PC 99 System Design Guide

A Technical Reference for Designing PCs and Peripherals for the Microsoft® Windows® Family of Operating Systems

Intel Corporation and Microsoft Corporation

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Welcome

This guide is for engineers who build personal computers, expansion cards, and peripheral devices that will be used with the Microsoft® Windows® 98 and Windows NT® version 5.0 operating systems. The goal of this document is to provide guidelines for hardware design that will result in the optimal user experience, particularly when the hardware is used with the Windows family of operating systems.

This guide is co-authored by Intel Corporation and Microsoft Corporation. The requirements and recommendations in this guide outline features that the hardware industry should consider in designing PCs and peripherals for various price levels and performance levels.

The clarifications, changes, and additional requirements in this guide define extensions to the requirements defined in *PC 98 System Design Guide* (Microsoft Press®, 1997; ISBN 1-57231-716-7) for 1998–99.

This guide includes PC 99 requirements for basic consumer and office implementations, such as desktop, mobile, and workstation systems, and for Entertainment PCs. In this guide, the following requirements are defined:

- Design requirements for specific types of systems that will run either Windows 98 or Windows NT operating systems
- Design requirements related to the OnNow design initiative, including requirements related to the Advanced Configuration and Power Interface (ACPI) specification, Plug and Play device configuration, and power management in PC systems
- Manageability requirements that focus on improving Windows 98 and Windows NT, with the end goal of reducing total cost of ownership (TCO)
- Clarifications and additional design requirements for devices supported under Windows 98 and Windows NT, including new graphics and video device capabilities, DVD, scanners and digital cameras, and other devices

This guide does not address PC systems designed to act as servers in networked environments. It also does not address non-PC handheld computers running on the Microsoft Windows CE operating system.

Important: The system requirements defined in this document provide guidelines for designing PC systems that deliver an enhanced user experience when implemented with Windows 98 and Windows NT operating systems. These design requirements are not related to the minimum or optimal system requirements for running the Windows family of operating systems. For information about minimum system requirements for both operating systems, see the web site at http://www.microsoft.com/windows/.

How to Use This Guide

The PC 99 requirements are defined by system type and for individual bus classes and device classes. This guide is divided into four parts, plus appendixes, with each chapter addressing a particular element of PC 99 design.

Part 1: System Design Issues. Introduces the important design issues for PC 99. Study this part first to understand the key design issues being addressed in the PC 99 requirements.

Part 2: PC 99 Systems. Presents system-type definitions and PC 99 requirements for each system type. Study this part for an understanding of the overall system requirements.

Part 3: Bus Design Guidelines. Presents requirements for each bus type and I/O host controller supported under Windows 98 and Windows NT. Study this part for a detailed understanding of how buses and controllers are to be implemented on PC 99 systems.

Part 4: Device Design Guidelines. Defines design requirements for each particular device type, whether the device is an integral part of a PC system or designed as an add-on device. Study this part for a detailed understanding of the design requirements for each device type.

Appendixes. Includes the PC 99 checklist, which summarizes all the requirements defined in this guide, plus other technical appendixes.

Updates to this guide, technical clarifications, and answers to frequently asked questions are available on the following web sites:
    http://www.microsoft.com/hwdev/pc99.htm
    http://developer.intel.com/design/desguide/

Required vs. Recommended PC 99 Features

In this guide, hardware features are described as *Required*, *Recommended*, or *Optional*. For PC 99, these terms are used to mean the following:

- **Required:** These basic features must be implemented in order for hardware to comply with PC 99 requirements.

- **Recommended:** These features add capabilities that are supported by the Windows family of operating systems. Recommended features take advantage of the native capabilities of the device drivers included with the operating system, usually without imposing major cost increases.

  Notice that for compliance testing, if a recommended feature is implemented, it must meet the requirements for that feature as defined in this guide.

  Note: If it is planned that a specific recommended feature will become a requirement in future versions of these guidelines, it is specifically noted in the text.

- **Optional:** These features are neither required nor recommended, but if the feature is implemented in a PC 99 system, it must meet the specified requirements. Optional features will not become requirements in the future.

In this guide, these words can be understood as follows with regard to PC 99 requirements:

- **Must:** Required
- **Should:** Recommended

Important: The requirements and recommendations in this guide are often provided in the form of references to industry specifications. These specifications might contain intellectual property of Intel, Microsoft, or other third parties. Each of these industry specifications might have different intellectual property licensing arrangements. It is the responsibility of the original equipment manufacturer (OEM) to consult these industry specifications or their issuance bodies for licensing specifics or details.

Conventions Used in This Guide

The following conventional terms are used throughout this guide. In addition, see the Glossary in the Appendixes part of this guide.

Convention	Meaning
Add-on device	Refers to devices that are traditionally added to the basic PC system to increase functionality. Examples include audio, networking, graphics, small computer system interface (SCSI) controller, and so on. Add-on devices fall into two categories: devices built on to the system board and devices on expansion cards added to the system through a system-board connector, such as Peripheral Component Interconnect (PCI).
Intel Architecture	Refers to computers based on 32-bit microprocessors that use the Intel Architecture instruction set, such as Intel® 80486, Intel Pentium®, Pentium Pro, Pentium II, or compatible processors.
PC 99	Collection of the additional requirements and recommendations defined in this guide that make up the 1999–2000 requirements for PC system design.
RISC-based or DEC Alpha	Refers to Windows NT-compatible computers based on reduced instruction set computing (RISC) architecture. Notice that all requirements and recommendations for DEC Alpha PCs are for the Windows NT operating system only.
System device	Also *on-board device.* Refers to devices on the system board such as interrupt controllers, keyboard controller, real-time clock, direct memory access (DMA) page registers, DMA controllers, memory controllers, floppy disk controller (FDC), hard disk controller (HDC), serial and parallel ports, PCI bridges, and so on. In today's PCs, these devices are typically integrated with the supporting chip set.
Windows	For PC 99, refers to the Microsoft Windows 98 operating system, including any add-on capabilities and any later versions of the operating system.
Windows NT	For PC 99, refers to the Microsoft Windows NT Workstation version 5.0 operating system, including any add-on capabilities and any later versions of the operating system.

PC 99 and the "Designed for Microsoft Windows" Logo Program

Microsoft will refer to the requirements and recommendations in this guide when defining requirements for the 1999–2000 "Designed for Microsoft Windows" hardware logo program. The "Designed for Microsoft Windows" logo program was developed by Microsoft to help end users easily identify hardware and software products designed specifically for the Windows 98 and Windows NT Workstation operating systems.

The logo program provides customers with the assurance that their hardware works with the Windows family of products, with an emphasis on how the system performs when running commercially marketed desktop applications. The end result Microsoft is seeking is a good user experience and lower cost of support for both vendors and users.

Licensing the logo enables vendors to use the logo on web sites, product packaging, advertising, collateral, and other marketing materials. The logo indicates to customers that the product is designed to meet a specific set of standards and to provide an optimal experience when run on either a Windows or Windows NT operating system.

Logo Compliance Dates. In general, the PC 99 requirements go into effect on July 1, 1999, for the "Designed for Microsoft Windows" logo. Compliance testing for some requirements will begin later because of the time required for supporting parts to become widely available. For information about actual compliance testing dates for specific requirements, see the web site at http://www.microsoft.com/hwdev/desguid/.

Logo Testing. Both hardware and software are tested before rights to use the "Designed for Microsoft Windows" logo are granted. The testing organization for the logo program is the Windows Hardware Quality Labs (WHQL), which provides compatibility testing services for Windows and Windows NT hardware and drivers.

Hardware developers whose products pass the WHQL testing program also receive a detailed test report, inclusion of tested hardware on the Windows Hardware Compatibility List (HCL), and free distribution of drivers on the Windows Update web site.

If you have questions about the program, contact WHQL:

Windows Hardware Quality Labs	http://www.microsoft.com/hwtest/
Microsoft Corporation	E-mail: whqlinfo@microsoft.com
One Microsoft Way	Fax: (425) 703-3872
Redmond, WA 98052-6399 USA	

References

The following list shows basic information resources available from Intel and Microsoft to help build hardware that is compliant with the PC 99 requirements. Each chapter in this guide also contains a reference section.

Resource	Address
Intel information for developers	http://developer.intel.com
Microsoft information for hardware manufacturers	http://www.microsoft.com/hwdev/ E-mail: ihv@microsoft.com
Windows and Windows NT Device Driver Kits (DDKs)	http://www.microsoft.com/ddk/

	Provided with Microsoft Developer Network (MSDN) Professional membership. To subscribe:
	    Fax: (425) 936-7329, Attn: Developer Network
	    E-mail: msdn@microsoft.com
	    http://www.microsoft.com/msdn/subscribe/

Hardware testing tools	http://www.microsoft.com/hwtest/

Acknowledgments

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Intel and Microsoft are especially grateful for the time and attention that many companies paid in reviewing early drafts of this guide. The feedback and data provided by these companies was invaluable in guiding the content of this guide.

3Com Corporation
3Dfx Interactive, Inc.
3Dlabs, Inc.
3M Company
Acer Lab, Inc.
Adaptec, Inc.

Advanced Micro Devices
Alcor Micro Inc.
APC
ATI Technologies, Inc.
Aureal Semiconductor
Award Software
Brooktree/Rockwell
Cadence Design Systems, Inc.
Chips & Technologies, Inc.
Chromatic Research, Inc.
Cirrus Logic, Inc.
COCOM A/S
Compaq Computer Corporation
Creative Computer Corporation
Creative Technology, Ltd.
Crucial Technology, Inc.
Cyrix Corporation
Dell Computer Corporation
Digital Equipment Corporation
Dolby Laboratories, Inc.
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Efficient Networks, Inc.
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Nanao Corporation
National Semiconductor
NEC Corporation
NEC Technologies, Inc.
NeoMagic Corporation

Nokia Display Products
NVIDIA Corporation
Olicom
Panasonic Industrial Company
Pericom Semiconductor Corporation
Philips Semiconductors
Phoenix Technologies Ltd.
Portable Systems, IBM Japan
Quantum Corporation
Raychem Corporation
Real 3D, Inc.
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Samsung Information Systems America Inc.
Schlumberger Well Services
Seagate Technology
SGS Thomson
Shure Brother, Inc.
Siemens Nixdorf
Silicon Graphics
Silicon Integrated Systems
Silicon Motion, Inc.
SMSC - Standard Microsystems Corporation
Sonnetech, Ltd.
STB Systems, Inc.
Symbios, Inc.
Synaptics, Inc.
SystemSoft Corporation
Texas Instruments, Inc.
Toshiba
Transmeta Group
Trident Microsystems, Inc.
Tulip Computers International
Universal Access AB
ViewSonic Corporation
Vobis Microcomputer AG
Xircom, Inc.
Yamaha Systems Technology

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PC 99 Design Issues

"PC 99" is a collection of PC system definitions and bus and device design requirements for 1999–2000. This chapter summarizes the design goals and key issues for PC 99.

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PC 99 Goals

The goals for PC 99 include the following:

- Advancing the quality of PC hardware, firmware, and device drivers to maximize customer benefit, satisfaction, and ease of use. This will result in greater customer satisfaction and lower cost of ownership and support.

- Ensuring the availability of quality hardware and drivers that support advanced features in Windows 98 and Windows NT Workstation while also ensuring the availability of lower-cost PCs that provide a good user experience with Windows 98 and Windows NT.

- Encouraging innovation so manufacturers and designers can pursue new design solutions and make advances for hardware.

To this end, the PC 99 guidelines refer to existing industry standards or specify performance goals or benchmarks rather than prescribing fixed hardware implementations. Where this is not possible, for example, for CPU and RAM requirements, it is because acceptable benchmarks were not available. When appropriate benchmarks and tests are available, these will be incorporated in the design guidelines.

The specific guidelines were selected for inclusion in this guide based on an evaluation of possible system and device features to determine how the requirements would support the PC 99 goals. Some guidelines are defined to provide clarification of available system support or design issues specifically related to the Windows 98 and Windows NT operating system architectures.

Legacy Migration Road Map

ISA-based devices continue to be the reason for many problems and support issues related to PC configuration. The most common causes for PC customer support calls continue to be resource conflicts or loss of functionality occurring when end users install ISA devices such as modems, audio, or multimedia devices. In addition, even with the performance capabilities of current processors and the advanced multitasking capabilities of Windows 98 and Windows NT, there is still a performance impact when a fast processor has to access a slow bus such as ISA.

To improve system performance, reduce customer support costs, and ensure true ease of use in PC systems and peripherals, manufacturers must plan to migrate all components in their systems away from ISA and legacy devices. With the addition of ACPI support and manageability features in Windows 98 and Windows NT 5.0, the operating systems provide a foundation for configuration, power management, and central administration of systems and devices.

As discussed throughout the history of these *Design Guides*, this migration has to be undertaken on a step-by-step basis. The first step, as defined in the PC 97 design guidelines, was elimination of non-Plug and Play devices from new systems. The second step, defined in the PC 98 guidelines, was the elimination of add-on devices that use legacy ports or the ISA bus.

The ultimate goal, however, is the complete elimination of the ISA bus.

The following summarizes the planned migration road map:

- All PC 99 systems types, like PC 98, are designed and shipped without ISA-based add-on devices and also without ISA expansion slots. If system-board devices such as BIOS ROM, Super I/O, audio, and keyboard controller are included, then each device must meet Plug and Play design specifications either as an ACPI device object (the preferred implementation) or as an ISA Plug and Play device.

  Printers are the only devices that can use COM or LPT ports. Manufacturers are strongly encouraged to begin implementing USB and IEEE 1394 connections for printers.

- ATA and legacy AT Attachment Packet Interface (ATAPI) devices should migrate toward IEEE 1394.

- Modems, scanners, and other input and imaging devices must not use legacy buses. USB is recommended for modems, and SCSI or IEEE 1394 is recommended as the default I/O bus for scanners and other imaging devices.

- Multiple solutions are immediately available for audio, the most common being PCI and USB.

- No graphics adapters can be implemented on ISA (a PC 97 requirement). AGP or PCI are the recommended connections.

The PC 99 guidelines allow OEMs to continue to provide legacy mouse devices and keyboards, but USB solutions are encouraged. Legacy and proprietary solutions for game devices are not compliant with PC 99 requirements.

Complete elimination of the ISA bus from system designs is expected to be broadly implemented across all category of PC designs beginning in the PC 99 time frame.

PC 99 System Types

This section describes the category of system types defined in the PC 99 guidelines. The guidelines for each of these system types provide a starting feature set that encourages differentiation among hardware manufacturers and among product lines based on the addition of advanced features and innovative implementations.

The PC 99 systems defined in this guide do not present a set of definitions for the minimum or best hardware required to run Windows 98 or Windows NT. Instead, this specification describes the hardware that will deliver to end users an optimal level of performance when running Win32®-based applications under Windows 98 or Windows NT.

PC 99 Consumer and Office Issues

The Consumer PC and Office PC system types describe mass-market categories. The vast majority of PCs in manufacturers' engineering plans meet the basic requirements defined for these system types in this guide. The basic levels of performance and capabilities specified for the PC 99 system type should be obtainable.

In this guide, a distinction is drawn between a PC designed for use in a home environment and a PC designed for use in a corporate environment. These distinctions are categorized as Consumer PC and Office PC, respectively.

It is expected that a single OEM system will meet the PC 99 basic requirements and that separate model numbers will designate the "Consumer" or "Office" characteristics. Each of these categories is a variation on the PC 99 basic requirement.

Consumer PC. These PCs are designed for non-networked environments, however, they will most likely participate with a public network such as the Internet. This category includes PCs intended for the home market designed especially for entertainment and game playing, plus those PCs intended for Small Office/Home Office (SOHO) markets. Whatever the destination market, the Consumer PC system contains a baseline of hardware features and technologies that can support the performance requirements for either market. The true differentiation among PCs intended for either entertainment or SOHO use is the software included with the system.

Consumer PC systems come equipped for immediate connection to the Internet using a modem or other public network access device. To support running games, graphical applications, and entertainment and educational media titles, a Consumer PC system includes higher quality graphics capabilities than are required for Office PC system.

Office PC. The greatest differentiating feature of an Office PC system is that it supports requirements intended to reduce TCO in the corporate environment, including support for an upgradable BIOS and remote boot capabilities. An Office PC system is designed to run productivity applications, particularly in a network environment, and it comes equipped with a network adapter.

The following tables summarize the basic components for each system type.

Note: Acronyms used in these summary tables are defined in the Glossary that follows the Appendixes in this guide.

Consumer PC 99 System Summary

PC 99 reference	Required	Recommended
System requirements Chapter 3, "PC 99 Basic Requirements"	300 MHz processor, 128K L2 cache, and 32 MB RAM PC 99 basic minimum, including OnNow support	64 MB RAM
System buses Part 3	2 USB ports No ISA add-on devices or expansion slots	IEEE 1394 Device Bay
I/O devices Chapter 13, "I/O Ports and Devices"	PC 99 basic minimum (keyboard and pointing device, plus connections for serial and parallel devices)	Devices use USB or other non-legacy connection IrDA-compliant IR devices
Graphics and video components Chapter 14, "Graphics Adapters" Chapter 15, "Video and Broadcast Components"	PC 99 basic minimum plus hardware support for 3-D acceleration	AGP Analog video input and capture Analog television tuner Television output
Audio components Chapter 17, "Audio Components"	—	PC 99 audio Digital ready Support music synthesis
Storage components Chapter 18, "Storage and Related Peripherals"	PC 99 basic minimum CD or DVD drive	IEEE 1394 as the host controller for secondary storage
Communications Chapter 19, "Modems" Chapter 20, "Network Communications"	Internal 56-Kbps V.90 data/fax modem	High-speed public network communications support

Office PC 99 System Summary

PC 99 reference	Required	Recommended
System requirements Chapter 3, "PC 99 Basic Requirements"	300 MHz processor, 128K L2 cache, and 64 MB RAM PC 99 basic minimum, including OnNow support and Manageability Baseline	—
System buses Part 3	2 USB ports No ISA add-on devices or expansion slots	IEEE 1394 Device Bay
I/O devices Chapter 13, "I/O Ports and Devices"	PC 99 basic minimum (keyboard and pointing device, plus connections for serial and parallel devices)	Devices use USB or other non-legacy connection IrDA-compliant IR devices Smart card
Graphics and video components Chapter 14, "Graphics Adapters" Chapter 15, "Video and Broadcast Components"	PC 99 basic minimum	3-D hardware acceleration DVD-Video and MPEG-2 playback
Audio components Chapter 17, "Audio Components"	—	PC 99 audio
Storage components Chapter 18, "Storage and Related Peripherals"	PC 99 basic minimum CD or DVD drive	IEEE 1394 as the host controller for secondary storage
Communications Chapter 19, "Modems" Chapter 20, "Network Communications"	Network adapter with NDIS 5.0 driver and support for remote new system setup	Internal 56-Kbps V.90 data/fax modem or other public network communications support

Mobile PC Design Issues

For mobile PC users, the issues of greatest importance are portability (weight) and availability (battery life). Many of the projected uses for Office and Consumer PC systems include CPU-intensive and memory-intensive activities that demand significant power and heat dissipation, which create enormous design challenges. Some solutions appropriate for PC 99 desktop systems will not work physically in the notebook environment.

New external buses, support for multimedia applications, and other changes in PC computing challenge mobile PC designers to incorporate features that users want in a way that does not reduce the value of the core system. The OnNow and ACPI standards allow the operating system to take over the critical operations, such as dynamic configuration and power management, in support of mobile PCs.

The overall goal for mobile PC design is the same as for Office and Consumer PC systems—enhanced user experience—but the design tradeoffs are different. The PC 99 guidelines present mobile PC requirements in a manner that will encourage industry innovation across a wide range of design solutions without creating extreme power demands. Mobile PC requirements allow OEMs the flexibility they need to manage power and heat considerations in their designs.

The key mobile PC design issues include:

- Low weight and small size
- Available battery life to meet user expectations
- Management of power demands and heat dissipation on mobile PCs to ensure reliable operation of internal components
- Docking or port replication design, with issues related to device configuration and alternating current (AC) versus battery power connections

A docked platform cannot always be equivalent to a desktop PC in functionality, although designers strive to achieve this. Therefore, the PCs described in these guidelines include exceptions and qualifications for some basic requirements as they apply for either mobile PCs and the mobile/docking station pair. Complete details are defined in Chapter 6, "Mobile PC 99." The following table summarizes the key components.

Mobile PC 99 System Summary

PC 99 reference	Required	Recommended
System requirements Chapter 3, "PC 99 Basic Requirements"	233 MHz processor, 128K L2 cache, and 32 MB RAM Smart Battery or ACPI Control Method battery PC 99 basic minimum, including OnNow support Manageability Baseline if Windows NT is preloaded	64 MB RAM for Windows NT installations
System buses Part 3	1 USB port CardBus No ISA add-on devices or expansion slots	IEEE 1394 Device Bay Zoomed Video on CardBus Support hot-pluggable devices without system reboot
I/O devices Chapter 13, "I/O Ports and Devices"	PC 99 basic minimum (keyboard and pointing device, plus connections for serial and parallel devices)	Devices use USB or other non-legacy connection IrDA-compliant IR devices
Graphics and video components Chapter 14, "Graphics Adapters" Chapter 15, "Video and Broadcast Components"	$800 \times 600 \times 16$ bpp resolution at 60 Hz Modified requirements if 3-D hardware acceleration is supported	AGP ("frame AGP") DVD-Video playback capabilities Television output
Audio components Chapter 17, "Audio Components"	—	PC 99 audio, with qualifications
Storage components Chapter 18, "Storage and Related Peripherals"	PC 99 basic minimum	CD or DVD drive
Communications Chapter 19, "Modems" Chapter 20, "Network Communications"	Integrated V.34 modem (or just CardBus slot)	Support alternative methods for network connection and remote new system setup

Workstation PC Design Issues

A Workstation PC system is a platform that goes beyond the requirements for a corporate client platform as articulated for Office PC systems, focusing on common design issues for professional workstations used for resource-intensive computing activities.

Software that might run on such platforms includes, but is not limited to, engineering and scientific applications such as CAD/CAM and other forms of simulation, media and content creation, software development, financial applications, and other types of mission-critical client-server applications.

Workstation PC 99 System Summary

PC 99 reference	Required	Recommended
System requirements Chapter 3, "PC 99 Basic Requirements"	RISC-based or 400 MHz processor; 512K L2 cache (per processor); 128 MB RAM; ECC memory protection Office PC 99 basic minimum, including OnNow support and Manageability Baseline	Multiple processors RAM can be expanded to at least 1 GB; 2 GB recommended
System buses Part 3	2 USB ports plus APIC support No ISA add-on devices or expansion slots	IEEE 1394 Device Bay
I/O devices Chapter 13, "I/O Ports and Devices"	PC 99 basic minimum (keyboard and pointing device, plus connections for serial and parallel devices)	Devices use USB or other non-legacy connection IrDA-compliant IR devices
Graphics and video components Chapter 14, "Graphics Adapters" Chapter 15, "Video and Broadcast Components"	If supporting graphics-intensive applications: 4 MB display RAM, and 3-D hardware acceleration	$1280 \times 1024 \times 24$ bpp resolution RGB-mode rasterization if supporting 32-bpp display modes
Audio components Chapter 17, "Audio Components"	—	PC 99 audio
Storage components Chapter 18, "Storage and Related Peripherals"	PC 99 basic minimum CD or DVD drive	SCSI controller Multiple hard drives
Communications Chapter 19, "Modems" Chapter 20, "Network Communications"	Network adapter with NDIS 5.0 driver and support for remote new system setup	High-speed dial-up link, with NDIS 5.0 driver

Entertainment PC Design Issues

The Entertainment PC is differentiated from the Consumer PC by its greater ease of use and the range and quality of its multimedia capabilities. For example, the graphics, video, and audio subsystems for Entertainment PCs are designed to optimize the capabilities of software that uses Microsoft DirectX® interfaces.

Following are the key design challenges for Entertainment PC systems:

- Combining a high-performance 2-D and 3-D graphics subsystem designed for the best games with better-than-television quality, full-screen, MPEG-2 motion video to deliver DVD movies, digital television (DTV), and so on.

- Enabling connection to large-screen displays, including standard televisions, for a more realistic graphics experience than smaller desktop monitors.

- Implementing a high-fidelity audio subsystem that equals consumer stereo systems, enabling delivery of rich content such as games with positional 3-D audio, professionally mastered music CDs, and so on.

- Enabling new media types to the PC for video, audio, and information data, such as analog and DTV signals from broadcast, cable, and satellite links.

- Enabling PC connections to consumer-electronic devices such as camcorders, VCRs, and home-theater stereo systems by way of USB and IEEE 1394.

- Providing home appliance usability for ease of use, in both desktop ("2-foot") and family room ("10-foot") usage models.

- Extending human input device support with remote control, game input controls, and other control devices that use USB, IEEE 1394, and other external connections.

- Bringing advanced but easy-to-use communications capabilities to the home, and integrating these with entertainment functions. Examples include caller ID, family-room speaker phone and video phone, and so on.

The Entertainment PC guidelines are intended to provide much room for innovation, such that OEMs will design to a variety of form factors. In addition to traditional desktop multimedia PC designs, Entertainment PCs will be designed for the PC Theater category. Notice that although the Entertainment PC guidelines call out some of the key design differences related to 2-foot and 10-foot usage models, it is not intended as a comprehensive specification of PC Theater design issues.

Whether defined for use on the desktop or in the family room, Entertainment PC guidelines are defined to deliver the best digital home entertainment of any platform or combination of devices. The following table summarizes the Entertainment PC 99 system components.

Entertainment PC 99 System Summary

PC 99 reference	Required	Recommended
System requirements Chapter 3, "PC 99 Basic Requirements"	300 MHz processor with 128K L2 cache and 64 MB RAM PC 99 basic minimum, including OnNow support	—
System buses Part 3	2 USB ports No ISA add-on devices or expansion slots	Device Bay Three IEEE 1394 ports, one easily accessible
I/O devices Chapter 13, "I/O Ports and Devices"	PC 99 basic minimum (keyboard and pointing device, plus connections for serial and parallel devices)	Devices use USB or other non-legacy connection IrDA-compliant IR devices All input devices are USB HID compliant
Graphics components Chapter 14, "Graphics Adapters" Chapter 16, "Monitors"	3-D hardware acceleration, with additional texture and performance requirements	Large-screen color monitor Television output
Video and broadcast components Chapter 15, "Video and Broadcast Components"	DVD-Video and MPEG-2 playback	Digital broadcast or satellite television support Analog video input and capture Analog television tuner DTV support
Audio components Chapter 17, "Audio Components"	PC 99 minimum audio	Digital ready Support music synthesis
Storage components Chapter 18, "Storage and Related Peripherals"	PC 99 basic minimum DVD drive and DVD-Video playback	IEEE 1394 as the host controller for secondary storage
Communications Chapter 19, "Modems"	Internal 56-Kbps V.90 data/fax modem	High-speed dial-up link with NDIS 5.0 support

PC 99 Design Issues and Compliance Dates

The requirements in this guide are intended to apply to PC systems and peripherals designed for delivery in the fourth quarter of 1999, which means that compliance testing for these guidelines will begin July 1, 1999.

This guide specifies many requirements that represent only incremental changes to existing designs, not changes that require a new design cycle. Most of these changes are "choice of supplier" questions, or clarify and strengthen BIOS and driver implementation details first presented in earlier *Design Guides*.

Compliance testing for any PC 99 guidelines that require significant hardware design changes will begin January 1, 2000, or other dates to be identified.

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PC 99 Design Initiatives

This chapter presents additional information about the key PC 99 design initiatives. Complete references for specifications and implementations discussed in this chapter are presented in Chapter 3, "PC 99 Basic Requirements."

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Wireless Design Issues

This section introduces the technical issues and PC 99 directions for infrared (IR) solutions and identifies the emerging industry standards that might impact radio frequency (RF) solutions.

Capabilities of IrDA Standard Solutions. IR solutions for PC 99 designs are based on the communication standards developed by the Infrared Data Association (IrDA). The two IR solutions based on IrDA-ratified standards are IrDA Data and IrDA Control (also known as IrBus). A third solution is represented by a variety of legacy unidirectional remote control IR protocols. The following summarizes the capabilities of each of these solutions:

- IrDA Data devices perform point-to-point, bi-directional, narrow cone, high-speed (115 Kb/s to 4 Mb/s), short-range (3 to 6 feet) reliable bulk transfers. The IrDA Data protocol enables file transfers over ad-hoc networks; for example, file transfers among laptop, Personal Digital Assistant (PDA), and desktop systems, and other non-PC devices such as cameras.

- IrDA Control (IrBus) enables simultaneous low-speed (75 Kb/s per device), low latency, relatively long range (up to 20 feet), wide cone, reliable communications among multiple devices, such as bi-directional keyboards, mice, multimedia, and game controls. An IrDA Control specification was approved in early 1998 by IrDA and the first products are expected to ship in late 1998.

- Legacy remote control IR protocols are widely used to control consumer-electronics devices such as televisions, VCRs, CD players, and so on. No standard is provided for legacy remote control devices by IrDA or any other standards body. PC systems designed to control such devices or to be controlled by existing IR remote controls must accommodate the lack of standards for these unidirectional protocols by adopting a universal consumer-IR approach.

Advantages of IrDA Protocols. Although system designers can choose to support one or more of the three IR solutions, designers are encouraged to use the IrDA Data and Control protocols. For many applications, the IrDA Control protocol has some significant advantages over the legacy remote control protocols that give it the potential to become a world-wide standard:

- IrDA Control is bi-directional, which enables "smart" control applications that both download and upload information.

- IrDA Control supports up to eight peripherals simultaneously, using a combination of Time Division Multiple Access (TDMA) and Packet Reservation Multiple Access (PRMA), based on a statistical slotting algorithm.

Because a separate dongle does not have to be provided for each control device, use of the IrDA Control protocol is of particular advantage to OEMs who want to bundle multiple wireless control devices with their systems, for example, a mouse, a keyboard, and two game pads.

PC 99 Directions for IR. Interoperability is a problem among all three of the IR protocols. Although future technology advances might allow some consolidation of IR transceiver ports, this is not expected for 1999–2000. Therefore, a PC 99 system must provide a separate transceiver for each protocol it supports. These transceivers must be physically isolated from each other.

If a PC 99 system is advertised as supporting all three IR solutions, the system must provide a physically isolated transceivers for each protocol, and it must expose each transceiver to the operating system. For example, to provide physical isolation, the IrDA Control transceiver could be placed on the front of the system, and the IrDA Data and legacy remote control transceivers could be placed on different sides of the system.

If a PC 99 system is advertised as supporting two of the protocols, for example, IrDA Data and IrDA Control, the system must provide two physically isolated transceivers, one for each protocol.

Many manufacturers are implementing integrated IR solutions for mobile PCs. Various form-factor and environmental issues have limited the adoption of wireless solutions for desktop PCs, including receiver placement in the office environment and limiting conflicting device signals. Universal Serial Bus (USB) IR bridging devices or hubs are expected to help resolve many of physical placement issues for desktops. A USB working group is developing guidelines on how USB will interface with both IrDA Data and IrDA Control devices, with first products expected to ship near the end of 1998.

Manufacturers must incorporate Fast IR solutions as soon as possible; particularly for mobile system designs. Fast IR transmits and receives data at speeds of 1.152 megabits per second (Mb/s) and 4.0 Mb/s. Fast IR includes design implementations that improve usability. Manufacturers must also include Serial IR (SIR) backward compatibility in their Fast IR solutions.

Emerging RF Standards. New standards groups for RF communications in the consumer market are emerging. In particular, the HomeRF Working Group (HRFWG), which is comprised of computer, telecommunications, and consumer electronics companies, is developing an interoperable RF common air interface called Shared Wireless Access Protocol (SWAP). Manufacturers should be aware of the SWAP specification effort, which will be recommended in future Consumer PC systems as a standard RF connection. Information is available on the HRFWG web site at http://www.homerf.org.

Video and Broadcast TV Design Issues

New technologies are becoming available that integrate the PC with television, making the PC more compelling for new audiences and new uses. These new technologies, which are built into Windows 98 and Windows NT Workstation 5.0, consist of broadcast components that allow PCs to receive television programming, data services, and new forms of entertainment that blend the two. These technologies are enhanced in the operating system with new user-interface elements appropriate for use on large-screen display devices such as a progressively scanned display or a television monitor.

The broadcast and video technologies in Windows 98 and Windows NT 5.0 are based on industry standards such as MPEG-2, Win32, ActiveX, and DirectX, and they are also built on current and emerging standards for broadcast networks and Internet protocols, enabling IP Multicast as a point-to-many networking standard for network traffic.

Broadcast network capabilities provide a transmission infrastructure that can support services such as automatic software and file updates. Broadcast technologies enable new applications and business opportunities such as:

- New types of programming that combine the PC, television, and the Internet.
- Multimedia Internet content delivered by broadcast networks and stored locally on the PC, reducing the Internet bandwidth bottleneck and improving the overall user experience.
- Secure, billable, and scaleable data services such as subscription services for software, electronic news, and entertainment, encouraging creation of new business models.

Hardware manufacturers can find new business opportunities in the convergence of consumer electronics and personal computing. This convergence also offers opportunities for cross-industry collaboration in creating new products and services.

The aim of the PC 99 guidelines is to ensure that PCs and related computer devices can do everything the TV, VCR, set-top box, and hi-fi system can do. This new set of capabilities requires careful design decisions for adding new features to the PC without taking away anything from the known features of the traditional TV and other devices. In particular, the assessment of picture quality includes image clarity, smooth resizing, and precision of frame delivery. The challenge for the designer is to ensure that the PC meets or exceeds the video and audio quality of traditional consumer appliances. Particular emphasis will be placed on checking that rendering is accurate for the highest motion content scenes.

Important design issues addressed in the PC 99 guidelines that relate to integrating video and broadcast TV capabilities with the PC include the following:

- Increased quality of video capture and playback, including an absence of banding related to poor scaling methods.
- Low-latency video delivery, displaying video from both internal and external video devices.
- Support for receiving digital TV broadcasts.
- Increased use of multiple screens and their associated display controllers. This allows a PC to run a word processing application in one room, while simultaneously supplying a TV located in another room with a DVD movie or TV content.
- Separation of "receiver" functions from "display" functions. The two will be linked by software running on the host processor. This allows different elementary streams such as MPEG video, audio, and data to be sent to the appropriate subsystems within the PC. It also prepares the way for the long range goal of a video home network.
- Introduction of Device Bay as a way of implementing TV receiver modules. This is in addition to the use of PCI adapters and external receiver boxes, which are also acceptable implementations.
- Required use of Microsoft DirectShow™ for video playback.

Notice that support for video playback under Windows 98 and Windows NT 5.0 is provided only under DirectShow, as described in the following section. No functionality will be added to Video for Windows (VfW) in any future versions of Microsoft operating systems.

DirectX and DirectShow

The Microsoft DirectX foundation provides low-latency interfaces to media hardware. Previously, the primary market focus for these technologies was entertainment titles, but these application programming interfaces (APIs) also provide a solid foundation for the media services required for Internet applications.

In addition, they also provide the media foundation for a broad range of productivity applications, enabling high-performance media with hardware acceleration.

Microsoft DirectDraw® is the Windows system component that allows direct manipulation of video display memory, hardware block transfers (bit-blters), hardware overlays, and page flipping. DirectDraw performs the common functions required by both hardware and software emulation implementations while maintaining compatibility with the Windows Graphics Device Interface (GDI). This provides compatibility with existing Windows applications and device drivers. The user will experience the highest quality performance when using new hardware that provides built-in DirectDraw acceleration and rendering capabilities.

Microsoft Direct3D® is a DirectX technology that provides access to hardware acceleration for 3-D rendering. Some basic and general 3-D capabilities will become pervasive in entertainment software by the end of 1999. These capabilities should be provided in all graphic cards to improve the performance of 3-D games, business graphics, Internet 3-D file viewing through virtual reality modeling language (VRML), and professional 3-D applications.

DirectShow provides access to hardware acceleration for MPEG-1 playback, which will become increasingly important for high-performance video in the context of games, Internet content viewing, computer-based training, and desktop video conferencing. Some PC 99 hardware requirements ensure support for video playback on all PCs running Windows operating systems. DirectShow is required to support video playback under the PC 99 guidelines.

Microsoft DirectSound® provides a low-level and high-performance audio API, including 3-D sound spacialization (DirectSound3D) and MIDI Microsoft (DirectMusic™) APIs.

Microsoft DirectInput® provides a low-level and high-performance input device API to support keyboards, mice, joysticks, and so on. Microsoft DirectPlay® provides a collaborative communications layer.

DirectMusic is described in "Audio Design Issues" later in this chapter.

Audio Design Issues

This section addresses the key design issues for audio.

Basic vs. Advanced Audio. The basic audio requirements defined in these guidelines identify the baseline operating system and hardware audio support available for existing and emerging multimedia applications. They are also designed to ensure that a minimum audio capability exists across a majority of platforms.

The advanced recommendations describe additional software and hardware features beyond the minimum requirements. These recommendations support vertical applications and provide scalability above the baseline audio capabilities by offering higher compatibility, performance, concurrency, or quality.

WDM and PC Audio. One key to the successful advancement of audio in the PC is WDM Audio class support. The architecture performs all audio processing in kernel mode, which significantly improves latency.

WDM also provides a more complete architecture than previous generations. Code common to all audio hardware on a given bus is now part of the operating system, making for faster development with more consistent results.

External Digital Audio. USB and IEEE 1394 provide excellent mechanisms for delivering digital audio to external peripherals for high-quality conversion (greater than 85 dB dynamic range) to and from analog. In the near term, the popularity of USB makes it a natural choice. In the long term, the consumer-electronics industry envisions IEEE 1394 transporting audio and video among many devices in a simple, high-performance manner.

PC Audio Transitions

For the foreseeable future, audio in the PC will continue to offer a wide array of possibilities. One notable trend is the movement toward solutions that use a hybrid of host-based and device-based audio data processing. Current and future versions of the DirectX APIs, including DirectSound, DirectSound3D, and DirectMusic will expand the degree of support for all styles of audio solutions, from host-based to fully hardware-based.

As the PC is increasingly called upon to play the part of a consumer-electronics device, for example, video-disc playback, sound quality becomes more important. A number of initiatives are underway to achieve optimal sound quality. Another implication of this trend is the need for simpler operation and hardware configuration.

The state of audio functionality is far from stagnant, presenting a challenge for the industry to maximize performance and simplicity, and to add more advanced features. The shift to higher quality and support for external digital connectivity will not happen overnight. One objective of the PC 99 audio guidelines is to facilitate the transition over the next few years. Four audio applications merit more detailed discussion and are described in the following sections:

- CD and DVD media playback
- Scalable music synthesis for games and multimedia
- Scalable audio for 3-D games
- Full-duplex H.323/H.324 video and audio conferencing

CD and DVD Media Playback

WDM audio supports the following features for CD and DVD media playback under Windows 98 and Windows NT 5.0:

- A kernel-mode CD driver that emulates MSCDEX commands and implements reading, parsing, and streaming of Red Book CD digital audio to the kernel-mode WDM system-wide mixer at 16-bit stereo 44.1 kHz.
- A Universal Disk Format (UDF) DVD file reader, splitter, and navigator that provides access for DirectShow clients to separate video and audio streams.
- A kernel-mode, system-wide software mixer, which supports DirectSound, DirectShow, and WINMM clients, plus kernel-mode WDM filters, including Red Book CD and MIDI drivers. The architecture provides the ability for algorithms from any vendor to decode the DVD audio and it supports mixing at 16-bit stereo 48 kHz.
- Flexible control of the output destination. The WDM drivers can send the master 16-bit 44.1-kHz or 48-kHz, or other format output to a PCI, USB, or IEEE 1394 audio device. Support is also provided for redirecting the PCI-device final-mix output to USB speakers.

As defined in Chapter 17, "Audio Components," baseline PC 99 audio hardware support for CD and DVD media playback requires that the built-in or external audio codec support playback of 16-bit stereo PCM data at either a 44.1-kHz or 48-kHz sample rate.

For MPEG content, the system designer might choose to include optional DirectShow or WDM kernel-mode streaming filter components, or hardware that can provide the following capabilities:

- Greater than 85-dB dynamic range codec audio quality to meet performance requirements of the consumer-electronics market

- Software or hardware Dolby AC-3 or MPEG-2 multichannel decode and downmix to stereo at 16-bit 48 kHz

- Software or hardware MPEG-1 layer-2 stereo at 16-bit 32, 44.1, or 48 kHz

- Software or hardware support for up to 24-bit 96-kHz linear PCM (LPCM) data, down-converted to 16-bit 48 kHz

Scalable Music Synthesis for Games and Multimedia

DirectMusic is a new set of core services featuring:

- An interactive music engine that enables the PC to generate a highly customized musical accompaniment capable of following on-screen action with precision.

