATA primary storage devices must support Ultra DMA at transfer rates of 33 MB per second or higher as defined in the ATA/ATAPI-5 standard, and as described in ATA-0119, “Controller supports Ultra DMA (ATA/33),” in Chapter 6.

## CD and DVD Devices

This section summarizes the requirements for CD peripherals. The device must also meet the general requirements defined in “PC 2001 Design for Storage Components,” including STOR-0341, “Storage components and optical devices support bus master capabilities.”

**STOR-0352. CD or DVD drive is CD-Enhanced compatible**

The CD or DVD drive must be able to mount multisession CD-ROM discs, even if track 1 is Red Book audio. CD-Enhanced support must be Blue Book compliant, as defined in *CD EXTRA (Enhanced Music CD) Specification, Version 1.0*.

**STOR-0353. CD or DVD drive supports specified logical and physical CD formats**

At a minimum, the CD or DVD drive must be compatible with the following formats for cross-media compatibility, based on compliance with the *MultiRead Specifications for CD-ROM, CD-R, CD-R/RW, & DVD-ROM Devices, Revision 1.11*:

- Logical formats: CD Red Book (CD-Audio), Yellow Book (CD-ROM), Orange Book parts II and III (packet writing if recordable), White Book, Blue Book, and Universal Disk Format (UDF) versions 1.5 and 2.0
- Physical formats: ROM (stamped), and Orange Book part II (CD-R) and part III (CD-RW)

**Note:** Any ATAPI CD or DVD drive designed to play back CD-I content must return a minimum of two track entries for the READ\_TOC (0x43) command. These two track entries must be a track 01 entry and a track 0xAA entry for the lead-out address. Drives that do not comply with this minimum requirement cannot play back CD-I movies.

**STOR-0354. CD or DVD drive complies with MMC-2**

CD drives must support the hardware and protocols documented in the NCITS specification.

**Note:** Support for the READ CD-DA command as defined in the MMC-2 standard is required.

**STOR–0355. CD drive supports multisession and compatibility forms of the READ\_TOC command**

Both multisession forms (01b and 10b) and the compatibility form (00b) of the READ\_TOC command must be implemented. This provides complete support for CD-ROM multisession capabilities.

For information about ATAPI peripheral support for CD-I content, see requirement STOR–0353, “CD or DVD drive supports specified logical and physical CD formats.”

**STOR–0356. CD or DVD changer complies with MMC-2**

If a CD or DVD changer with a capacity for seven or fewer discs is present, the changer must comply with the MMC-2 standard.

**STOR–0357. CD or DVD device supports digital audio extraction with sector accurate reads**

The READ\_CD command and READ\_RAW commands must provide sector-accurate reads, as defined in the MMC-2 standard. Data alignment accuracy must be equivalent to that of data reads. Because of the lack of ECC bytes used for data tracks, the data itself may contain inaccuracies due to physical defects of the media. Furthermore, CD and DVD drives must implement “CD Capabilities and Mechanical Status Page” (2Ah), as defined in the MMC-2 standard. The “CD-DA Commands Supported” and “CD-DA Stream is Accurate” bits must be set and their functionality must be implemented.

## DVD Devices

This section summarizes specific requirements for DVD devices. For information about the requirements for DVD-Video and MPEG-2 playback performance, see “DVD-Video Playback Requirements” and “MPEG-2 Video Playback Requirements” in Chapter 9, “Video.” For more information about DVD support under Windows Me and Windows 2000 operating systems, see “DVD and Microsoft Operating Systems,” listed in “Storage References.”

**STOR–0360. DVD device provides 2 MB per second minimum transfer rate or better performance anywhere on the disc**

The minimum sustained DVD device media transfer rate must be at least 2 MB per second for read operations from the DVD disc.

This requirement sets the minimum speed needed for DVD-Video playback during MPEG-2 decoding on Windows platforms. This requirement applies to the minimum read speed (2 MB per second) on any production level DVD-Video media, at any location on the disc. This minimum rate requirement does not apply

to DVD data discs that the user records, or discs being read in error-correcting, defect management mode. OEMs must continue to ship DVD drives that produce an acceptable user experience and conform to the specifications cited in STOR-0341, "Storage components and optical devices support bus master capabilities," and STOR-0353, "CD or DVD drive supports specified logical and physical CD formats."