- An open architecture that provides custom sound sets that can be played back on music products from any manufacturer.

- MIDI APIs that provide much better timing and musical stream control.

Microsoft is providing DirectMusic with Windows NT 5.0 and as an add-on for Windows 98 and Windows 95. For more information on DirectMusic and the interactive music architecture, see http://www.microsoft.com/directx/. The DirectMusic details of interest to hardware manufacturers include:

- An API that allows applications to manage Downloadable Sounds (DLS) files and download the relevant instruments to hardware or software synthesizers. For information, see *DLS Specification, Version 1.0*, at http://www.midi.org.

- A software synthesizer to accommodate situations where no hardware capability exists. The architecture allows third-party software synthesizers to connect with DirectMusic.

- A new timing model with a kernel-mode sequencer that allows the components to track either a system clock or sample clock on the audio hardware. There is also a provision for the synthesizer to report latency, subsequently receiving MIDI data with the appropriate advanced-scheduling. As a result, hardware and software synthesizers will play completely in sync.

- A decompression model that enables developers to encode DLS files using any of the ACM codecs. The system performs real-time decompression of the file before making it available to the hardware or software synthesizer.

Because of the availability of a software synthesizer, PC 99 does not require hardware to support DirectMusic. To create a more efficient implementation with higher performance, the hardware designer must address the following trade-offs:

- CPU utilization versus hardware cost. Hardware synthesizers typically consume fewer system resources during playback of a DirectMusic application.

- Sound quality versus hardware cost. Hardware synthesizers typically operate at a higher master sample rate and use higher-order interpolation than software synthesizers.

Scalable Audio for 3-D Games

The APIs provide standard interfaces for applications to use one or more streams of 3-D-positioned audio. The DirectSound3D Hardware Emulation Layer (HEL) enables optimal configuration based on CPU performance and installed hardware, and enables three levels of 3-D support:

- Software-simulated 3-D using simple inter-aural delay processing

- True Head Related Transfer Function (HRTF) 3-D filtering optimized for the media-enhancement instruction set in the central processor

- Hardware acceleration

WDM audio supports the following features specifically for 3-D games under Windows 98 and Windows NT 5.0:

- Software emulation of legacy hardware to support MS-DOS–based games in Windows 98. WDM drivers, which run in kernel mode, provide virtual Sound Blaster Pro, MPU 401, and legacy joystick interfaces.

  Direct access to audio hardware has never been supported in Windows NT; WDM audio services for Windows NT do not include support for MS-DOS–based games.

- A standard interface for the application to provide multiple streams of 3-D–positioned audio. DirectSound3D supports hardware acceleration, software-simulated 3-D using inter-aural delay processing, and true HRTF 3-D processing. The architecture supports optimal configuration based on CPU performance and installed hardware.

- A wave-table General MIDI synthesizer, existing entirely in kernel-mode software. This provides 32 voices of music synthesis with 22.05-kHz output. DirectShow, DirectMusic, WINMM, and virtual MPU 401 can use the synthesizer functions. The architecture supports optimal configuration based on CPU performance and installed hardware.

- A high-quality kernel-mode software sample rate converter (SRC) capability, which converts data streams, including composite mixes of all 11.025-kHz or 22.05-kHz sources, to the final output mix format, typically 16-bit 44.1 kHz. General SRC support includes other rates.

- A kernel-mode system-wide software mixer, which supports DirectSound, DirectShow, and WINMM clients, plus kernel-mode WDM filters, including Red Book CD and MIDI drivers. The mixer implements highly optimized, same sample rate PCM mixing at 8-bit or 16-bit 11.025, 22.05, 44.1, and 48 kHz. General mixing support includes other formats.

- Flexible control of the output destination. The WDM drivers can send the master 16-bit 44.1-kHz, 48-kHz, or other format output to a PCI, USB, or IEEE 1394 audio device. Support is also provided for redirection of PCI-device final-mix output to USB speakers.

As defined in Chapter 17, "Audio Components," the minimum PC 99 audio hardware support necessary for 3-D games is built-in or external audio codec support for playback of 16-bit stereo PCM data at a 44.1-kHz sample rate.

The system designer might choose to include the following optional software or hardware to provide additional capabilities:

- Optimized software or digital-ready hardware acceleration for higher quality or concurrency DLS wave-table MIDI synthesis, with associated mixing and SRC support.

- Optimized software or digital-ready hardware acceleration for higher concurrency HRTF 3-D positional audio, with associated mixing and SRC support.

Full-Duplex H.323/H.324 Video and Audio Conferencing

WDM audio supports the following features for full-duplex video and audio conferencing under Windows 98 and Windows NT 5.0:

- Native 32-bit support for simultaneous audio input and output, not dependent on 16-bit MMSYS components.

- Input and output position reporting mechanisms for synchronization of speaker and microphone streams, accurate to 1 ms or better.

- WDM Stream class driver that provides access to acoustic echo cancellation (AEC) reference interfaces supported by hardware codecs.

As defined in Chapter 17, "Audio Components," baseline PC 99 audio hardware support for H.323/H.324 video and audio conferencing requires full-duplex audio capability. The system designer might choose to include optional hardware to provide hardware AEC references for echo cancellation filtering.

Modem Design Issues

The Windows 98 and Windows NT operating systems and Win32-based applications use data, fax, voice, and voice/data integration features in modems. The fundamental design principle for compatibility with Windows and Windows NT is for the device to be supported by the Universal Modem Driver (Unimodem), which uses INF files to characterize the behavior of a device. Unimodem requirements are defined in the Windows Modem Developers Kit (MDK), available at http://www.microsoft.com/hwdev/.

PC 99 guidelines are designed to address the following issues:

- Providing higher-speed dial-up access based on standardized pulse-code modulation (PCM) modems, based on ITU V.90.

- Augmenting modem functions to support low-latency multimedia applications.

- Addressing persistent cost-of-ownership problems, particularly modem detection and installation, and Internet Service Provider (ISP) call failures.

- Migrating modem functions into the operating system to save costs and provide upgrade flexibility.

This section provides more information about the key design issues for modems.

Migrating to Higher Speeds with PCM Modems

ISP access is a driving force for modem use. PCM modems enable the highest possible download speeds from central sites that are digitally connected to the Public Switched Telephone Network (PSTN).

The ITU-T standard for PCM modems, V.90, was completed in February 1998. V.90 capabilities are a minimum PC 99 requirement for modems designed for desktop systems.

Supporting Low-Latency Multimedia Applications

The growth of the Internet, with web sites featuring real-time streaming sound and video, has meant an increase in the transport of natural data types such as voice and video across modem connections. The requirements imposed on modems for such data types are different from those related to simple file transfer. Specifically:

- Data integrity, of critical importance in file transfer operations, is less important for voice or video.

- Data compression capabilities of modems, which often go unused because digitized sound and video tend to be highly compressed.

- Data latency, both average delay value and delay jitter, become quite important for natural data types, especially for interactive applications. Latency is a minor issue for file transfer, because the total transfer time for the file is usually far greater than the delay value.

- Data flow interruptions for data pump retrains or rate renegotiations, which are benign to file transfers, are intolerable for natural data types.

To address the low-latency demands of multimedia applications, the V.42 and V.42 *bis* protocol layers in the modem can be disabled. This removes the large buffering delays and data-forwarding jitter associated with these protocols. The Synchronous Access Mode procedures defined in ITU-T Recommendation V.80 can be enabled as an alternative to V.42 and V.42 *bis* to support low-latency, bandwidth-efficient connections.

On V.34 connections, data interruptions related to retrains and rate renegotiations can be reduced by the use of the Seamless Rate Change (SRC) procedures defined in new Annex A/V.34 (1998). SRC allows the modem to adjust its speed to match line conditions without disturbing the flow of data.

Addressing Cost of Ownership for Modems

The two largest cost-of-ownership issues for modems are installation problems and operations problems related to creating connections. Plug and Play minimizes installation problems when correctly implemented. However, the explosion in ISP usage has increased the percentage of modem connections made on local calls, as opposed to long distance, and has highlighted operations problems on such connections. According to public studies, 16.2 percent of ISP access calls fail to connect, and ISPs are commonly spending six dollars per subscriber per month in technical support. Only a small percentage of access calls fail after the connection is made.

The rate of access calls that fail to connect is not acceptable. The elements needed to lower the failed connection rate are:

- Local call impairments must be included in industry-standard modem test suites, so that modem data pumps are designed and evaluated for such conditions.

- Modem and PSTN diagnostics must be implemented so that the causes of field failures can be identified.

- Modem upgrades should be made easily with revised code developed from the diagnostic feedback.

- Deterministic modem identification must be implemented so that upgraded modems still work.

TSB-37A is the industry-standard model of the North American PSTN, widely used for evaluating modem performance by simulating telephone connections. Investigation by some of the regional Bell operating companies discovered that although TSB-37A does a good job simulating long-distance connections, it does not account for certain impairments specific to local calls that might affect modem performance.

TSB-37A is currently under revision; the revised standard, TSB-37B, will include accurate simulation of local connections. TSB-37B is expected to be completed in 1998, and its use should allow for a more accurate prediction of modem performance on local calls.

Microsoft, in consultation with leading ISPs and modem manufacturers, is developing a standard method for modems to report last-call statistics: the Unimodem Diagnostics command, or AT#UD, as described in the specification at http://www.microsoft.com/hwdev/respec/. This command can be used by Windows and ISP software to determine the reported last-call information which is essential to uncover problems in user modems, local phone loops, local offices, and ISP-side modems so that they can be diagnosed and fixed.

Requiring modem replacement as a solution is too costly for both the user and the manufacturer. Some manufacturers, such as those who make Windows-based modems, already make their modems with upgradable memory, allowing feature and fix upgrades for their customers. Easy upgradability for end users must become an industry-wide standard.

But even upgrades can pose hazards. For modems that do not support Plug and Play, the Windows Modem class installer reads a series of AT commands, implements a proprietary algorithm to generate a 32-bit ID, and uses that ID to match to the modem driver. Manufacturers might inadvertently change the responses that the Unimodem depends on for computing the unique Unimodem ID, such as AT+GM*x,* ATI, and other commands, leaving the user with a modem that is recognized as a "Standard Modem" instead of the actual modem name.

To address the detection problem, modem vendors are required to use bus-specific Plug and Play means to deliver the Compatible ID command, and they are encouraged to use standard methods to report accurate manufacturer and modem names. For information, see specifications for new Unimodem commands and related articles at http://www.microsoft.com/hwdev/modem/.

Migrating Functions to the Operating System with Windows Modems

A traditional modem has several functions implemented in hardware or firmware:

- Telephone network connection—connectors, transformers, relays, codec
- Digital signal processing—V.90, V.34, V.8 *bis*, dual-tone multifrequency (DTMF), voice processing, speakerphone echo cancellation, and so on
- Modem controller—AT command interpreter (V.250)
- Protocol stacks—V.42 error control, V.42 *bis* data compression

A Windows modem moves some of these functions into Windows drivers. A controllerless modem, also known as a host-based controller, is a modem that consists of a digital signal processor (DSP) without the usual microcontroller. The host CPU provides the AT command interpreter, modem control functions, V.42, and V.42bis implementation.

A software modem, also known as host-based signal-processing modem or pumpless modem, performs signal processing on the host microprocessor and implements the controller. The modem hardware consists only of a telephone-line interface, digital-to-analog converter (DAC), and analog-to-digital converter (ADC) circuitry such as an *Audio Codec '97 2.0* modem codec, plus a little bit more. However, the hardware does not contain a DSP or a microcontroller.

Advantages of software modems, in addition to cost savings, include the following:

- Modem design provides great flexibility for upgrading to new standards, engineering fixes, and so on.
- Separate data and control paths are available to the hardware.
- Data processing occurs in the CPU, where it fits.

    However, in many microcontroller-based modems, V.42 *bis* throughput is limited in some situations by available microcontroller processing power.

Disadvantages of software modems include the following:

- CPU-based functions compete for resources with other uses, such as the operating system, applications, multimedia codecs, and so on.
- Modem design is dependent on a specific operating system environment in order to function. For example, a Windows modem does not function in the pre-boot environment or under real-mode MS-DOS.
- Modem implementation requires Windows-savvy code development to ensure that the modem drivers are well-behaved in the system and to ensure straightforward installation and operating system upgrades.

Controllerless and software modems are built as custom drivers that are required to run in real time within the Windows environment. WDM modem support can provide a common interface.

Software modems are one of the first computationally intensive services where third-party vendors are providing kernel-mode drivers that can have significant impact on operating system scheduling services. To assure reasonable system performance to the end user, this guide introduces performance guidelines for software modems.

These guidelines are primarily meant to guide designers in the development of WDM-based software modem implementations. The instrumentation techniques suggested might not be applicable to industry standard external "black box" testing of modem performance.

Similar guidelines might need to be established for other services and drivers as support moves into kernel mode. As an example, DirectSound3D, DirectMusic, software MPEG, and AC-3 decoders for DVD are being implemented by some vendors as user-mode services.

Network Communications Design Issues

The Network Driver Interface Specification (NDIS) 5.0 represents a number of extensions to the interface described in NDIS 3.0 and 4.0. The basic requirements, services, terminology, and architecture of the earlier versions also apply to NDIS 5.0. The new NDIS architecture will be included in the Windows 98 and Windows NT 5.0 operating systems.

NDIS 5.0 consists of all functionality defined in NDIS 4.0, plus the following extensions:

- NDIS power management, required for network power management and network wake up.

- Plug and Play.

- WMI-based hardware instrumentation, providing support for structured, cross-platform management of NDIS miniports and their associated adapters.

- Mechanisms that off-load tasks such as TCP/IP checksum, IP Security, TCP message segmentation, and Fast Packet Forwarding to intelligent hardware.

- Broadcast media extension, required for broadcast components.

- Deserialized miniport, improving performance on Windows NT multiprocessor systems.

  Information about the miniport driver model is included in the Windows NT 5.0 DDK.

- Connection-oriented NDIS, supporting native access to connection-oriented media such as ISDN and ATM, including ATM/ADSL, ATM/cable modem, and so on, plus support for Quality of Service (QoS) when supported by the media.

  Previously, NDIS primarily supported network adapter driver development and deployment of connectionless network media such as Ethernet, Token Ring, ArcNet, and Fiber Distributed Data Interface (FDDI). NDIS 5.0 extends this interface to provide efficient support for connection-oriented media such as ATM (including ATM/ADSL, ATM/cable modem, and so on) and ISDN with isochronous data transfer for media that supports QoS. The new architecture also enables support for streaming multimedia data such as audio and video over the NDIS media.

- Intermediate driver support, required for broadcast components, virtual LANs; LAN emulation over new media such as ATM, satellite or broadcast television, and so on; packet scheduling for QoS; and NDIS support over WDM-supported buses, such as IEEE 1394 and USB.

The PC 99 guidelines also introduce home networking as a significant new area for design concerns, with different constraints than conventional networking. These guidelines introduce minimal standards for quality, with few technical standards, to allow time for the market to develop.

Scanner and Digital Still Image Device Design Issues

The integration of imaging devices on the Windows platform presents a wealth of business opportunities by transforming end-user computer interactions to those which are visually exciting and inherently more natural because of their visual nature. Contextual information can be conveyed as never before.

Changes in Windows 98 and Windows NT 5.0 address both consumer and business market segments with support for still image devices by providing broad, extensible operating system services. Imaging under the Windows platform will continue to grow to meet the challenging needs of the pre-press, publishing, and document imaging markets, as well as the burgeoning consumer market, by allowing for a range of possibilities from simple to complex.

New PC 99 design issues make the PC the premier imaging platform. To accomplish this, hardware vendors need to seamlessly integrate their devices with Windows. Issues include designing ways to:

- Initiate workflow for the user, such as incorporating push model support in all imaging peripherals.
- Reduce the complexity of working with imaging devices by using operating system services where available. This allows a consistent user interface, simplifying steps in image acquisition, processing, and output.

- Ensure consistent color from acquisition to output by working with Windows Integrated Color Management (ICM), providing for a positive end-user experience.
- Integrate higher bandwidth peripheral connections with the PC for faster image transfer and better user experience. Peripheral connection should migrate from:
  - Legacy serial to USB
  - Serial IR (SIR) to Fast IR (FIR)
  - Parallel to IEEE 1394
  - SCSI to IEEE 1394

PC 99 requirements for imaging devices set the state for future Windows imaging support. By complying with these design guidelines, the imaging IHV creates a better end user experience on the Windows platform and also readies its product lines for upcoming system services based on the operating system's current building blocks.

Device Bay and Modular PC Design

Device Bay is a technology that enables adding and upgrading peripheral devices without opening the chassis and without turning off or rebooting the PC. Device Bay also enables peripheral devices to be easily swapped between platforms.

The *Device Bay Interface Specification* is an industry specification co-authored, and jointly owned and managed by Compaq Computer Corporation, Intel Corporation, and Microsoft Corporation. To obtain the Device Bay specification, see the web site at http://www.device-bay.org.

The Device Bay specification defines an architecture that supports hot-swapping devices and the interoperability of peripherals and platforms. A bay can be built into the chassis of any PC system that meets the operating system requirements plus all the connector receptacle, bus interface, mechanical form factor, power, thermal, and controller logic requirements, as defined in the Device Bay specification.

Device Bay devices must use one or both of the industry-standard extensible bus interfaces: IEEE 1394 or USB. These buses provide a broad range of bandwidths and scalable performance to support the requirements of PC peripherals for at least the next five years.

Device Bay Device Categories. Device Bay provides manageability and interoperability for a range of PC peripherals and PC categories, including business, and consumer desktop and portable computers, as well as home-theater technology.

The Device Bay technologies support devices for mass storage, security, and communications and connectivity, and for a variety of other devices. Device Bay technology allows OEMs, retailers, and end users to easily add peripherals to support specific application needs. For example, an IEEE 1394 hard disk drive could be added to provide a large storage medium for digital imaging or audio authoring, a DVD drive could be added to enable DVD-Video playback, or a smart card reader could be added for secure online banking or shopping.

Device Bay technologies also support swapping a hard disk drive—and thus a set of data and applications—between a desktop system and a laptop PC. In the corporate environment, a hard disk drive could be removed from a failed system and inserted into a working system, minimizing employee downtime and lowering TCO.

PC 99 and Device Bay. Device Bay is recommended for PC 99 systems. The following features are required to implement Device Bay in a PC system design:

- One USB and one IEEE 1394 port for each Device Bay-capable bay in the system; power for the bay in compliance with the Device Bay specification; and a controller for the bay, which must be a Device Bay Controller, in compliance with the Device Bay specification.

- Peripherals that interface with either USB, IEEE 1394, or both. If a USB connection is used, it must support USB device class specifications.

PC 99 compliance testing for Device Bay is expected to begin January 1, 1999, subject to availability of hardware components. For complete requirements, see Chapter 3, "PC 99 Basic Requirements."

OnNow and ACPI Design Issues

The OnNow design initiative is a comprehensive, system-wide approach to system and device power control based on a group of new specifications. OnNow is the term for a PC that is always on and responds immediately to user requests or other events, but it appears to be off when not in use.

Since *PC 98 System Design Guide* was published, the following industry advances have been made on the OnNow design initiative:

- OEMs and system-board manufacturers are shipping ACPI-ready portable and desktop computers. They are making ACPI-compliant BIOS implementations available to their customers with the ACPI-enabled operating systems shipped by Microsoft.

- Advanced features of OnNow, such as wake-on-LAN, low-power desktop system boards, and PCI bus implementations that support wakeup from D3 (cold), are in development and being tested.

- The assembler, debugger, and compatibility testing tools provided by Microsoft have been finalized, enabling system manufacturers to design, develop, and test ACPI chip sets, firmware, and system boards.

- Implementation of the Windows user interface, device driver interfaces, application interfaces, and policy manager interfaces have been completed and documented.

The key design progress for OnNow and ACPI focuses on the following capabilities:

- Migration of system configuration from the Plug and Play BIOS to ACPI. ACPI leverages the Plug and Play BIOS data structures in a way that is compatible with both Windows 98 and Windows NT 5.0, but independent of processor architecture implementations.

- Migration of legacy power management from BIOS Advanced Power Management (APM) 1.2 to ACPI for Windows 98 and Windows NT 5.0.

- Device and device driver design for compatibility with OnNow operating systems.

Current information about specifications and progress for this initiative, including details for technical implementations, can be found on the web site at http://www.microsoft.com/hwdev/onnow.htm.

Windows Driver Model

The Windows Driver Model (WDM) is designed to allow binary compatibility of for Windows 98 and Windows NT 5.0 drivers for targeted device classes. For bus and device classes with WDM support, driver developers write only small minidrivers to expose device-specific features.

The WDM core provided by Microsoft for Windows 98 and Windows NT 5.0 is a subset of Windows NT kernel services, with new cross-platform APIs for Plug and Play, power management, and Windows Management Instrumentation (WMI). For each bus class and device class with WDM-based support, Microsoft provides a class driver, which is a device abstraction for a particular class of devices.

Microsoft provides the WDM core services, which are documented in the Windows NT 5.0 DDK and the Windows 98 DDK. WDM support for Windows 98 and Windows NT includes the following:

- USB and IEEE 1394 devices
- HID-compliant devices

- WDM digital audio
- Still and video imaging
- DVD decoding
- USB and driver-based software modems

Key support for many devices relies on the WDM Stream class driver, which optimizes data flow in the operating system kernel.

Manageability Initiatives

The purpose of the manageability initiatives described in this guide is to help plan, deploy, proactively maintain, and centrally control a distributed computing environment in order to reduce the overall cost of owning and managing computers. To do this, management technology must bring together information from different technology disciplines to provide services oriented toward management functions, which can in turn decrease TCO.

To succeed in significantly reducing TCO, management solutions must adapt to the needs and tasks of the environment to be managed. The solutions must therefore be open, flexible, and extensible: They need to support new technologies and integrate management functions supplied by more than one vendor. Such systems must conform to appropriate existing standards and have sufficient flexibility to extend support to emerging standards and technologies.

Providing management solutions requires establishing a management infrastructure in the operating system, exposing this infrastructure, and building the tools to use it. This includes:

- Providing instrumentation as the infrastructure for manageability.
- Supporting management tools.
- Supporting new developments such as policy management in Windows 98 and Windows NT 5.0.
- Providing interfaces for enterprise management vendors.

For hardware platform designers, the technology used for platform instrumentation is of direct interest because it is a design element for their systems. Some earlier PC platforms were instrumented with the Desktop Management Interface (DMI), as described in the *Network PC System Design Guidelines*.

In the PC 99 time frame, new Windows management infrastructure components are requirements for Office and Workstation PC systems, and also for mobile PCs that come preloaded with Windows NT.

C H A P T E R   3

PC 99 Basic Requirements

This chapter summarizes the basic features required for all PC 99 systems, with specific requirements for Consumer, Office, Mobile, Workstation, and Entertainment PC systems.

For definitions of common terms, acronyms, and abbreviations used in this guide, see the Glossary; see also "Conventions Used in This Guide" in "Welcome."

Important: The system requirements defined in this guide provide guidelines for designing PC systems that will result in an optimal user experience with typical Windows-based applications running under either the Microsoft Windows 98 or Windows NT Workstation operating systems. These design requirements are not the basic system requirements for running Windows operating systems.

Contents

PC 99 General System Requirements

This section presents a summary of the general system requirements and recommendations, including system board, memory, and BIOS requirements.

3.1. System performance meets PC 99 minimum requirements

Consumer	Office	Mobile	Workstation	Entertainment
300 MHz, 32 MB	300 MHz, 64 MB	233 MHz, 32 MB	400 MHz, 128 MB	300 MHz 64 MB

The performance requirements for PC 99 systems are based on the minimum computational capabilities and performance necessary to support the demands of Windows-based applications together with the estimated processing demand and processing capability of the lowest-end processor in mid-1999.

The minimum performance requirement consists of the following:

- **3.1.1 System includes CPU and L2 cache that meets PC 99 minimum requirements.** The minimum microprocessor capability is specified to support the demands of rich media, Internet access, and conferencing. The performance requirement for media enhancement is specified to ensure that the system meets performance targets at minimum platform power.

  This processor requirement does not specify a particular processor form factor or package type.

  - Consumer PC, Office PC, and Entertainment PC: 300 MHz Intel Architecture compatible processor with 128K Level 2 (L2) cache

  - Mobile PC: 233 MHz Intel Architecture compatible processor with 128K L2 cache

  - Workstation PC: 400 MHz or greater Intel Architecture compatible processor with 512K L2 cache

    For multiprocessor workstations, a minimum 512K cache is required per processor.

  Recommended: Processor supports multimedia extensions.

  This processor requirement does not specify a particular processor form factor or package type. DEC Alpha implementations that meet or exceed these performance requirements are also acceptable for systems that run Windows NT.

- **3.1.2 System memory meets PC 99 minimum requirements.**
    - Consumer PC and Mobile PC: 32 MB required; 64 MB recommended
    - Office PC and Entertainment PC: 64 MB
    - Workstation PC: 128 MB RAM

    For all systems, a minimum of 28 MB of memory must be available for the system to use at boot time. These minimum RAM requirements do not preclude applications that use dynamically allocated memory for audio or video playback or other temporary uses.

- **3.1.3 Multiprocessor support is MPS and ACPI compliant.** If multi-processor support is provided in any system using Intel Architecture, such support must comply with *MultiProcessor Specification, Version 1.4* or later, and the Advanced Programmable Interrupt Controller (APIC) extension to the *Advanced Configuration and Power Interface Specification* (ACPI)*, Revision 1.0* or later specification.

    Support for both MPS 1.4 and ACPI 1.0 helps customers through the transition from Windows NT 4.0 to Windows NT 5.0; however, Windows NT 5.0 uses only ACPI methods. A DEC Alpha system meets the requirements for multiprocessor support.

Note: All requirements in this guide for DEC Alpha PCs are for the Windows NT operating system only. There are no plans to enable Windows to run on DEC Alpha PCs.

Mobile PC Note   For complete performance guidelines and exceptions for workstation and mobile PCs, see Chapter 4, "Workstation PC 99," and Chapter 6, "Mobile PC 99."

3.2. System design meets ACPI 1.0 specification and PC 99 requirements
Required for all system types, with exceptions for mobile PCs

The system board must support *Advanced Configuration and Power Interface Specification, Revision 1.0* or later. This requirement ensures that the system correctly supports Plug and Play and power management. ACPI support must include the following:

- **3.2.1 System includes power management timer, button, and alarm.** The system must include power-management timer and Power button in compliance with the ACPI 1.0 specification. This should be implemented as described in requirement 3.3, "Hardware design supports OnNow and Instantly Available PC initiatives." A separate reset switch is an acceptable alternative to the ACPI-specified override mechanism.

Real-time clock alarm that supports wake-up due to a scheduled time and day of the month. Notice that the day-of-month feature is a requirement, although it is an optional feature in the ACPI 1.0 specification.

The system must also provide a system control interrupt and Status and Enable (STS/EN) bits for the power-management timer, power button, and real-time clock.

- **3.2.2 System supports S5 state.** The system must support the S5 (soft-off) state, as required in the ACPI 1.0 specification, plus either the S1, S2, or S3 sleep state. Support of S4 or S4BIOS is optional. It is recommended that the S3 sleep state, meaning Suspend To RAM, is supported to provide the optimal user experience and power savings.

  Recommended: The system supports one sleep state that reduces overall system power consumption in accordance with the EPA ENERGY STAR guidelines for computers.

  Note: It is likely that support for the S3 state will be required in future design guides.

- **3.2.3 System includes a description table for system-board devices and ACPI control methods for configuring buses and devices.** The description table for system-board devices (including host PCI bridges) defines the complete hierarchy, including all non-Plug and Play devices to be enumerated and all other devices for which power management or removal capabilities have been added in the system-board design.

  The system must include ACPI control methods necessary for configuring each bus and device enumerated using ACPI, as described in requirement 3.12, "Each bus and device meets Plug and Play specifications."

- **3.2.4 USB controller can wake the system from at least one supported sleep state.** The Universal Serial Bus (USB) host controller must support wake-up capabilities in one of the following system states: S1 or S2. Supporting wake-up from the S3 state is recommended.

  Notice that if wake-up from the S2 or S3 state is supported, wake-up must be supported for all higher power sleep states. For example, if the controller supports wake-up from the S2 state, it must also support wake-up from the S1 state.

  Supporting wake-up from the S3 state is expected to become a requirement in future versions of these guidelines.

- **3.2.5 System provides no user-accessible method for disabling ACPI in the BIOS.** If the system includes a BIOS setting that the manufacturer can use to switch between ACPI and APM modes, this setting must not be exposed to the end user in CMOS setting or other means once a Microsoft ACPI-enabled operating system has been installed. Disabling ACPI will cause boot failures, because Windows NT relies on it for identification and initialization of system devices. Not having an option to "disable" ACPI support does not impact the ability to properly load an operating system that is not ACPI compatible.

The following power management features are recommended for all PC 99 systems:

- **System should implement ACPI thermal model and fan control.** It is recommended to implement a thermal model and fan control as defined in Section 12 of the ACPI 1.0 specification as a means of running the PC quietly while it is working and turning the fan off while it is sleeping.

  Notice that a hardware-based, open-loop thermal control is an acceptable implementation for system cooling if it meets requirement 3.7, "Audible noise meets PC 99 requirements." However, the recommended implementation is a closed-loop control using the PC's processor, an embedded controller, or both. If a closed-loop implementation is used, it must comply with the ACPI 1.0 specification.

- **BIOS should support standard options for automatic restart in the event of system power loss.** It is recommended to have a BIOS setup option that allows users to select the desired restart behavior of the PC after a system power loss. Systems should provide three standard restart options:

  1) Always restart

  2) Remain off

  3) Return to the same state (either off or on) as before power loss

  The third option (return to last state) should be set as the system default.

  If this restart selection feature is supported, it must be implemented as an OEM extension using ACPI control methods to facilitate future standardization and enhanced support in Windows operating systems such as a standard application programming interface (API).

  Also, in addition to any user interface provided by a BIOS setup program, a user interface to select the restart option must be implemented as a property page extension to the Windows Power Management control panel.

Note: Any other system-board power management or Plug and Play features must be implemented in compliance with the ACPI 1.0 specification, even if a particular feature is not a specific requirement or recommendation.

3.3. Hardware design supports OnNow and Instantly Available PC initiatives

Required for all system types, with exceptions for mobile PCs

Elements of the OnNow design initiative ensure that the operating system and device drivers control the state of individual devices and the system board. The Instantly Available PC initiative is fully consistent with the OnNow design initiative and provides guidelines for hardware design to ensure efficient power management on the desktop.

These initiatives are based on these goals for the user experience:

- The user experiences the PC as off when it is in a sleep state
- The user can easily see whether the PC is working or sleeping
- The user can easily control power through switches and software

Based on these goals, the following is required to support the OnNow and Instantly Available PC initiatives:

- **3.3.1 System and devices appear as off in the sleep state.** At a minimum, all media drives, display, sound, input devices, and fans must be perceived as off while the system is in a sleep state, for example, no noise or lights other than the status indicator.

- **3.3.2 System provides one or more indicators to show whether the system is in the working or sleep state.**

  Recommended: A non-flashing, light-emitting diode (LED) sleep indicator that is a different color than the wake indicator. A slowly blinking LED indicator (less than 1 Hz) is also an acceptable implementation. This applies for S1, S2, and S3 system states.

  The nonvolatile sleep state, S4 or S4BIOS, should appear to the user as the off state (S5); therefore, all of these states should have the same indicator.

  If telephone answering machine capabilities are built into the system, then a Message Waiting indicator should be included on desktop systems.

- **3.3.3 System provides software-controlled, ACPI-based power switch.** The system must provide an easily accessible power switch that can be controlled by software and that supports the functionality required in Section 4.7.2.2.1 of the ACPI 1.0 specification.

  This requirement for an easily accessible power switch does not preclude power-control capabilities, such as closing the lid on a mobile PC.

The following provides implementation guidelines for the power switch:

- The power switch can be implemented as either a power button or a sleep button. It is recommended to implement both buttons for desktop and mobile PCs. If both buttons are implemented, the sleep button should be the user's primary switch interface and must be easily distinguishable from the power button. The preferred implementation is to hide the power button.

- The function of these buttons is determined by the operating system. The default action for the sleep button is to cause the machine to enter a sleep state. The default action for the power button is to shut down the operating system and power off the machine.

  In a single-button configuration, the button can be used for either sleep/wake transitions (G0<–>G1/S1-S4) or off/on transitions (G0<–>G2/S5), depending on user preference and the policy set in the operating system.

  In a two-button configuration that includes separate power and sleep buttons, the user interface provided by the operating system will allow only the default actions.

- In case of a hardware or software failure that prevents normal operation of the software-controlled buttons, the switch capabilities must include an override mechanism for turning off the PC.

  A 4-second override mechanism is recommended in Section 4.7.2.2.1 of the ACPI 1.0 specification. The override can be on either the power button or the sleep button in a two-button configuration, but it is recommended that the override be associated with the sleep button in order to establish an industry-standard implementation.

  An acceptable but not recommended alternative to the 4-second override is a separate hidden or recessed switch that cannot be mistaken for either the power button or the sleep button.

  Notice that the override mechanism is not an alternative way for the user to turn off the PC in normal operation; it is only a fail-safe function for fault conditions.

- If the power switch is provided on the keyboard, the key must be clearly labeled and must consist of a single keystroke for turning on the PC, to ensure accessibility for persons with disabilities. (Two keystrokes can be used to turn off the PC.) For information about scan codes for keyboard power switches, see the information available on the web site at http://www.microsoft.com/hwdev/desinit/scancode.htm.

- **3.3.4 Each device supports the power management specifications for its class.** All devices and drivers must support the D0 and D3 power states consistent with the definitions in the relevant device class power management reference specification and the *Default Device Class Power Management Specification, Version 1.0* or later. Support of D1 and D2 states is optional unless stated as required in the relevant device class specification.

  This means that each device can successfully survive a system sleep/wake transition (where the device transitions from D0 to D3 to D0) without losing functionality and without requiring user intervention to restore functionality. This applies whether or not system power is removed while the device is in the D3 power state.

  There is no power consumption requirement for devices in the D3 power state. It is recommended, however, that devices implement the D3 power state such that device power consumption is reduced to near zero. This recognizes that there is no requirement to retain any device context because it will be preserved or restored by the driver when returning to the D0 power state.

  PCI, USB, IEEE 1394, and PC Card buses must support power management requirements as defined in their related bus standards. For information, see the respective chapters in Part 3 of this guide.

- **3.3.5 System power supply provides "standby" power for system wake-up events.** A minimum of 720mA of "standby" power is required to support wake-up devices on PCI or USB when the system is in the ACPI S3, S4, or S5 state. For more information, see the Instantly Available PC System Power Delivery Requirements and Recommendations available from the web site at http://developer.intel.com/design/power/supply98.htm.

Mobile PC Note   This requirement for the system power supply does not apply to mobile PCs.

3.4. BIOS meets PC 99 requirements for OnNow support

Required for all system types

This requirement does not apply for DEC Alpha PCs, except for the requirement for fast power-on self test (POST).

The intention of this requirement is to ensure that the end user is not presented with confusing information and unnecessary visual display, and to ensure that access to error information remains available using a hot key.

The following BIOS capabilities are required for OnNow support:

- **3.4.1 BIOS supports Fast POST.** The system must be available to the user as quickly as possible. Although a specific time limit is not established, the basic recommendation is that power on to the bootstrap loader should occur within 5 seconds, plus hard disk ready time, option ROMs, and time required for error correction code (ECC) scrubbing.

  Future design guidelines are likely to require a specific time limit for boot speed. In the meantime, the following are recommended ways to reduce processing overhead to make system boot time as fast as possible:

  - No video memory test and limited test DRAM size.

  - No tests for serial or parallel ports.

  - No floppy disk test or media check (the system boots from a hard disk or network).

  - No tests for the hard disk controller or drive type (if the system does not include swappable drives).

  - Test execution is controlled using Windows-based control panel or application that can be scheduled to run periodically at off-hours.

  - Fast POST mode for BIOS (the mode can be disabled by the user for troubleshooting).

  - Compliance with the *Simple Boot Flag Specification, Version 1.0* or later. This enables the BIOS to boot quickly when the last boot was successful and to perform diagnostics only if a problem occurred on the previous boot. Enabling and disabling this feature can be provided in the BIOS configuration program for compatibility with operating systems that do not support the Simple Boot Flag.

- **3.4.2 Resume from sleep state (S1–S4) to operating system handoff occurs within 500 ms.** This requirement does not apply for the S4BIOS state. For all other sleep states, the time to operating system handoff is measured from when the processor starts running (first instruction) until the BIOS jumps to the Waking Vector in the ACPI firmware control structure table, as described in Section 5.2.6 in the ACPI 1.0 specification.

- **3.4.3 System presents minimal start-up display.** System start-up must only draw the end user's attention in case of errors or when there is a need for user action. By default, the system must be configured so the screen display does not display memory counts, device status, and so on, but presents a "clean" BIOS start-up.

  The default configuration must allow a beep during the boot process only in case of an error. The only screen display allowed is the OEM splash screen, which can include information such as copyright notices.

However, the system start-up process can include the following:

- Manufacturer branding messages.
- A blank start-up screen.
- A hot-key override to display screen messages for troubleshooting or to display user-definable CMOS settings.
- Text-based messages related to end-user action. Examples are: messages to display the setup hot key, the system help hot key, password entry, network log on for remote booting, and so on.
- A CMOS option to turn the clean start-up screen off and on.

3.5. BIOS meets PC 99 requirements for boot support

Required for all systems, with exceptions for mobile PCs

This requirement does not apply for DEC Alpha PCs.

ACPI BIOS entries, as defined in Section 1.6 of the ACPI 1.0 specification, should be the same for supporting either Windows 98 or Windows NT 5.0. In general, the run-time services portion of the Plug and Play BIOS is replaced by ACPI and therefore is not required. The Extended System Configuration Data (ESCD) calling interface is not supported by Windows 98 or Windows NT 5.0.

The BIOS boot support requirements include the following:

- **3.5.1 BIOS supports preboot execution environment, with unique system ID provided in print.** For Office PC 99, the system's execution environment must conform to the description given in "Attachment B: Preboot Execution Environment" of *Network PC System Design Guidelines.*

  For Consumer PC 99 and Entertainment PC 99, this means providing a unique PXENV system identifier (ID) structure in the system BIOS or CMOS, as defined in "Attachment B: Preboot Execution Environment" of *Network PC System Design Guidelines.*

  In addition, for Office PC and Workstation PC systems, the unique system ID must be provided to the user in printed form, for assistance in environments where it might be used as part of pre-staging systems. This mechanism is left up to the system manufacturer, but suggested means include posting the unique system ID on the system chassis or case, or printed on the shipping carton. The printed form will likely become a requirement for Consumer PC and Entertainment PC systems in future versions of these design guidelines.

- **3.5.2 BIOS supports booting the system from a CD or DVD device.** For any system that includes a CD or DVD drive, the system BIOS or option ROM must support the No Emulation mode in *El Torito—Bootable CD-ROM Format Specification, Version 1.0,* by IBM and Phoenix Technologies, Limited, or an equivalent method that supports the process for installing Windows from compact disc.

- **3.5.3 BIOS supports booting the system from the network.** For any system that includes a network adapter, the system BIOS must comply with the requirements defined in Sections 3 and 4, as they apply to Plug and Play devices, of the *Compaq, Phoenix, Intel BIOS Boot Specification, Version 1.01*, which describes the requirements for Initial Program Load (IPL) devices.

  The system must also allow all boot devices to be configured as to order of precedence for boot. This mechanism must clearly show how the system will order boot devices when end users are making configuration choices. For example, in a system that permits booting from floppy drive, hard drive, CD or DVD drive, and network adapter, it must be clear to the end user how to set a boot order that favors a specific device such as the network adapter.

  In addition, for any system that includes a network adapter, a key sequence must be provided to invoke a pop-up screen that allows the user to force a system boot initiated from the network adapter. This key sequence must be enabled by default. Configuration of this feature can be provided through a CMOS configuration setting. When this feature is enabled, the boot display must indicate the key sequence that will invoke the pop-up screen that would allow a network boot. This display must appear for a duration sufficient to be read by users, but must not lengthen the overall time needed to boot the machine.

  This feature must be implemented in accordance with Appendix C of the *Compaq, Phoenix, Intel BIOS Boot Specification, Version 1.01*. Notice that this feature is a PC 99 requirement, although it is optional in the *BIOS Boot Specification*.

  For a consistent user experience across all system brands and types, it is suggested that system and BIOS manufacturers standardize on the F12 key to perform this action. It is expected that F12 or another standard key sequence will become a requirement in future versions of the design guidelines.

- **3.5.4 BIOS properly accommodates all dates.** Dates, including the year 2000 and beyond, correctly supported in BIOS and CMOS.

- **3.5.5 BIOS on Office PC supports security.** Office PC systems must provide some mechanism for security, such as a pre-boot password, to protect enable/disable capabilities for hardware components before the operating system boots.

  This capability is also recommended for other system types. The purpose of this feature is to prevent end users from accidentally or purposefully circumventing operating system–level security and control as applied by an administrator.

- **3.5.6 BIOS on Office PC supports BIOS updates and revisions.** BIOS updates must be implemented in order for BIOS ROMs to be upgraded to a new image through OEM-provided programs. The following methods can be used to meet this requirement:

  - Through a remote new system setup mechanism downloaded and executed at boot time as described in Chapter 20, "Network Communications"

  - Through a normal file access and execution methods when the system is fully booted into the normal operating system environment

  If option ROMs are provided, they must also be capable of being upgraded.

  Recommended: Implement a mechanism to authenticate the requester of the update programming. Implement a mechanism to validate that the program arrived intact after download.

- **3.5.7 BIOS provides boot support for USB keyboards and hubs.** For systems based on Intel Architecture compatible processors, the system BIOS must provide boot support for USB keyboards and hubs as defined in *Universal Serial Bus PC Legacy Compatibility Specification, Version 0.9* or later. This support must provide the ability for the user to enter the system's BIOS setup program and provide enough functionality to get a USB-aware operating system installed and booted.

Mobile PC Note   Mobile PCs, which have built-in keyboards, are exempt from this requirement for BIOS support of USB keyboards.

- **3.5.8 System BIOS supports console redirection of a serial port.** This capability provides support during system startup for debugging and troubleshooting activities. If a legacy serial port is implemented, the BIOS must provide an option to configure at least one legacy serial port to use either 2F8h or 3F8h. This allows the port to be treated as a boot device by the BIOS and is required to be usable by components as a diagnostic port in the event that system debugging is required by either the BIOS or the operating system.

  Recommended: System BIOS or option ROM provides boot support for primary ATAPI bootable floppy disk drive in compliance with *ATAPI Removable Media BIOS Specification (ARMD), Version 1.0* or later. Complying with this specification provides Int 13h and Int 40h support for bootable floppy drives as the primary or secondary floppy device.

PC 99 Physical Design Requirements

This section summarizes physical design requirements and recommendations for PC 99 systems. These requirements are in addition to those related to the OnNow initiative for power-state indicators and easily accessible power switches.

3.6. All expansion slots in the system are accessible for users to insert cards

Required for all system types, with extra guidelines for mobile

The internal expansion slots cannot be physically blocked by components or devices provided with the system. This requirement does not exclude configurations that allow space only for half-height cards for some slots, for passive back planes for connectors, and so on.

Mobile PC Note   For mobile guidelines and exceptions, see Chapter 6, "Mobile PC 99."

3.7. Audible noise meets PC 99 requirements

Required for all system types

A PC 99 system must be "silent" in any sleep state. That is, it must be perceived as not significantly noisier than the off state to typical users, relevant to an operating position appropriate to the PC's form factor (such as desktop, minitower, or laptop) and the ambient noise level of its normal usage environment (such as corporate office, home office, family room, and so on). This requirement applies primarily to fan noise, as all other devices will not be active in the sleep state.

It is hoped that this definition will become more objective over time through standardization of acoustic noise measurement and reporting procedures for PCs. Intel and Microsoft are working on proposals for acoustic noise measurement and reporting. The goal is to achieve common PC acoustic noise measurement methods based on established international standards. With such methods in place, end users will be able to receive reliable acoustic noise specifications about PCs similar to those available for other product categories such as automobiles and appliances.

Although this requirement does not specify noise limits for PCs in idle and working states, manufacturers are encouraged to design systems that operate as quietly as possible, especially PCs designed for use in the home family room.

3.8. System and component design practices follow accessibility guidelines

Recommended for all system types

Accessibility design guidelines are provided in Appendix C, "Accessibility." These guidelines were developed in consultation with the Trace Research and Development Center at the University of Wisconsin at Madison, see the web site at http://trace.wisc.edu. In particular, the following guidelines are recommended for implementation on all system types:

- All modifier keys should be capable of being read and operated by software, including Fn and similar OEM-specific keys. This capability allows users to access these keys and the functions that rely on them through operating system features such as StickyKeys and SerialKeys and through third-party software such as voice recognition and on-screen keyboard utilities.
- Computers should have sound systems that are sufficient to run high-end voice-recognition software utilities that support large vocabularies with continuous speech.

This recommendation for following accessibility guidelines will not become a requirement in future versions of this design guide. For extensive references and resources, see Appendix C, "Accessibility."

3.9. Internal system modification capabilities are not accessible to end users

Recommended for all system types

This recommendation is based on goals to reduce total cost of ownership (TCO) by ensuring that end users are prevented from accidentally or purposefully altering the predefined software and hardware configurations. This recommendation can encompass a lockable or sealed-case design, where internal expansion capabilities are not end-user accessible.

3.10. System design provides physical security

Recommended for all system types

To prevent unauthorized hardware access, the following security features are recommended for PC 99 systems:

- External drive devices should have locking capabilities. Each removable media device should be capable of being locked to prevent unauthorized data access. This means that the device is rendered inoperable, either electronically or mechanically, when locked.
- PC case and switches should have locking capabilities to prevent unauthorized internal access. An OEM-specific method can be implemented, either electronically or mechanically.

PC 99 General Device Requirements

The requirements in this section apply for every device, whether present on the system board or as an expansion device provided by the OEM in a default system configuration. Most general device requirements are related to Plug and Play capabilities.

3.11. Each device and driver meets PC 99 device requirements

Required for all system types

Each device must comply with all requirements defined in this guide for the related device class, whether the device is provided in the PC system as an expansion card or as an external device.

Drivers must be provided for both Windows and Windows NT operating systems. The manufacturer does not need to supply a driver for a device if the device passes PC 99 compliance testing using a driver provided with the operating system.

In addition to the device requirements in this section, see also the specific requirements for each device class in Part 4 of this guide.

3.12. Each bus and device meets Plug and Play specifications

Required for all system types

Each bus and device provided in a PC 99 system must meet the current Plug and Play specifications related to its class, including requirements defined in Section 6 of the ACPI 1.0 specification and clarifications published for some Plug and Play specifications. This includes requirements for automatic device configuration, resource allocation, and dynamic disable capabilities.

For information about Plug and Play support under Windows NT 5.0, see the Windows NT 5.0 Device Driver Kit (DDK).

The following shows current version numbers for all Plug and Play specifications:

- *PCI Local Bus Specification, Revision 2.1*
- *Plug and Play External COM Device Specification, Version 1.0*
- *Plug and Play Industry Standard Architecture (ISA) Specification, Version 1.0a,* and *Clarification to Plug and Play ISA Specification, Version 1.0a*
- *Plug and Play Parallel Port Device Specification, Version 1.0b*
- *Plug and Play Small Computer System Interface Specification, Version 1.0*
- *Universal Serial Bus Specification, Version 1.0*

Plug and Play specifications for IEEE 1394 are defined in this guide. For information, see Chapter 8, "IEEE 1394."

Note: Standard system devices are excluded from this requirement. The system can reserve static resources for devices such as programmable interrupt controllers (PICs) 1 and 2, 8254-2 timer, 8042 keyboard controller, real-time clock, direct memory access (DMA) page registers, DMA controllers 1 and 2, and math coprocessor. For systems based on Intel Architecture compatible processors, these fixed resources are located at I/O addresses under 100h and can also include a Nonmaskable Interrupt (NMI).

All system-board devices must use ISA-compatible addresses. This includes devices with I/O port addresses within the reserved range 0h–0xFFh. For information about legacy system I/O addresses, see Appendix D, "Legacy Support."

In addition, systems designed to run only on Windows NT are not required to meet requirements for legacy Plug and Play support. If the system is designed to run both Windows 98 and Windows NT, it must meet all requirements for legacy Plug and Play support.

3.13. Unique Plug and Play device ID provided for each system device and add-on device

Required for all system types

Each device connected to an expansion bus must be able to supply its own unique ID. The following are the specific requirements for Plug and Play device IDs:

- Each separate function or device on the system board must be separately enumerated; therefore, each must provide a device ID in the manner required in the current Plug and Play specification for the bus it uses.

- If a device on an expansion card is enumerated by the BIOS, it must have a unique ID and its own resources according to the current device ID requirements for the bus to which the card is connected. This includes devices that are separately enumerated on multifunction cards or multifunction chips.

  Multifunction CardBus devices must meet the requirements defined in Chapter 12, "PC Card."

In addition, for Office PCs, if an OEM uses a proprietary mechanism to assign asset or serial numbers to hardware, this information must be available to the operating system using Windows hardware instrumentation technology, as defined in the *Network PC System Design Guidelines, Version 1.0b.*

The following are exceptions to the requirement for a unique Plug and Play ID:

- Legacy devices attached to the ISA bus on the system board do not have unique Plug and Play IDs—for example, serial ports, parallel ports, or Personal System/2 (PS/2) compatible port devices. The method for device identification is defined in the *Plug and Play ISA Specification, Version 1.0a,* and the ACPI 1.0 specification.

- Some multifunction devices, such as Super I/O, might include devices that do not have unique Plug and Play IDs or unique PCI subsystem IDs, but that are supported by drivers provided with the Windows operating system.

- A device such as a multifunction PCI device that supports a number of functions but uses only a single set of relocatable resources does not have to provide separate IDs for each function included on the device.

3.14. Option ROMs meet Plug and Play requirements
Required for all system types
This requirement applies only for devices that might use option ROM on systems based on Intel Architecture compatible processors, whether the device is present on the system board or provided through an expansion card.

Option ROMs are usually located on cards used as system boot devices. During the boot process, option ROMs initialize the boot devices, which provide the primary input, primary output, and IPL device to boot the system. However, Plug and Play option ROMs can be used to supply the Plug and Play expansion header to devices other than boot devices, enabling them to initialize both devices when the system boots.

Option ROM requirements for specific devices are defined in Chapter 10, "ATA and ATAPI," Chapter 11, "SCSI," Chapter 14, "Graphics Adapters," and Chapter 18, "Storage and Related Peripherals."

Note: Systems designed to run only on Windows NT are not required to meet these requirements for legacy Plug and Play support.

3.15. "PNP" vendor code used only to define a legacy device's Compatible ID
Required for all system types
All legacy devices not enumerated by the system-board interface must not use the acronym for Plug and Play, "PNP" in their vendor and device codes. The PNP vendor code is reserved for Microsoft and for vendors whose hardware is specifically assigned a particular ID. Other hardware can use a PNP code only when defining a device's Compatible ID and only after first indicating the device's Hardware ID in the Plug and Play header.

Use of Compatible IDs are recommended for devices that use device drivers provided with the Windows operating system, such as a Standard PC COM Port (PNP0500).

For information about using PNP Compatible IDs, see Appendix B, "Device Identifiers." To obtain a unique PNP vendor ID, please send a request by e-mail to pnpid@microsoft.com.

3.16. Device driver and installation meet PC 99 requirements
Required for all system types

Each device must have drivers for both Windows and Windows NT operating systems to ensure correct support under both operating systems. For some device classes, this support can be provided using a Windows Driver Model (WDM) driver, as defined in the related device requirements in Part 4 of this guide.

The manufacturer does not need to supply a driver for a device if the device passes PC 99 compliance testing using a driver provided with the operating system. If the manufacturer does supply a driver, the requirements for device drivers and installation include the following:

- **3.16.1 All devices and drivers must pass PC 99 compliance testing.** Each device included in a system must comply with the requirements defined in these guidelines and must have supporting 32-bit device drivers for the CPU platform and operating system.

   Each device must have a driver for both Windows 98 and Windows NT 5.0. A device is not required to have a driver for both CPU platforms, but a system must include the correct device drivers for the platform.

   The installation and loading of a driver must not reduce or eliminate functionality of other devices installed on the system.

   For systems that come with Windows NT pre-installed, only 32-bit protected-mode components must be installed. No real-mode or 16-bit protected-mode components can be provided in order to operate under Windows NT.

   Under Windows 98, the graphics adapter driver is a Win16 module. All other components must be 32-bit protected-mode components.

- **3.16.2 Devices with WDM support in Windows include WDM-based drivers.** For any device for which WDM-based support is provided in the operating system, the driver supplied by the manufacturer must be a WDM minidriver. This applies whether the system comes pre-installed with Windows 98 or Windows NT 5.0.

- **3.16.3 Driver supports Plug and Play and power management IRPs.** Every driver (or minidriver) must support Plug and Play and power management I/O request packets (IRPs). This applies whether the system comes pre-installed with Windows 98 or Windows NT 5.0.

  For VxD drivers for Windows 98, the following requirements apply:

  - Every VxD must support Plug and Play and power management messages.
  - The driver must provide power management support as required by any device class power management reference specification.

- **3.16.4 All configuration settings are stored in the registry.** The driver must not use initialization files (INI) for configuration settings.

  The driver must also include correct provider, version, and copyright entries. This information is displayed in the user interface, such as Device Manager in Windows.

- **3.16.5 All INF and other file information is correct.** The correct minidriver, virtual device drivers (VxDs), or any other manufacturer-supplied files specified in the device's information file (INF) must be installed in the correct location.

  For manufacturer-provided files, the vendor must *not* be identified as Microsoft and all other copyright and version information must be correct for the manufacturer.

  Files provided by the vendor must not use the same file names as used by files included in Microsoft operating systems and provided as either retail or OEM products, unless specifically agreed upon with Microsoft.

- **3.16.6 Installation uses methods defined in the DDK.** Driver installation and removal must use Windows-based methods as defined in the Windows and Windows NT DDKs.

  The device driver must be able to be removed using Windows-based software, which can be managed using either the Windows Control Panel option for removing devices or its own remove utility. For information, see the driver installation information in the \SRC\General directory in the Windows NT 5.0 DDK; see also "Windows 95 Class Installers and Network Driver Installers" in the Windows 95 DDK.

  However, any software applications included with the device can be installed using an alternate Windows-based installation method as defined in the Microsoft Platform Software Developers Kit (SDK).

Also, any software components and registry entries installed during driver installation must be removed during driver uninstallation.

Any real-mode components provided for backward compatibility under Windows 98 should use separate installation procedures. Although installation of Windows-based components must not make entries in Autoexec.bat or Config.sys, the separate real-mode installation program can make such entries but must not modify the registry, Win.ini, or System.ini.

- **3.16.7 Driver supports unattended installation.** It must be possible for the device's driver to be installed using a mechanism such as a script or special software for supplying required parameters without the user being present.

- **3.16.8 Driver includes Help file if special parameters are used.** To ensure that the user can correctly change settings, a Windows Help file must be provided if special driver parameters are used. The device's installation routine must install the Help file as part of the setup program. The user interface for the device's dialog boxes must display the correct Help file, and the Help file must contain relevant information to assist the user. The guidelines for implementing a Help file are defined in the Windows NT DDK.

3.17. Minimal user interaction needed to install and configure devices

Required for all system types

After physically installing the device, the user must not be required to perform any action other than to insert the disks that contain drivers and other files. The user should have to restart the system only for devices that do not support hot plugging.

As specified in requirement 3.19, "Hot-plugging capabilities for buses and devices meet PC 99 requirements," devices that use USB, IEEE 1394, or PC Card must support hot-plugging. For devices that use other buses, detection occurs when the system is powered on after the device is inserted.

The following requirements must be met:

- **3.17.1 The device is immediately functional without restarting the system.** It is acceptable to require rebooting for primary system devices such as the primary graphics adapter and the primary hard disk controller; furthermore, ATA drives are not required to implemented Cable Select (CS) settings. In all cases, however, changing configuration settings must not require the end user to make jumper changes.

- **3.17.2 Software settings are available for configuring all resources.** All buses and devices on both the system board and all expansion cards must be capable of being configured by the operating system and by software, such as the Device Manager in Windows, so that the user does not need to open the PC case to change the configuration. DIP switches on boot devices can be used for an initial power-on default state or for non-Plug and Play system compatibility, but such settings must be capable of being overridden by software configuration after power on occurs under Plug and Play operating systems.

  Note: This requirement does not apply for jumper settings used by the OEM to set CPU speed, select a keyboard, or make other basic system-related settings in the factory. This requirement applies only for settings that the end user must make to configure the hardware.

- **3.17.3 Dynamic disable capabilities are supported for all devices.** All devices must be capable of being automatically disabled by the system. Also, disabling the device must result in the freeing of all its resources for use by other devices.

  The following devices are exempt from this requirement: all legacy devices using the I/O range under 100h, keyboard controller, floppy disk controller (FDC), hard disk controller, VGA memory and I/O addresses, and any BIOS memory ranges required for legacy boot support.

3.18. Connections use icons, plus keyed or shrouded connectors, with color coding

Required for all system types, with exceptions for mobile PCs

This requirement helps ensure that the end user can correctly make the physical connections required for adding a device to a system. This requirement includes the following:

- **3.18.1 Connector's physical design ensures that the user cannot insert it into the wrong port.** Wherever possible, keyed or shrouded connectors or other configurations should be used to prevent misconnection. For specific requirements related to keyed connectors and cables for I/O controllers and peripherals, see Chapter 10, "ATA and ATAPI," and Chapter 11, "SCSI."

- **3.18.2 Icons are provided for all external connectors.** The icons can be molded, printed, or affixed as permanent stickers, which can include text. Icons can be based on existing vendor designs or on the examples listed in Appendix A, "Icons."

Mobile PC Note   For mobile PC designs, connector icons might not fit on the back of the case. In such designs, it is acceptable to wrap the icons to the bottom of the unit or place them on the inside of an access door.

- **3.18.3 Systems use a color-coding scheme for connectors and ports.**
  All PC 99 systems must implement a color-coding scheme for their ports and
  device connectors.

  The following list shows the PC 99 recommendation for color codes. The
  selection of these specific colors was done using criteria established by Human
  Factors and Industrial Design professionals from multiple companies who are
  involved in the design of computer hardware.

  Recommended Color Codes for Connectors

Connector	Recommended color	Pantone
Analog VGA	Blue	661C
Audio line in	Light blue	284C
Audio line out	Lime	577C
Digital monitor/flat panel	White	
IEEE 1394	Grey	424C
Microphone	Pink	701C
MIDI/game	Gold	131C
Parallel	Burgundy	235C
PS/2-compatible keyboard	Purple	2715C
PS/2-compatible mouse	Green	3395C
Serial	Teal or Turquoise	322C
Speaker out/subwoofer	Orange	157C
Right-to-left speaker	Brown	4645C
USB	Black	426C
Video out	Yellow	123C
SCSI, network, telephone, modem, and so on	None	—

It is recommended that retail peripherals also implement color coding, and those
that do are required to use the colors noted earlier in order to correspond with
PC 99 systems that adopt this scheme.

It is expected that system and peripheral color coding in accordance with this
scheme will become a requirement in future design guides.

Mobile PC Note   Mobile PCs are not required to comply with the requirement for color coding.

Note: It is recognized that the physical design will not change for legacy ports such
as the PS/2-compatible mouse and keyboard ports, analog audio and video jacks,
and the microphone and speaker jacks. Therefore, they cannot fully meet this
requirement. However, icons and labels must be provided and color-coding applied
wherever possible to help the user make the correct connections.

3.19. Hot-plugging capabilities for buses and devices meet PC 99 requirements

Required for all system types

Recommended: A locking mechanism to ensure that devices are removed only under operating system control or during sleep or off states.

To ensure reliable support for hot-plugging capabilities, the following requirements must be met:

- **3.19.1 USB, IEEE 1394, and PC Card devices and buses support hot-plugging.** When designed under their respective specifications, USB, IEEE 1394, and PC Card all support hot-plugging. Any device designed to use any of these connections must support being added or removed while the system is fully powered on.

  The exception to this requirement is any device required for booting such as the primary graphics adapter. For information about supporting multiple graphics adapters, see Chapter 14, "Graphics Adapters."

- **3.19.2 Hot-plugging for PCI devices uses ACPI-based methods.** Hot-plugging is not required for PCI devices. Windows 98 and Windows NT 5.0 support dynamic enumeration, installation, and removal of PCI devices only if there is a supported hardware insert/remove notification mechanism. The notification mechanism is defined as part of the bus standard for CardBus bus controllers. For other solutions, such as those required for docking stations or other devices, the hardware insert/remove notification mechanism must be implemented as defined in Section 5.6.3 of the ACPI 1.0 specification.

  In order to properly function with the native support in the operating system, developing industry standards such as those referred to as PCI Hot Plug and Compact PCI must use ACPI-based methods for supporting hardware insertion and removal as defined in the ACPI 1.0 specification.

- **3.19.3 All removable media support media status notification.** Removable media must support the appropriate media status notification method to ensure that no loss of data or system failure results when such media is removed from the system.

  For media status notification requirements for CD and DVD drives, AT-Attachment (ATA), and ATA Packet Interface (ATAPI) removable devices, see requirement 18.2, "Removable media devices support media status notification." Device Bay guidelines are defined in requirement 3.20, "System includes Device Bay 1.0-compatible bay."

Recommended: Ensure that surprise removal of any swappable device does not cause a system failure. A failure related to surprise removal of a swappable device includes any spontaneous reboot, system stall, or blue screen. At a minimum, the device driver should ensure that the PC system does not fail if the user accidentally pulls the device out of its socket. The only absolute way to ensure against system failure is to prevent surprise removals by including a locking mechanism, which is recommended for PC 99 systems.

Another method of protection is to have the driver check whether its device is present when it receives certain interrupts. For example, CardBus cards share the same PCI interrupt as their socket controller, so interrupt handlers for both the card driver and socket driver are chained to the same PCI interrupt request (IRQ). To prevent a system fault after surprise removal of the CardBus card, its driver must check whether its device is still present whenever it reads a value such as 0xFFh in its status register, and then it must be able to recover gracefully when this occurs.

In all cases, for any failure that might occur, the PC system as a whole should be able to recover gracefully and report the condition to the end user. For implementation details and for additional design guidelines, see the article about hot-plugging support at http://www.microsoft.com/hwdev/busbios/rem_devs.htm.

3.20. System includes Device Bay 1.0-compatible bay
Recommended for all system types
If implemented in a PC 99 system, Device Bay capabilities must meet the following requirements:

- The system includes a Device Bay Controller (DBC) compliant with *Device Bay Interface Specification, Version 1.0* or later. If the DBC is implemented as a USB device, it must be compliant with *Universal Serial Bus Device Class Definition for Device Bay Controllers, Version 1.0* or later.

- The system includes one USB port and one IEEE 1394 port for each Device Bay-capable bay in the system.

Any Device Bay peripherals provided with a PC 99 system must meet the following requirements:

- Device complies with *Device Bay Interface Specification*, *Version 1.0* or later.

- Device uses either the USB bus, IEEE 1394 bus, or both.

- If the device uses the USB bus, it must also comply with the relevant USB device class specifications.

3.21. Multifunction add-on devices meet PC 99 device requirements for each device

Required for all system types

Multifunction add-on devices can contain more than one device. They must comply with requirement 3.16, "Device driver and installation meet PC 99 requirements," including the requirements for automated software-only settings for device configuration, device drivers, and Windows-based installation. In addition, the following requirements must be met:

- **3.21.1 Each enumerated device has a unique device ID.** Each function or device on the multifunction add-on device that is individually enumerated by the BIOS must provide a device ID for the bus it uses.

- **3.21.2 System can separately access and configure each logical device.** The system must be able to separately access each logical device that is individually enumerated by the BIOS, configure the device resources independently, and disable individual devices in the event of a conflict.

- **3.21.3 Each enumerated device meets its own resource requirements.** For each individually enumerated device, resource configuration requirements are the same as for an equivalent device on a separate expansion card. This requirement means that registers cannot be shared among individually enumerated devices on a multifunction add-on device, but it does not supersede device requirements among different bus classes.

The exception to this requirement is a device such as a multifunction PCI device that supports several functions but uses only a single set of relocatable resources. When each device is not individually enumerated, there is no requirement to provide separate IDs and resources for each function on the device. However, see also requirement 9.8, "Functions in a multifunction PCI device do not share writeable PCI Configuration Space bits."

3.22. All devices support correct 16-bit decoding for I/O port addresses

Required for all system types

Each device must support a unique I/O port address in the 16-bit address range. This requirement means that, at a minimum, the upper address lines (A10–A15) can be used as the device enable address, so that the device does not respond to addresses outside of the 10-bit address range. CardBus controllers and cards must meet the requirements defined in Chapter 12, "PC Card."

Devices that use less than 16-bit I/O decode create conflicts that cannot be resolved by a Plug and Play operating system. Phantom (alias) addressing is not supported by the Windows operating system and cannot be used to meet this requirement.

Notice that this requirement does not apply for the three ISA auto-configuration registers used during device enumeration and configuration. The ADDRESS, WRITE_DATA, and READ_DATA registers will continue to use 12-bit decoding as described in the *ISA Plug and Play Specification, Version 1.0a.*

3.23. All PC 99 input devices support Microsoft DirectInput and work simultaneously

Required for all system types

All input devices implemented in PC 99 systems that do not use drivers provided with the operating system must have drivers that support Microsoft DirectInput. All input devices must also be able to correctly provide simultaneous input. This means that no input device is automatically disabled when another input device is in use— and applies for external PS/2-compatible devices, so that connecting the external device does not disable an internal PS/2-compatible device.

Note: The built-in drivers provided with Windows 98 and Windows NT 5.0 meet this requirement. For information about implementing drivers that support simultaneous use of devices, see the Microsoft DirectX DDK.

PC 99 Buses and Devices

This section defines specific requirements for buses and devices provided in a PC 99 system, in addition to requirement 3.2, "System design meets ACPI 1.0 specification and PC 99 requirements."

PC 99 System Buses

This section defines the general requirements for system buses. Additional requirements for specific buses are defined in Part 3 of this guide.

3.24. Each bus meets written specifications and PC 99 requirements

Required for all system types

In the past, some bus designs did not fully implement all of the bus requirements on every expansion card connector. Each bus and connector used in the system must meet all the requirements for that bus as defined in Part 3 of this guide.

Each bus and device provided in a PC 99 system must also meet the current Plug and Play specifications related to its class, including requirements defined in the ACPI 1.0 specification and the clarifications published for some Plug and Play specifications. This includes requirements for automatic device configuration, resource allocation, and dynamic disable capabilities. See also the related Plug and Play requirements in "PC 99 General Device Requirements" earlier in this chapter.

3.25. System includes USB with two USB ports, minimum

Required for all system types, with exceptions for mobile PCs

Recommended: System should have at least one USB Human Interface Device (HID), such as a keyboard or pointing device.

USB provides a bi-directional, isochronous, dynamically attachable serial interface for adding peripheral devices. These devices may include single-bus game controllers, communications devices, and input devices.

The USB controller must be capable of waking the system as defined in Section 3.4.4 of the ACPI 1.0 specification. This capability is part of the requirement for ACPI compliance, as defined in requirement 3.2, "System design meets ACPI 1.0 specification and PC 99 requirements."

The USB implementation in the system must also meet the requirements defined in the USB specifications plus any additional requirements defined in Chapter 7, "USB."

Mobile PC Note   Only one port is required for mobile PCs, as defined in Chapter 6, "Mobile PC 99."

3.26. System includes support for IEEE 1394

Recommended for all system types, with 3 ports recommended for Entertainment PCs

It is recommended that all systems have at least one IEEE 1394 port for external expansion devices, such as scanners and external drives. If implemented, the ports must be compliant with IEEE P1394.a and OHCI Version 1.0, as described in Chapter 8, "IEEE 1394."

Note: Implementation of IEEE 1394 is likely to become a requirement for desktop systems in future versions of these design guidelines.

Mobile PC Note   For guidelines to any implementation of IEEE 1394 on mobile PCs, see Chapter 6, "Mobile PC 99."

3.27. If present, PCI bus meets PCI 2.1 or later, plus PC 99 requirements
Required for all system types
If PCI is used in a PC system, the PCI bus must meet the following requirements:

- *PCI Local Bus Specification (PCI 2.1), Revision 2.1* or later.
- *PCI Power Management Specification (PCI-PM), Revision 1.1* or later.
- Additional requirements defined in Chapter 9, "PCI," including:
  - System and devices support all Engineering Change Notices (ECNs) for PCI 2.1 approved by July 1, 1998. In particular, all devices must comply with the Maximum Completion Time ECN.
  - Bus master privileges are supported for all connectors.
  - Modem PCI-based network and modem adapters support generation of a power management event (PME#) wake signal.
  - Systems that support S3 or S4 states must provide both 3.3 V and 3.3 Vaux power on all connections.

Recommended: PCI devices, chip sets, and expansion slots support the requirements defined in the PCI 2.2 specification. For information about PCI specifications, see http://www.pcisig.com.

3.28. System does not include ISA expansion devices or slots
Required for all system types
ISA expansion devices cannot be included in a PC 99 system. This means that ISA implementations of expansion devices such as audio, modems, or network adapters are not acceptable for PC 99 systems, nor can the ATA controller use an ISA bus. This applies whether the devices are implemented as add-on cards or integrated on the system board.

PC 99 systems must not include ISA slots. Instead, provide non-legacy buses and connectors for system expansion, most notably PCI, USB, and IEEE 1394. Because of hardware incompatibilities and configuration limitations inherent in the ISA legacy architecture, ISA expansion devices are a well-documented cause of costly support problems that continue to burden end-users and the PC industry at large. The benefits of designing ISA-free systems include easier and more stable system configuration, lower support cost, and improved performance.

It is acceptable for all PC 99 systems to use ISA protocols and signaling or ISA-like protocols and signaling for implementations of on-board legacy devices. For such implementations, interrupts are supported using the legacy 8259 or APIC (for Windows NT 5.0). It is recommended that APIC be used in all designs. Any on-board legacy implementations, such as BIOS ROM, Super I/O, 8042 controllers, math coprocessors, and so on, are allowed and must meet the requirements defined in Appendix D, "Legacy Support."

These on-board legacy devices should be implemented using alternative bus extensions such as Low Pin Count (LPC) rather than ISA. The LPC Interface allows the legacy I/O on-board components, typically integrated in a Super I/O chip, to migrate from the ISA/X-bus to the LPC Interface while retaining full software compatibility. The *Low Pin Count Interface Specification* is available from the web site at http://developer.intel.com/design/pcisets/lpc/index.htm.

PC 99 I/O Devices

This section defines the general requirements for I/O devices. Additional requirements are defined in "PC 99 Graphics Adapters, Video, and Broadcast Services" and "PC 99 Storage and Related Peripherals" later in this chapter.

Mobile PC Note   For specific keyboard and pointing device guidelines for mobile systems, see Chapter 6, "Mobile PC 99."

3.29. System includes keyboard connection and keyboard
Required for all system types
Recommended: USB.

The external keyboard connection requirements on any PC can be met by using either USB, a PS/2-style port, or wireless capabilities in the system. A mobile or all-in-one system that has a built-in keyboard must also provide the capability for an external keyboard connection. This connection can be implemented using a port replicator or a single PS/2-style port with special cabling for both an external keyboard and an external mouse. For complete requirements for keyboard ports and peripherals, see Chapter 13, "I/O Ports and Devices."

3.30. System includes pointing-device connection and pointing device
Required for all system types
Recommended: USB or other external bus.

The external pointing-device connection requirements on any PC can be met by using USB, a PS/2-style port, or wireless capabilities in the system. A mobile or all-in-one system that has a built-in pointing device must also provide the capability for an external pointing-device connection. This can be implemented using a port replicator or a single PS/2-style port with special cabling for both an external keyboard and an external pointing device.

A second serial port is not an acceptable external connection for a pointing device.

Note: All input devices must have drivers that support Microsoft DirectInput, as defined in requirement 3.23, "All PC 99 input devices support Microsoft DirectInput and work simultaneously."

For requirements for pointing-device ports and peripherals, see Chapter 13, "I/O Ports and Devices."

3.31. System includes connection for external parallel devices

Required for all system types

Recommended: USB or other external bus.

The requirement for an external connection for parallel devices can be met by using USB or another external bus. This capability can also be provided as a parallel port with extended capabilities port (ECP) capabilities, but a legacy parallel port is not the recommended implementation. For complete parallel port requirements, see Chapter 13, "I/O Ports and Devices."

3.32. System includes connection for external serial devices

Required for all system types

Recommended: USB or CardBus.

The requirement for an external connection for serial devices can be met by using USB or CardBus. An RS-232C serial connection can also be implemented using a 16550A or equivalent serial port, but a legacy serial port is not recommended. For complete serial port requirements, see Chapter 13, "I/O Ports and Devices."

3.33. System includes IR devices compliant with IrDA specifications

Recommended for all system types

Wireless capabilities are not required; if they are implemented, infrared (IR) devices included with PC 99 systems must comply with approved Infrared Data Association (IrDA) Data, IrDA Control, or both specifications. This includes wireless data transfer devices, as well as wireless input devices, for example, IR keyboards, pointing devices, joysticks, game pads, and so on.

If the system is intended to run data transfer applications with other IrDA Data devices, it must be in compliance with the IrDA Data specifications and must support standard Fast IR (FIR) input speeds of 4 Mb/s. An IrDA Data device must use an NDIS 5.0 miniport driver.

If an IrDA Control application is used in a PC 99 system, it must be in compliance with the IrDA Control specification.

If a system is intended for the consumer market, support for both IrDA Control and IrDA Data is recommended to meet the consumer's expectations for IR device interoperability. The emergence of still-image cameras with IrDA Data capability increases the importance of IrDA Data support in consumer systems.

For background information about designing IR solutions, see "Wireless Design Issues" in Chapter 2, "PC 99 Design Issues." For information about wireless requirements, see Chapter 13, "I/O Ports and Devices."

3.34. System includes PC 99-compatible CD or DVD drive and controller

Consumer	Office	Mobile	Workstation	Entertainment
Required	Recommended	Recommended	Required	DVD required

Recommended: DVD drive.

The host controller for the CD or DVD drive must meet the specific requirements defined for SCSI or ATA/ATAPI or the related bus it uses in Part 3 of this guide. The CD or DVD drive must meet the requirements defined in Chapter 18, "Storage and Related Peripherals."

Mobile PC Note   If a CD drive is provided, the minimum media transfer rate must be no less than 1200 KB per second. The minimum required media transfer rate for a CD drive on a mobile PC must be no less than 600 KB per second.

If a DVD drive is provided, the minimum media transfer rate must be at least 2 MB per second for read operations from the disk. Support for DVD-Video playback is recommended, which must meet the requirements for quality standards defined in Chapter 15, "Video and Broadcast Components."

3.35. System includes audio support that meets PC 99 requirements

Consumer	Office	Mobile	Workstation	Entertainment
Recommended	Recommended	Recommended	Recommended	Required

Although audio is a standard feature in most PC market segments, it is understood that certain small office/home office (SOHO) and Office PC designs that focus on cost will not require audio. For PC 99 systems that contain audio, the audio must meet the performance metrics defined in Chapter 17, "Audio Components."

3.36. System includes a modem or other public network communications support

Consumer	Office	Mobile	Workstation	Entertainment
Required	Recommended	Required	Required	Required

The minimum modem requirements call for an internal 56-Kbps V.90 data/fax modem, representing the current market trends for modems available in 1999.

This requirement can also be met by including support for alternative digital or analog public network communications devices, including ISDN, xDSL, or cable modem, as appropriate to customer demand and geographic locale. For complete information about requirements for communications devices, see Chapter 19, "Modems."

Mobile PC Note   The presence of a CardBus slot on the mobile PC meets the requirements for providing a modem. The minimum capabilities for an integrated modem is V.80 or better, as defined in Chapter 6, "Mobile PC 99."

3.37. System includes a network adapter

Consumer	Office	Mobile	Workstation	Entertainment
Recommended	Required	Recommended	Required	Recommended

Ethernet adapters are recommended for Consumer and Entertainment PCs, to enable easy home networking and connection to high-speed Internet access devices, such as cable and xDSL modems.

For complete information about network adapter requirements, see Chapter 20, "Network Communications."

Mobile PC Note The presence of a CardBus slot on the mobile PC meets the requirements for providing a network adapter, as defined in Chapter 6, "Mobile PC 99."

Note: It is recognized that OEMs supply Office PC systems to corporations with specific feature requirements. For example, a customer might want to insert network adapters at the end-user site. An Office PC system submitted for compliance testing must include a network adapter.

Including the network adapter with the PC system assists in enabling remote new system setup. To meet the requirements for remote new system setup, a vendor's implementation method must be compatible with the technology defined in *Network PC System Design Guidelines, Version 1.0b*. One possible implementation for remote new system setup for Intel Architecture platforms is described in *Wired for Management Baseline, Version 1.1a.*

3.38. System includes smart card support

Recommended for all system types

If implemented in a PC 99 system, smart card readers and cards must be compatible with *Interoperability Specification for ICCs and Personal Computer Systems,* available at http://www.smartcardsys.com.

In addition, smart card readers and device drivers must be Plug and Play-compliant and must adhere to the Microsoft Smart Card DDK for the Windows and Windows NT platforms. Smart card applications and service-provider dynamic link libraries (DLLs) must adhere to the Microsoft Smart Card SDK that is part of the Microsoft Platform SDK. For complete smart card requirements, see Chapter 13, "I/O Ports and Devices."

The smart card system for a system with digital satellite television support represents a different technology, as discussed in Chapter 15, "Video and Broadcast Components."

PC 99 Graphics Adapters, Video, and Broadcast Services

This section summarizes the requirements for graphics adapters and monitors. For complete details, including recommendations for hardware acceleration, see Chapter 14, "Graphics Adapters."

3.39. Graphics adapter meets PC 99 minimum requirements

Required for all system types, with specific guidelines for each system type

The following list summarizes the key requirements for graphics adapters on desktop PC systems:

- Graphics adapters must use PCI, Accelerated Graphics Port (AGP), or other high-speed bus. For maximum performance, it is recommended that AGP be used for the primary graphics adapter.

- Graphics adapters for Consumer PC, Entertainment PC, and Workstation PC systems (depending on the intended market) must support 3-D hardware acceleration.

    Graphics adapter works normally with the default VGA mode driver, which is required for operating system installation.

    The adapter and driver must support multiple adapters and multiple monitors, which ensures that the end user has guaranteed automatic support to allow the operating system to correctly configure use of multiple monitors or multiple graphics adapters.

- Graphics adapters must support screen resolutions as defined by VESA up to the required maximum, including:

    $640 \times 480 \times$ [8, 15 or 16, 24 or 32] bpp
    $800 \times 600 \times$ [8, 15 or 16, 24 or 32] bpp
    $1024 \times 768 \times$ [8, 15 or 16] bpp

Mobile PC Note   For information about application-specific requirements for workstations, see Chapter 4, "Workstation PC 99." For information about requirements for the built-in display adapter on a mobile PC, see Chapter 6, "Mobile PC 99."

3.40. Color monitor is DDC-compliant with unique EDID identifier

Required for all system types, with exceptions for mobile PCs

A monitor designed for or included with a PC 99 system must be compliant with *Display Data Channel Standard, Version 3.0,* Level 2B (DDC2B), which defines the communications channel between the display and host system.

The monitor also must transmit an Extended Display Identification Data (EDID) structure containing unique ID Manufacturer Name and ID Product Code identifiers, plus all required fields as defined in Section 3 of *Extended Display Identification Data Standard, Version 3.0* or later.

For complete requirements for monitors, including requirements for Integrated Color Management (ICM), ergonomic timing standards, and display data channel (DDC) support, see Chapter 16, "Monitors."

Mobile PC Note   For exceptions and guidelines that apply for the built-in display on mobile systems, see Chapter 6, "Mobile PC 99."

3.41. System meets PC 99 DVD-Video and MPEG-2 playback requirements, if system supports DVD-Video

Required for all system types, with exceptions for mobile PCs

Systems with DVD drives are not required to support DVD-Video playback. If the system is designed to support DVD-Video, it must meet the requirements for DVD-Video and Moving Picture Expert Group (MPEG)-2 playback.

Under Windows and Windows NT, operating-system playback support for MPEG-1 is provided through Microsoft DirectShow. This requirement refers to built-in system support for DVD-Video playback or any other MPEG-2 playback capabilities, whether provided as a hardware decoder, a software decoder, or a combination of the two.

The graphics adapter requirements for supporting MPEG-2 and DVD-Video playback are described in Chapter 14, "Graphics Adapters," and Chapter 15, "Video and Broadcast Components."

Mobile PC Note   These capabilities are recommended for mobile PCs, with modified requirements, as described in Chapter 6, "Mobile PC 99."

3.42. Adapter supports television output if system does not include a large-screen monitor

Recommended for all system types

The ability to connect and use a standard National Television System Committee (NTSC) or Phase Alternation Line (PAL) television as a large display surface is key to the ability to deliver realistic television, movie, and game experiences.

For complete information about the television output requirements, see Chapter 14, "Graphics Adapters." For information about large-screen monitor requirements for Entertainment PC systems, see Chapter 16, "Monitors."