#### **STOR-0361. DVD drive supports defect management**

DVD drives must support defect management that is transparent to the operating system, according to industry standards. Defect management for DVD-RAM media is defined in *DVD Specifications for Rewritable Disc, Part 1: Physical Specifications*, published by Toshiba Corporation. Defect management for DVD+RW is defined in ECMA-274. Information on ECMA-274 is listed in "Storage References."

## CD Devices

This section describes the requirements for CD devices.

#### **STOR-0362. CD device provides 8x minimum transfer rate or better performance**

This requirement sets the minimum speed (1200 KB per second when running in the fully on power state) needed for production-level CD reading on Windows platforms. This requirement applies to the minimum read speed (8x) on any production-level CD media, such as application or game software, at any location on the disc. This minimum speed requirement does not apply to end-user recorded CD data discs or discs being read in error-correcting, defect management mode, or to CD devices attached on buses such as USB 1.0 or later that cannot sustain this data rate.

## Rewritable Optical ATAPI Devices

This section summarizes specific requirements for rewriteable optical storage devices. The device must also meet the general requirements defined in "PC 2001 Design for Storage Components."

#### **STOR-0363. Block rewriteable optical ATAPI device complies with INF-8070i, version 1.2**

INF-8070i defines the requirements for block rewriteable ATAPI devices, including specifications for logical unit number (LUN) implementation, media status notification, and device write protection. This document also includes required support for the Read Format Capacities command.

## PC 2001 Design for Storage Components

This section summarizes requirements related to Plug and Play and other resource-related design issues for storage devices.

### **STOR–0364. Device and controller comply with Storage Device Class Power Management Reference Specification**

The *Storage Device Class Power Management Reference Specification, Version 1.0* provides definitions of the OnNow device power states (D0–D3) for these devices. The specification also covers device functionality expected in each power state and possible wakeup event definitions for the class. Support is required for power states D0, D1, and D3 for hard disks, CD and DVD drives, and other mass storage devices. Hard disks, CD, and DVD drives, and other mass storage devices are required to resume properly from the D3 power state after power to the device is removed. Support for the D1 state is not required for floppy disk devices.

If implemented, the ability to cause a wakeup event must meet the requirements as defined in the *Storage Device Class Power Management Reference Specification, Version 1.0*.

## Device Drivers and Installation for Storage

This section summarizes the basic requirements for device drivers and installation procedures for storage devices.

### **STOR–0365. Device driver for partitioned media supports all Windows Me and Windows 2000 partition types**

Device drivers that support partitioned media must support all Windows Me and Windows 2000 partition types, which include but are not limited to FAT 16, FAT 32, and Windows NT file system (NTFS).

## Storage References

Following are the references, services, and tools cited in this chapter that are available to help build hardware that works optimally with Windows operating systems.

*ATA Attachment with Packet Interface –5 (ATA/ATAPI-5)*

<ftp://fission.dt.wdc.com/pub/standards/x3t13/project/d1321r3.pdf>

ATA and ATAPI draft standards and other working documents

<http://www.t13.org>

*ATAPI Removal Rewriteable Media Devices (INF-8070i)*

<ftp://fission.dt.wdc.com/pub/standards/SFF/specs/INF-8070.PDF>

Other ATA and SCSI standards

Global Engineering Documents

<http://global.ihs.com/>

“DVD and Microsoft Operating Systems”

<http://www.microsoft.com/hwdev/devdes/dvdwp.htm>

*DVD Specifications for Rewritable Disc, Part 1: Physical Specifications*

Published by Toshiba Corporation

<http://www.toshiba.com>

ECMA Standards: *ECMA-267 (DVD-ROM)*, *ECMA-272, 273 (DVD-RAM)* and *ECMA-274 (+RW)*

<http://www.ecma.ch/>

*Media Status Notification Support Specification, Version 1.03*

<http://www.microsoft.com/hwdev/respec/storspec.htm>

*MMC-2: See SCSI Multimedia Commands – 2.*

*MultiRead Specifications for CD-ROM, CD-R, CD-R/RW, & DVD-ROM Devices, Revision 1.11*

<http://www.osta.org/html/mrspec.html>

*Multisession Compact Disc Specification*

*CD EXTRA (Enhanced Music CD) Specification, Version 1.0*

Philips Consumer Electronics B.V.