3.43. System supports PC 99 analog video input and capture capabilities

Recommended for all system types

If video-capture capability is implemented in a PC 99 system, it must meet the requirements defined in Chapter 15, "Video and Broadcast Components."

Support for video input and capture is recommended, implemented as an add-on device or a direct interface on the system board. Systems with USB or IEEE 1394 support are capable of supporting the new low-cost digital video cameras entering the market. It is recommended that systems include more than one IEEE 1394 port if the PC comes bundled with an IEEE 1394 video conferencing camera.

All video input sources and capture devices must implement driver support as defined for the WDM Stream class in the Windows NT 5.0 DDK.

3.44. System includes analog television tuner

Recommended for all system types

Recommended: Digital broadcast or satellite television tuner.

If this capability is implemented in a PC 99 system, it must meet the requirements defined in Chapter 15, "Video and Broadcast Components."

PC 99 Storage and Related Peripherals

This section summarizes the requirements for storage devices. For system requirements related to CD drives and floppy disk drives, see the "PC 99 Buses and Devices" section earlier in this chapter.

3.45. System BIOS and option ROMs support Int 13h Extensions

Required for all system types

This requirement applies for systems that run either Windows or Windows NT, but does not apply for DEC Alpha PCs.

The Int 13h Extensions ensure correct support for high-capacity drives. Support for the fixed-disk access subset of Int 13h Extensions must be provided in the system BIOS and in any option ROMs for storage devices that include BIOS support. The Int 13h Extensions are defined in the Windows NT 5.0 DDK and in the "Layered Block Device Drivers" section of the Windows 95 DDK.

3.46. Host controller for storage device meets PC 99 requirements

Required for all system types

The host controller in a PC 99 system must meet requirements defined for the bus it uses. ATA or SCSI controllers must also meet the requirements outlined in Chapter 10, "ATA and ATAPI," or Chapter 11, "SCSI."

3.47. Host controllers and hard disk devices support bus mastering

Required for all system types

Recommended: IEEE 1394 as the host controller for secondary storage.

The host controller for hard disk devices must support bus mastering, whether using ATA, SCSI, or IEEE 1394. Bus mastering support must also be enabled for secondary storage devices, including hard disks, CD, DVD, and tape drives. Bus master capabilities must meet the related specification for the particular controller, as defined in Chapter 10, "ATA and ATAPI," and Chapter 11, "SCSI."

Use of the ISA bus by storage devices is not acceptable for PC 99 systems.

Note: This requirement does not apply to legacy FDCs and will not become a requirement for FDCs in the future.

3.48. Hard drive meets PC 99 requirements

Required for all system types

The hard disk drive must meet the requirements defined in Chapter 18, "Storage and Related Peripherals," plus the requirements in the following related bus chapter:

- Hard disk drives implemented as ATA peripherals must also meet the requirements outlined in Chapter 10, "ATA and ATAPI."
- Hard disk drives implemented as SCSI peripherals must also meet the requirements outlined in Chapter 11, "SCSI."
- Storage devices that use the IEEE 1394 bus must meet the requirement defined in Chapter 8, "IEEE 1394."

3.49. Operating system recognizes the boot drive in a multiple-drive system

Required for all system types

The implementation of boot-drive determination in multiple-drive systems is defined in Section 5.0 of the *Compaq, Intel, Phoenix BIOS Boot Specification, Version 1.01*. This is the format that both Windows and Windows NT operating systems use for determining the boot drive when new bootable devices are introduced to a PC. The system designer can use an equivalent method for boot-drive determination but the method must ensure that the Windows and Windows NT operating systems recognize the boot drive.

3.50. Floppy disk capabilities, if implemented, do not use legacy FDC

Recommended for all system types

To support migration away from legacy devices, it is recommended that support for floppy disk drives be provided by using a solution other than an FDC. Solutions could include an MMC-2-compliant ATAPI floppy drive, USB, PC Card, SCSI, or an ATA expansion card.

Any floppy disk implementation or legacy FDC that is included on a PC 99 system must meet the requirements specified in Chapter 18, "Storage and Related Peripherals." Requirements for ATAPI peripherals are defined in Chapter 10, "ATA and ATAPI." See also the related recommendation for BIOS or option ROM boot support in requirement 3.5, "BIOS meets PC 99 requirements for boot support."

Manageability Component Instrumentation Requirements

This section presents new requirements and recommendations for PC 99 systems related to the Wired for Management (WfM) initiative and the Zero Administration initiative for Windows. The WfM initiative seeks to raise the level of management capabilities for mobile, desktop, and server platforms. The Zero Administration initiative seeks to ensure a controlled, highly manageable enterprise.

The baseline for these requirements is *Windows Hardware Instrumentation Implementation Guidelines*, *Version 1.0* (WHIIG), which also defines the Windows-specific requirements of the *Wired for Management Baseline Specification, Version 2.0,* for hardware instrumentation.

Collectively, the items in this section represent the Manageability Baseline requirements for Office PC 99. Platform management information requirements are defined for two key areas:

- Component instrumentation: Interfaces through which information is supplied by platform management components.
- Management information providers: Interfaces used by applications to access platform management information.

Tips for implementing management capabilities. For PC 99 systems and components, these are the design steps to pursue:

- For each component, implement the component instrumentation features defined for PC 99 systems in WHIIG.
- For each component, extend the Web-Based Enterprise Management (WBEM) and Common Information Model (CIM) schema to expose the device's custom features in any CIM-ready management browser.

- For all instrumented components, test against the baseline features required in WHIIG.
- For those components that require Windows Management Instrumentation (WMI), ensure that WMI is enabled in device minidrivers as defined in the Windows NT 5.0 DDK.
- Refer to WHIIG for other driver requirements and design tips.

3.51. System supports WHIIG

Consumer	Office	Mobile	Workstation	Entertainment
Not applicable	Required	Required with Windows NT	Required	Not applicable

The related requirement is defined in *Windows Hardware Instrumentation Implementation Guidelines*, *Version 1.0*.

Mobile PC Note   Support for WHIIG, WMI, and enabling a management information service provider are required for mobile systems that come with Windows NT preinstalled.

3.52. System includes driver support for WMI

Consumer	Office	Mobile	Workstation	Entertainment
Not applicable	Required	Required with Windows NT	Required	Not applicable

Requirements and recommendations related to implementing WMI for Windows NT 5.0 and Windows are defined in WHIIG.

Support for WMI, CIM, and Win32 extension schema objects and data must be implemented as defined in WHIIG.

3.53. Management information service provider enabled by default

Consumer	Office	Mobile	Workstation	Entertainment
Not applicable	Required	Required with Windows NT	Required	Not applicable

The management information service providers must be enabled on Office PC 99 systems as defined in WHIIG.

Also, newly developed applications for managing WBEM-capable systems must comply with the appropriate CIM schema specifications and Windows-based applications programming models.

3.54. Expansion devices can be remotely managed

Consumer	Office	Mobile	Workstation	Entertainment
Not applicable	Required	Recommended	Required	Not applicable

Devices provided as expansion devices must be capable of being remotely managed to ensure that control and TCO policies can be realized. For example, for any implementation of a floppy disk drive on an Office PC system, the drive must be capable of being remotely disabled as a boot selection and provisions must be made for locking.

It is not a requirement that certain devices be capable of being remotely disabled, including the primary hard disk drive, the network adapter, and any standard devices that use legacy connections, such as a keyboard or pointing device that uses a PS/2-compatible connection. However, it must be possible that permissions, policies, or other methods can be used to remotely manage capabilities such as hard disk access or to control end-user ability to change the MAC address or configuration settings for the network adapter.

See also requirement 3.5, "BIOS meets PC 99 requirements for boot support."

3.55. SMBIOS 2.2 static table support is provided

Consumer	Office	Mobile	Workstation	Entertainment
Not applicable	Required	Recommended	Required	Not applicable

Windows NT 5.0 can present SMBIOS 2.2 or later static table data in WBEM. System designers can provide platform-specific static information at boot time using this mechanisms. For more information about SMBIOS, see *System Management BIOS Reference Specification, Version 2.2.*

SMBIOS static table support is likely to become a requirement in future versions of these guidelines.

PC 99 System References

The following represents some of the references, services, and tools available to help build hardware that is optimized to work with Windows operating systems.

Advanced Configuration and Power Interface Specification, Revision 1.0
   http://www.teleport.com/~acpi/

ATAPI Removable Media BIOS Specification (ARMD), Version 1.0
Other ATA and SCSI specifications
   Global Engineering Documents
   Fax: (303) 397-2740
   Phone: (800) 854-7179 (U.S.)
            (613) 237-4250 (Canada)
            (303) 792-2181 (Outside North America)

Plug and Play External COM Device Specification, Version 1.0
Plug and Play Industry Standard Architecture (ISA) Specification, Version 1.0a
     and *Clarification to Plug and Play ISA Specification, Version 1.0a*
Plug and Play Parallel Port Device Specification, Version 1.0b
Plug and Play Small Computer System Interface Specification, Version 1.0
    http://www.microsoft.com/hwdev/respec/pnpspecs.htm

Default Device Class Power Management Specification, Version 1.0,
     and other device class power management specifications
    http://www.microsoft.com/hwdev/onnow.htm

Device Bay Interface Specification, Version 1.0
    http://www.device-bay.org

Display Data Channel Standard, Version 3.0
Extended Display Identification Data Standard, Version 3.0
    http://www.vesa.org

Compaq, Phoenix, Intel BIOS Boot Specification, Version 1.01
El Torito—Bootable CD-ROM Format Specification, Version 1.0
    http://www.ptltd.com/techs/specs.html

Instantly Available PC System Power Delivery Requirements
     and Recommendations Specification
    http://developer.intel.com/design/power/supply98.htm

Interoperability Specification for ICCs and Personal Computer Systems
    http://www.smartcardsys.com

Low Pin Count Interface Specification
    http://developer.intel.com/design/pcisets/lpc/index.htm

Media Status Notification Support Specification, Version 1.03
    http://www.microsoft.com/hwdev/respec/storspec.htm

Microsoft Windows 95 DDK, Windows 98 DDK, and Windows NT DDK
    MSDN Professional membership

MultiProcessor Specification, Version 1.4
    Intel part number 242016-002
    http://developer.intel.com

Network PC Design Guide, Version 1.0b
    http://www.microsoft.com/hwdev/netpc.htm
    http://www.intel.com/businesscomputing/netpc/netpc.htm

PCI Local Bus Specification, Revision 2.1 (PCI 2.1) and later
PCI Power Management Specification, Revision 1.1 (PCI-PM 1.1)
    http://www.pcisig.com

Serial Infrared (SIR) Physical Layer Specification
Control IR (CIR or IrBUS) Specification
  Other Infrared Data Association documents (available only to IrDA members)
  Fax: (510) 943-5600
  E-mail: irda@netcom.com

Simple Boot Flag Specification, Version 1.0
  http://www.microsoft.com/hwdev/desinit/simp_bios.htm

System Management BIOS Reference Specification, Version 2.2
  ftp://download.intel.com/ial/wfm/smbios.pdf
  http://www.phoenix.com/techs/specs.html

Universal Serial Bus PC Legacy Compatibility Specification, Version 0.9
Universal Serial Bus Specification, Version 1.0 or later
USB Device Class Definition for Human Interface Devices, Version 1.0
  Other USB device class specifications
  http://www.usb.org

Web-Based Enterprise Management (WBEM) information
  http://wbem.freerange.com
  http://www.dmtf.org/work/cim.html
  http://www.microsoft.com/management/wbem/

Windows Hardware Instrumentation Implementation Guidelines, *Version 1.0*
  White papers and guidelines for WMI
  http://www.microsoft.com/hwdev/manageability/

Wired for Management Baseline Specification
  Version 1.1a—http://www.intel.com/managedpc/spec.htm
  Version 2.0—http://developer.intel.com/ial/wfm/

Checklist for PC 99 Basic Requirements

If a recommended feature is implemented, it must meet the requirements for that feature as defined in this document.

Consumer	Office	Mobile	Workstation	Entertainment
3.1. System performance meets PC 99 minimum requirements				
300 MHz,	*300 MHz,*	*233 MHz,*	*400 MHz,*	*300 MHz*
32 MB	*64 MB*	*32 MB*	*128 MB*	*64 MB*
3.2. System design meets ACPI 1.0 specification and PC 99 requirements				
Required for all system types, with exceptions for mobile PCs				
3.3. Hardware design supports OnNow and Instantly Available PC initiatives				
Required for all system types, with exceptions for mobile PCs				
3.4. BIOS meets PC 99 requirements for OnNow support				
Required for all system types				

Consumer	Office	Mobile	Workstation	Entertainment

3.5. BIOS meets PC 99 requirements for boot support
Required for all systems, with exceptions for mobile PCs

3.6. All expansion slots in the system are accessible for users to insert cards
Required for all system types, with extra guidelines for mobile

3.7. Audible noise meets PC 99 requirements
Required for all system types

3.8. System and component design practices follow accessibility guidelines
Recommended for all system types

3.9. Internal system modification capabilities are not accessible to end users
Recommended for all system types

3.10. System design provides physical security
Recommended for all system types

3.11. Each device and driver meets PC 99 device requirements
Required for all system types

3.12. Each bus and device meets Plug and Play specifications
Required for all system types

3.13. Unique Plug and Play device ID provided for each system device and add-on device
Required for all system types

3.14. Option ROMs meet Plug and Play requirements
Required for all system types

3.15. "PNP" vendor code used only to define a legacy device's Compatible ID
Required for all system types

3.16. Device driver and installation meet PC 99 requirements
Required for all system types

3.17. Minimal user interaction needed to install and configure devices
Required for all system types

3.18. Connections use icons, plus keyed or shrouded connectors, with color coding
Required for all system types, with exceptions for mobile PCs

3.19. Hot-plugging capabilities for buses and devices meet PC 99 requirements
Required for all system types

3.20. System includes Device Bay 1.0-compatible bay
Recommended for all system types

3.21. Multifunction add-on devices meet PC 99 device requirements for each device
Required for all system types

3.22. All devices support correct 16-bit decoding for I/O port addresses
Required for all system types

3.23. All PC 99 input devices support Microsoft DirectInput and work simultaneously
Required for all system types

3.24. Each bus meets written specifications and PC 99 requirements
Required for all system types

3.25. System includes USB with two USB ports, minimum
Required for all system types, with exceptions for mobile PCs

3.26. System includes support for IEEE 1394
Recommended for all system types, with 3 ports recommended for Entertainment PCs

	Consumer	Office	Mobile	Workstation	Entertainment

3.27. If present, PCI bus meets PCI 2.1 or later, plus PC 99 requirements
Required for all system types

3.28. System does not include ISA expansion devices or slots
Required for all system types

3.29. System includes keyboard connection and keyboard
Required for all system types

3.30. System includes pointing-device connection and pointing device
Required for all system types

3.31. System includes connection for external parallel devices
Required for all system types

3.32. System includes connection for external serial devices
Required for all system types

3.33. System includes IR devices compliant with IrDA specifications
Recommended for all system types

3.34. System includes PC 99-compatible CD or DVD drive and controller

Consumer	Office	Mobile	Workstation	Entertainment
Required	*Recommended*	*Recommended*	*Required*	*DVD required*

3.35. System includes audio support that meets PC 99 requirements

Consumer	Office	Mobile	Workstation	Entertainment
Recommended	*Recommended*	*Recommended*	*Recommended*	*Required*

3.36. System includes a modem or other public network communications support

Consumer	Office	Mobile	Workstation	Entertainment
Required	*Recommended*	*Required*	*Required*	*Required*

3.37. System includes a network adapter

Consumer	Office	Mobile	Workstation	Entertainment
Recommended	*Required*	*Recommended*	*Required*	*Recommended*

3.38. System includes smart card support
Recommended for all system types

3.39. Graphics adapter meets PC 99 minimum requirements
Required for all system types, with specific guidelines for each system type

3.40. Color monitor is DDC-compliant with unique EDID identifier
Required for all system types, with exceptions for mobile PCs

3.41. System meets PC 99 DVD-Video and MPEG-2 playback requirements, if system supports DVD-Video
Required for all system types, with exceptions for mobile PCs

3.42. Adapter supports television output if system does not include a large-screen monitor
Recommended for all system types

3.43. System supports PC 99 analog video input and capture capabilities
Recommended for all system types

3.44. System includes analog television tuner
Recommended for all system types

3.45. System BIOS and option ROMs support Int 13h Extensions
Required for all system types

3.46. Host controller for storage device meets PC 99 requirements
Required for all system types

3.47. Host controllers and hard disk devices support bus mastering
Required for all system types

3.48. Hard drive meets PC 99 requirements
Required for all system types

Consumer	Office	Mobile	Workstation	Entertainment

3.49. Operating system recognizes the boot drive in a multiple-drive system
Required for all system types

3.50. Floppy disk capabilities, if implemented, do not use legacy FDC
Recommended for all system types

3.51. System supports WHIIG

Consumer	Office	Mobile	Workstation	Entertainment
Not applicable	*Required*	*Required with Windows NT*	*Required*	*Not applicable*

3.52. System includes driver support for WMI

Consumer	Office	Mobile	Workstation	Entertainment
Not applicable	*Required*	*Required with Windows NT*	*Required*	*Not applicable*

3.53. Management information service provider enabled by default

Consumer	Office	Mobile	Workstation	Entertainment
Not applicable	*Required*	*Required with Windows NT*	*Required*	*Not applicable*

3.54. Expansion devices can be remotely managed

Consumer	Office	Mobile	Workstation	Entertainment
Not applicable	*Required*	*Recommended*	*Required*	*Not applicable*

3.55. SMBIOS 2.2 static table support is provided

Consumer	Office	Mobile	Workstation	Entertainment
Not applicable	*Required*	*Recommended*	*Required*	*Not applicable*

C H A P T E R   4

Workstation PC 99

This chapter provides a summary of the key requirements for workstations designed as PC 99 systems. If there is a conflict with requirements or recommendations made elsewhere in this guide, the items in this chapter have precedence for workstations. Unless a specific requirement or exception is defined in this chapter, all PC 99 requirements apply as defined in Chapter 3, "PC 99 Basic Requirements."

Important: The system requirements defined in this chapter provide guidelines for designing PC systems that will result in the optimal user experience with typical Win32-based applications running under the Microsoft Windows NT Workstation operating system. These design requirements are not basic system requirements for running the Windows NT Workstation operating system.

Contents

Workstation Design Requirements

This chapter describes the requirements that define a workstation optimized to run Windows NT Workstation and to support Win32-based applications or 64-bit software. Workstation PC is a platform for users whose principal computing tasks involve running mission-critical networked applications, engineering or scientific applications, media-authoring tools, or software-development tools.

Although Windows NT Workstation is used on stand-alone systems, the PC 99 system requirements support the more common use of Windows NT Workstation as a platform for network productivity.

The key design issues for workstations include processor, memory, and bus architecture requirements that support intensive computational activities.

Note: It is recognized that OEMs supply Workstation PC systems to customers with specific feature requirements. For example, a customer might want to insert network adapters at the end-user site. However, a Workstation PC system submitted for compliance testing must include all required features.

4.1. Workstation meets all requirements for Office PC 99
Required
Each component indicated as a requirement for an Office PC system is also a requirement for workstations, as defined in Chapter 3, "PC 99 Basic Requirements."

Note: Systems designed to run only on Windows NT are not required to meet PC 99 requirements for legacy Plug and Play support. If the system is designed to run either Windows 98 or Windows NT, it must meet all PC 99 requirements for legacy Plug and Play support.

4.2. Workstation performance meets Workstation PC 99 minimum requirements
Required
Minimum Workstation PC 99 performance requirements include the following:

- Microprocessor performance equivalent to a RISC-based processor or Intel Architecture 400 MHz or greater processor
- 128 MB RAM, minimum
- Minimum 512K L2 cache (per processor for multiple processors)

The system must be able to cache all the physical memory that it claims to support.

4.3. Workstation supports multiple processors

Recommended

For systems in which more than one Intel Architecture processor can be installed, the system must employ those processors symmetrically and must comply with the ACPI 1.0 specification and *MultiProcessor Specification* (MPS), *Version 1.4* or later. Support for both MPS 1.4 and ACPI helps customers through the transition from Windows NT 4.0 to Windows NT 5.0. ACPI will eventually supersede MPS.

An ARC-compliant or ACE-compliant RISC-based system meets the requirements for multiprocessor support.

If multiprocessor support is provided, each processor must have a separate L2 cache.

4.4. Workstation RAM can be expanded

Recommended

If the capability for expanding RAM is implemented, workstation RAM must be capable of being expanded to 1 GB and should be capable of being expanded to at least 2 GB. The system must be able to cache all the physical memory that it claims to support.

4.5. Workstation system memory includes ECC memory protection

Required

The system memory and L2 cache must be protected with Error Correction Code (ECC) memory protection. All ECC RAM visible to the operating system must be cacheable. The ECC hardware must be able to detect at least a double-bit error in one word and to correct a single-bit error in one word, where "word" means the width in bits of the memory subsystem. A detected error that cannot be corrected must result in a system fault.

4.6. Workstation includes APIC support

Required

The workstation must include Advanced Programmable Interrupt Controller (APIC) support that complies with ACPI 1.0 by including the Multiple APIC Description Table (Section 5.2.8).

Features such as targeted interrupts, broadcast interrupts, and prior-owner interrupts must be supported. Intel Architecture processor implementations can use the Intel APIC component.

4.7. Workstation includes high-performance components
Recommended

The basic PC 99 requirements support high-performance such as bus mastering for I/O and storage and write combining for processors that support this capability.

Recommended: Workstation PC should ensure that drivers are tuned for 32-bit or 64-bit performance.

4.8. Workstation supports 64-bit I/O bus architecture
Required for 64-bit platforms

For PCI, 64-bit workstations must support the 64-bit physical address space. PCI adapters must be able to address any location in that address space. This is a recommendation for 32-bit workstations.

4.9. Workstation does not include ISA expansion slots
Required

A workstation must not include ISA expansion slots. ISA devices cannot meet the high-performance requirements for workstations, resulting in performance bottlenecks.

4.10. Graphics subsystem supports workstation performance demands
Required, with special conditions depending on PC 99 market category

This requirement is for a workstation designed to support high-resolution graphics applications. A Workstation PC does not have to meet this requirement if it is designed for financial or transaction-based markets and is not intended to support graphics-intensive applications.

For a workstation designed to support graphics-intensive applications, the following support must be provided:

- 4 MB of display RAM.
- 3-D hardware acceleration based on Microsoft Direct3D, OpenGL, or both methods.

  Direct3D hardware designed to support OpenGL-based applications must be capable of meeting the OpenGL rasterization rules. Direct3D drivers must report through the appropriate capabilities bit whether the hardware actually conforms to OpenGL requirements.

  For information about requirements for 3-D hardware acceleration supported by Direct3D, see Chapter 14, "Graphics Adapters." For information about OpenGL rasterization requirements and conformance rules, see the web site at http://www.sgi.com/Technology/OpenGL/arb.html.

The following features are recommended for the graphics subsystem:

- $1280 \times 1024 \times 24$ bpp resolution should be supported for workstation systems intended for use with computer-aided design (CAD) or other high-performance graphical applications.
- Hardware that implements 32-bpp display modes, for example, display hardware for high-end engineering workstations, should implement RGB-mode rasterization.

4.11. Storage components rely on SCSI controller

Recommended

SCSI is a flexible I/O bus that supports good performance for access and throughput, meeting a workstation's intensive data transfer needs. For more information about related requirements, see Chapter 11, "SCSI."

4.12. Workstation includes multiple hard drives

Recommended

Recommended: Hardware acceleration of redundant array of inexpensive disks (RAID) drives.

Multiple hard drives can be incorporated for improved performance (multiple spindle access and striping with RAID 0) or for data integrity (RAID 1/5).

If multiple hard drives are implemented, the design must provide a means for the operating system to determine the boot drive. One implementation of boot-drive determination in multiple-drive systems is defined in Section 5.0 of the *Compaq, Intel, Phoenix BIOS Boot Specification, Version 1.01*. The format defined in this specification is what Windows NT uses for determining the boot drive as new bootable devices are introduced for servers. The system designer can use an equivalent method for boot-drive determination, but the method must ensure that the boot drive is recognized by the Windows NT Workstation operating system.

For all related requirements for storage, see Chapter 18, "Storage and Related Peripherals."

Workstation PC 99 References

The following represents some of the references, services, and tools available to help build hardware that is optimized to work with Windows operating systems.

Accelerated Graphics Port Interface Specification, Revision 2.0
    http://developer.intel.com

Advanced Configuration and Power Interface Specification, Revision 1.0
    http://www.teleport.com/~acpi/

Compaq, Phoenix, Intel BIOS Boot Specification, Version 1.01
  http://www.microsoft.com/hwdev/respec/pnpspecs.htm

Microsoft Windows NT 5.0 DDK
  MSDN Professional membership

MultiProcessor Specification, Version 1.4
  Intel part number: 242016-002
  http://developer.intel.com

OpenGL conformance rules from the OpenGL Architectural Review Board
  http://www.sgi.com/Technology/openGL/arb.html
  UseNet news group for OpenGL at comp.graphics.opengl

Checklist for Workstation PC 99

If a recommended feature is implemented, it must meet the PC 99 requirements for that feature as defined in this document.

4.1. Workstation meets all requirements for Office PC 99
Required

4.2. Workstation performance meets Workstation PC 99 minimum requirements
Required

4.3. Workstation supports multiple processors
Recommended

4.4. Workstation RAM can be expanded
Recommended

4.5. Workstation system memory includes ECC memory protection
Required

4.6. Workstation includes APIC support
Required

4.7. Workstation includes high-performance components
Recommended

4.8. Workstation supports 64-bit I/O bus architecture
Required for 64-bit platforms

4.9. Workstation does not include ISA expansion slots
Required

4.10. Graphics subsystem supports workstation performance demands
Required, with special conditions depending on PC 99 market category

4.11. Storage components rely on SCSI controller
Recommended

4.12. Workstation includes multiple hard drives
Recommended

C H A P T E R   5

Entertainment PC 99

This chapter provides a summary of the key requirements for Entertainment PC systems.

Unless a specific requirement or exception is defined in this chapter, all requirements apply for Entertainment PCs as defined in Chapter 3, "PC 99 Basic Requirements" and in Parts 3 and 4 of this guide. If there is a conflict with requirements or recommendations made elsewhere in this guide, the items in this chapter have precedence for Entertainment PCs.

Important: The system requirements defined in this guide provide guidelines for designing PC systems that will result in the optimal user experience with typical Windows-based applications running under either the Microsoft Windows 98 or Windows NT Workstation operating systems. These design requirements are not the basic system requirements for running any Windows operating systems.

Contents

Entertainment PC System Requirements

This section summarizes the requirements for the basic components of Entertainment PC systems.

5.1. System performance meets Entertainment PC 99 minimum requirements

Required

For Entertainment PC systems based on Intel Architecture processors, minimum performance requirements include the following:

- 300 MHz processor with 128 L2 cache.

  This processor requirement does not specify a particular processor form factor or package type.

- 64 MB minimum system memory.

  The basic limitations for memory available to the operating system apply for Entertainment PCs, as defined in requirement 3.1, "System performance meets PC 99 minimum requirements."

5.2. Entertainment PC includes three IEEE 1394 ports, with at least one easily accessible connector

Recommended

The Entertainment PC system should include three IEEE 1394 ports, with at least one IEEE 1394 connector in an easily accessible location (not on the rear panel) to support camcorders and other digital consumer-electronics devices.

The recommended location for an easily accessible connector is to place a port on the front of the PC. The additional connectors for static connections to continuously used devices can be placed on the rear of the PC.

If implemented, the IEEE 1394 ports must meet the requirements defined in Chapter 8, "IEEE 1394."

5.3. All Entertainment PC input devices meet USB HID specifications

Recommended

All keyboards, pointing devices, game pads, and their connections should comply with the *USB Device Class Definition for Human Interface Devices, Version 1.0* or later, and *USB HID Usages Table.* This is recommended whether the devices are implemented as wired or wireless.

The game device should support at least four devices simultaneously.

Note: For Entertainment PC systems, wireless connections are recommended for the keyboard, pointing device, and game pad. This can be implemented for a pointing device by using a remote-control pointing device or a wireless keyboard with a connector that enables a standard mouse to be attached. The ability to attach a standard two-button mouse is strongly encouraged, although the device itself does not need to be included with the PC.

For more information about requirements for input devices, see Chapter 13, "I/O Ports and Devices."

5.4. Entertainment PC includes a remote-control pointing device
Recommended

There is no requirement for implementing an infrared (IR) or radio frequency (RF) remote-control pointing device.

If a remote-control pointing device is implemented on an Entertainment PC system, all buttons and any additional controls implemented must comply with the current USB HID specifications, including HID usage-code specifications and command structures defined in the *USB HID Usages Table*.

Also, the remote-control device must have the controls defined in the following table.

Required Controls for Remote-Control Devices

Label	Icon	Function
Power	—	Toggle switch between On and Standby power state
Start	Windows flag[1]	Display Start menu (same action as the keyboard Windows logo key)
—	—	Mouse pointer control, including left and right mouse buttons

[1] Windows flag is implemented under a Microsoft licensing agreement.

In addition, the following buttons are recommended for remote-control devices.

Recommended Controls for Remote-Control Devices

Label	Icon	Function
Cancel	—	Same as the keyboard ESCAPE key
Enter	—	Same as the keyboard ENTER key
Menu	—	Display application menus or toolbar (same as the keyboard F10 key)
Switch	—	Switch between applications (same as the keyboard ALT+TAB combination)
Close	—	Close active window (same as the keyboard ALT+F4 combination)

Entertainment PC Audio Requirements

High-quality audio is a key differentiating feature for Entertainment PC systems. Audio fidelity and functions must be significantly better than for traditional PCs, and on par with consumer-electronics stereos.

Using IEEE 1394 for positional 3-D audio and connections to home-theater systems will enable more realistic game and video experiences. Implementation is using the audio subsystem as an external digital-to-analog converter (DAC) attached to a secondary IEEE 1394 port on the rear of the PC. This isolates the analog audio stream from the RF noise of internal PC components while enabling easy connection to either legacy analog or new Plug and Play-compatible digital stereo components.

5.5. Entertainment PC audio subsystem meets PC 99 audio requirements
Required
Recommended: Audio hardware accelerator is ready for digital audio.

Audio on an Entertainment PC system must meet PC 99 audio requirements, which include requirements for audio hardware capabilities, performance metrics, and external connections. For more information, see Chapter 17, "Audio Components."

Entertainment PC Graphics Components

This section summarizes the Entertainment PC system requirements for graphics adapters and monitors. For complete information about requirements for the graphics subsystem, see Chapter 17, "Graphics Adapters."

5.6. Graphics subsystem meets Entertainment PC 99 requirements for 3-D acceleration

Required

Acceleration features for 3-D graphics using Microsoft Direct 3D must be implemented as defined in "Hardware Acceleration for 3-D Graphics" in Chapter 14, "Graphics Adapters."

For the Entertainment PC graphics adapter, the following capabilities are required beyond those hardware acceleration capabilities required for Consumer PC systems:

- 14.29, "Hardware supports multi-texturing"
- 14.33, "Hardware supports Z comparison modes and Direct3D-compatible formats"
- 14.34, "Hardware meets PC 99 3-D accelerator performance requirements"

5.7. Entertainment PC includes support for television output if the system doesn't have a large-screen monitor

Recommended

Support for NTSC, PAL, or both types of television output is recommended unless the system is bundled with a large-screen super VGA (SVGA) monitor.

For Entertainment PC, connecting to a television is key to its ability to deliver more realistic television, movie, and game experiences, and to enable social computing activities. Television output integrated with the PC graphics adapter will deliver much higher image quality than external converters. As such, this feature optimizes the usability of an Entertainment PC system connected directly to a television in the family room and for desktop systems configured to transmit graphics and video to a television in another room.

This capability must meet the PC 99 requirements for television output for composite and S-Video connectors, parameter control, and hardware filtering and scaling capabilities as defined in "Television Output Requirements" in Chapter 14, "Graphics Adapters."

5.8. Entertainment PC includes large-screen DDC2B color entertainment monitor

Recommended

A large-screen SVGA monitor that meets the *Display Data Channel Standard, Version 3.0*, Level 2 B specification (DDC2B) is recommended for Entertainment PC systems designed for the family room. Games, movies, and other entertainment software experiences are greatly enhanced by display screens comparable to modern television sizes: 27 inches and larger in the United States.

An Entertainment PC system that includes a large-screen monitor must meet the requirements for entertainment monitors defined in Chapter 16, "Monitors."

Entertainment PC Video and Broadcast Components

This section summarizes the Entertainment PC system hardware requirements for video capture, television output, and DVD playback support. For complete information about the requirements summarized in this section, see Chapter 15, "Video and Broadcast Components."

5.9. Entertainment PC DVD and TV playback meet PC 99 requirements

Required

DVD-Video support is required for Entertainment PC; therefore, DVD playback capabilities must meet PC 99 requirements. If MPEG-2 hardware is included in an Entertainment PC system, it must also meet the PC 99 requirements for video playback as defined in Chapter 14, "Graphics Adapters," and Chapter 15, "Video and Broadcast Components."

5.10. Entertainment PC includes analog video input and capture capabilities

Recommended

If implemented on an Entertainment PC system, this capability must meet the requirements defined in "Video Input and Capture Requirements" in Chapter 15, "Video and Broadcast Components."

If implemented, the video input connector should be easily accessible on the Entertainment PC system, and therefore should not be located on the rear panel.

5.11. Entertainment PC includes analog television tuner

Recommended

If implemented on an Entertainment PC system, this capability must meet the requirements defined in "Analog TV Tuner/Decoder and VBI Capture Requirements" in Chapter 15, "Video and Broadcast Components."

The NTSC or PAL decode component of the television tuner and analog video input subsystems must properly support extraction of data transmitted during the vertical blanking interval (VBI). This includes allowing certain scan lines to be placed within a separate memory buffer.

5.12. Entertainment PC includes digital broadcast satellite subsystem

Recommended

If implemented on an Entertainment PC system, this capability must meet the requirements defined in "Digital Broadcast TV Requirements" in Chapter 15, "Video and Broadcast Components."

If this capability is included, the implementation must include a digital broadcast satellite network card, a smart card, and drivers that meet PC 99 requirements.

5.13. Entertainment PC includes DTV support

Recommended

If implemented on an Entertainment PC system, this capability must meet the requirements defined in "Digital Broadcast TV Requirements" in Chapter 15, "Video and Broadcast Components."

Support for digital television (DTV) is recommended for Entertainment PC systems. If implemented, the hardware and software support for an Advanced Television Systems Committee (ATSC) tuner/demodulator, MPEG-2 decode capabilities, and graphics adapter must meet the PC 99 requirements.

Entertainment PC 99 References

The following represents some of the references, services, and tools available to help build hardware that is optimized to work with Windows operating systems.

Display Data Channel Standard, Version 3.0
   http://www.vesa.org

USB Device Class Definition for Human Interface Devices, Version 1.0
USB HID Usages Table
   http://www.usb.org

Checklist for Entertainment PC 99

If a recommended feature is implemented, it must meet the PC 99 requirements for that feature as defined in this document.

5.1. System performance meets Entertainment PC 99 minimum requirements
Required

5.2. Entertainment PC includes three IEEE 1394 ports, with at least one easily accessible connector
Recommended

5.3. All Entertainment PC input devices meet USB HID specifications
Recommended

5.4. Entertainment PC includes a remote-control pointing device
Recommended

5.5. Entertainment PC audio subsystem meets PC 99 audio requirements
Required

5.6. Graphics subsystem meets Entertainment PC 99 requirements for 3-D acceleration
Required

5.7. Entertainment PC includes support for television output if the system doesn't have a large-screen monitor
Recommended

5.8. Entertainment PC includes large-screen DDC2B color entertainment monitor
Recommended

5.9. Entertainment PC DVD and TV playback meet PC 99 requirements
Required

5.10. Entertainment PC includes analog video input and capture capabilities
Recommended

5.11. Entertainment PC includes analog television tuner
Recommended

5.12. Entertainment PC includes digital broadcast satellite subsystem
Recommended

5.13. Entertainment PC includes DTV support
Recommended

C H A P T E R 6

Mobile PC 99

This chapter provides a summary of the key PC 99 requirements for mobile PCs, mini-notebooks, docking stations, and mini-docks. Mobile PC systems have thermal, portability, battery run-time and battery life, size, weight, and connectivity tradeoffs required for their design that differ from the tradeoffs made for stationary systems.

For background information about the design issues related to mobile PCs, see Chapter 1, "PC 99 Design Issues."

Important: Unless a specific requirement or exception is defined in this chapter, all requirements apply for mobile PCs as defined in Chapter 3, "PC 99 Basic Requirements" and in Parts 3 and 4 of this guide. If there is a conflict with requirements or recommendations made elsewhere in this guide, the items in this chapter have precedence for mobile PCs.

The system requirements defined in this guide provide guidelines for designing PC systems that will result in the optimal user experience with typical Windows-based applications running under either the Microsoft Windows 98 or Windows NT Workstation operating systems. These design requirements are *not* the basic system requirements for running any of the Windows operating systems.

Contents

Mobile PC System Design Requirements

This section summarizes the additional design exceptions and design requirements for mobile PCs.

Unless an explicit exception is stated in this section, the PC 99 requirements apply for mobile PCs as defined in Chapter 1, "PC 99 Basic Requirements," and in Parts 3 and 4 of this guide. However, if there is any conflict with requirements or recommendations stated elsewhere in this guide, the items in this section have precedence for mobile PCs.

6.1. Mobile PC performance meets Mobile PC 99 minimum requirements
Required

For mobile PC systems based on Intel Architecture compatible processors, minimum PC 99 performance requirements include the following:

- 233 MHz processor with 128K L2 cache.

  This processor requirement does not specify a particular processor form factor or package type.

- 32 MB minimum system memory. The basic PC 99 limitations for memory available to the operating system apply for mobile PCs, as defined in the requirement 3.1.2, "System memory meets PC 99 minimum requirements."

  Recommended: 64 MB RAM for Windows NT installations.

Mini-notebook Note   For mini-notebook systems, the minimum system performance requirement is 233-MHz processor with no L2 cache and 16 MB RAM.

6.2. Mobile PC supports Smart Battery or ACPI Control Method battery
Required

Recommended: Smart Battery.

- **6.2.1 Smart Battery meets PC 99 requirements.** If Smart Battery is implemented, the following requirements apply:
  - An ACPI embedded controller-based (EC) System Management Bus (SMBus) interface is required, as described in Section 13 of the ACPI 1.0 specification.
  - The battery must support the complete command set and meet the accuracy requirements defined in *Smart Battery System Specification*, *Version 1.0.*
  - A Smart Battery Charger, if used, must comply with the command requirements defined in *Smart Battery Charger Specification, Version 1.0.*
  - A single-battery system that does not use a Smart Battery Charger must report the presence or absence of AC power and issue AC state change notifications by way of the EC interface, using Smart Battery Charger commands.

- A multiple-battery system that does not use a Smart Battery Charger must report the presence or absence of AC and issue AC state change notifications using the EC by emulating a Smart Battery Selector status register.

- If a multiple-battery system is implemented, the system can use a Smart Battery Selector that complies with the *Smart Battery Selector Specification, Version 1.0*. The battery selection or alternate control scheme that is implemented must comply with the intent of the *Smart Battery Selector Specification.* It must expose emulated Smart Battery Selector registers to the operating system.

The intent is that battery systems returning "Smart Battery System" data by way of the EC SMBus interface do so in a manner consistent with the Smart Battery System specifications. They must return all battery data, the charger status register, and all selector registers in a manner transparent to the operating system, allowing the standard Smart Battery System drivers provided with the operating system to work properly.

All Smart Battery specifications are available at http://www.sbs-forum.org.

- **6.2.2 ACPI Control Method Battery meets PC 99 requirements.** If an ACPI Control Method Battery, as defined in Section 11 of the ACPI 1.0 specification, is implemented, the following requirements apply:

  - All data returned must be meaningful and accurate. If the accuracy cannot be guaranteed, return the unknown value, which typically is 0xFFFFFFFF.

  - If a multiple-battery system is implemented, it must follow the guidelines defined in the *ACPI Implementers Guide*, which is available from the web site at http://www.teleport.com/~acpi/.

  - Although most of the data fields returned by a Control Method battery are optional or recommended in the ACPI 1.0 specification, the following data fields are required for PC 99:

Field	Requirements
_BIF field	Power Unit must report 0x0000000. That is, batteries are required to report their Battery Remaining Capacity in mWH and their Battery Present Rate in mW.
	Design Capacity, reported in mWH.
	Design Capacity of Low.
_BST	Battery Remaining Capacity, reported in mWH.
	Battery Present Rate, reported in mW.

Recommended: _BTP support.

- Batteries must be able to supply at least the capacity they report (Battery Remaining Capacity) at all times, even when the system is running on AC power. It is acceptable to supply more energy than they report, but they must never over-report capacity.

- Batteries must accurately report the Battery Present Rate, providing data that is not stale.

6.3. Expansion capabilities of mobile PC are accessible to users
Required

Expansion capabilities in a mobile PC usually require external connections and, occasionally, additional internal components. The expansion slot is almost always physically blocked by access doors. Such doors are recommended for traveling integrity and to minimize entry of dust. This requirement is met if the user can access such external expansion slots without tools.

Internal expansion capabilities that require internal replacements, such as CPU, memory, built-in modem, and so on, are exempt from this requirement.

6.4. Mobile PC connections use icons plus keyed or shrouded connectors
Required

This requirement is the same as for PC 99 desktop systems, except that for mobile PC designs, with small-height considerations, connector icons might not fit on the back of the case. In such cases, it is acceptable to wrap the icons to the bottom of the unit or place them on the inside of an access door.

Mobile PCs are not required to implement color coding for connectors.

6.5. Mobile PC includes one USB port
Required

For mobile PCs, one USB port must be built into the PC, not provided solely by docking stations, although these units can provide extra USB connectors. This USB port can be either a high-power or low-power port, or it can be dynamically configurable at the discretion of the OEM, as provided for by Section 7.2.1 of the USB 1.0 specification.

Mobile systems are **not** required to meet the requirement for the USB host controller to be able to wake the system from S3 state, as defined in requirement 3.2, "System design meets ACPI 1.0 specification and PC 99 requirements."

Mobile systems that have built-in keyboards are **not** required to include BIOS support for USB keyboards and hubs as defined in requirement 3.5, "BIOS meets PC 99 requirements for boot support."

6.6. USB-connected device does not maintain fully on power state

Required

An internal device that connects to the mobile PC using USB must not continually maintain the system in a fully-on power state. Such a device will override system power-management settings that control power-saving modes to protect battery life. When any USB device is connected but not active, the driver must allow system power management to suspend the notebook.

6.7. Mobile PC includes an IEEE 1394 port

Recommended

It might not be possible to meet mobile system design requirements for power control, power budgeting, power state management, and thermal management with designs based solely on the IEEE P1394.a standard and OHCI 1.0 specification. Therefore, implementation of an IEEE 1394 port on a mobile system will not become a requirement until these power issues have been resolved in future versions of the IEEE 1394 standard and OHCI specification.

The implementation of IEEE 1394 on a mobile PC must meet the requirements defined in Chapter 8, "IEEE 1394," with the following exceptions and additions:

- One external IEEE P1394.a-compliant port is required.

- When the IEEE 1394 node on a mobile system is not active, it must not degrade battery life, system reliability, or CPU performances.

- There are no requirements for a mobile unit to source or sink power. This is an exception to requirement 8.34, "IEEE 1394-enabled PC sources cable power."

  Instead, the mobile PC should declare itself as a Power Class 04 device, defining its specific power source/sink characteristics in the Configuration State Registers (CSR) space. This is an exception to requirement 8.30, "Devices report power source and cable power consumption in Self_id packet."

- A mobile unit with a single external port is not required to power its PHY when the system transitions to the Off state. If more than one port is implemented, mechanisms must be implemented to prevent the passing of power from any one port to any other port when the system (and its PHY) transitions to the Off state. This is an exception to requirement 8.25, "Self-powered devices propagate the power bus through each connector," and requirement 8.29, "Devices provide sufficient power to their PHY at appropriate times."

Recommended: The IEEE 1394 port on the mobile unit should not be blocked when the system is docked. If, however, the port is blocked (when internal ports have not been implemented), it should be possible to power off the internal link and PHY.

Guidelines for implementing IEEE 1394 on a docking station or mini-dock are defined in "Docking Station Requirements" later in this chapter.

6.8. Mobile PC includes CardBus
Required
Recommended: Zoomed Video (ZV) support.

At least one 32-bit Type-2 CardBus slot (not 16-bit) is required. All CardBus implementations must comply with the requirements defined in Chapter 12, "PC Card," including information about the default initialization of the CardBus controller under both Windows 98 and Windows NT operating systems.

Note: Each device in a multifunction add-on device—such as a CardBus card—must separately meet the power management device class specifications for its device class and be independently power managed. This means that both device A and device B on the same add-on card do not have to be idle before the devices can be power managed. For information, see Chapter 12, "PC Card."

6.9. Mobile PC keyboard and pointing device meet PC 99 requirements
Required
The internal keyboard and any built-in pointing devices, such a mouse, stylus, pen, touch pad, touch screen, trackball, stick, and so on, required for a mobile PC should use standard system-board devices. The USB port can be used to support the requirement for external pointing device and keyboard connections. Alternatively, two PS/2-style ports can be implemented for the pointing device and keyboard, or a single PS/2-style port can be provided for both the pointing device and the keyboard.

For more information, see Chapter 13, "I/O Ports and Devices," which also provides information about implementing the recommended Windows and Application logo keys on mobile PCs.

The BIOS and the driver for the internal pointing device must accommodate standard external pointing devices such that all features of the external device are available when it is attached to the system. At a minimum, if the internal pointing device is a PS/2-type device, the BIOS must provide an option to detect when an external PS/2-type pointing device is connected at startup and disable the internal pointing device. In this case, the driver for the internal pointing device must not load. This should be the default BIOS option.

Recommended: The BIOS should provide a user-settable option to enable dual operation of the internal and external pointing device.

6.10. Mobile PC includes IR devices compliant with IrDA specifications

Recommended

IR capabilities are not required for mobile PCs. If implemented, all devices must meet the PC 99 requirements for IrDA devices as defined in the "Wireless Component Requirements" section of Chapter 13, "I/O Ports and Devices." See also "Wireless Design Issues" in Chapter 2, "PC 99 Design Issues."

In addition, the software must have access to turning the interface off (D3 power state) and on (D0 power state) using bus-specific methods or the methods defined in Section 3.4 of the ACPI 1.0 specification.

6.11. Mobile PC includes support for installing the operating system

Required

The mobile system, as purchased, might not include all peripherals required for operating system installation. The user might need to access another PC 99 computer using a serial, parallel, or network connection to complete installation.

This basic PC 99 requirement is met as long as it is possible for the user to obtain the required device support for operating system installation, even if it requires a separate purchase.

6.12. Mobile PC includes audio that meets Mobile PC 99 audio requirements

Recommended

If audio is implemented in a mobile PC system, it must meet the requirements for PC 99 audio as defined in Chapter 17, "Audio Components," with exceptions as defined in this section. These exceptions for mobile PC systems arise from design challenges such as lower power and smaller form factors.

For mobile PCs, the following exceptions and differences are defined for audio requirement 17.4, "Audio performance meets PC 99 requirements":

- Dynamic range requirements are relaxed by 10 dB FS A
- THD+N requirements are relaxed by 10 dB FS
- Required frequency response is 20 Hz to 15 kHz, measured using 3 dB corners
- Cross-talk requirements are relaxed by 10 dB FS
- For mobile PCs that implement a 3.3 V audio codec in order to decrease system power, the required Full Scale Output Voltage (FSOP) for line output is ≥0.7 Vrms

  Notice that frequency response is measured at line out.

It is the intent of the PC 99 design requirements to allow for the audio controller to be implemented on the mobile unit with output capabilities implemented on a docking station. For related audio requirements for the mobile PC/docking station pair, see the "Docking Station Requirements" section later in this chapter.

6.13. Mobile PC includes communications device

Recommended

Notice that the presence of a CardBus slot on the mobile PC meets the PC 99 requirement for providing either a modem or network adapter with a Mobile PC 99 system, with the following exceptions:

- If modem capabilities are integrated in the base platform, then V.34 or higher is required. All other requirements for modems must be met as defined in Chapter 19, "Modems."

- For a network adapter, support is optional, rather than required, for remote new system setup capabilities. All other requirements for network communications must be met as defined in Chapter 20, "Network Communications."

Support for remote wake-up is not required to be built into mobile PCs. However, CardBus implementation that support the power management event (PME) signal meets this capability. For information about PME signal definition, see *PCI Bus Power Management Interface Specification for PCI to CardBus Bridge, Revision 1.0* or later.

6.14. Mobile system supports hot-pluggable devices and alternative network connections

Recommended

For a mobile system, the following are recommended design considerations:

- The system should support hot-pluggable and warm-pluggable devices that do not require a system reboot for insertion or removal.

  Guidelines are defined in requirement 3.19, "Hot-plugging capabilities for buses and devices meet PC 99 requirements."

- The system should include alternative methods for network connection, because a LAN or dialup connection might not always be available. Methods can include a floppy boot disk, PC Card network adapter, LAN on the system board, or docking to support remote new system setup.

6.15. Mobile system meets Mobile Power Guidelines '99

Recommended

The Mobile PC faces many power challenges in the future. The *Mobile Power Guidelines '99* are part of a comprehensive industry initiative that addresses these challenges to deliver mobile PCs that are high-performance, feature-rich, and power efficient.

For more information, see the *Mobile Power Guidelines '99, Revision 1.0* or later, available at http://developer.intel.com/design/mobile/intelpower/. Compliance with *Mobile Power Guidelines* will not become a requirement in future versions of these guidelines.

6.16. Mobile system includes CD or DVD drive

Recommended

Because of form factor constraints, a CD or DVD drive might not fit in a mobile PC.

If a CD drive is included in a mobile PC system or is designed as an add-on device to be attached to a mobile PC system, the minimum CD drive media transfer rate must be no less than 600 KB per second when running in the fully on (D0) state.

Recommended: The minimum CD drive media transfer rate for read operations should be 1200 KB per second or greater when running in the D0 state.

If a DVD drive is included in a mobile PC system or designed as an add-on device to be attached to a mobile PC system, there is no requirement for a minimum transfer rate. It is recommended that the device provide no less than 2 MB per second sustained rate anywhere on the disk media for read operations.

6.17. Mobile system meets Manageability Baseline requirements

Required if Windows NT is preinstalled

Mobile systems that come preinstalled with Windows NT must comply with the following PC 99 Manageability Baseline requirements, as defined in Chapter 3, "PC 99 Basic Requirements":

- 3.51, "System supports WHIIG"
- 3.52, "System includes driver support for WMI"
- 3.53, "Management information service provider enabled by default"

The following components of the Manageability Baseline are recommended for mobile PC systems:

- 3.54, "Expansion devices can be remotely managed"
- 3.55, "SMBIOS 2.2 static table support is provided"

Mobile PC Graphics Requirements

This section defines the specific requirements for graphics display capabilities on a mobile PC 99 system.

Unless an explicit exception is stated in this section, the PC 99 requirements apply for mobile PCs as defined in Chapter 14, "Graphics Adapters." However, if there is any conflict with requirements or recommendations stated elsewhere in this guide, the items in this section have precedence for mobile PCs.

6.18. Built-in display adapter meets Mobile PC 99 minimum capability
Required
For a mobile PC's external display support, the graphics subsystem must support the PC 99 requirements as defined in Chapter 14, "Graphics Adapters," with the exceptions noted in this section.

The built-in (internal) graphics adapter must support 2-D hardware acceleration, and the primary display surface must be a minimum of 800×600 resolution, with 1024×768 recommended.

If the built-in graphics adapter supports attaching an external display, the display surface must be supported by at least the following:

- All PC 99 required low resolution modes at 60 Hz or better VESA ergonomic timing rates (vertical refresh rate)
- The following minimum resolutions at 60 Hz VESA ergonomic timing rates:
  - 640×480: 8 bpp and either 15 bpp or 16 bpp
  - 800×600: 8 bpp and either 15 bpp or 16 bpp
  - 1024×768: 8 bpp

All minimum required resolutions must be non-interlaced and free from tearing.

Other non-required modes can be implemented at 60 Hz timing rates; double-buffering is not required. It is recognized that implementations of higher non-required resolutions on a mobile system can be interlaced and might not be free from tearing.

Mini-notebook Note   For mini-notebooks, the minimum required resolution for the primary display surface is $640 \times 480 \times 8$ bpp.

6.19. Built-in display adapter with 3-D hardware acceleration capabilities meets Mobile PC 99 minimum capability

Required

Hardware-accelerated 3-D is not a requirement for mobile PC platforms, although some systems are implementing 3-D support in the 1999 time frame. This requirement defines guidelines for mobile chipsets that use Direct3D capabilities.

If a mobile PC platform is designed to support hardware-accelerated 3-D using Direct3D, then the 3-D requirements for performance and features are required as defined in Chapter 14, "Graphics Adapters," with exceptions as defined in this section.

Mobile 3-D chip sets currently being introduced are limited to 2 MB of local frame buffer memory, and some will have all frame buffer in main memory.
To accommodate this, and because of the design constraints in the mobile platform, the following exceptions apply for 3-D hardware acceleration.

- Resolution for mobile PCs is required to be 640×480, rather than 800×600 required for desktop systems, 16 bpp, double-buffered with Z-buffer.

  No minimum texture cache is required.

  Recommended: Mobile systems that include 4 MB of local frame buffer memory should support the 3-D requirements at 800 x 600 resolution.

- Support is recommended but *not* required for alpha blending (both source and destination), specular highlighting, multi-texturing, anti-aliasing, depth-based fog, and per-vertex fog, as defined in requirement 14.27, "Hardware supports PC 99-required RGB rasterization."

- Hardware texture mapping is *not* required, as defined in requirement 14.31, "Hardware complies with texture size limitations."

These recommendations and exceptions apply individually; implementing a single recommended 3-D feature on a mobile system does not require implementing other recommended 3-D features.

6.20. Mobile system meets Mobile PC 99 requirements for supporting multiple adapters and multiple monitors

Required

Multiple adapter support is not required, unless the mobile system supports a full docking station with an additional graphics adapter or user-accessible capabilities for adding one or more graphics adapters.

If a full docking station is implemented, the mobile unit BIOS, graphics adapter, and driver must have support for multiple adapters as defined in the "Multiple-Adapter and Multiple-Monitor Support" section of Chapter 14, "Graphics Adapters." This support allows a user to add a graphics adapter in the docking station.

If the built-in graphics adapter supports attaching an external display, multiple monitor support is optional for the internal adapter. The primary and secondary display do not need to support independent or simultaneous displays, especially different resolutions of the same image. Compromises are acceptable: other graphics requirements do not need to be met while independent displays are attempted. For example, playing a 3-D game on the internal display while showing an MPEG movie on the external display does not need to perform to normal levels of acceptability or even work at all.

6.21. External graphics adapter interface supports DDC monitor detection
Required

Mobile systems are not required to support detection of the display based on the *Display Data Channel Standard, Version 3.0* (DDC) if the display is permanently attached and connected using an internal interface.

However, mobile systems must support DDC2B if an external graphics interface port is implemented. The complete PC 99 requirements are defined in requirement 14.13, "Adapter supports DDC monitor detection."

6.22. Mobile system with MPEG-2 or DVD playback features meets Mobile PC 99 requirements for video playback
Required

MPEG-2, DVD, and DVD playback features are not required for a mobile system.

However, if video playback capabilities are implemented, the mobile system must support the related requirements defined in Chapter 14, "Graphics Adapters," and Chapter 15, "Video and Broadcast Components," with the following exceptions:

- Support for the video overlay surface must include the following:
  - Support is required for only one of the YUV formats defined
  - Scaling is not required (including underscan, downscaling, overscan, and arithmetic stretching)
  - Overlay alpha blending in 32 bpp is not required, as defined in requirement 14.16, "Hardware supports alpha blending of graphics and video"
  - Other requirements apply as defined in requirement 14.14, "Hardware supports video overlay surface with scaling"
- IRQ support for a video port is recommended, rather than required. Other requirements apply as defined in requirement 14.17, "Video port meets PC 99 specifications if present on graphics adapter."

- PAL support is recommend, rather than required.

  Note: It is not possible to support all video components on PAL with only 2 MB of frame buffer memory.

- At least one of the following minimum video performance capabilities is required, in comparison to the performance requirements defined in Chapter 15, "Video and Broadcast Components":

  - 80 percent of the fields per second at full frame size
  - 50 percent horizontal and 50 percent vertical reduction in frame size at full fields per second

  However, if a mobile system meets the minimum performance requirements defined for an Office PC 99 system, then the performance standards apply as defined in requirements 15.19, "MPEG-2 MP@ML playback meets PC 99 requirements," and 15.21, " MPEG-2 video decode implementations meet PC 99 quality."

6.23. Mobile system with AGP supports meets Mobile PC 99 requirements
Required

If AGP support is implemented in a mobile PC system, it must meet the PC 99 requirements defined in requirement 14.51, "AGP meets PC 99 implementation guidelines," with these exceptions:

- A minimum speed of 1x is acceptable for mobile PCs.
- GART support is recommended, rather than required.

  If GART support is implemented on a mobile PC system, it must comply with the requirements specified in *AGP Interface Specification, Revision 1.0* or later.

Notice that an AGP implementation using a memory-mapped frame buffer (frame AGP) rather than GART does not support bus mastering.

6.24. System meets Mobile PC 99 requirements if television output is implemented
Required

Television output is not required for a mobile system. If this capability is implemented, the mobile system must support the requirements defined in Chapter 14, "Graphics Adapters," with the following exceptions:

- The television output adapter must use 2-tap minimum hardware filtering techniques for flicker reduction. All other requirements are as defined in item 14.38, "Adapter supports flicker filter."
- It is acceptable for television output to be enabled manually. Mobile PCs are not required to support automatic default boot mode as defined in requirement 14.36, "Default boot mode supports appropriate locale."

6.25. Built-in mobile display supports ICC color management

Required

This capability is required for mobile flat-panel displays, as defined in requirement 16.2, "Monitor supports Integrated Color Management."

The OEM must preinstall an INF and International Color Consortium(ICC) profile for the LCD display if it cannot be detected using DDC or other standard mechanisms. Notice that for model variations that use more than one type of panel, the end-user will have to select the correct panel during Setup if the panel is not DDC compliant. For information, see the color management information available from the web site at http://www.microsoft.com/hwdev/devdes/icm.htm.

Docking Station Requirements

Mobile PC docking systems allow docking of a PC, with additional hardware capabilities. A docking station allows the end user to add other devices to the mobile PC system—for example, sound, network adapter, hard disks, CD drive, different display adapter, SCSI, modems, and so on.

Docking systems can support hot, warm, or cold docking. Warm docking refers to docking and undocking the mobile PC while the system is in a low power state (as defined in the ACPI 1.0 specification) but is not powered off. Hot docking refers to docking and undocking the mobile PC while the system is operating at full power and is in an active working state.

Resource conflicts can occur when a mobile PC is paired with a docking station that allows users to add non-proprietary expansion cards to the system. For a mobile PC and docking station pair, the system designer must ensure that the docking system is capable of arbitrating resources for conflicts that might occur if an expansion card is added to the docking station. However, the system designer does not need to add to the mobile PC unit all of the PC 99 resource-arbitration capabilities.

The requirements in this section apply for mobile designs that include a docking station. There is no requirement that a mobile PC must have a docking station.

Docking Definitions

This section defines the these types of docking modules that interface to a mobile PC platform.

- **Mini-Dock:** A mini-dock provides external cable connections as an extension of the connector receptacles on the mobile PC unit. A mini-dock also incorporates some form of active electronics to create extended mobile PC platform features and functions. The added active electronics might provide additional user-accessible CardBus slots, communication receptacles, or both, such as RS-232, IEEE 1284, IEEE 1394, and so on. The mini-dock does not provide user-accessible PCI slots, but might provide internal PCI expansion capabilities accessible only to the OEM.

  A mini-dock does not have internal user-upgradable capabilities for adding desktop peripherals or I/O expansion cards. Hence, a mini-dock can be considered a "sealed" docking station, where all expansion capabilities are provided using external expansion ports, so that the operating system always knows what to expect about available devices. However, this does not preclude designs that include internal components that can be upgraded by the OEM or trained service personnel.

- **Docking Station:** A docking station, when interconnected with the mobile PC platform, is typically designed to extend the features and functions of the mobile PC to be equivalent to that of a desktop platform system. Requirements and specifications for features and functions available when a mobile PC platform has been interconnected with a docking station are, typically, the same as those for a desktop platform system.

A docking station incorporates native bus expansion slots. It is user expandable to include desktop peripherals and expansion cards.

General Docking Requirements

The methods for the following dock identification scenarios can be supported by the system BIOS, which requires a mobile system to be aware of each type of docking station and features it supports, or by the docking station itself, which could contain the ACPI table needed to differentiate the model, unique ID, and features in the dock. Either method would allow the system BIOS to pass this information to the operating system without actually having to support every conceivable combination.

Windows NT 5.0 requires that drivers for devices in a dock must fully support dynamic loading and unloading, as well as all Windows NT 5.0-based power management and Plug and Play messages. In certain designs, some devices that are normally considered system devices can be treated as static devices.

In the case of a desktop system, static devices might not necessarily have to have their driver be capable of dynamically unloading, for example, a custom keyboard driver or custom storage driver. However, in some docking designs, such devices are sometimes "mirrored" in a docking station. Under these conditions, the driver must be able to be unloaded dynamically; otherwise, the operating system cannot stop the device, preventing a mobile ejection.

6.26. System supports PCI docking through a bridge connector

Recommended

The system should support docking through a bridge connector, with the actual bridge on the docking station and not on the mobile unit. The bridge can be positive or subtractive decoding. The bridge should create a new bus number, assuring that devices behind the bridge are not on the same bus number as other devices in the system.

After a warm dock, the BIOS should not configure the bridge or any other devices in the docking station. Configuring the docking station devices is the responsibility of the operating system.

Notice that implementing delayed transactions for PCI-to-PCI docking bridges is required in PCI 2.1 or later only when certain timing conditions are not met. For PC 99 design requirements, this is interpreted to mean that delayed transactions are required only when "targets cannot complete the initial data phase within the requirements of this specification," as stated in PCI 2.1 or later. Delayed transactions, which provide a performance advantage, are a hardware-related timing issue; they are not related to operating system requirements.

6.27. Docked mobile PC supports state change notification using ACPI
Required

When a mobile PC is "docked" to a mini-dock or docking station, specific notification must be made using ACPI methods to enable the operating system to properly change states or enumerate new devices that appear in the system. This notification must occur during a "hot" docking event or when the system returns from a warm or cold dock.

All notification events and docking control must be implemented as defined in Sections 5.6.3 and 6.3 of the ACPI 1.0 specification.

6.28. Docked mobile PC has the ability to identify the specific model of the dock
Required

The system must be capable of uniquely identifying to the operating system a specific system configuration. Each separate system in the same model line should have a unique ID. This is to prevent the problems with current implementations that require the operating system to "cycle" different docking profiles at every docking event to try to identify what specific model of dock is attached.

6.29. Docked mobile PC has the ability to uniquely identify the dock
Required

The system must be capable of uniquely identifying an individual dock. This allows support for users that dock laptops into differently configured docks to have different features or settings at different locations and again prevents the operating system from unnecessary enumeration of the system on docking events.

6.30. Mobile PC/docking station combination meets PC 99 requirements
Required

There is no requirement that a mobile PC must have a docking station.

However, if a mobile PC supports a docking station, manufacturers must submit the combined docking station and mobile PC for PC 99 compatibility testing, and this combination must pass testing.

The docking unit must be able to power the mobile system and charge the mobile system's battery under the control of the mobile system.

Some PC 99 requirements might apply to a mobile PC/docking station combination that do not apply to the mobile PC as a standalone unit. The intent for PC 99 is that such requirements apply only because of facilities present in the docking station. For example, if a docking station provides graphics capabilities that substitute for the graphics capabilities of the mobile unit, the PC 99 graphics requirements apply for the mobile PC/docking station combination when the substituted graphics component is in use. If the mobile PC is supplying all graphics capabilities, then Mobile PC 99 graphics requirements still apply.

This does not require that all new PC 99 mobiles that have docking station support automatically have new docking station designs designed to meet PC 99 requirements. PC 99 mobile PCs can support docking stations that have already been tested to meet earlier design guideline requirements. The combination of a PC 99 mobile and an earlier design docking station must still be submitted for testing, and general system requirements still apply. The relevant requirements in this case are the following:

- The user cannot experience resource conflicts.
- All drivers for earlier docking stations must be updated as necessary to support the pre-installed operating system.

For example, in order for older docking stations to work properly with a PC 99 mobile PC running Windows NT 5.0, all drivers must be updated to support dynamic loading, Plug and Play, and power management messages. This does not imply that new features must be added, but rather that the mobile system/ operating system combination must have full control over the features in the docking station.

This exception does not imply that a new docking station can comply with a reduced set of PC 99 requirements based on an earlier design guideline. If a docking station is a new design released during the time that this design guide is in effect, such combinations of mobile and docking station must meet all PC 99 requirements.

6.31. Docking station meets all PC 99 system requirements
Required

All basic PC 99 requirements must be met by the dock and its devices, as defined in Chapter 3, "PC 99 Basic Requirements." These include requirements for ACPI, Plug and Play, power management, and bus and device specifications.

The docking station must meet the PC 99 BIOS requirement for multiple adapters and multiple monitors, which allows for the graphics capabilities in the mobile unit to be fully operational (either the LCD panel or external connector) in the event that a user adds another graphics adapter to the docking station.

Many docking stations support VCR-style docking in which the notebook is closed when docked, so the user is prevented from accessing the notebook display. It is recommended that users not be precluded from accessing their notebook display when docked and that users have the option of simultaneously using the main display on the docking station and the notebook display.

Windows NT 5.0 is designed such that all devices on a docking station (whether built in or added on) must be Plug and Play devices, either based on ACPI or a bus standard described in the PC 99 guidelines.

Note: ISA slots are not allowed in docking stations, as defined in requirement 3.28, "System does not include ISA expansion devices or slots."

6.32. Mobile/docking station interface is supported using ACPI-defined mechanisms

Required

The mobile unit must provide docking notification using mechanisms defined in the ACPI 1.0 specification. Non-Plug and Play devices must be enumerated, configured, and disabled using ACPI-based methods. All notification events and docking control must be implemented as defined in Sections 5.6.3 and 6.3 of the ACPI 1.0 specification.

6.33. Mobile PC/docking station combination supports automatic resource assignment and dynamic disable capabilities

Required

The mobile PC unit that is part of a docking system does not require all of the resource-arbitration capabilities required for expandable PC systems. However, the system as a whole must be capable of completely and dynamically disabling static onboard and add-on devices, and of freeing all the resources used by that device when the mobile unit is docked.

This requirement applies for all Plug and Play devices, but excludes fixed-resource devices such as the DMA controller, interrupt controller, and so on, as summarized in requirement 3.12, "Each bus and device meets Plug and Play specifications."

With this capability, individual devices in the mobile PC can be disabled when the unit is docked, allowing the appropriate devices in the docking station to be enabled. The system could fail if an add-on card requires resources that conflict with a device on either the mobile PC or the docking station. The mobile PC/docking station combination must be able to resolve resource conflicts among all the devices in the docking system.

This means that docking station devices must be available to replace disabled devices in the mobile PC, and these devices must meet the basic Plug and Play resource arbitration requirements for PC 99, as described in the "PC 99 General Device Requirements" section in Chapter 3, "PC 99 Basic Requirements." However, it is up to the design engineer of a mobile PC/docking station combination to determine which component (mobile PC or docking station) will resolve the conflict when the mobile unit is docked.

For more information about resource arbitration when two devices such as two keyboards or two mice are present, see requirement 13.49, "Dynamic resource configuration is supported for all devices."

Note: Under Windows NT 5.0, drive letter assignments will not change when drives are added or removed by way of a docking event. That is, all drives in the mobile PC will retain their originally assigned drive letters. Designers should note this differing capability in comparison with Windows 95/98.

6.34. Docking station supports warm docking

Required

Recommended: Support hot docking.

Docking or undocking a mobile unit from a docking station must not require powering off the system and must not require a system reboot.

Removable ATA devices in the docking station and the mobile unit are required to report changes using ACPI-based methods.

6.35. Docking system supports fail-safe docking

Required

The system must provide a fail-safe mechanism for attaching and detaching the mobile unit. The mechanism, in combination with operating system capabilities and methods defined in Sections 6.3 and 5.63 of the ACPI 1.0 specification, must ensure the following:

- The undock button signals the user's intent to the system.
- Docking can occur only when the mobile unit is in the correct power state. The power state depends on whether the system is designed to support cold, warm, or hot docking.
- The user can initiate undocking through Windows-based software choices. Notice, however, that a hardware "button" must also be provided, because experience shows that users often do not find the software option and remove mobile units without operating system notification.

- The undock button or software choice sends a signal to the operating system so that the user is warned if resources are in danger of being lost.

- A safe-undock indicator is provided so the user can identify when it is safe to remove the mobile unit. This can be an LED or any other mechanism chosen by the vendor. If a physical mechanism automatically undocks the mobile PC or if hot docking is supported, then the safe-undock indicator is not required.

There is no requirement for mechanical lockout to block the user from removing the mobile unit without operating-system notification.

6.36. Docking station includes an IEEE 1394 port
Recommended
it is recommended that the docking station include at least one IEEE 1394 port, as defined in requirement 3.26, "System includes support for IEEE 1394." Requirements for implementing IEEE 1394 on a docking station are defined in Chapter 8, "IEEE 1394."

6.37. Docking station/mobile pair meets PC 99 audio requirements
Recommended
If audio is implemented, the docking station/mobile PC pair must meet the requirements for PC 99 audio as defined in Chapter 17, "Audio Components," with additional requirements as follows:

- The user must be able to select speakers in the mobile unit or the docking station.

- The docking station is not required to implement full desktop audio capabilities, but it can supplement the audio capabilities of the mobile unit.

Mini-Dock Requirements

A mobile PC with a mini-dock does not need to meet the expansion card require-ments and does not need to meet all the resource requirements of a mobile PC/docking station combination. A mini-dock is not required to provide an undock or eject button.

However, some mobile PC system designs include a mini-dock that has dedicated features for networking, additional CardBus slots, a CD drive, and so on. This means that the system could have additional resource requirements to the point that all available IRQs in the system are already allocated; in this case, the CardBus slots (for example) would not have any IRQs available, rendering them useless.

In such cases, the mini-dock must contain devices that replace any devices in the mobile PC that do not meet the IRQ, DMA, I/O port, and memory requirements for PC 99. This allows the operating system to disable the device on the mobile PC, to enable the corresponding device on the mini-dock, and then to arbitrate resources among the remaining devices in the mobile unit and on the mini-dock.

The requirements in this section apply for any mini-dock designed for a PC 99 mobile PC. There is no requirement that a mobile PC must have a mini-dock.

6.38. Mini-dock supports automatic resource assignment and dynamic disable capabilities for replacement devices

Required

A mini-dock that can accept expansion cards must contain devices that replace any devices in the mobile PC not meeting PC 99 requirements for IRQ, DMA, I/O port, and memory resources. This allows the operating system to disable the device on the mobile PC, enable the corresponding device on the mini-dock, and arbitrate resources among the remaining devices in the mobile unit and on the mini-dock.

Devices in the system must be capable of being dynamically disabled so that the user can choose to free resources in order to allow other devices in the system to function.

Tip: To avoid resource shortages, the system designer can take advantage of the capability of Yenta-compliant CardBus controllers' capability to assign a shared PCI interrupt for R2 PC Cards, rather than using IRQs, as defined in requirement 12.23, "PC Card 16 card driver supports sharing of level-mode interrupts." For information, see the related article at http://www.microsoft.com/hwdev/cardbus/.

6.39. Mini-dock supports warm docking

Required

Docking or undocking a mobile unit from a mini-dock must not require powering off the system and must not require a system reboot.

Removable ATA devices in the mini-dock and the mobile unit are required to report changes using ACPI-based methods.

6.40. Mini-dock supports fail-safe docking

Required

The system must provide a fail-safe mechanism for attaching and detaching the mobile unit. The mechanism, in combination with operating system capabilities and methods defined in Sections 5.63 and 6.3 of the ACPI 1.0 specification, must ensure the following:

- Docking can occur only when the mobile unit is in the correct power state. The power state depends on whether the system is designed to support cold, warm, or hot docking.
- The mini-dock has an undock button that signals the user's intent to the system.
- The user can initiate undocking through a Windows-based software choice or the hardware undock button. Either choice must cause a signal to be sent to the operating system so that the user is warned if resources are in danger of being lost.
- A safe-undock indicator must be provided so the user can identify when it is safe to remove the mobile unit. The indicator can be an LED or any other mechanism chosen by the vendor. If a physical mechanism automatically undocks the mobile PC or if hot docking is supported, then the safe-undock indicator is not required.

There is no requirement for mechanical lockout to block the user from removing the mobile unit without operating system notification.

6.41. Mini-dock includes an IEEE 1394 port

Recommended

The mini-dock can include a IEEE 1394 port. Requirements for implementing IEEE 1394 on a mini-dock are defined in Chapter 8, "IEEE 1394," with the exceptions defined in requirement 6.7, "Mobile PC includes an IEEE 1394 port."

Recommended: If the mini-dock includes IEEE 1394 capabilities and has a combination of more than one internal and external ports, the mini-dock should maintain its source of power when the mobile PC unit is removed from the mini-dock.

Mini-notebook Guidelines

This section summarizes specific requirements for mini-notebook mobile PCs. A mini-notebook is defined as a system that has a carry weight of three pounds or less, including all hardware required to run the Windows operating system.

6.42. Mini-notebook performance meets PC 99 minimum requirements
Required

For mini-notebook systems, the minimum PC 99 performance requirements consist of the following:

- System includes all functionality required to run the Windows operating system.
- System can support synchronization of personal information management (PIM), file, and e-mail with a PC 99 desktop system.

  This connectivity requirement can be satisfied by the inclusion of one or more of the following components: parallel port, serial port, IrDA port, USB, CardBus, modem, LAN, or wireless connection.

- Minimum required CPU performance is 233-MHz processor with no L2 cache.
- Minimum required system memory is 16 MB.

  The PC 99 basic system requirements apply: no more than 4 MB of system memory can be locked and unavailable to the operating system.

- Minimum required primary display surface is 640 × 480 × 8 bpp.

  Compliance with 15-bpp or 16-bpp specifications is recommended.

All other Mobile PC 99 and PC 99 basic system requirements beyond those listed here as the minimum requirements are optional for mini-notebooks, including the requirement for supporting an external keyboard and point device or ICC color management.

Mobile PC 99 References

The following represents some of the references, services, and tools available to help build hardware that is optimized to work with Windows operating systems.

Advanced Configuration and Power Interface Specification, Revision 1.0
    http://www.teleport.com/~acpi/

Accelerated Graphics Port Interface Specification, Revision 1.0
    http://developer.intel.com

El Torito—Bootable CD-ROM Format Specification, Version 1.0
Compaq, Intel, Phoenix BIOS Boot Specification, Version 1.01
    http://www.ptltd.com/techs/specs.html

Intel hardware developer site
    http://developer.intel.com

Microsoft Windows 98 DDK and Windows NT 5.0 DDK
    MSDN Professional membership

Mobile Power Guidelines '99, Revision 1.0
    http://developer.intel.com/design/mobile/intelpower/

PCI Revision 2.1 or later
*PCI Bus Power Management Interface Specification for PCI to CardBus Bridge,
    Revision 1.0*
    http://www.pcisig.com

Plug and Play specifications
    http://www.microsoft.com/hwdev/respec/pnpspecs.htm

Smart Battery Charger Specification, Version 1.0
Smart Battery Data Specification, Version 1.0
Smart Battery Selector Specification, Version 1.0
Smart Battery System Specification, Version 1.0
    http://www.sbs-forum.org

Checklist for Mobile PC 99

If a recommended feature is implemented, it must meet the PC 99 requirements for that feature as defined in this document.

6.1. Mobile PC performance meets Mobile PC 99 minimum requirements
Required

6.2. Mobile PC supports Smart Battery or ACPI Control Method battery
Required

6.3. Expansion capabilities of mobile PC are accessible to users
Required

6.4. Mobile PC connections use icons plus keyed or shrouded connectors
Required

6.5. Mobile PC includes one USB port
Required

6.6. USB-connected device does not maintain fully on power state
Required

6.7. Mobile PC includes an IEEE 1394 port
Recommended

6.8. Mobile PC includes CardBus
Required

6.9. Mobile PC keyboard and pointing device meet PC 99 requirements
Required

6.10. Mobile PC includes IR devices compliant with IrDA specifications
Recommended

6.11. Mobile PC includes support for installing the operating system
Required

6.12. Mobile PC includes audio that meets Mobile PC 99 audio requirements
Recommended

6.13. Mobile PC includes communications device
Recommended

6.14. Mobile system supports hot-pluggable devices and alternative network connections
Recommended

6.15. Mobile system meets Mobile Power Guidelines '99
Recommended

6.16. Mobile system includes CD or DVD drive
Recommended

6.17. Mobile system meets Manageability Baseline requirements
Required if Windows NT is preinstalled

6.18. Built-in display adapter meets Mobile PC 99 minimum capability
Required

6.19. Built-in display adapter with 3-D hardware acceleration capabilities meets Mobile PC 99 minimum capability
Required

6.20. Mobile system meets Mobile PC 99 requirements for supporting multiple adapters and multiple monitors
Required

6.21. External graphics adapter interface supports DDC monitor detection
Required

6.22. Mobile system with MPEG-2 or DVD playback features meets Mobile PC 99 requirements for video playback
Required

6.23. Mobile system with AGP supports meets Mobile PC 99 requirements
Required

6.24. System meets Mobile PC 99 requirements if television output is implemented
Required

6.25. Built-in mobile display supports ICC color management
Required

6.26. System supports PCI docking through a bridge connector
Recommended

6.27. Docked mobile PC supports state change notification using ACPI
Required

6.28. Docked mobile PC has the ability to identify the specific model of the dock
Required

6.29. Docked mobile PC has the ability to uniquely identify the dock
Required

6.30. Mobile PC/docking station combination meets PC 99 requirements
Required

6.31. Docking station meets all PC 99 system requirements
Required

6.32. Mobile/docking station interface is supported using ACPI-defined mechanisms
Required

6.33. Mobile PC/docking station combination supports automatic resource assignment and dynamic disable capabilities
Required

6.34. Docking station supports warm docking
Required

6.35. Docking system supports fail-safe docking
Required

6.36. Docking station includes an IEEE 1394 port
Recommended

6.37. Docking station/mobile pair meets PC 99 audio requirements
Recommended

6.38. Mini-dock supports automatic resource assignment and dynamic disable capabilities for replacement devices
Required

6.39. Mini-dock supports warm docking
Required

6.40. Mini-dock supports fail-safe docking
Required

6.41. Mini-dock includes an IEEE 1394 port
Recommended

6.42. Mini-notebook performance meets PC 99 minimum requirements
Required

C H A P T E R   7

USB

This chapter presents the requirements and recommendations for Universal Serial Bus (USB).

USB provides an expandable, hot-pluggable Plug and Play serial interface that ensures a standard, low-cost socket for adding external peripheral devices ranging from interactive HID devices such as joysticks and pointing devices to isochronous devices such as telephony, audio, and imaging devices. USB allows cascading hubs that can be integrated into desktop devices such as monitors and keyboards.

USB is required on all PC 99 systems, and migration of I/O devices from legacy ports to USB is recommended. In particular, the joystick, pointing device, and keyboard devices that ship with PC systems should be USB.

Any device that plugs into a USB port is considered a USB device and must comply with the requirements defined in these guidelines. If the device provides the capabilities of one or more functions or it provides a hub to the host, it must comply with the requirements in this chapter.

Manufacturers should ensure that their USB devices are tested at the compatibility workshops provided by the USB Implementers Forum.

Contents

USB Basic Requirements

This section summarizes the basic USB design requirements.

7.1. System includes USB with two USB ports, minimum
Required for all system types, with exceptions for mobile PCs
USB must be included on all PC 99 system types.

Mobile PC Note   At least two USB ports are required for every system type except Mobile PC, which must include at least one USB port. USB support must be provided for the full bandwidth specified in the *USB Specification, Version 1.0* or later.

When a system has more than one host controller, each host controller must provide full bandwidth and isochronous support. Host controllers should be located on the PCI bus to meet this requirement.

7.2. Systems include BIOS support for USB keyboards and hubs
Required
PC 99 systems, except those with captive keyboards, such as a mobile PC system, must have BIOS support for USB keyboards and hubs. This support must provide the ability for the user to enter the BIOS setup utility and also provide enough functionality to install and boot a USB-aware operating system. USB keyboards built as standalone devices, part of a composite device, or part of a compound device must all be recognized and usable. The BIOS is required to support keyboards behind at least one level of external hubs.

For systems with multiple USB host controllers, BIOS support for USB keyboards and hubs is required for at least one of the host controllers.

7.3. All USB hardware complies with USB 1.0 specification
Required
Recommended: All USB hardware complies with USB 1.1 specification.