Coordination Office Optical–Magnetic Media Systems

Building SWA-109, PO Box 80002

5600 JB Eindhoven, The Netherlands

Fax: (31) (40) 732113

*PCI IDE Controller Specification, Revision 1.0*

<http://www.pcisig.com/data/tech/ideboth.zip>

*Reduced Block Commands (RBC)*

<ftp://ftp.t10.org/t10/drafts/rbc/rbc-r10a.pdf>

*SCSI-3 Block Commands (SBC)*

<ftp://ftp.t10.org/t10/drafts/sbc/sbc-r08c.pdf>

For more information on SBC standards, see  
Global Engineering Documents

Phone: (800) 854-7179 (US)

(613) 237-4250 (Canada)

(303) 792-2181 (Outside North America)

Fax: (303) 397-2740

<http://global.ihs.com/>

*SCSI-3 Parallel Interface (SPI)*

ANSI X3.253-1995

[http://web.ansi.org/public/std\\_info.html](http://web.ansi.org/public/std_info.html)

*SCSI Multimedia Commands – 2 (MMC-2)*

ANSI NCITS 333-2000

<ftp://ftp.t10.org/t10/drafts/mmc2/mmc2r11a.pdf>

*SCSI Parallel Interface – 2 (SPI-2)*

ANSI X3.302-1998

[http://web.ansi.org/public/std\\_info.html](http://web.ansi.org/public/std_info.html)

*SCSI Parallel Interface-3 (SPI-3)*

<ftp://ftp.t10.org/t10/drafts/spi3/spi3r14.pdf>

*Serial Bus Protocol 2 (SBP-2)*

ANSI NCITS 325-1998

[http://web.ansi.org/public/std\\_info.html](http://web.ansi.org/public/std_info.html)

SPI, SPI-2: See *SCSI-3 Parallel Interface (SPI)*.

*Storage Device Class Power Management Reference Specification, Version 1.0*

<http://www.microsoft.com/hwdev/specs/PMref/>

## Storage Technology Web page

<http://www.microsoft.com/hwdev/storage/>

*Universal Serial Bus Mass Storage Class Specification Overview, V1.0 Revision*

<http://www.usb.org/developers/devclass.html>

## Windows 98 DDK and Windows 2000 DDK

<http://www.microsoft.com/ddk/>

## Checklist for Storage

- STOR-0341. Storage components and optical devices support bus master capabilities
- STOR-0342. Removable media devices support media status notification
- STOR-0343. USB storage devices comply with the USB mass storage class specification
- SCSI-0109. Differential devices support DIFFSENS as defined in SPI-3 or later standard
- STOR-0345. External devices use automatic termination or an accessible termination switch
- STOR-0346. Devices supports the STOP/START UNIT command as defined in the SBC standard
- STOR-0347. Peripherals comply with ATA/ATAPI-5
- STOR-0348. ATAPI devices support DEVICE RESET command
- STOR-0349. ATA device supports ATA STANDBY command
- STOR-0350. ATA devices support Ultra DMA
- STOR-0352. CD or DVD drive is CD-Enhanced compatible
- STOR-0353. CD or DVD drive supports specified logical and physical CD formats
- STOR-0354. CD or DVD drive complies with MMC-2
- STOR-0355. CD drive supports multisession and compatibility forms of the READ\_TOC command
- STOR-0356. CD or DVD changer complies with MMC-2
- STOR-0357. CD or DVD device supports digital audio extraction with sector accurate reads
- STOR-0360. DVD device provides 2 MB per second minimum transfer rate or better performance anywhere on the disc
- STOR-0361. DVD drive supports defect management
- STOR-0362. CD device provides 8x minimum transfer rate or better performance
- STOR-0363. Block rewriteable optical ATAPI device complies with INF-8070i, version 1.2
- STOR-0364. Device and controller comply with Storage Device Class Power Management Reference Specification
- STOR-0365. Device driver for partitioned media supports all Windows Me and Windows 2000 partition types