All USB hardware must comply with *USB Specification, Version 1.0,* and should comply with *USB Specification, Version 1.1.* Compliance with the USB specification ensures that USB hardware has complete Plug and Play capabilities and is implemented in a standard way. Compliance with this requirement is demonstrated on the compliance process of the USB Implementers Forum.

For example, on any system with USB capabilities, a user must be able to dynamically attach any USB peripheral to any USB connector. The operating system should automatically recognize it, load and initialize the appropriate drivers, and make the device available for use.

7.4. Connections use USB icon

Required

USB icons are required for external cables, connecting cables, and connection ports. The icon can be molded, printed, or affixed as a permanent sticker. Because the location and number of USB ports can vary, appropriate icons on ports and cables are important ease-of-use factors.

Icons can be based on vendor designs or vendors can use the recommended USB icon defined in Chapter 6 of the USB 1.1 specification and illustrated here:

> The USB icon should be molded into the connector and also placed on the product for ease of identifying the USB port. It is recommended that the icon on the product and the one on the plug be adjacent to each other when the plug and receptacle are mated. This icon can be used for both series A and B connector schemes. On the plug, there should be a 0.635-mm rectangular recessed area around the icon such that there is a perceptible feel of the icon.

7.5. Devices and drivers support maximum flexibility of hardware interface options

Required

Device and driver designs must provide maximum flexibility for interface options so that the operating system or other resource manager can coordinate user preferences, allowing multiple devices and applications simultaneously.

- **7.5.1. Devices and drivers provide multiple alternate settings.** Devices and drivers must provide multiple alternate settings for each interface where any alternate setting consumes isochronous bandwidth.

- **7.5.2. Devices and drivers must not use isochronous bandwidth for alternate setting 0.** Devices should consume bandwidth only when the device is being used.

USB Host Controller Requirements

This section summarizes USB class specifications and standards for host controllers.

7.6. USB host controller meets either OpenHCI or UHCI specification
Required

The host controller must comply with the specifications for either *Open Host Controller Interface* (OpenHCI), published by Compaq, Microsoft, and National Semiconductor, or *Universal HCI* (UHCI), published by Intel. Hardware manufacturers who design to one of these specifications are not required to provide an additional device driver for their host controller under the Windows or Windows NT Workstation operating systems.

Multiple OpenHCI and UHCI USB controllers are supported concurrently by the operating system.

7.7. USB host controller can wake the system
Required

The USB host controller must support wake-up capabilities in at least one of the following system states: S1 or S2. Supporting wake-up from the S3 state is recommended. Notice that if wake-up from the S2 state is supported, wake-up from the S1 state must also be supported. Similarly, if wake-up from the S3 state is supported, wake-up from the S1 and S2 states must be supported.

Supporting wake-up from S3 is expected to become a requirement in future versions of these guidelines.

If the system contains multiple USB host controllers, only one is required to support wake-up capability, although it is recommended that all host controllers support wake-up capability.

USB Hub Requirements

This section summarizes USB class specifications and standards for hubs.

7.8. USB hubs comply with USB 1.1 specification
Recommended

The *USB Specification, Version 1.1*, defines requirements for USB hubs that resolve some ambiguities and other problems in the original 1.0 specification.

7.9. Bus-powered USB hubs provide ports that can be individually power switched

Recommended

To minimize USB power consumption requirements, bus-powered hubs must provide ports that can be individually power switched. This contributes to the goal of reducing overall system power consumption. It is especially important in mobile environments, where power consumption must be absolutely controlled when the system is on battery power.

USB Power Management

This section summarizes the specific USB power management requirements.

7.10. Systems and devices comply with USB power management requirements

Required

PC 99 systems and devices must comply with the power management requirements in the *USB Specification, Version 1.0* or later.

In addition, all devices must comply with the Interface Power Management feature in the *USB Common Class Specification, Revision 1.0* or later.

Design Features for USB Peripherals

This section summarizes requirements related to bus-class specifications and standards for peripherals that use USB.

7.11. USB devices meet requirements in related USB device class specification

Required

A USB peripheral that fits into one of the USB device class definitions must comply with the related USB device class specification. USB class drivers in the operating system are implemented to support devices that comply with the particular device class specification.

Class driver extensions and WDM support provided in Windows 98 and Windows NT 5.0 allow IHVs to innovate and differentiate their products while still meeting class compliance in their base operational modes.

Devices can use the generic class drivers provided with the operating system, or manufacturers can create drivers or WDM minidrivers, depending on the device class, to exploit any additional unique hardware features.

USB References

The following represents some of the references, services, and tools available to help build hardware optimized to work with Windows operating systems.

Default Device Power Management Specification, Version 1.0, and other
   device class power management specifications
      http://www.microsoft.com/hwdev/onnow.htm

Intel information about USB, including the UHCI design guide for USB
      http://developer.intel.com/design/litcentr/
      http://developer.intel.com/design/usb/

Microsoft Windows 98 DDK and Windows NT 5.0 DDK
      MSDN Professional membership

OpenHCI: Open Host Controller Interface Specification for USB, Release 1.0a
      http://www.microsoft.com/hwdev/respec/

USB Class Definition for Communications Devices, Version 1.0
USB Common Class Specification, Revision 1.0
USB Device Class Definition for Audio Devices, Version 0.9
USB Device Class Definition for Human Interface Devices (HID), Version 1.0
USB Device Class Definition for Mass Storage Devices, Revision 1.09
USB Device Class Definition for Printing Devices, Version 1.0
USB HID Usage Tables, Version 1.0
USB Monitor Control Class Specification, Revision 1.0
USB PC Legacy Compatibility Specification, Revision 0.9
USB Usage Tables for HID Power Devices, Release 1.0
USB Specification, Version 1.0 and later
      http://www.usb.org/developers/

USB Implementers Forum
      Phone: (503) 264-0590
      Fax: (503) 693-7975
      http://www.usb.org

White papers and guidelines for Microsoft operating systems
      http://www.microsoft.com/hwdev/usb/

Checklist for USB

If a recommended feature is implemented, it must meet the PC 99 requirements for that feature as defined in this document.

7.1. System includes USB with two USB ports, minimum
Required for all system types, with exceptions for mobile PCs

7.2. Systems include BIOS support for USB keyboards and hubs
Required

7.3. All USB hardware complies with USB 1.0 specification
Required

7.4. Connections use USB icon
Required

7.5. Devices and drivers support maximum flexibility of hardware interface options
Required

7.6. USB host controller meets either OpenHCI or UHCI specification
Required

7.7. USB host controller can wake the system
Required

7.8. USB hubs comply with USB 1.1 specification
Recommended

7.9. Bus-powered USB hubs provide ports that can be individually power switched
Recommended

7.10. Systems and devices comply with USB power management requirements
Required

7.11. USB devices meet requirements in related USB device class specification
Required

C H A P T E R   8

IEEE 1394

This chapter summarizes PC 99 design requirements for hardware designed using the current IEEE 1394 standards. The IEEE 1394 high-speed serial bus complements USB by providing enhanced PC connectivity for a wide range of devices, including consumer audio/video (A/V) components, storage peripherals, other PCs, and portable devices.

IEEE 1394 has been adopted by the consumer-electronics industry and is expected to provide a volume, Plug and Play-compatible expansion interface for the PC. The 100-Mb/s, 200-Mb/s, and 400-Mb/s transfer rates currently specified in IEEE P1394.a and the proposed enhancements in IEEE P1394.b are well suited to multistreaming I/O requirements.

Contents

IEEE 1394 Basic Requirements

The following is a summary of the IEEE 1394 design considerations related to PC systems, as addressed in this chapter:

- Compliance with IEEE 1394 standards, specifically IEEE 1394-1995 and IEEE P1394.a

- Support for the 1394 Open Host Controller Interface (OpenHCI) specification for controllers, specifically OHCI Revision 1.0

- Plug and Play support for device configuration, control and status registers (CSRs), connectors and cabling, and connection fault handling

- Cable power distribution, including requirements for source devices, sink devices, self-powered devices, and supporting CSRs

- Device power management, CSRs, and soft-power protocols

- Device command protocols for audio, video imaging, still imaging, and storage device classes

This section defines the basic PC 99 requirements for IEEE 1394.

8.1. Controllers and devices support mandatory features in IEEE P1394.a with backward compatibility with IEEE 1394-1995

Required

Designs that interface to the IEEE 1394 bus must support the following industry standards and supplemental specifications:

- IEEE 1394-1995 standard

- IEEE P1394.a, an amendment to IEEE 1394-1995

- IEEE 1212-1991 and function discovery in IEEE 1212-199x

8.2. Controllers comply with OpenHCI for IEEE 1394

Required

The 1394 OpenHCI Revision 1.0 specification for IEEE 1394 defines standard hardware and software for PC connections to the IEEE 1394 bus. OpenHCI defines standard register addresses and functions, data structures, and DMA models. The benefits of this standard include improved performance, security, and error handling.

A 1394 OpenHCI device is bus manager-capable, including bus mastering for BANDWIDTH_AVAILABLE and CHANNELS_AVAILABLE registers.

Host adapters and host controllers must implement the mandatory features of 1394 OHCI Revision 1.0, including support for a minimum of four isochronous transmit contexts, four isochronous receive contexts, two asynch transmit contexts, two asynch receive contexts, self ID context, and physical DMA.

Devices besides bus managers and bus controllers that implement IEEE 1394 are not required to implement an OpenHCI-compliant host controller in their Link.

8.3. OpenHCI controllers and devices support advances defined in IEEE P1394.a

Required

The advances in the IEEE P1394.a specification enhance system performance and integration of component systems. The mandatory features specified in IEEE P1394.a must be supported by all host controllers, peripherals, and Link and physical layer device (PHY) components. Mandatory IEEE P1394.a features that must be supported by all devices and controllers include:

- S100–S400 operation of all PHY ports in host controllers
- S100–S400 operation of all device-side PHYs
- PHY autonomous features for connection debounce and hysterisis
- Arbitration enhancements that promote a high quality of operation and end-user experience

8.4. Host supports peak data rate of 400 Mb/s, minimum

Required

The integration of component systems that enable concurrent applications demands minimum bandwidth for an effective user experience. A peak data rate of 400 Mb/s is required of all host controllers and PHY ports available externally in the system for 1999. The host controller must support 100-Mb/s, 200-Mb/s, and 400-Mb/s data rates as specified in IEEE 1394-1995 and IEEE P1394.a. All externally-accessible host controller ports must support S100-400 operation.

8.5. Design avoids excessive currents resulting from ground-fault potential among devices

Recommended

PC-based peripherals are not required to implement isolation because of the usual assumption of a common green-wire ground for all linked devices. Accordingly, the requirement for electrical isolation has been targeted for removal from the IEEE standard. If optional galvanic isolation is implemented, it should conform to the P1394.a specification, which replaces references in IEEE 1394-1995 Annex A and Annex J.6. Power supply, PHY power, connector power, and cable power isolation with appropriate ground returns for signal ground and power "green wire ground." Systems that could connect to devices or other systems where a ground fault potential can exist should implement good isolation design practices.

Other bodies, such as IEC, UL, and ANSI, govern safety and regulatory considerations for computers, networks, and consumer electronics devices. IEEE 1394 systems and devices should conform to the appropriate safety and regulatory concerns in this area. The exact specification for each class of device or system is outside of the scope of this design guide.

For local area network (LAN) configurations, it is desirable to avoid excessive currents resulting from ground-fault potential among devices. The related design problem can be solved for such configurations by building isolation into the power supply and by AC coupling of the PHY and Link interface of selective AC-powered subsystems.

Requirements for IEEE 1394 Devices

This section summarizes additional requirements for IEEE 1394 peripherals such as consumer-electronics devices.

8.6. Device command protocols conform to standard device class interfaces
Required

IEEE 1394 storage class devices must conform to the IEC 61883 standards for the CIP (Common Isochronous Packet) format, the CMP (Connection Management Procedures) procedures, and the FCP (Function Command Protocol) protocols.

8.7. Devices support peak data rate of 400 Mb/s, minimum
Required

For PC 99 designs, S400 IEEE 1394 devices are recommended; S100 devices are strongly discouraged; and S200 devices should limit their peak bus utilization to less than 50 percent.

For a device with more than one port, each port must support S100, S200, and S400 PHY operations. All new peripherals and systems should use S400 PHY ports. Existing devices using only S100 or S200 PHY ports are acceptable.

Also, application bandwidth can be limited by speed traps (a slow device separating two faster devices), which impose speed-dependent cabling considerations on the end user.

8.8. Devices requiring support for high-bandwidth data transfer use IEEE 1394
Recommended

For devices that require support for high-bandwidth data transfers and Plug and Play connectivity, the IEEE 1394 bus is recommended. Such devices include the following:

Archival storage (tape, high density disk, cartridge, or other removable memory media)	DVD and CD drives
	Hard disk drives
	High-resolution scanners Magneto-optical devices
Component audio	
Connectivity peripherals	PC docking stations
Digital camcorder	Printers
Digital VCR	Set-top television controllers
DTV	Video conferencing cameras

Plug and Play for IEEE 1394

This section summarizes the Plug and Play requirements for IEEE 1394 peripheral devices and PC host controllers.

8.9. Plug and Play devices demonstrate interoperability with other devices
Required

All devices must support Plug and Play for intended applications in both a minimal and an extended bus configuration. A minimal configuration is the minimum number of devices necessary to demonstrate the primary application of the device. An extended configuration is an advanced application with at least two devices added to the minimal configuration. The added devices can be extraneous to the application.

The following is a summary of compliance testing guidelines for this requirement:

- Intended applications must be documented before testing.

- Both test configurations must consist of a core matrix of stable devices that have demonstrated full interoperability in the absence of the test device. To be included in the core test matrix, a device must have demonstrated compliance of its PHY, Link, and Transaction layers as specified in the IEEE 1394-1995 and P1394.a standards.

- The core matrix of devices must be established by an independent agency with actual testing performed by an independent third party or as part of an industry compatibility workshop.

- IEEE 1394 devices and systems must meet the Personal Computer Compatibility and Interoperability profile, independent of their additional use as peer-to-peer or non-PC devices.

- IEEE 1394 devices must conform to the Plug and Play guidelines as applied to IEEE 1394 devices. For a reference to the Plug and Play guidelines, see http://www.microsoft.com/hwdev/onnow.htm.

8.10. Topology faults do not cause the bus to fail

Required

Standard IEEE 1394 protocols have been defined to eliminate topology faults. However, to ensure correct implementation, the following items describe test criteria for industry compatibility workshops. In each case, device connection or removal must not stall the bus, even if the device itself does not function. The PC must detect each fault. The compliance criteria include the following:

- Surprise removal. All isochronous-capable devices must support the Connection Management Protocol specified in IEC 61883, or the most recent specification, in order to resume streaming connections following a bus reset and to de-allocate channels upon surprise removal of a device.

- Safe removal. All devices that provide a front-panel power switch must signal the operating system in response to a local shut-down request, such as hot unplugging, in order to allow safe removal. Safe removal requires that the end user monitor the PC bus manager's response to the request before removing the device.

- Greater than 16 hops. If the bus extends beyond 16 hops or total distance exceeds the maximum cable length and maximum number of nodes/hops, appropriate mechanisms such as PHY pinging and preservation of adequate timing margins must be used. For bus faults generated by cable delays or scenarios where the bus toplogy exceeds 16 hops, 63 nodes must be detected, reported, and correctable to the end user.

- Greater than 63 devices on a local IEEE 1394 bus. If the 63-device limit is exceeded, the 64th and later devices will be assigned a physical ID of 63. The 64th device must be detected by the bus manager and must provide a warning message to the user.

8.11. Removable media devices support media status notification

Required

Removable media devices must use an electronic switch to notify the bus manager in the event of media change requests. This is necessary to enable device applications to lock, unlock, and eject media.

Removable devices must conform to either the National Committee for Information Technology Standards (NCITS) Reduced Block Command (RBC) set standard or to the SFF 8090, Revision 2.0 specification. The MMC-2 specification, when it is approved, will replace SFF 8090.

8.12. Devices that can initiate peer-to-peer communications also support remote programming
Required

To enhance systems integration, all devices capable of initiating peer-to-peer communications and designed for use with the PC must also support a programming language that enables remote control for PC applications. This allows a third device, such as a PC or device controller, to initiate data transmission between two devices.

Plug and Play for Device Configuration ROM

This section defines the Plug and Play requirements related to device configuration ROM.

8.13. Device provides a configuration ROM for unique device identification
Required

For Plug and Play device control, the device configuration ROM must provide configuration information as specified in the Revision 2.0 P1394.a standard and as outlined in the configuration ROM table. The configuration ROM is required for unique detection of the device and is used by the PC to enumerate the bus and to load the correct device driver.

For up-to-date information about the configuration ROM under Windows 98 and Windows NT Workstation 5.0, see the information about IEEE 1394 on the web site at http://www.microsoft.com/hwdev/1394/.

8.14. Device configuration ROM implements general ROM format
Required

The general configuration ROM format is specified in the IEEE 1394-1995 and ISO/IEC 13213:1994 standards. The general ROM format is an extensible tree structure that enables a managed environment by providing node-specific and unit-specific information as required for Plug and Play, power management, and isochronous data transfers. The general ROM format also provides for definition of multifunction device units. The bus information block and root directory of the general ROM format are required as specified in configuration ROM table.

8.15. Bus information block implemented at a base address offset of 0404h
Required

The format of the bus information block is defined by the IEEE 1394-1995 standard. The first quadlet of the bus information block at offset 404h is the configuration ROM signature field used to identify an IEEE 1394 configuration ROM. This quadlet must contain the ASCII string "**1394**."

Part 3 PC 99 Bus Design Guidelines

Part 3 PC 99 Bus Design Guidelines

The second quadlet of the bus information block at offset 408h contains several bits that indicate node capabilities. These bits are defined as shown in the following table, together with their required values.

Note: All devices must support the *irmc*, *cmc*, *isc*, *bmc*, and *pmc* bits and, for host controllers, all these bits must be 1.

Bits Indicating Node Capabilities at Offset 408h

Bit or field	Value and description
irmc bit	Indicates that the node supports isochronous resource manager capabilities.
cmc bit	Must be 1 if the node supports cycle master capabilities; otherwise, this value must be 0.
isc bit	Must be 1 if the node supports isochronous operations; otherwise, this value must be 0.
bmc bit	Indicates that the node supports bus manager capabilities.
pmc bit	Indicates that the node is power manager capable. The *pmc* bit is not defined by the IEEE 1394-1995 standard and is an extension created by this specification.
cyc_clk_acc field	Specifies the accuracy of the node's cycle master clock in parts per million. If the *cmc* bit is 1, the field's value must be between 0 and 100. If the *cmc* bit is 0, this field must be all ones.
Max_rec field	Defines the maximum payload size of a block-write transaction addressed to the node. The range of the maximum payload size is from 4 to 2048 bytes. A *max_rec* value of 0 indicates that the maximum payload size is not specified. Otherwise, within the range of defined payload sizes, the maximum size is equal to $2^{\text{max\_rec}+1}$. The *max_rec* field does not place any limits on the maximum payload size in asynchronous data packets— either requests or responses—that the node might transmit.

8.16. Configuration ROM provides globally unique device ID
Required

The third and fourth quadlets of the bus information block of the configuration ROM must provide a globally unique device ID, which appears in configuration ROM table beginning at offset 40Ch. This unique 64-bit node ID is the only way to recognize the presence of a given device, because the physical device addresses can change following a bus reset. The unique ID is required for device detection and PC device driver loading.

If a bus node supports multiple units, then the unique 64-bit ID must not be referential to any one unit directory in order to allow for unique identification of a unit in a multifunction device.

The globally unique device ID in the bus information block must be invariant when read with quadlet read requests—it must not be alterable in any way by software.

8.17. Root directory is located at a fixed address following the bus information block

Required

The root directory must be located at a fixed address following the bus information block. All other directories and leaves are addressed by entries in their parent directories, starting with the root directory. The root directory contains pointers to the root-dependent directory, a node-power directory as specified in *1394 Trade Association Power Specification, Part 3: Power State Management*, and unit directories for each independent device function.

8.18. Configuration ROM includes a unit directory for each independent device function

Required

A unit directory is required for independent function and control of each device unit. A valid pointer to a unit directory must be provided at offset 0x20h, in compliance with the general ROM format specified in IEEE 1394-1995 and the directory format specified in ISO/IEC 13213:1994.

8.19. Each unit directory provides a valid Unit_Spec_Id and Unit_Sw_Version

Required

Within a unit directory, Unit_Spec_Id identifies the specification authority and Unit_Sw_Version identifies the particular document describing the unit. When added to the beginning of Unit_Spec_Id, then Unit_Sw_Version uniquely identifies the unit's software interface.

8.20. Each unit directory provides a pointer to a unit-dependent directory

Required

The unit-dependent leaf directory must provide additional information about the device unit's vendor and model in associated leaf directories. The format of the information contained in the vendor and model leaves is specific to Unit_Spec_Id and Unit_Sw_Version.

A valid pointer to a unit-dependent directory must be in accordance with the generic directory format specified in ISO/IEC 13213:1994. The unit-dependent directory must provide valid pointers to vendor and model leaves.

8.21. Vendor and model leaves support textual descriptor leaf format

Required

Textual descriptors are required for Unit_Spec_ID and Unit_Sw_Version entries in the configuration ROM in order to display this information to the user. Textual descriptors are recommended for all other configuration ROM entries. Each textual descriptor points to a leaf that contains a single character string.

Alternately, the textual descriptor can point to a directory that points to one or more textual descriptor leaves corresponding to supported languages. Leaf format and textual descriptor leaves are specified in ISO/IEC 13213:1994.

Textual descriptor leaves must include the following:

- The spec_type field must be "0" to correspond to a 24-bit specifier_id for a standards body, or "1" to correspond to a 24-bit specifier_id for a defining vendor company_id.

- The language_id field must be derived from the Windows NT locale number (a quadlet), OR'd with 0x80000000.

- Text string_info must be in ASCII for any language_id in the range 0–7fffffff or in Unicode for any language_id in the range 0x80000000–0xffffffff.

8.22. Unit-dependent directory provides a pointer to the unit's CSRs
Required

Each unit's CSRs must be in separate, non-overlapping address spaces to maintain independent device control. If CSRs can be used to interact with a device unit, the unit-dependent directory must provide a pointer to the base address of the unit's CSRs. This provides an easy way for an application or a device driver to access the unit's CSRs.

Plug and Play for Cabling and Connectors

This section defines the Plug and Play requirements for IEEE 1394 cabling and connectors.

8.23. Device provides more than one connector port
Recommended

Devices should provide at least two (preferably three) 6-pin connector ports for optimum cabling options, subject to cable-power distribution constraints. Fewer than three ports promotes long daisy chains, increasing the potential for speed traps. Therefore, three-port IEEE 1394 device nodes are recommended, with exceptions noted in requirement 8.24, "Device uses the approved IEEE P1394.a connector."

For internal-only devices, a minimum of two ports enables daisy chaining of devices. However, a limit of 15 hops (end-to-end distance) restricts total devices to 16, sufficient for most internal configurations.

Single-port devices are permissible, but it is recommended that devices provide more than one port to enable connectivity to other peripherals when the system does not provide multiple ports.

Devices that consume cable power should be limited to a single connector to encourage short source-to-sink power delivery while eliminating the build up of voltage drop associated with a long daisy chain of power consumers.

Mobile PC Note   Only one external port is recommended for mobile systems.

8.24. Device uses the approved IEEE 1394 connectors
Required

Recommended: Device uses a 6-pin connector.

If the device implements a 4-pin connector, it must be a single port, leaf device because the connector cannot pass cable power to other devices. The connector must conform to the 4-pin connector in the IEEE P1394.a specification.

If the device uses the 6-pin connector, it must also conform to the specifications for connectors in IEEE P1394.a. It is recommended that all PC peripheral devices implement the 6-pin connector. All host controller ports that are externally accessible should support the 6-pin connector.

Consistent use of the standard 6-pin IEEE 1394 connector eliminates an undesirable break in the power bus for power-dependent device applications. Other benefits include volume pricing and consistent electrical performance. Therefore, all external pluggable IEEE 1394 devices must use the standard 6-pin IEEE 1394 connector. The exception is an option to use the 4-pin IEEE P1394.a connector for miniature single-port (leaf-node) devices, as defined in requirement 8.26, "Only single-port leaf-node devices use 4-pin connectors."

Device designers can decide to use the connector described in *Device Bay Specification, Version 1.0*. If so, the design must be compliant with all connector and electrical requirements of that specification.

8.25. Self-powered devices propagate the power bus through each connector
Required

Self-powered devices that provide their own power source and do not consume cable power must maintain the electrical integrity of the power bus for other devices dependent on it. Therefore, all self-powered devices must propagate the power bus through each connector.

8.26. Only single-port leaf-node devices use 4-pin connectors
Required

A 4-pin connector is not recommended because it adds an additional, and possibly confusing, cable choice for end users. Therefore, under these guidelines, a 4-pin (powerless) A/V connector can only be implemented for single-connector leaf-node devices.

8.27. Device connectors exhibit common speed and power characteristics
Required

Devices with multiple connectors must exhibit common characteristics at each connector to reduce end-user cabling choices. All connectors on a device must exhibit homogeneous speed, power, and mechanical characteristics such that:

- Multiconnector devices use the 6-pin connector
- All device connectors propagate the power bus
- All device connectors support a common peak data rate

Optionally, all devices providing cable power through 6-pin connectors must provide diode isolation as specified in the *1394 Trade Association Power Specification Part 1: Cable Power Distribution*.

8.28. Standard S400-rated IEEE 1394 cable is provided with devices
Required

For Plug and Play, it is important to use one standard-performance cable for all device configurations to eliminate cable choices for the end user. This is especially important given the range of devices possible on an IEEE 1394 bus. A mix of cable types and ratings creates an unfriendly user experience. Therefore, all cables must be have a minimum S400 rating and, if bundled, must be shipped with a standard cable.

Plug and Play Power Interfaces

This section summarizes Plug and Play requirements for cable power distribution.

For Plug and Play, all devices—whether cable or self-powered—must comply with the applicable requirements in *1394 Trade Association Power Specification, Part 3: Power State Management.* These requirements enable a power management-capable bus manager to provide instant-on application support while reducing system-wide device power consumption.

In addition, all devices must comply with the *1394 Trade Association Power Specification Part 1: Cable Power Distribution.* Although the requirements for devices that do not consume or produce cable power are minimal, all devices share responsibility for propagating the power bus as defined in the Cable Power Distribution specification.

A standard cable-power distribution model is necessary to reduce the likelihood of power-fault conditions, such as insufficient power for connection of a cable-powered device and surprise removal of a device power source. In addition, a bus manager that is power management-capable can allocate or de-allocate available power within diode-isolated power domains, accounting for the overall power budget and voltage drop.

Plug and Play requirements in this section highlight details specified in the applicable power specifications.

Mobile PC Note   Exceptions for power interfaces for mobile systems are defined in Chapter 6, "Mobile PC 99."

8.29. Devices provide sufficient power to their PHY at appropriate times
Required

The host controller and all devices that have more than one port must perform the bus repeater function when powered down as specified in the IEEE P1394.a specification. A device power switch must supply local power to the PHY when the standard and *1394 Trade Association Power Specification*.

8.30. Devices report power source and cable power consumption in Self_id packet
Required

The host controller and all self-powered devices must report zero power consumed in the power class field of the Self_id packet. Alternately, if a device consumes cable power only to keep its PHY alive, it must report this consumption in the Self_id packet. This allows the power manager to reserve power for this occasion.

8.31. Devices implement link power control
Required

The host controller and all cable-powered and self-powered devices must implement the Link_on packet and Link_off bit in the State_Clear register. These controls allow a power management-capable bus manager to control the node's power state. Access to the device configuration ROM must be possible following a Link_on. A device cannot increment its power consumption by more than 3 watts following a Link_on. Self-powered devices can power up with Link_on. However, cable-powered devices must rely on the power manager to enable their link.

8.32. Device requiring power increments in excess of Link_on implements unit-power CSRs

Required

The host controller and all cable-powered and self-powered devices that require power increments in excess of Link_on power must implement standard unit-power CSRs as specified in *1394 Trade Association Power Specification, Part 3: Power State Management.* This is necessary to allow for seamless integration of centralized power management capabilities when a device is connected to a mini-system.

In addition, all devices of a given device class must implement a standard set of unit power states as specified in the device class power management specification for that device class. For example, all VCRs must exhibit a consistent behavior with respect to power states and transitions between states. This is necessary to provide a consistent user experience.

Note: Please check with the 1394 Trade Association or send e-mail to 1394@microsoft.com to determine whether a power class specification exists for your device type. Alternatively, you are encouraged to draft a proposal for your device type and submit it to the 1394 Trade Association architecture working group for review and approval.

8.33. Devices that source cable power report this capability

Required

This reporting is necessary to enable centralized power management. A device that sources 20 volts or more of cable power at 15 watts minimum must report that it provides power in its Self_id packet as specified in IEEE 1394-1995. Devices that provide less than 20 volts at 15 watts can be discovered using configuration ROM information as described in *1394 Trade Association Power Specification, Part 3: Power State Management.*

8.34. IEEE 1394-enabled PC sources cable power

Required

An AC-powered PC must source cable power to the bus. Cable power, in turn, enhances Plug and Play with a single connection for low-cost cable-powered devices. Battery-powered mobile and notebook devices are exempt from this requirement, whether or not the device is connected to an AC adapter.

8.35. Power source supplies appropriate cable power

Recommended

A power provider must provide its declared power capacity under full load conditions. A power source can be a power provider or an alternative power provider, and it must supply an appropriate amount of power as defined in the IEEE P1394.a standard and *1394 Trade Association Power Specification Part 1: Cable Power Distribution.*

For example, it might be difficult for a power provider to supply a minimum power class limit such as 15 watts of power, so alternative implementations are allowed. This type of design could provide a reasonable amount of power, such as 12 V at 0.5 amp, or approximately 6 watts. The system can therefore supply power for most devices that use cable power. If the device supports less than specified by the minimum power class definition in the P1394.a standard and *1394 Trade Association Power Specification Part 1: Cable Power Distribution*, it must report in its Self_id packet that it does not source power, and the configuration ROM must specify the exact power it provides.

8.36. Devices notify the power manager of power change requests
Required
The host controller and all devices that produce or consume cable power must use an electronic power switch to notify the power manager of requests from the front panel to change the power state. This function must be accomplished using the notification request protocol specified in *1394 Trade Association Power Specification, Part 3: Power State Management.* This protocol provides a time-out for defaulting to local control as is necessary for operation in non-power-managed environments.

This same mechanism is required for safe removal of a device (hot unplugging).

Power Management for IEEE 1394 Devices

All devices on the IEEE 1394 bus must comply with the power management requirements outlined in this section.

8.37. Devices and controllers comply with Cable Power Distribution specification
Required
The cable power distribution model has been defined to provide guidelines for implementation of devices that propagate, source, or sink cable power. Thus, all devices must satisfy power distribution requirements. *1394 Trade Association Power Specification Part 1: Cable Power Distribution* addresses interoperability and power distribution necessary for operation of both power-managed bus configurations and, with some restrictions, unmanaged bus configurations.

8.38. Devices and controllers comply with IEEE 1394 power specification

Required

Power-management CSRs and protocols provide an enhanced Plug and Play experience for end users. All devices must support power-state, power-capabilities, and power-status commands as defined in *1394 Trade Association Power Specification, Part 3: Power State Management.* Cable-power devices must support the notification request protocol. Wake-up and battery-status CSRs are optional but recommended.

IEEE 1394 References

The following represents some of the references, services, and tools available to help build hardware that is optimized to work with Windows operating systems.

1394 Trade Association
  E-mail: 1394-sig@1394ta.org
  http://www.1394ta.org

1394 Glass Optical Fiber Specification: *Proposal to Extend the P1394.b S-800–S1600 100m Glass Optical Fiber (GOF) Link Specifications*
  http://www.zayante.com/p1394b/GOFmedia/ts980709-GOF-Extension.pdf

1394 Trade Association Power Specification Part 1: Cable Power Distribution
1394 Trade Association Power Specification, Part 3: Power State Management
  ftp://ftp.p1394pm.org/pub/p1394pm/

Device Bay Specification, Version 1.0
  http://www.device-bay.org

IEC 61883 Digital Interface for Consumer Electronic Audio/Video Equipment
  http://www.iec.ch

IEEE 1394 Standards
  ASK*IEEE
  Telephone: (800) 949-4333
  Fax: (212) 310-4091
  E-mail: askieee@ieee.org

  Global Engineering Documents
  Phone: (800) 854-7179 (US)
             (613) 237-4250 (Canada)
             (303) 792-2181 (Outside North America)
  Fax: (303) 397-2740

ISO/IEC 13213:1994 Control and Status Registers (CSR) Architecture for Microcomputer Buses
  http://www.iso.ch/cate/d21416.html

Intel information about IEEE 1394 implementations
    http://developer.intel.com

Microsoft Windows NT 5.0 DDK
    MSDN Professional membership

MMC-2 Multi-Media Command Set-2
    ftp://ftp.symbios.com/pub/standards/io/t10/drafts/mmc2/mmc*xxxx*.pdf

National Committee for Information Technology Standards (NCITS) Reduced
    Block Commands (RBC) Draft Proposal T10/97-260r0
    ftp://ftp.symbios.com/pub/standards/io/t10/drafts/rbc/

Open Host Controller Interface Specification
    ftp://ftp.austin.ibm.com/pub/chrptech/1394ohci/

Plug and Play specifications
    http://www.microsoft.com/hwdev/respec/pnpspecs.htm

SFF Committee publications
    FaxAccess: (408) 741-1600 (fax-back)
    Fax: (408) 867-2115

White papers and guidelines for Microsoft operating systems
    http://www.microsoft.com/hwdev/1394/

Checklist for IEEE 1394

If a recommended feature is implemented, it must meet the PC 99 requirements for that feature as defined in this document.

8.1. Controllers and devices support mandatory features in IEEE P1394.a with backward compatibility with IEEE 1394-1995
Required

8.2. Controllers comply with OpenHCI for IEEE 1394
Required

8.3. OpenHCI controllers and devices support advances defined in IEEE P1394.a
Required

8.4. Host supports peak data rate of 400 Mb/s, minimum
Required

8.5. Design avoids excessive currents resulting from ground-fault potential among devices
Recommended

8.6. Device command protocols conform to standard device class interfaces
Required

8.7. Devices support peak data rate of 400 Mb/s, minimum
Required

8.8. Devices requiring support for high-bandwidth data transfer use IEEE 1394
Recommended

8.9. Plug and Play devices demonstrate interoperability with other devices
Required

8.10. Topology faults do not cause the bus to fail
Required

8.11. Removable media devices support media status notification
Required

8.12. Devices that can initiate peer-to-peer communications also support remote programming
Required

8.13. Device provides a configuration ROM for unique device identification
Required

8.14. Device configuration ROM implements general ROM format
Required

8.15. Bus information block implemented at a base address offset of 0404h
Required

8.16. Configuration ROM provides globally unique device ID
Required

8.17. Root directory is located at a fixed address following the bus information block
Required

8.18. Configuration ROM includes a unit directory for each independent device function
Required

8.19. Each unit directory provides a valid Unit_Spec_Id and Unit_Sw_Version
Required

8.20. Each unit directory provides a pointer to a unit-dependent directory
Required

8.21. Vendor and model leaves support textual descriptor leaf format
Required

8.22. Unit-dependent directory provides a pointer to the unit's CSRs
Required

8.23. Device provides more than one connector port
Recommended

8.24. Device uses the approved IEEE 1394 connectors
Required

8.25. Self-powered devices propagate the power bus through each connector
Required

8.26. Only single-port leaf-node devices use 4-pin connectors
Required

8.27. Device connectors exhibit common speed and power characteristics
Required

8.28. Standard S400-rated IEEE 1394 cable is provided with devices
Required

8.29. Devices provide sufficient power to their PHY at appropriate times
Required

8.30. Devices report power source and cable power consumption in Self_id packet
Required

8.31. Devices implement link power control
Required

8.32. Device requiring power increments in excess of Link_on implements unit-power CSRs
Required

8.33. Devices that source cable power report this capability
Required

8.34. IEEE 1394-enabled PC sources cable power
Required

8.35. Power source supplies appropriate cable power
Recommended

8.36. Devices notify the power manager of power change requests
Required

8.37. Devices and controllers comply with Cable Power Distribution specification
Required

8.38. Devices and controllers comply with IEEE 1394 power specification
Required

C H A P T E R   9

PCI

This chapter presents the PC 99 requirements and recommendations for Peripheral Component Interconnect (PCI) host controllers and peripherals.

The PCI architecture has become the most common method used to extend PCs for add-on adapters. Windows and Windows NT Workstation use the basic PCI infrastructure to gain information about devices attached to the PCI bus. The ability of PCI to supply such information makes it an integral part of the Plug and Play architecture in Windows.

CardBus and device class-specific requirements related to PCI are defined in the following chapters:

- Chapter 12, "PC Card"
- Chapter 14, "Graphics Adapters"
- Chapter 15, "Video and Broadcast Components"
- Chapter 17, "Audio Components"
- Chapter 19, "Modems"
- Chapter 20, "Network Communications"

Contents

PCI Basic Requirements

This section summarizes the basic design requirements for PCI.

9.1. All components comply with PCI 2.1
Required

Recommended: All components comply with *PCI Local Bus Specification, Revision 2.2* (PCI 2.2).

All cards, bridges, and devices that use PCI must be designed to meet the requirements defined in *PCI Local Bus Specification, Revision 2.1* (PCI 2.1), and must also comply with all Engineering Change Notices (ECNs) for PCI 2.1 approved by July 1, 1998. PCI specifications and a list of approved ECNs are available from the PCI Special Interest Group (PCISIG), available at http://www.pcisig.com/.

Compliance with this requirement is demonstrated based on the compliance process of the PCI SIG.

9.2. System does not contain ghost devices
Required

A computer must not include any ghost devices, which are devices that do not decode the Type 1/Type 0 indicator. Such a device will appear on multiple PCI buses.

A PCI card should be visible through hardware configuration access at only one bus/device/function coordinate.

9.3. System uses standard method to close BAR windows on nonsubtractive decode PCI bridges
Required

PCI-to-PCI bridges must comply with the *PCI to PCI Bridge Specification, Revision 1.0.* Setting the base address register (BAR) to its maximum value and the limit register to zeros should effectively close the I/O or memory window references in that bridge BAR.

9.4. System provides 3.3 V to all PCI connectors
Required

PC 99 systems are required to provide 3.3 volts with amperage as defined by PCI 2.1 to all PCI connectors. This requirement enables the development of 3.3 V PCI adapters without the cost of voltage regulators.

9.5. PCI add-on devices support both 5 V and 3.3 V signaling
Recommended
All PCI add-on devices should be Universal Boards as defined in Section 4.1 of PCI 2.1 and PCI 2.2, or be 3.3 V devices that are "5 V tolerant." These devices support both 3.3 V and 5 V signaling, and they will allow a smooth market transition as systems change from 5 V to 3.3 V signaling.

This capability will be required in future versions of this design guide.

PCI Controller Requirements

This section summarizes PCI controller requirements.

9.6. System-board bus complies with PCI 2.1
Required
Recommended: System-board bus complies with PCI 2.2.

The system-board bus hardware must comply with PCI 2.1 and should comply with PCI 2.2. The bus design must fully implement all bus requirements on every expansion card connector.

9.7. Bus master privileges are supported for all connectors
Required
To ensure full Plug and Play functionality on a PCI bus with expansion cards, all PCI connectors on the system board must be able to allow any PCI expansion card to have bus master privileges.

9.8. Functions in a multifunction PCI device do not share writable PCI Configuration Space bits
Required
The operating system treats each function of a multifunction PCI device as an independent device. As such, there can be no sharing between functions of writable PCI Configuration Space bits, such as the Command register.

Notice that the PC Card 16-bit Interface Legacy Mode BAR—offset 44h in the Type 2 PCI header—is the only exception to this requirement. This register must be shared between the two functions, just as they must share the same compatibility registers with the Exchangeable Card Architecture (ExCA) programming model, as defined in the *PCI to PCMCIA CardBus Bridge Register Description* (Yenta specification), by Intel.

For more information about design requirements for CardBus controllers, see "PC Card Socket Controller Requirements" in Chapter 12, "PC Card."

9.9. All PCI devices complete memory write transaction (as a target) within specified times

Required

All devices must comply with the Maximum Completion Time ECN that is approved for PCI 2.1 and that is also documented in PCI 2.2.

Complying with this requirement ensures shorter transaction latencies on PCI, allowing more robust handling of isochronous streams in the system.

Plug and Play for PCI Controllers and Peripherals

This section summarizes the Plug and Play requirements for PCI devices.

9.10. Devices use PCI 2.1 Configuration Space for Plug and Play device ID

Required

The PCI specification describes the Configuration Space used by the system to identify and configure each device attached to the bus. The Configuration Space is a 256-byte address space for each device and contains sufficient information for the system to identify the capabilities of the device. Configuration of the device is also controlled from this address space.

Configuration Space is made up of a header region and a device-dependent region. Each Configuration Space must have a 64-byte header at offset 0. All the device registers that the device uses for initialization, configuration, and catastrophic error handling must fit in the space between byte 64 and byte 255.

All other registers that the device uses during normal operation must be located in normal I/O or memory space. Unimplemented registers or reads to reserved registers must complete normally and return zero (0). Writes to reserved registers must complete normally, and the data must be discarded.

9.11. Device IDs include Subsystem IDs

Required

The Subsystem ID (SID) and Subsystem Vendor ID (SVID) fields are required to comply with the Subsystem ID ECN to PCI 2.1 or the equivalent requirement in PCI 2.2. The Subsystem ID ECN is available to PCI SIG members on the web at http://www.pcisig.com.

- The PCI SIG assigns valid, non-zero values for the SVID register.
- The vendor assigns values for the SID register. To be valid, these values must be non-zero and unique to a subsystem configuration.

Valid non-zero values in the SVID and SID registers are necessary for the correct enumeration of the PCI device. When these registers are populated correctly for a PCI subsystem or add-on board, the operating system can differentiate between subsystems and add-on boards based on the same PCI chip.

The PCI specification and these guidelines require that the SVID and SID registers are loaded with valid non-zero values before the operating system accesses the Configuration Space registers on a PCI device or function. This is required both at initial operating system load and after any transition of the PCI bus from B3 (the unpowered bus state) back to B0 (the fully powered bus state).

For add-on boards, this requirement must be done by hardware on the board itself—for example, by way of serial EEPROM—and not by an extension BIOS or device driver. This is because the extension BIOS code or driver code is not guaranteed to run in all relevant cases, especially for system sleep transitions or dynamic bus power state transitions in which the bus becomes unpowered. Hardware methods to support this include:

- Pin strapping at Reset
- Loading from an attached parallel or serial ROM

For subsystems on system boards that contain a PCI device, the SVID and SID registers must also be loaded with valid non-zero values before the operating system accesses the device. The exceptions to this requirement are PCI-to-PCI bridges and core chip sets.

If a PCI device is designed to be used exclusively in a subsystem on the system board, then the system-board vendor can load valid non-zero values into the SVID and SID registers using code that is guaranteed to run before the operating system accesses the registers.

The system BIOS power-on self test (POST) code or ACPI control methods (_PS0 for PCI bus B3 to B0 transitions) are guaranteed to run before the operating system accesses the SVID or SID registers. Once the operating system has control of the system, the SVID and SID registers must not be directly writeable—that is, the read-only bit must be set and valid. See the note on using the POST method for loading SVID and SID register values related to multiple-monitor support for display devices in requirement 14.45, "Each device has a Plug and Play device ID."

9.12. Configuration Space is correctly populated

Required

The following items are specific requirements for the Configuration Space:

- **9.12.1. Populate the class code register (09h) for all devices.** Follow the base class, sub-class, and programming interface values outlined in PCI 2.1 or later.

- **9.12.2. Devices must not fill BARs with random values.** See PCI 2.1 or later for correct usage of these registers. Notice that BARs 10h, 14h, 18h, 1Ch, 20h, and 24h should return zero if they are not used, indicating that no memory or I/O space is needed.

Also, for performance reasons, it is recommended that run-time registers for PCI devices should not be placed in the Configuration Space.

Note: Windows places extra constraints on a few Configuration Space registers and has uncovered some problem usage of other registers. Microsoft provides a program to help debug the use of the Configuration Space. The Pci.exe program is available at ftp://ftp.microsoft.com/developr/drg/plug-and-play/pci/pci.exe.

9.13. Interrupt routing is supported using ACPI

Required

The system must provide interrupt routing information using a _PRT object, as defined in Section 6.2.3 of the ACPI 1.0 specification.

9.14. BIOS does not configure I/O systems to share PCI interrupts

Recommended

This applies to boot devices configured by the BIOS on systems based on Intel Architecture processors. The operating system should configure all other devices. For systems that will run the Windows operating system, OEMs should design the BIOS so that it does not configure the I/O systems in the PC to share PCI interrupts for boot devices.

An exception exists for legacy audio devices following the configuration guidelines outlined in *Implementing Legacy Audio Devices on the PCI Bus*, available at http://www.intel.com/pc-supp/platform/ac97/wp/leg_pci.htm.

Windows does not support sharing an IRQ between real-mode and protected-mode code within the I/O subsystem. An example of this is an NDIS 2.0 driver (real mode) and a SCSI miniport driver (protected mode) for two PCI devices that share the same IRQ. The problem is that the IRQ needs to be reflected to real mode for the NDIS 2.0 driver to work.

However, if the IRQ is reflected to real mode, the real-mode SCSI driver, which usually is not called because Windows takes over in protected mode, might touch the hardware, causing the SCSI miniport to be confused. Windows resolves this problem either by switching everything to protected mode or by falling back to real mode.

9.15. BIOS configures boot device IRQ and writes to the interrupt line register

Required

This requirement applies to boot devices configured by the BIOS on systems based on Intel Architecture processors. Windows should configure all other devices because, after an IRQ is assigned by the system BIOS, Windows cannot change the IRQ. If the BIOS assigns the IRQ and Windows needs it for another device, a sharing problem occurs.

The BIOS must configure the boot device IRQ to a PCI-based IRQ and must write the IRQ into the interrupt line register 3Ch, even if the BIOS does not enable the device. This way, the operating system can still enable the device with the known IRQ at configuration time, if possible.

See also requirement 12.23, "16-bit PC Card card driver supports sharing of level-mode interrupts."

9.16. Systems that support hot plugging for any PCI device use ACPI-based methods

Required

Hot-plugging capabilities are not required for PCI devices. Windows 98 and Windows NT 5.0 support dynamic enumeration, installation, and removal of PCI devices only if there is a supported hardware insert/remove notification mechanism.

The appropriate notification mechanism is supported as a bus standard for CardBus bus controllers. For other solutions, such as those required for docking stations or hot-plugging PCI devices, the hardware insert/remove notification mechanism must be implemented as defined in Section 5.6.3 of the ACPI 1.0 specification.

Power Management for PCI Controllers and Peripherals

This section summarizes the specific PCI power management requirements.

9.17. All PCI components comply with PCI Bus Power Management Interface specification

Required

The PCI bus, any PCI-to-PCI bridges on the bus, and all add-on capable devices on the PCI bus must comply with *PCI Bus Power Management Interface Specification, Revision 1.1* or later. This includes correct implementation of the PCI Configuration Space registers used by power management operations, and the appropriate device state (D_x) definitions.

ACPI is not an acceptable alternative for PC 99.

9.18. System provide support for 3.3 Vaux if a system supports S3 or S4 states

Required

System support for delivery of 3.3 Vaux to the PCI bus must be capable of powering a single PCI slot with 375 mA at 3.3 V and it must also be capable of powering each of the other PCI slots on the segment with 20 mA at 3.3 V whenever the PCI bus is in the B3 state.

Systems must be capable of delivering 375 mA at 3.3 V to all PCI slots whenever the PCI bus is in any "bus powered" state: B0, B1, or B2.

9.19. Bus power states are correctly implemented

Required

The PCI bus must be in a bus state (B_x) no higher than the system sleeping state (S_x). This means that if the system enters S1, the bus must be in B1, B2, or B3. If the system enters S2, the bus must be in B2 or B3, and if the system enters S3, the bus must be in B3. Of course, in S4 and S5, the system power is removed, so the bus state is B3. A PCI bus segment must not transition to the B3 state until all downstream devices have transitioned to D3.

Control of a PCI bus segment's power is managed using the originating bus bridge for that PCI bus segment.

- For CPU-to-PCI bridges, these controls must be implemented using ACPI or the *PCI Power Management Interface Specification, Revision 1.1* or later.

- For PCI-to-PCI bridges, these controls must be implemented in compliance with the *PCI Power Management Interface Specification, Revision 1.1.* or later.

9.20. PCI-based modem and network adapters support wake-up
Required

PCI-based modem and network adapters must support wake-up as follows:

- Modem adapters must be capable of generating a power management event (PME# assertion) from the D3 cold device state. It is recommended that modem adapters support capture of Caller ID with hardware support for the AT+VRID, "resend caller ID," voice modem command.

- Network adapters must support the generation of a power management event (PME# assertion) from the D3 cold device state if the physical layer technology is generally capable of operating under the voltage and current constraints of the D3 cold device state. Network adapters must also support the minimum requirements for network packet filtering/wake-up capability as defined in requirement 20.56, "Device supports wake-up events."

PCI References

The following represents some of the references, services, and tools available to help build hardware that is optimized to work with Windows operating systems.

Advanced Configuration and Power Interface Specification, Revision 1.0
    http://www.teleport.com/~acpi/

Default Device Class Power Management Reference Specification, Version 1.0,
    and other power management specifications
    http://www.microsoft.com/hwdev/onnow.htm

"Efficient Use of PCI," Platform Architecture Labs, Intel Corporation
    http://support.intel.com/support/chipsets/pc1001.htm

Implementing Legacy Audio Devices on the PCI Bus
    http://www.intel.com/pc-supp/platform/ac97/wp/leg_pci.htm

Microsoft testing tools, specifications, and information, including "IDs and Serial
    Numbers for Plug and Play" and other related articles
    E-mail: pciinfo@microsoft.com
    http://www.microsoft.com/hwtest/
    http://www.microsoft.com/hwdev/pci/

PCI Bus Power Management Interface Specification, Revision 1.1
PCI Local Bus Specification, Revision 2.1 and later
PCI to PCI Bridge Specification, Revision1.0.
   PCI SIG
   Phone: (800) 433-5177
   http://www.pcisig.com

PCI to PCMCIA CardBus Bridge Register Description (Yenta specification)
   http://www.pc-card.com

Checklist for PCI

If a recommended feature is implemented, it must meet the PC 99 requirements for that feature as defined in this document.

9.1. All components comply with PCI 2.1
Required

9.2. System does not contain ghost devices
Required

9.3. System uses standard method to close BAR windows on nonsubtractive decode PCI bridges
Required

9.4. System provides 3.3 V to all PCI connectors
Required

9.5. PCI add-on devices support both 5 V and 3.3 V signaling
Recommended

9.6. System-board bus complies with PCI 2.1
Required

9.7. Bus master privileges are supported for all connectors
Required

9.8. Functions in a multifunction PCI device do not share writable PCI Configuration Space bits
Required

9.9. All PCI devices complete memory write transaction (as a target) within specified times
Required

9.10. Devices use PCI 2.1 Configuration Space for Plug and Play device ID
Required

9.11. Device IDs include Subsystem IDs
Required

9.12. Configuration Space is correctly populated
Required

9.13. Interrupt routing is supported using ACPI
Required

9.14. BIOS does not configure I/O systems to share PCI interrupts
Recommended

9.15. BIOS configures boot device IRQ and writes to the interrupt line register
Required

9.16. Systems that support hot plugging for any PCI device use ACPI-based methods
Required

9.17. All PCI components comply with PCI Bus Power Management Interface specification
Required

9.18. System provide support for 3.3 Vaux if a system supports S3 or S4 states
Required

9.19. Bus power states are correctly implemented
Required

9.20. PCI-based modem and network adapters support wake-up
Required

C H A P T E R   1 0

ATA and ATAPI

This chapter presents the requirements and recommendations for ATA (AT Attachment), ATAPI (ATA Packet Interface) controllers and peripherals. ATA—also known as IDE (Integrated Device Electronics)—is one of the most widely used interfaces in the PC world.

The use of ATA in a PC 99 system is optional. If ATA is used, however, all components must comply with the requirements defined in this chapter.

Contents

ATA Controller Requirements

This section summarizes the specifications and standards for Windows-compatible ATA controllers.

10.1. Controller and peripherals comply with ATA-2, ATA-3, or ATA/ATAPI-4 standards

Required

All ATA/ATAPI controllers and peripherals must meet the hardware and software design requirements listed in the ATA-2, ATA-3, or ATA/ATAPI-4 Revision 17 or later standard.

Storage subsystems that require advanced features such as command queuing should use IEEE 1394 for the storage interface.

10.2. Bootable ATA controller supports El Torito No Emulation mode

Required

A bootable ATA storage controller must support the No Emulation mode defined in *El Torito—Bootable CD-ROM Format Specification, Version 1.0,* or an equivalent method that supports the Windows NT Workstation CD-ROM installation process.

10.3. Option ROMs support Int 13h Extensions

Required

The Int 13h Extensions ensure correct support for high-capacity drives, consistent drive-letter mapping between real mode and protected mode, and other capabilities for both Windows and Windows NT operating systems. Support for the fixed-disk access subset of Int 13h Extensions must be provided in the system BIOS and in any option ROMs for storage devices that include BIOS support.

The system BIOS must support the use of logical block addressing (LBA) for drives with LBA addressable area greater than 16,515,072 sectors. Support for drives with capacities greater than 8.4 GB must be provided through the extended services (functions 4xh and greater) of the Int 13h Extensions as defined in *Information Technology Enhanced BIOS Services for Disk Drives [T13-1226DT], Revision 7,* available at ftp://fission.dt.wdc.com/pub/standards/x3t13/project/.

The Int 13h Extensions are defined in the "Layered Block Device Drivers" section of the Windows 95 DDK and in the Windows NT 5.0 DDK.

10.4. Dual ATA adapters use single FIFO with asynchronous access or dual FIFOs and channels

Required

Although the use of an ATA adapter with more than one channel is optional, if included, dual ATA adapters must be designed so that either channel might be used at any time; the operating system does not have to serialize access between the primary and secondary channel. This means either that the two channels are totally independent or that anything shared, such as a programmed I/O (PIO) read pre-fetch buffer, is protected by a hardware arbitrator.

Section 5.0 of the *Compaq, Intel, Phoenix BIOS Boot Specification* defines an implementation for dual asynchronous channels. This specification is available at http://www.ptltd.com/techs/specs.html.

A design implementing a single first in/first out (FIFO) that uses a hardware solution to synchronize access to both channels meets this requirement if the design does not require that a request on one channel be completed before another can be started. A software-based solution is not acceptable.

Dual-channel controllers that require special software to serialize channel I/O for a single prefetch FIFO do not meet these requirements. Such designs require serial access to one of four devices, defeating the primary advantage of asynchronous dual-channel controllers. Furthermore, such devices are non-standard and require custom driver support.

10.5. System BIOS and devices support LBA

Required

To enable support for ATA disk drives that have capacities greater than 528 MB (1,030,176 logical blocks), the system BIOS must use LBA for all read and write operations to the device. The LBA bit in the Device/Head register must be set to one. The ATA 1226 technical report defines the proper implementation of LBA.

Although ATAPI was defined to be transparent to the BIOS, the BIOS must recognize the presence of ATAPI devices using the signature defined in SFF 8020i.

10.6. System BIOS supports ARMD

Recommended

The system BIOS or option ROM should provide boot support for the primary ATAPI bootable floppy disk drive in compliance with *ATAPI Removable Media BIOS Specification (ARMD), Version 1.0* or later. Complying with this specification provides Int 13h and Int 40h support for bootable floppy drives as the primary or secondary floppy device.

10.7. Controller and peripherals support Ultra DMA

Required

The programming register set for PCI IDE bus master direct memory access (DMA) is defined in ATA-4 or SFF 8038i. ATA drives must comply with ATA-4 to ensure fully featured hardware and Windows-compatible device driver support.

All controllers and ATA hard drive peripherals must support Ultra DMA at transfer rates up to 33 MB per second as defined in ATA/ATAPI-4 Revision 17. In addition to improved transfer rates, Ultra DMA also provides error checking for improved robustness over previous ATA implementations. PCI chip sets must implement DMA as defined in SFF 8038i.

Ultra DMA is only recommended for ATAPI devices. If a device does not support the Ultra DMA transfer protocol, it must, at a minimum, implement the termination scheme required by this protocol to ensure that all devices coexist with Ultra DMA devices.

The system BIOS should configure the drive and host controller, optimized for Ultra DMA operation if possible, however, programmed I/O (PIO) mode must continue to work. The ACPI software should also support the restoration of these settings in ACPI control methods _GTM, _STM, and _GTF, for which there are no standard registers, if the controller loses timing context across a suspend and resume cycle. The BIOS pre-operating system boot disk services, (INT13h read and write) need not actually use Ultra DMA for access of the drive prior to operating system boot.

Definitions for the above ACPI control methods can be found in Section 5 of the *Advanced Configuration and Power Interface Specification, Revision 1.0* or later, with consideration of the ACPI errata available on the web site at http://www.teleport.com/~acpi/tech.htm.

10.8. Controller and peripheral connections include Pin 1 cable designation with keyed and shrouded connectors

Required

Pin 1 orientation must be designated by one edge of the keyed ribbon cable and also on the keyed connector of the ATA or ATAPI controller and peripheral device. Designation of the keyed connector must be clearly indicated on or near the connector.

ATAPI Peripheral General Requirements

This section defines the requirements for all ATAPI devices. Specific requirements for floppy drives, hard drives, CD drives, and DVD drives are defined in Chapter 18, "Storage and Related Peripherals."

10.9. Peripherals comply with ATA/ATAPI-4 or SFF 8020i v.2.5
Required

The ATA/ATAPI-4 standard defines hardware and software design guidelines for ATAPI devices. The operating system also supports enumeration based on SFF 8020i, Version 2.5 or later.

See also requirement 10.3, "Option ROMs support Int 13h Extensions."

10.10. Removable media devices support media status notification
Required

Removable media storage devices must support media status notification as specified in requirement 18.2, "Removable media devices support media status notification."

10.11. BIOS enumeration of all ATAPI devices complies with ATA/ATAPI-4 or SFF 8020i v.2.5
Required

The ATA/ATAPI-4 standard defines the enumeration process for all ATAPI devices. The operating system also supports enumeration based on SFF 8020i, Version 2.5 or later.

See also requirement 18.9, "System BIOS or option ROM supports bootable ARMD."

10.12. ATAPI devices support DEVICE RESET command
Required

ATAPI devices must respond to the DEVICE RESET command regardless of their internal state, as defined in the ATA/ATAPI-4 standard or Section 6.2 of SFF 8020i, Version 2.5 or later. The controller can be reset by going into a power-on state (requests cleared, signature present), but any non-default mode values must be left in their current state with the DRV bit unchanged.

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

Plug and Play for ATA Controllers and Peripherals

This section summarizes the Plug and Play requirements for ATA controllers and peripherals.

10.13. Each device has a Plug and Play device ID
Required

For each system-board device there must be a Plug and Play device-specific ID.

Each ATA controller or peripheral device must provide device IDs in the manner required for the bus it uses, as defined in the related chapter for the specific bus in Part 3 of this guide.

For example, an add-on PCI IDE device must comply with PCI 2.1 and also must provide a Subsystem ID and Subsystem Vendor ID as defined in Chapter 9, "PCI." PCI IDE controllers integrated into core logic on the system board do not have to provide Subsystem IDs and Subsystem Vendor IDs, but must meet other PCI 2.1 requirements.

10.14. Dynamic resource configuration is supported for all devices
Required

For ATA controllers and peripheral devices, the system must be capable of automatically assigning, disabling, and relocating the resources used by the device. In the event of an irreconcilable conflict with other devices, the operating system must be able to disable the adapter. Disabling a device must result in freeing all its resources for use by other devices.

The primary hard disk controller is not required to support dynamic disable capabilities.

Configuring or adding a device to the system must not require changing jumpers or switches on either the device or the system board.

Note: This requirement does not apply to jumper settings used by the OEM to make basic system-related settings in the factory. This requirement applies only to settings that the end user must make to configure the hardware.

10.15. Resource configuration meets bus requirements
Required

Plug and Play resource configuration requirements are defined by the bus used by the ATA/ATAPI controllers and peripheral devices, as defined in the related chapter for the specific bus in Part 3 of this guide.

10.16. ISA address ranges 3F7h and 377h are not claimed by ATA controllers
Required

Although ATA controllers might use these addresses, 3F7h and 377h also contain registers used by the FDC. To prevent resource conflicts, these addresses must not be claimed as device-register resources.

Power Management for ATA Devices

This section summarizes the specific ATA power management requirements. Power management requirements for peripherals that use ATA are defined in the related device-class chapters in Part 4 of this guide.

10.17. Bus and device meet PC 99 power management requirements
Required

The ATA channel must comply with the *Storage Device Class Power Management Reference Specification, Version 1.0* or later. Additional power management requirements are specified based on industry-defined standards for the bus used by the controller, such as PCI, and for the device. For more information, see the related chapter for the specific bus in Part 3 of this guide.

The ability to cause a wake-up event as defined in *Storage Device Class Power Management Reference Specification* is an optional feature.

10.18. ATA device supports ATA STANDBY command
Required

ATA drives must implement the ATA STANDBY command as defined in the ATA/ATAPI-4 standard or SFF 8020i.

For mobile ATA drives, it is recommended that a Read operation typically be completed within 5 seconds of applying power or leaving ATA STANDBY mode and transitioning to ATA ACTIVE. For desktop systems, the recommendation is 10 seconds. Information on system power states and transitions can be found in *Storage Device Class Power Management Reference Specification, Version 1.0* or later.

The drive spinup time recommendation is not expected to become a requirement in future versions of this guide.

ATA and ATAPI References

The following represents some of the references, services, and tools available to help build hardware that is optimized to work with Windows operating systems.

Advanced Configuration and Power Interface Specification, Revision 1.0. or later
    http://www.teleport.com/~acpi/tech.htm.

AT Attachment 2 [X3T9.2 948D] and *AT Attachment 3* [X3T10 2008D] standards
ATA/ATAPI-4 Revision 17 Working Draft Standard
ATA Packet Interface for CD-ROM (SFF 8020i)
Other ATA standards
    Global Engineering Documents
    Fax: (303) 397-2740
    Phone: (800) 854-7179 (U.S.)
                   (613) 237-4250 (Canada)
                   (303) 792-2181 (Outside North America)

    ATA and ATAPI draft standards and other working documents are available at
    ftp://fission.dt.wdc.com/pub/standards/ and
    ftp://ftp.symbios.com/pub/standards/io/

Compaq, Intel, Phoenix BIOS Boot Specification, Version 1.01
El Torito—Bootable CD-ROM Format Specification, Version 1.0
    http://www.ptltd.com/techs/specs.html

Media Status Notification Support Specification, Version 1.03
    http://www.microsoft.com/hwdev/respec/

Microsoft Windows 95 DDK and Windows NT 5.0 DDK
    MSDN Professional membership

MMC-2 Multi-Media Command Set-2
    ftp://ftp.symbios.com/pub/standards/io/t10/drafts/mmc2/mmc*xxxx*.pdf

PCI Local Bus Specification, Revision 2.1 (PCI 2.1)
    http://www.pcisig.com

SFF Committee publications
    FaxAccess: (408) 741-1600 (fax-back)
    Fax: (408) 867-2115

Storage Device Class Power Management Reference Specification, Version 1.0
    http://www.microsoft.com/hwdev/onnow.htm

White papers and guidelines for Microsoft operating systems
    http://www.microsoft.com/hwdev/storage/

Checklist for ATA and ATAPI

If a recommended feature is implemented, it must meet the requirements for that feature as defined in this document.

10.1. Controller and peripherals comply with ATA-2, ATA-3, or ATA/ATAPI-4 standards
Required

10.2. Bootable ATA controller supports El Torito No Emulation mode
Required

10.3. Option ROMs support Int 13h Extensions
Required

10.4. Dual ATA adapters use single FIFO with asynchronous access or dual FIFOs and channels
Required

10.5. System BIOS and devices support LBA
Required

10.6. System BIOS supports ARMD
Recommended

10.7. Controller and peripherals support Ultra DMA
Required

10.8. Controller and peripheral connections include Pin 1 cable designation with keyed and shrouded connectors
Required

10.9. Peripherals comply with ATA/ATAPI-4 or SFF 8020i v.2.5
Required

10.10. Removable media devices support media status notification
Required

10.11. BIOS enumeration of all ATAPI devices complies with ATA/ATAPI-4 or SFF 8020i v.2.5
Required

10.12. ATAPI devices support DEVICE RESET command
Required

10.13. Each device has a Plug and Play device ID
Required

10.14. Dynamic resource configuration is supported for all devices
Required

10.15. Resource configuration meets bus requirements
Required

10.16. ISA address ranges 3F7h and 377h are not claimed by ATA controllers
Required

10.17. Bus and device meet PC 99 power management requirements
Required

10.18. ATA device supports ATA STANDBY command
Required

C H A P T E R   1 1

SCSI

This chapter presents the requirements and recommendations for the small computer system interface (SCSI).

SCSI is a flexible I/O bus that is used in the design of a wide variety of peripherals, including disk drives, CD drives, tape drives, scanners, and magneto-optical drives. The SCSI host adapter is the circuitry that serves as an interface between the system and one or more SCSI peripherals. A host adapter can be a card that plugs into the system's expansion bus, such as a PCI card, or it can be designed directly into the system board.

The use of SCSI in a PC 99 system is optional, but if SCSI is used, all components must comply with the requirements defined in this chapter.

Contents

SCSI Host Adapter Requirements

This section summarizes class specifications and standards for SCSI host adapters.

11.1. SCSI host controller supports bus mastering
Required

The host controller must support PCI bus mastering; PCI bus mastering must be enabled by default.

11.2. Bootable SCSI controller supports El Torito No Emulation mode
Required

A bootable SCSI storage controller must support the No Emulation mode defined in *El Torito—Bootable CD-ROM Format Specification, Version 1.0,* or an equivalent method that supports the Windows NT Workstation CD-ROM installation process.

11.3. Option ROM supports Int 13h Extensions
Required

The Int 13h Extensions ensure correct support for high-capacity drives, consistent drive-letter mapping between real and protected modes, and other capabilities for both Windows and Windows NT. Support for the fixed-disk access subset of Int 13h Extensions must be provided in the system BIOS and in any option ROMs for storage devices that include BIOS support.

The Int 13h Extensions are defined in the "Layered Block Device Drivers" section of the Windows 95 DDK and in the Windows NT 5.0 DDK.

11.4. Option ROM supports virtual DMA services
Required

Plug and Play SCSI host adapters must support virtual DMA services in the host-adapter option ROM and must support bus mastering. Virtual DMA supports scatter/gather capabilities, solving the problem of mapping linear addresses (segment:offset) into physical addresses.

11.5. Bus type is clearly indicated on connectors for all adapters, peripherals, cables, and terminators
Required

Connectors for each SCSI adapter, peripheral, cable, and terminator must be clearly labeled to indicate the bus type. All external SCSI connectors must display the appropriate SCSI icon defined in *Small Computer Interface Parallel Interface* (SPI) standard, Annex H, and must display any clarifying abbreviations or acronyms. The following are applicable acronyms and their definitions:

- DIFF – differential. A signaling method that employs differential drivers and receivers to improve signal-to-noise ratios and increase maximum cable lengths. This includes both low voltage differential (LVD) and high voltage differential (HVD) types.

- SE – single-ended. A signaling method that employs drivers and receivers to increase circuit density.
- LVD – low voltage differential. A signaling method similar to DIFF but with lower signaling voltages supporting higher transfer rates.

11.6. Differential devices support DIFFSENS as defined in SPI standard
Required
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 standard.

11.7. Automatic termination circuit and SCSI terminators meet SCSI-3 standard
Required
SCSI add-on adapters and on-board controllers must use automatic termination, which allows a user to add external devices without removing the PC case. Terminators used in the SCSI host adapter must be regulated terminators, also known as active, SCSI-3 SPI, SCSI-2 alternative-2, or Boulay terminators. SCSI termination built onto internal cables must meet SCSI-3 standard.

11.8. Terminator power is supplied to the SCSI bus with overcurrent protection
Required
This requirement has two components:

- **11.8.1 Host adapter must supply terminator power.** The base requirement for system-board implementations using PCI or another expansion bus is that the host adapter must supply terminator power (TERMPWR) to the SCSI bus. All terminators on the host adapter, as well as those on the internal and external SCSI bus, must be powered from the TERMPWR lines on the SCSI bus.

- **11.8.2 The circuit that supplies TERMPWR must have built-in overcurrent protection.** Devices that provide TERMPWR must also provide some means of limiting the current through use of a self-resetting device. For example, a positive-temperature coefficient device or circuit breaker can be designed into the circuit. These devices open during an overcurrent condition and close after the condition ends.

Mobile PC Note   Although recommended, this item is not required for battery-powered systems that implement the SCSI host adapter as a PC Card device, because of battery consumption issues.

11.9. External connector meets SCSI-2 or later standard

Required

Although an external connector is optional, if an external connector is provided, it must be a high-density connector and must meet the requirements defined in the SCSI-2 or later standard.

11.10. Controller and peripherals implement SCSI bus data protection signal

Required

The SCSI host adapter and all SCSI peripherals must implement the SCSI bus data protection signal defined in the SPI standard, and data protection must be enabled by default. This signal was formerly referred to as the parity signal.

SCSI Peripheral Requirements

This section summarizes requirements related to specifications and standards for SCSI peripherals.

11.11. SCSI connections use keyed and shrouded connectors

Required

For internal and external configurations, the SCSI bus cable must be plugged into shrouded and keyed connectors on the host adapter and devices. This ensures that the cable is properly positioned so the user cannot plug in cables incorrectly.

For internal configurations, Pin 1 orientation must be designated on one edge of the ribbon cable and also on the keyed connector of the SCSI peripheral device. For more information, see requirement 3.18, "Connections use icons, plus keyed or shrouded connectors, with color coding."

11.12. External devices use automatic termination or an accessible on-board termination switch

Required

The recommended implementation for an external SCSI peripheral device is to provide automatic termination. In the absence of automatic termination, a mechanical means must be provided for setting termination and the switch must be accessible to the user without opening the device chassis.

11.13. Shielded device connector meets SCSI-2 or later standard

Required

Device connectors must meet the standards defined in the SCSI-2 or later standard.

11.14. Removable media devices support media status notification

Required

SCSI removable media storage devices must support media status notification as specified in requirement 18.2, "Removable media devices support media status notification."

Plug and Play for SCSI Host Adapters and Peripherals

This section summarizes the Plug and Play requirements for SCSI devices.

11.15. Each device has a Plug and Play device ID

Required

For each system-board device, there must be a Plug and Play device-specific ID.

Each SCSI controller or peripheral device must provide device IDs as defined in the *Plug and Play SCSI Specification, Version 1.0*, and in the specification for the bus it uses as defined in the related chapter in Part 3 of this guide.

For example, a PCI device must comply with PCI 2.1 and also must provide a Subsystem ID and Subsystem Vendor ID as defined in Chapter 9, "PCI." PCI controllers integrated into core logic on the system board do not have to provide Subsystem IDs and Subsystem Vendor IDs, but must meet other PCI 2.1 requirements.

11.16. Dynamic resource configuration is supported for all devices

Required

For SCSI on-board controllers and add-on adapters, the system must be capable of automatically assigning, disabling, and relocating the resources used by the device. Configuring the device or adding it to the system must not require changing jumpers or switches on either the device or the system board.

In the event of an irreconcilable conflict with other devices, the operating system must be able to disable the adapter. Disabling a device must result in freeing its resources for use by other devices.

Note: This requirement does not apply to jumper settings used by the OEM to make basic system-related settings in the factory. This requirement applies only to settings that the end user must make to configure the hardware.

11.17. Resource configuration meets bus requirements

Required

Plug and Play resource-configuration requirements are defined by the bus used by the SCSI controllers and peripheral devices, as defined in the related chapter for the specific bus in Part 3 of this guide.

11.18. SCAM support is disabled by default

Required

SCSI Configured Automatically (SCAM) support is not recommended. If support is present, it must be disabled by default. SCAM is not supported by Windows operating systems; enabling SCAM can cause the system to become unstable or inoperable.

Plug and Play for SCSI must be implemented as defined in *Plug and Play SCSI Specification, Version 1.0.*

11.19. SCSI devices that support hot-plugging meet PC 99 requirements

Required

To ensure reliable support for hot-plugging capabilities, the following requirements must be met by any SCSI devices that allow hot-plugging:

- **11.19.1 Hot-plugging for PCI devices uses ACPI-based methods.** Windows 98 and Windows NT 5.0 support dynamic enumeration, installation, and removal of devices connected by way of the PCI bus only if there is a supported hardware insert/remove notification mechanism as defined in Section 5.6.3 of the ACPI 1.0 specification.

  In order to properly function with the native support in the operating system, developing industry standards such as those referred to as PCI Hot Plug and Compact PCI must use ACPI-based methods for supporting hardware insertion and removal as defined in the ACPI 1.0 specification.

- **11.19.2 All removable media support media status notification.** Removable media must support the appropriate media status notification method to ensure that no loss of data or system failure results when such media is removed from the system. See requirement 11.14, "Removable media devices support media status notification."

Recommended: A locking mechanism to ensure that devices are removed only under operating system control or during sleep or off states. For implementation details and additional design guidelines, see the article about hot-plugging support at http://www.microsoft.com/hwdev/busbios/rem_devs.htm.

11.20. SCSI controllers provide multi-initiator support

Recommended

Multi-initiator support allows two SCSI controllers—each installed in a separate computer system—to coexist on a shared SCSI bus with a set of shared devices. If this capability is supported, the SCSI IDs must be changeable from the default SCSI controller ID of 7 and the boot-time SCSI bus reset operation must be able to be disabled on each controller attached to a shared bus.

This capability is recommended for hardware that will be used on systems using the clustering service available under Microsoft Windows NT Server Enterprise Edition. To use this service, a SCSI adapter and a SCSI peripheral must provide multi-initiator support for at least two initiators.

Power Management for SCSI Devices

This section summarizes the specific power management requirements for the SCSI bus class. Power management requirements for other device classes are defined in Part 4 of this guide.

11.21. Bus and device meet PC 99 power management requirements
Required

Storage devices must comply with the *Storage Device Class Power Management Reference Specification, Version 1.0* or later. The ability to cause a wake-up event as defined in *Storage Device Class Power Management Reference Specification* is an optional feature.

Additional power management requirements are specified based on industry-defined standards for the bus used by the controller, as defined in the related chapter for the specific bus in Part 3 of this guide. See also Part 4 of this guide for the related device class power management requirements for a particular device type.

For mobile drives, it is recommended that a Read operation typically be completed within 5 seconds of applying power or issuing a START UNIT command; for desktop systems, the recommendation is 10 seconds.

The drive spinup time recommendation is not expected to become a requirement in future versions of this guide.

11.22. Hardware supports the STOP/START UNIT command as defined in the SPI standard
Required

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 ensure that the operating system responds to appropriate driver calls, the STOP/START UNIT command must be implemented as defined in the SPI (SCSI-3) standard.

11.23. STOP/START UNIT command is used to decrease power consumption

Required

Wherever appropriate, such as for storage disks, the STOP UNIT command must be used to decrease the power consumption of the base platform.

Removing power should not be used as the method for spinning down storage disks.

SCSI References

The following represents some of the references, services, and tools available to help build hardware that is optimized to work with Windows operating systems.

Compaq, Intel, Phoenix BIOS Boot Specification, Version 1.01
El Torito—Bootable CD-ROM Format Specification, Version 1.0
   http://www.ptltd.com/techs/specs.html

MMC-2 Multi-Media Command Set-2
   ftp://ftp.symbios.com/pub/standards/io/t10/drafts/mmc2/mmc*xxxx*.pdf

Microsoft Windows 95 DDK and Windows NT DDK
   MSDN Professional membership

NCITS Reduced Block Commands (RBC) Draft Proposal (T10/97-260r0)
   ftp://ftp.symbios.com/pub/standards/io/t10/drafts/rbc/

PCI Local Bus Specification, Revision 2.1 (PCI 2.1)
   http://www.pcisig.com

Plug and Play SCSI Specification, Version 1.0
   http://www.microsoft.com/hwdev/respec/pnpspecs.htm

Small Computer Interface (SCSI-2) [X3T9.2-375R] standard
Small Computer Interface (SCSI-3) *Parallel Interface* (SPI)
      [X3T9.2/91-10] standard
Other SCSI standards and documents
   Global Engineering Documents
   Fax: (303) 397-2740
   Phone: (800) 854-7179 (U.S.)
               (613) 237-4250 (Canada)
               (303) 792-2181 (Outside North America)

SCSI draft standards and other working documents are available at
   ftp://ftp.symbios.com/pub/standards/io/t10/

Small Form Factor (SFF) Committee publications
   FaxAccess: (408) 741-1600 (fax-back)
   Fax: (408) 867-2115

Storage Device Class Power Management Reference Specification, Version 1.0
Other device class power management reference specifications
    http://www.microsoft.com/hwdev/onnow.htm

White papers and guidelines for Microsoft operating systems
    http://www.microsoft.com/hwdev/storage/

Checklist for SCSI

If a recommended feature is implemented, it must meet the requirements for that
feature as defined in this document.

11.1. SCSI host controller supports bus mastering
Required

11.2. Bootable SCSI controller supports El Torito No Emulation mode
Required

11.3. Option ROM supports Int 13h Extensions
Required

11.4. Option ROM supports virtual DMA services
Required

11.5. Bus type is clearly indicated on connectors for all adapters, peripherals, cables, and terminators
Required

11.6. Differential devices support DIFFSENS as defined in SPI standard
Required

11.7. Automatic termination circuit and SCSI terminators meet SCSI-3 standard
Required

11.8. Terminator power is supplied to the SCSI bus with overcurrent protection
Required

11.9. External connector meets SCSI-2 or later standard
Required

11.10. Controller and peripherals implement SCSI bus data protection signal
Required

11.11. SCSI connections use keyed and shrouded connectors
Required

11.12. External devices use automatic termination or an accessible on-board termination switch
Required

11.13. Shielded device connector meets SCSI-2 or later standard
Required

11.14. Removable media devices support media status notification
Required

11.15. Each device has a Plug and Play device ID
Required

11.16. Dynamic resource configuration is supported for all devices
Required

11.17. Resource configuration meets bus requirements
Required

11.18. SCAM support is disabled by default
Required

11.19. SCSI devices that support hot-plugging meet PC 99 requirements
Required

11.20. SCSI controllers provide multi-initiator support
Recommended

11.21. Bus and device meet PC 99 power management requirements
Required

11.22. Hardware supports the STOP/START UNIT command as defined in the SPI standard
Required

11.23. STOP/START UNIT command is used to decrease power consumption
Required

C H A P T E R   1 2

PC Card

This chapter presents requirements and recommendations for PC Card.
This includes 16-bit PC Card, previously referred to as Personal Computer Memory
Card International Association (PCMCIA) cards, CardBus cards, and PC Card
socket controllers.

Windows 98 and Windows NT Workstations support 16-bit PC Card I/O cards and
CardBus I/O cards. Memory 16-bit PC Card cards are supported only as legacy
devices. For any PC Card device to work effectively with Windows or
Windows NT, the manufacturer must implement a minimum set of tuples
documented in the PC Card standard. Windows uses these tuples to identify
and configure any 16-bit PC Card card, and it might also use these tuples for
CardBus cards.

Contents

PC Card Basic Requirements

This section summarizes the basic requirements for PC Card.

12.1. All devices comply with the PC Card standards
Required
Designs for PC Card socket controllers and cards must all be based on the PC Card standards.

The *February 1995 PC Card Standard* added requirements for minimum card information structure (CIS), 3.3-volt cards, multifunction cards, and cards that use DMA. It also introduced requirements for CardBus (32-bit) cards. The *March 1997 PC Card Standard* incorporated all corrections, changes, and adopted proposals as of that date.

All PC Card devices must comply with these standards for PC 99.

12.2. System and ZV-compatible 16-bit PC Cards comply with ZV standard definitions
Required
The PC Card standards define the requirements for Zoomed Video (ZV) cards and system support.

PC Card Socket Controller Requirements

This section summarizes requirements and standards for socket controllers.

12.3. Controller supports industry-standard ExCA register set
Required
The built-in software supporting 16-bit PC Card cards in Windows includes drivers for the industry-standard Exchangeable Card Architecture-compatible (ExCA-compatible) socket controllers. To be compatible with these drivers, socket-controller implementations must support the industry-standard ExCA base register set.

Notice that some controllers do not fully implement the register set and therefore are incompatible. Also, some controllers implement extended registers or enhancements. The built-in Windows drivers do not exploit these features, even though the controller might be compatible.

12.4. System maintains mapping of IRQ Routing Register bits to system interrupt vectors

Required

The system design must maintain the mapping of the PC Card controller's IRQ Routing Register bits to system interrupt vectors. This means that when an interrupt is programmed in the controller to occur on the IRQx pin, the system's IRQ routing causes the interrupt controller to generate the interrupt vector for IRQx and no other IRQ.

12.5. IRQ connections can be determined by using the 0805 register

Required

Windows uses the 0805 register on CardBus controllers to determine which ISA IRQs are connected to the controller. This register must engage (drive low) the corresponding ISA IRQ when programmed with a value. It must disengage the IRQ (float high) when programmed at zero (0). This behavior must be achieved without requiring the operating system to program any non-standard registers.

12.6. CardBus controllers support both ISA and PCI interrupts

Required

PC Card software dynamically configures the bridge to use ISA interrupts for 16-bit PC Card cards and to use Peripheral Component Interface (PCI) interrupts for CardBus cards. As defined in requirement 12.5, "IRQ connections can be determined by using the 0805 register," and requirement 12.4, "System maintains mapping of IRQ Routing Register bits to system interrupt vectors," CardBus controllers must maintain mapping of IRQ routing. Also, notice that systems implementing CardBus controllers must fully support PCI 2.1 as well as additional PCI requirements for IRQ routing as described in requirement 9.13, "Interrupt routing is supported using ACPI," and requirement 9.14, "BIOS does not configure I/O systems to share PCI interrupts."

12.7. System supports industry-standard definition for CardBus bridges

Required

Systems must support the definition in *PCI to PCMCIA CardBus Bridge Register Description* (Yenta specification) for CardBus controllers (PCI-to-CardBus bridges). This definition includes a common PCI Configuration Space header assigned the Header Type field value of 82h.

Although this requirement is not yet incorporated into the PCI standard, Windows supports it. Any controller features that are not part of the Yenta specification will not be used in standard drivers. The BIOS is responsible for any hardware initialization or setup required to make the controller comply with the Yenta specification or other requirements listed in this chapter.

Because CardBus host controllers are PCI bus bridges, they will be supported (enumerated and configured) by the PCI software in Windows in the same manner as other PCI bus bridges. For more information, see requirement 9.3, "System uses standard method to close BAR windows on nonsubtractive decode PCI bridges."

12.8. BIOS initializes CardBus controller in 82365-compatible mode and supports backward compatibility

Recommended

CardBus controllers are enumerated and configured in the same way as other PCI bus bridges. The PCI bus bridge support in Windows 98 is based on requirements for PCI interrupt routing and bridge-window configuration. Because of this, full compliance with the latest PCI specifications is a requirement for CardBus support. See Chapter 9, "PCI."

There are steps the BIOS can take to achieve backward compatibility with Windows. Specifically, the BIOS can initialize the CardBus controller in Intel 82365-compatible mode and report it as device "PNP0E03, Intel 82365-compatible CardBus controller." The requirements are as follows for BIOS POST time (CardBus controller ConfigSpace initialization):

- Command register (offset 0x04) set to 0x07 (IOSpaceEnable, MemSpaceEnable, BusMasterEnable).

- RegisterBaseAddress (offset 0x10) set to 0. If support for other environments is needed, such as Windows 3.1 or MS-DOS®, some other value can be set.

- All memory and I/O windows (offset 0x1c–0x38) set to 0.

- Interrupt Line register (offset 0x3c) set to 0xff (no IRQ assigned). If support for other environments is needed, such as Windows 3.1 or MS-DOS, an assigned IRQ line can be set. Notice, however, that this register must be set to 0xff at the time that the device is disabled by the operating system, and then set into CardBus mode. More information about BIOS enumeration is presented later in this requirement.

- Other controller-specific initialization as required to put the controller in legacy mode.

This puts the CardBus controller into legacy mode where the Windows Socket Services driver can access it as an Intel PC Card I/O card–compatible (PCIC-compatible) controller at an I/O address, for example, 0x3e0.

Notice that the BIOS must be at least PCI 2.1-compliant and must support the $PIR Interrupt Routing Table. The $PIR table must return the necessary PCI IRQ routing information, including the routing information for the CardBus controller. In general, if the CardBus controller is on the system board, there must be a slot routing entry for it in the table. If the CardBus controller is a PCI add-on card, there must be routing information entries for each PCI slot in the system.

During Plug and Play BIOS enumeration, the BIOS should report the CardBus controller as *pnp0e03 with a compatible ID of *pnp0e00 and the I/O resource of two ports, for example, 0x3e0–0x3e1.

For more information, see the white paper on CardBus host controllers and Windows compatibility at http://www.microsoft.com/hwdev/cardbus/.

12.9. CardBus controllers do not share writable PCI Configuration Space bits
Required

CardBus controllers are multifunction PCI devices, and Windows treats each function as an independent device. As such, there can be no sharing between functions of writable PCI Configuration Space bits, such as the Command register.

Notice that the 16-bit PC Card interface legacy-mode BAR (offset 44h in the Type 2 PCI header) is the only exception to this requirement. This BAR must be shared between the two functions in order to be compatible with the ExCA programming model.

12.10. Each 16-bit PC Card memory window in CardBus controller has it own page register
Required

For complete flexibility and support of typical configurations, CardBus controllers must support the independent location of R2 memory windows anywhere in the full system address space as recommended in the Yenta specification.

Controllers that share a single page register among all 16-bit PC Card memory windows require that all 16-bit PC Card memory windows must be located within the same 16-MB block. This is often not possible with typical (16 MB) DRAM and bridge (positive-decode) configurations. The result is disabled cards.

Plug and Play Design for 16-bit PC Card Cards

This section summarizes the Plug and Play requirements for 16-bit PC Card cards.

The Windows operating system determines what type of card is plugged into the PC Card socket by examining the tuples on the card. For Plug and Play functionality, 16-bit PC Card I/O cards must support a set of required information and configuration tuples. The PCMCIA bus enumerator uses these tuples to identify the card, load the correct device driver, and indicate all possible configurations to the Plug and Play configuration manager. The operating system then dynamically assigns a valid configuration based on this information.

12.11. Card supports required I/O card tuples

Required

The following items must be implemented for any 16-bit PC Card I/O card that connects to a PC 99 system:

- The 16-bit PC Card card must contain:
  - The device information tuple (CISTPL_DEVICE, 01h for cards capable of 5 V operation or CISTPL_DEVICE_0C, 1Ch for cards capable of 3.3 V operation).
  - The Level 1 (L1) version/product information tuple (CISTPL_VERS_1, 15h).
  - The configuration tuple (CISTPL_CONFIG, 1Ah).
  - The configuration table entry tuple (CISTPL_CFTABLE_ENTRY, 1Bh).
- A 16-bit PC Card card with more than 64 MB Common Memory must contain the extended device information tuple (CISTPL_EXTDEVICE, 09h).
- The L1 version/product information tuple must contain the product name and manufacturer name in the product information string (TPLLV1_INFO, byte 4).
- The product name and manufacturer name in the L1 version/product information tuple must be composed only of ASCII characters greater than ASCII 20h and less than ASCII 7Fh.

Windows uses the information contained in the required and recommended tuples to create a unique device ID for the card and to assimilate configuration information for the device. Windows uses the device configuration tuples to determine the general characteristics of the card.

Required I/O Card Tuples

Tuple ID	Tuple code	Description and comments
01h	CISTPL_DEVICE	Device information (common memory). For non-memory cards, this tuple must be present, but the device type will be NULL.
15h	CISTPL_VERS_1	L1 version/product information strings: Product information, Product name, Product number, Other manufacturer information
1Ah	CISTPL_CONF	Configuration. Indicates the location of configuration registers and registers present.
1Bh	CISTPL_CE	Configuration table entry. Appropriate configuration requirements for I/O space, interrupts, memory, and so on should be specified.
20h	CISTPL_MANFID	Manufacturer ID. Card manufacturer ID code. Defines manufacturer for this card.
21h	CISTPL_FUNCID	Function ID. Provides function information about the card. Also includes system initialization information.

The device information tuple provides information about the memory devices used in the card's common memory space. The device type, size, and speed are used to configure the socket for efficient access to the card. This tuple must be present on 16-bit PC Card I/O cards, but the device type must be NULL.

The L1 version/product information tuple contains human-readable information about the product and its manufacturer. This information is intended to be displayed to the user where necessary. Windows uses the information contained in the product information string and product name string to construct the device ID for that card. It also scans through the tuple, starting at the very beginning and continuing to the end of the product name string.

The information gathered from the L1 version/product information tuple is used to construct the unique device ID. Because the optional third and fourth strings in the tuple are not used in the unique ID, devices that require unique numbers on each card can use these strings to store that information.

The configuration tuple tells the software where to locate the configuration registers that program the card's configuration, as well as which registers are present on the card.

Each configuration table entry tuple completely describes one valid configuration in which the card can operate. Each entry describes power, timing, I/O space, interrupt, and memory space requirements for the given configuration. Configuration software selects one of these configurations for the card based on the resources currently available in the system.

The manufacturer ID tuple (CISTPL_MANFID, 20h) and the function ID tuple (CISTPL_FUNCID, 21h) add extra flexibility to a PC Card that connects to the PC:

- The manufacturer ID tuple provides unique information about the card manufacturer. This code is registered with PCMCIA. Windows uses the manufacturer ID tuple as one source for creating a 16-bit CRC used in the construction of the device ID.

- The function ID tuple provides information about the class of device or what function the card provides, for example, memory, modem, disk, and so on. This information helps the software perform necessary installation tasks and locate compatible drivers. Although it is not required to make this determination, Windows uses the function ID tuple internally to determine what type of device is on the PC Card.

12.12. Configuration table entry tuples listed in priority order

Required

Configuration table entry tuples are placed in the preferred order for configuring the device. Windows processes the tuples in the order they are placed in the Card Information Structure (CIS). From these tuples, Windows creates a logical configuration in this order and prioritizes them in the same order. Notice that for multiple voltage cards, the voltage policy is to prioritize 3.3-volt configurations, if they are supported by the system, over 5-volt configurations, regardless of the order of the configuration table entry tuples (CISTPL_CFTABLE_ENTRY).

12.13. Card specifies maximum configuration options

Required

Many older PC Cards specified fixed configurations in order to address compatibility with existing software. However, this is not the intended use for tuples; the configuration software should be responsible for compatibility. The tuples should be used only to describe its maximum configurability, ruling out configurations not supported by the hardware.

If fixed configurations must be provided for an operating system other than Windows, there must be one or more entries that specify the maximum configurability that the hardware can handle. An example of "maximum configurability" is to specify "any IRQ" rather than only IRQ 3 or IRQ 4.

Plug and Play Design for CardBus

This section summarizes the Plug and Play requirements for CardBus cards. CardBus was designed as a combination of the 16-bit PC Card and PCI. The goal is to gain the benefits of PCI in a PC Card format. Consistent with this goal, Windows support for CardBus places specific requirements on CardBus cards.

12.14. Configuration Space meets Common Silicon Guidelines

Required

The Common Silicon Guidelines are defined in Section 2.6 of the *PC Card Standard Guidelines, Volume 10.*

The standard for CardBus defines a PCI-like Configuration Space that is not fully compliant with the PCI specification. Specifically, under the CardBus standard, card vendors do not have to implement certain critical fields in the Configuration Space, described in the PC Card standard as allocated. In the PC Card standard guidelines for silicon common to both PCI and CardBus products, the implementation of these fields is recommended.

However, to maintain compatibility with existing PCI system software and drivers for PC 99, Windows will support only CardBus cards whose Configuration Space is designed to meet the Common Silicon Guidelines. This is a requirement because CardBus configuration is performed by the PCI software, which can deal with all aspects of PCI topology configuration, including bridging. Without the allocated fields, the cards cannot be fully treated as PCI devices and cannot be supported under Windows.

The required allocated fields are listed in the following table.

Required Allocated Fields

Field	Description and comments
Vendor ID	This read-only field contains a unique ID (in PCI space) for the card manufacturer. The PCI SIG allocates unique IDs.
Device ID Revision ID	These read-only fields are vendor-assigned values that uniquely identify the device (among all vendors of PCI or CardBus products).
Class Code	This read-only field is defined in PCI 2.1. It describes what type of device the card is.
Max_Lat Min_Gnt	These read-only fields specify the desired settings for Latency Timer values according to PCI 2.1. A value of 0 indicates the device has no major requirements for the settings of Latency Timers.
Interrupt Line	This register must be read-write and must not be connected to anything, just as on PCI cards. This register is used to store the current IRQ routing for the device.

12.15. RESERVED fields comply with PCI 2.1

Required

The CardBus specification also lists two RESERVED fields (offset 2C in the Configuration Space), which have since been defined in PCI 2.1. These fields are also required on CardBus cards for Windows compatibility.

Required RESERVED Fields

Field	Description
Subsystem ID	If different from Device ID
Subsystem Vendor ID	If different from Vendor ID

12.16. CardBus card implements required and recommended tuples

Required

For CardBus, Windows also requires the same set of card tuples recommended in the PC Card guidelines, as summarized in the following table.

Required CardBus Tuples

Tuple ID	Tuple code	Comments
04h	CISTPL_CONFIG_CB	—
05h	CISTPL_CFTABLE_ENTRY_CB	—
07h	CISTPL_BAR	—
13h	CISTPL_LINKTARGET	Required as first tuple in PC Card standard.
15h	CISTPL_VERS_1	—
20h	CISTPL_MANFID	—
FFh	CISTPL_END	Required as end-of-chain tuple in PC Card standard.
21h	CISTPL_FUNCID	Recommended in PC Card standard; required for PC 99.

PC 99 Requirements for PC Card

This section summarizes additional requirements for PC Card.

Power Management for PC Card

This section summarizes the specific power management requirements for PC Card. Power management requirements for specific device classes are defined in the related chapters in Part 4 of this guide.

12.17. Socket controller complies with device class power management reference specification

Required

This applies for both 16-bit PC Card-only controllers and CardBus controllers.

The *PC Card Controller Device Class Power Management Reference Specification, Version 1.0* or later, provides class-specific definitions of the OnNow device power states (D0–D3) for these devices. The specification also covers device functionality expected in each power state and the possible wake-up event definitions for the class, for example, whether card insertion should wake the system.

12.18. 16-bit PC Card cards implement power-related events using ReqAttn bit and #STSCHG mechanism

Required

Any 16-bit PC Card card that is capable of signaling a wake-up event to the system, as defined in the device class power management reference specification for its class, must implement the ReqAttn bit and its associated enable bit in the Extended Status register, and must signal on the #STSCHG line.

12.19. CardBus controllers and cards implement PCI power management specifications

Required

PCI-to-CardBus bridges must comply with the requirements defined in *PCI Bus Power Management Interface Specification, Revision 1.0* or later. CardBus cards must also comply with the requirements defined in *PCI Bus Power Management Interface Specification, Revision 1.1* or later.

The CardBus card must use the CSTSCHG pin to signal wake-up events. This is because there is no PME# pin on the CardBus interface, and the CardBus card must use PME_EN in the card's Configuration Space to enable wake-up events. Specifically, setting the PME_EN bit in the card's Configuration Space must provide the same behavior as setting both the GWAK and WKUP bits in the card's Function Event Mask register.

For more information, see "Power Management for PCI Controllers and Peripherals" in Chapter 9, "PCI."

Device Drivers and Installation for PC Card

This section summarizes requirements for PC Card device drivers.

12.20. No user intervention required for correctly installing devices

Required

The user must not be required to perform any device-installation action other than to insert disks that contain drivers and other files.

12.21. Device is immediately functional without restarting the system

Required

The user must be able to begin using the device without having to restart the system. Device use begins either after installation is complete or whenever the device is inserted in the system.

12.22. ZV-compatible PC Card driver uses DirectDraw LVE

Required

ZV-compatible PC Card drivers must use software interfaces based on 32-bit DirectDraw Live Video Extensions (LVE) in order to configure the graphics controller to receive video input using the ZV port. This includes programming the graphics controller to configure the format of the video data, its location on screen, and so on. LVE is part of DirectX 3.0 and later versions.

ZV card device drivers must handle dynamic graphics state changes, such as resolution changes, color depth changes, and switching to and from full-screen MS-DOS–based applications.

12.23. 16-bit PC Card card driver supports sharing of level-mode interrupts

Required

CardBus systems support both 16-bit PC Card cards and CardBus cards. In this environment, interrupt sharing becomes an issue because CardBus controllers can use PCI interrupts, which are level-sensitive and sharable. To help alleviate interrupt limitations in CardBus systems, Windows operating systems can take advantage of PCI interrupt-sharing capabilities.

In cases where no ISA IRQs are available to a 16-bit PC Card card in a CardBus controller, the operating system will assign a PCI interrupt to the card. Therefore, it is recommended that 16-bit PC Card card drivers are updated to support interrupt sharing. However, it is a requirement that 16-bit PC Card card drivers must "hook" the interrupt, whether it is sharable or not, before its hardware generates any interrupts.

See also requirement 9.15, "BIOS configures boot device IRQ and writes to the interrupt line register."

PC Card References

The following represents some of the references, services, and tools available to help build hardware that is optimized to work with Windows operating systems.

Microsoft Windows 95 DDK and Windows NT 5.0 DDK
    MSDN Professional membership

PC Card Controller Device Class Power Management Reference Specification, Version 1.0
    http://www.microsoft.com/hwdev/onnow.htm

PC Card diagnostic utility (Dtpl.exe) and white papers for CardBus
    http://www.microsoft.com/hwdev/pci/

PCI Bus Power Management Interface Specification, Revision 1.0 and later
PCI Local Bus Specification, Revision 2.1 (PCI 2.1)
    http://www.pcisig.com

PCMCIA standards, including *PC Card Standard Guidelines* and *PCI to
PCMCIA CardBus Bridge Register Description* (Yenta specification)
PCMCIA
2635 North First Street, Suite 209
San Jose, CA 95134 USA
Phone: (408) 433-2273
Fax: (408) 433-9558
E-mail: office@pcmcia.org
http://www.pc-card.com/

White papers and guidelines for Microsoft operating systems
http://www.microsoft.com/hwdev/cardbus/

Checklist for PC Card

If a recommended feature is implemented, it must meet the requirements for that
feature as defined in this document.

12.1. All devices comply with the PC Card standards
Required

12.2. System and ZV-compatible 16-bit PC Cards comply with ZV standard definitions
Required

12.3. Controller supports industry-standard ExCA register set
Required

12.4. System maintains mapping of IRQ Routing Register bits to system interrupt vectors
Required

12.5. IRQ connections can be determined by using the 0805 register
Required

12.6. CardBus controllers support both ISA and PCI interrupts
Required

12.7. System supports industry-standard definition for CardBus bridges
Required

*12.8. BIOS initializes CardBus controller in 82365-compatible mode and supports backward
compatibility*
Recommended

12.9. CardBus controllers do not share writable PCI Configuration Space bits
Required

12.10. Each 16-bit PC Card memory window in CardBus controller has it own page register
Required

12.11. Card supports required I/O card tuples
Required

12.12. Configuration table entry tuples listed in priority order
Required

12.13. Card specifies maximum configuration options
Required

12.14. Configuration Space meets Common Silicon Guidelines
Required

12.15. RESERVED fields comply with PCI 2.1
Required

12.16. CardBus card implements required and recommended tuples
Required

12.17. Socket controller complies with device class power management reference specification
Required

12.18. 16-bit PC Card cards implement power-related events using ReqAttn bit and #STSCHG mechanism
Required

12.19. CardBus controllers and cards implement PCI power management specifications
Required

12.20. No user intervention required for correctly installing devices
Required

12.21. Device is immediately functional without restarting the system
Required

12.22. ZV-compatible PC Card driver uses DirectDraw LVE
Required

12.23. 16-bit PC Card card driver supports sharing of level-mode interrupts
Required

C H A P T E R   1 3

I/O Ports and Devices

This chapter presents requirements and recommendations for I/O ports and devices, including serial and parallel ports, wireless capabilities, and input devices and connectors.

System designers are encouraged to consider solutions such as USB rather than traditional connections for external devices. USB support is required for PC 99 systems, and easy connectivity is important in situations where devices might be interchanged on a regular basis. USB is expected to replace legacy serial and parallel ports as the dominant external connector in the near future.

Contents

System Requirements for I/O Ports and Devices

This section summarizes requirements for serial and parallel ports.

13.1. System includes connection for external serial devices
Required for all system types
Recommended: USB or PC Card.

This capability can also be provided as a 16550A serial port or as equivalent I/O capabilities in the system. If a legacy serial port is implemented in a PC 99 system, it must meet the requirements defined in this chapter. If two legacy serial ports are implemented, additional requirements are defined.

For Office PC systems, remote management capabilities must be implemented as defined in *Network PC System Design Guidelines, Version 1.0b*.

See also requirement 3.5.9, "System BIOS support for console redirection of a serial port." This capability provides support during system startup for debugging and troubleshooting activities. The BIOS must configure at least one serial port to use either 2F8h or 3F8h. This allows the port to be treated as a boot device by the BIOS and is intended to be usable by components as a diagnostic port in the event that system debugging is required by either the BIOS or the operating system.

13.2. System includes connection for external parallel devices
Required for all system types
Recommended: USB, IEEE 1394, or PC Card.

This connection can also be provided as a parallel port with extended capabilities port (ECP)-mode capabilities. If a legacy port is implemented in a PC 99 system, it must meet the requirements defined in this chapter.

If a parallel port is present, remote management capabilities must be implemented as defined in *Network PC System Design Guidelines*. On a RISC-based system, the keyboard must work as the input device using the Advanced RISC Computing (ARC) interfaces.

13.3. System includes external connection for keyboard
Required for all system types
Recommended: USB.

Although USB is the preferred solution, this connection can also be implemented as a PS/2-style port or by using wireless capabilities in the system.

Mobile PC Note	For a mobile PC, the required USB port can be used to support the requirement for an external pointing device and keyboard connections. However, two PS/2-style ports can be implemented for the pointing device and keyboard, or a single PS/2-style port can be provided for both the pointing device and the keyboard. If a single PS/2-style port is used, the design must include two separate clocks and two separate data lines, and a special cable must be provided that allows both the external keyboard and pointing device to use the single port.

13.4. System includes pointing-device connection and pointing device

Required for all system types

Recommended: USB or wireless.

Although USB is the preferred solution, this connection can also be implemented using a PS/2-style port.

Mobile PC Note	For issues related to mobile PCs, see requirement 13.3, "System includes external connection for keyboard."

13.5. System includes USB game pad or joystick

Required for all system types; wireless recommended for Entertainment PC

This device must support the *USB Human Interface Device Class Specification, Version 1.0* or later. For more information about requirements for USB peripherals, see Chapter 7, "USB."

Important: No devices that use legacy or proprietary ports can be included in a PC 99 system.

13.6. System includes built-in wireless capabilities

Recommended for all system types

Wireless capabilities can be provided as built-in capabilities in the system or by using PC Card, IEEE 1394, or USB. If wireless capabilities are included in the system, the requirements must be met that are defined in "Wireless Component Requirements" later in this chapter.

13.7. Devices use USB or external bus connections rather than legacy serial or parallel ports

Consumer	Office	Mobile	Workstation	Entertainment
Required	*Recommended*	*Recommended*	*Required*	*Required*

This will become a requirement for all system types in future versions of these guidelines.

Although legacy parallel and serial ports can be provided on a PC 99 system, no devices that use these ports should be provided with a system, with the exception of printers. A legacy serial port cannot be used as the connection for the mouse or modem.

13.8. All devices meet PC 99 general device requirements
Required

These include the requirements for a device ID, automated software-only settings for device configuration, device drivers and Windows-based installation, and icons for external connectors. For more information, see "PC 99 General Device Requirements" in Chapter 3, "PC 99 Basic Requirements."

Serial Port Requirements

Serial ports have been used on computers for decades. In the past, standard baud rates for most serial ports were around 19.2K. Now that systems and peripherals have become more demanding, higher-speed devices are necessary to meet the needs of the newest generation of serial ports.

This section summarizes the hardware design features for serial ports. The general device requirements are defined in "System Requirements for I/O Ports and Devices" earlier in this chapter.

Non-legacy Serial Port Requirements

This section defines requirements for non-legacy implementations in support of serial port capabilities.

13.9. Serial port meets device class specifications for its bus
Required

As required for all PC 99 devices, a serial port implementation that uses a non-legacy bus must meet the specific device class requirements for that bus.

For example, a USB serial port implementation must comply with all related USB specifications, including:

- *Universal Serial Bus Specification, Version 1.0* or later (also known as the USB core specification)

- *Universal Serial Bus Device Class Definition for Communication Devices, Version 1.0* or later

  The "Standard Serial Interface Circuit Emulation" appendix in the *USB Device Class Definition for Communication Devices* specifically addresses serial-port compatibility.

Legacy Serial Port Requirements

This section defines requirements for legacy serial ports. Legacy ports are not recommended for PC 99 systems, but if implemented, such ports must meet the requirements defined in this section.

13.10. Legacy serial port is implemented as 16550A UART or equivalent and supports 115.2K baud
Required

A 16550A buffered Universal Asynchronous Receiver/Transmitter (UART) or equivalent buffered legacy serial port is required to support high-speed communications while reducing the CPU requirements for servicing the device. The device must be able to support 115.2K baud.

13.11. Legacy serial port supports dynamic resource configuration
Required

A legacy serial port must provide flexible resource configuration and complete dynamic disable capabilities as defined in the *Plug and Play External COM Device Specification, Version 1.0.*

These are the recommended resource settings for non-PCI devices:

- Four I/O locations for each port, where the standard ISA I/O addresses are 3F8h, 2F8h, 3E8h, 2E8h. Using the standard addresses ensures the proper functioning of software that directly addresses these locations.

- Two IRQ signals, where the standard is programmable interrupt controller-based (PIC-based) IRQ 3 and IRQ 4. Using the standard IRQ signals ensures the proper functioning of software written for systems that use standard IRQ signals.

Two IRQs are required for each port. If two serial ports are implemented in the system, the IRQs can be assigned as follows:

- For serial port A: PIC-based IRQ 4 and IRQ 11

- For serial port B: PIC-based IRQ 3 and IRQ 10

An IR adapter port might replace a serial port in a system. In such a case, the IR port should use the resource configuration that would otherwise be assigned to the second serial port.

Notice that, as for all devices, IRQ sharing is required if the minimum resource requirement cannot be met.

13.12. Conflict resolution for legacy serial port ensures availability of at least one serial port

Required

In the event of an irreconcilable conflict with other serial ports on the system, a legacy serial port must be capable of being disabled by Plug and Play software. This allows at least one of the two conflicting serial ports to operate correctly.

Parallel Port Requirements

This section summarizes the basic design features for parallel ports and peripherals. Each parallel port on a PC 99 system must meet the requirements listed in this section. The general device requirements are defined in "System Requirements for I/O Ports and Devices" earlier in this chapter.

Non-legacy Parallel Port Requirements

This section defines requirements for recommended non-legacy implementations to support parallel port capabilities.

13.13. Parallel port meets device class specifications for its bus

Required

As required for all PC 99 devices, a parallel port implementation that uses a non-legacy bus must meet the specific device class requirements for that bus.

For example, a parallel port implementation that uses USB must comply with all related USB specifications, including the USB core specification and any specific device class specification.

Legacy Parallel Port Requirements

This section defines requirements for legacy parallel ports.

13.14. Flexible resource configuration supported for each parallel port

Required

A legacy parallel port must provide flexible resource configuration following the *Plug and Play Parallel Port Device Specification, Version 1.0b.* Resource requirements must be met for each device of this type on the system. The requirements cannot be split between two ports on the system.

For non-PCI devices, the following are the minimum resource requirements for each parallel port on the system:

- Required: Support ISA I/O addresses of 378h and 278h, plus 3BC or a vendor-assigned I/O address. Using these standard I/O addresses ensures proper functioning of software written for operating systems that directly address these locations.

  Recommended: Map the base I/O address to four additional locations.

- Required: Support PIC-based IRQ 5 and IRQ 7. Using these standard IRQs ensures proper functioning of software written for operating systems that use standard IRQ signals.

  Recommended: Support five additional IRQ signals.

- Required: Support two unique DMA channel selections if the parallel port design supports block data transfers to memory using DMA controllers. Notice also that the DMA function will not work on a parallel port without an IRQ because the end of a DMA transfer is signaled by an interrupt.

To ensure Plug and Play support for resolution of resource conflicts, a full list of options for all possible configuration combinations must be enumerated, including:

- Options for both ECP mode, which requires an I/O address, an IRQ, and a DMA selection, and standard LPT mode, which requires only an I/O address.

- Options that specify only the I/O address, allowing Windows to assign the IRQ and DMA channel.

On Intel Architecture systems, the operating system considers the parallel port base address (/) stored in the first BIOS Data Area (BDA) locations to be LPT1. The address stored in the second location is LPT2, and so on. On RISC-based systems, the information is in the ARC tree. On all ACPI-based systems, the information is obtained through the ACPI tree.

13.15. EPP support does not use restricted I/O addresses
Required
Some enhanced parallel port (EPP) implementations require eight contiguous I/O ports. If EPP support is implemented, the hardware cannot use the ISA I/O address 3BCh as a base I/O address because VGA devices require use of port 3C0h.

13.16. Compatibility, nibble mode, and ECP protocols meet IEEE 1284-1994 specifications

Required

Support for a parallel port must include, at a minimum, the compatibility-mode and nibble-mode protocols required by the IEEE 1284-1994 specification. This allows other IEEE 1284-compliant devices to be connected without problems.

The port must also support the ECP protocol as defined by IEEE 1284 to allow connections with higher-speed parallel peripherals.

Recommended: Enable ECP by default.

13.17. Port connectors meet IEEE 1284-I specifications, minimum

Required

IEEE 1284-I–compliant ports use a standard DB25 connector found on existing system parallel port designs. This is called an IEEE 1284-A connector in the specification.

IEEE 1284-II–compliant ports use an IEEE 1284-C connector. This connector is used on both the port and the peripheral device.

The parallel port design must provide enough space between the connectors and the surrounding enclosure to allow for a mating connector, connector shell, and latch assembly. The IEEE 1284 specification recommends an IEEE 1284-C connector for all new ports and devices.

13.18. IEEE 1284 peripherals have Plug and Play device IDs

Required

The device ID is described fully in the IEEE 1284 specification. All characters in the device identification string must consist only of ASCII values 20h–7Fh. The device identification string consists of a leading zero (0), a hexadecimal value that represents the length of the string, and then a set of fields in ASCII that have a unique identification string.

In addition to the requirements specified in *Plug and Play Parallel Port Device Specification, Version 1.0b,* the device ID string must contain the following keys, at minimum. The keys are case-sensitive and can be abbreviated in INF files as indicated.

Key	Abbreviated string
MANUFACTURER	MFG
MODEL	MDL
CLASS	CLS
DESCRIPTION	DES

All MANUFACTURER and MODEL key values must remain unique for each manufacturer. All MANUFACTURER, MODEL, CLASS, and DESCRIPTION key values must remain static for a specific unit, where ID values do not change for different hardware configurations. For example, a user simply adding a memory module to a printer should not change the MODEL key value reported as part of the device ID. However, if the user adds memory by installing an upgrade kit that requires a different driver or requires the existing driver to behave differently, then changing the MODEL value is acceptable as part of the upgrade installation process.

The CLASS key describes the type of parallel device. The CLASS key can contain the values PRINTER, MODEM, NET, HDC, PCMCIA, MEDIA, FDC, PORTS, SCANNER, or DIGCAM. HDC refers to hard disk controller. MEDIA refers to any multimedia device. FDC refers to floppy disk controller.

The DESCRIPTION key is an ASCII string of up to 128 characters that contains a description of the device the manufacturer wants to have presented if a device driver is not found for the peripheral.

For information about how the system determines the correct peripheral device driver, see the Windows 95 DDK and Windows NT Workstation 5.0 DDK.

13.19. Device identification string provides a Compatible ID key
Recommended
The Compatible ID (CID) key can provide a value that exactly matches a peripheral name supported by a device driver shipped with Windows. The value must match a value listed in the device's INF file.

13.20. Daisy-chained parallel port device is Plug and Play capable
Required
Daisy-chained parallel port devices must be Plug and Play capable. The daisy-chained parallel port device must be capable of answering Plug and Play requests from the host.

Because of end-of-chain issues with IEEE 1284 and IEEE 1284.3, it is also required that all pass-through devices comply with IEEE 1284.3.

Mouse Port and Peripheral Requirements

This section defines the specific requirements for pointing-device connections and peripherals. Because the Windows and Windows NT operating systems require a pointing device, a PC 99 system board should include an auxiliary port for an external pointing device, most commonly a mouse. It is recommended that systems designers use the USB port for the connection and also that they consider implementing wireless support for an external pointing device.

The general device requirements are defined in "System Requirements for I/O Ports and Devices" earlier in this chapter.

For wireless capabilities requirements, see "Wireless Component Requirements" later in this chapter.

13.21. Pointing-device connection meets requirements for its bus class

Required

The following requirements must be met, depending on the connection type used in the system. These requirements ensure that all Plug and Play requirements are met and that Microsoft drivers support the pointing device. If a PS/2-style port is used, the following requirements must be met:

- Comply in full with requirements in *Personal System/2 Specification,* by IBM.
- Use an 8042 chip (or equivalent) to ensure compatibility with Windows. In most cases, the existing 8042 keyboard port is sufficient; the chip initiates a PIC-based IRQ 12 interrupt when the pointing device is connected.
- Support PCI-based IRQ 12 to ensure the proper functioning of software written for legacy systems that use this IRQ signal.
- Return expected codes, including send ID (0F2h) and response acknowledgement (ACK) (0FAh), plus 1-byte ID.

If a USB port is used, the following requirements must be met:

- Meet requirements in *USB Specification, Version 1.0* or later
- Meet requirements in *USB Human Interface Device Class Specifications, Version 1.0* or later
- Implement minidriver support based on WDM Human Interface Device (HID) class support in the operating system, as defined in the Windows NT 5.0 DDK

13.22. Remote control pointing device provides PC 99 minimum support

Recommended

If a remote-control device is provided with a PC 99 system, the range of functions implemented on the device will depend on whether the remote control is designed for the business desktop or for Entertainment PC 99. For specific requirements for Entertainment PC 99, see requirement 5.4, "Entertainment PC includes a remote-control pointing device."

There is no defined list of functions that must be included on a remote-control device, but such a device might provide the following types of functions and buttons:

- Power button that turns devices on and off.
- Start button, such as the Windows logo key, that causes a Start menu to be displayed. For information about the Windows logo key, see "Keyboard Port and Peripheral Requirements" later in this chapter.
- Menu button that causes an application-specific menu to be displayed.
- Help button that causes application-specific Help file to be displayed.
- Select button that functions similarly to the ENTER key on a keyboard.
- Directional capabilities, which function similarly to the arrow keys on a keyboard.

The following functions and buttons can also be considered for a remote-control device used with an Entertainment PC system:

- Television button to select the television as the device that will receive input
- Mute button
- Device control buttons, including Volume Up, Volume Down, Channel Up, Channel Down, Fast Forward, Rewind, Play, Stop, Pause, and Record
- Number keys equivalent to a telephone keypad

Keyboard Port and Peripheral Requirements

The primary input component for a PC is the keyboard. An 8042 microcontroller or its equivalent has traditionally controlled the keyboard connection on the system board. However, USB connections and wireless connections are important design considerations for keyboards. These design requirements do not exclude—but they do not encourage—implementing a legacy AT-style keyboard port.

This section summarizes the specific hardware feature requirements for keyboard ports and peripherals. Some keyboard port requirements differ, depending on the type of port being used.

The general device requirements are defined in "System Requirements for I/O Ports and Devices" earlier in this chapter.

For requirements that apply if wireless capabilities are provided for the keyboard, see "Wireless Component Requirements" later in this chapter.

13.23. Keyboard connection meets requirements for its bus class
Required

These requirements depend on the type of connection designed into the system and ensure that all Plug and Play requirements are met, and that Microsoft drivers support this device.

If a PS/2-style keyboard port is used, it must meet the following requirements:

- Support IRQ 1 on Intel Architecture to ensure the proper functioning of software written for legacy systems, which expect to use this IRQ signal

- Map the I/O address ports to 60h and 64h

- Return expected scan codes, including send ID (0F2h) and response ACK (0FAh), plus 2-byte ID

If a USB connection is used, it must meet the following requirements:

- *USB Specification, Version 1.0* or later

- *USB Human Interface Device Class Specifications, Version 1.0* or later

- Minidriver support based on WDM HID class support in the operating system

If a USB keyboard is the sole keyboard implementation in an Intel Architecture system, it must support the USB Boot Device specification. The system BIOS must provide boot support as specified in requirement 3.5, "BIOS meets PC 99 requirements for boot support," and as defined in *Universal Serial Bus PC Legacy Compatibility Specification, Version 0.9* or later.

13.24. No interference occurs between multiple keyboards
Required

Mobile PC Note   If the system includes more than one keyboard, there must be no conflicts. For example, when a mobile PC is connected to a docking station, more than one keyboard can be attached to the system simultaneously. The keyboard ports on a mobile PC and a docking station must be able to resolve conflicts between the two ports when the mobile unit is docked. Windows supports multiple configurations through the registry and will determine which keyboard to enable.

For more information about managing resources and devices for a mobile PC/docking station pair, see Chapter 6, "Mobile PC 99."

13.25. Keyboard includes Windows and Application logo keys

Recommended

The following are requirements for a keyboard design that includes any Windows logo keys:

- The keyboard must be developed according to technical requirements in *New Key Support for Microsoft Windows Operating Systems and Applications.*

- The keyboard must be compatible at the Windows virtual key-code level.

- The keyboard must pass the requirements in the Windows logo key testing software.

- The Windows logo key must function as a modifier (CTRL, SHIFT, or ALT).

- The Windows Flag trademark must be clearly distinguished on the key top according to the guidelines provided in *New Key Support for Microsoft Windows Operating Systems and Applications*.

The following are recommendations for a keyboard design that includes any Windows logo keys:

- Both left and right Windows logo keys are not required in order to offer full functionality under the Windows operating system.

- The Application key can be a dual-function key and can be used to replace the FN key. In this case, a single press-and-release action sends the scan code for the Application key, and holding this key down while pressing another key will modify it to perform the FN function.

Mobile PC Note   Given the crowded nature of compact keyboards on mobile PCs and keyboards that support double-byte characters, such as Japanese-language keyboards, it might be difficult to add three new keys. For mobile PCs, minimal implementation of new keys includes the addition of one Windows logo key and one Application key.

Game Controller Requirements

This section presents the minimum requirements for game-control devices.

Legacy and proprietary game-pad solutions are not acceptable for PC 99. Game pads, joysticks, and other input devices must be implemented as USB devices.

The general device requirements are defined in "System Requirements for I/O Ports and Devices" earlier in this chapter.

13.26. Device meets USB HID class specification requirements

Required

Game-control devices and drivers must support the *USB Human Interface Device Class Specification, Version 1.0* or later.

Wireless Component Requirements

This section defines requirements for wireless components, provided either as infrared (IR) and radio frequency (RF) devices, based on communication standards developed by the Infrared Data Association (IrDA).

For background information about design issues related to IR solutions, see "Wireless Design Issues" in Chapter 2, "PC 99 Design Issues." For information about requirements for wireless networking devices, see "IrDA Requirements for Network Communications" in Chapter 20, "Network Communications."

The requirements listed in this section must be met if wireless capabilities are provided in the system. The general device requirements are defined in "System Requirements for I/O Ports and Devices" earlier in this chapter.

Manufacturers who are implementing designs that include IrDA Control devices, also known as IrBus, are strongly encouraged to join IrDA and to obtain the IrDA-approved version of the IrDA Control specification, plus information on the availability of parts and driver software.

13.27. IR device uses NDIS 5.0 miniport driver

Required

This requirement applies for IrDA Data devices. An NDIS 5.0, IrDA miniport driver is required for all IrDA Data devices. For documentation and sample source code for building a miniport driver, see the Windows NT 5.0 DDK.

13.28. IR device meets IrDA specifications

Required

Recommended: Support specifications for both IrDA Data and IrDA Control devices.

An IR device must be designed to comply with approved IrDA specifications.

If the system is intended to run data transfer applications with other IrDA Data devices, it must be in compliance with the IrDA Data specification.

If an IrDA Control application is used in a PC 99 system, it must be in compliance with the IrDA Control specification, which was approved by IrDA in early 1998. The first IrDA Control-compliant devices are expected to ship in late 1998.

If a system is intended for the consumer market, support for both IrDA Control and IrDA Data is recommended to meet the consumer's expectations for IR device interoperability. The emergence of still-image cameras with IrDA Data capability increases the importance of IrDA Data support in consumer systems.

13.29. IR device meets PC 99 bus and port specifications
Required

The requirements for all bus classes are defined in Part 3 of this guide.
In particular:

- The Windows operating system includes built-in support for devices that use a serial I/O interface; in this case, a wireless device must also comply with the requirements specified in "Serial Port Requirements" earlier in this chapter.

- A wireless device that uses a parallel port must comply with the requirements specified in "Parallel Port Requirements" earlier in this chapter.

- A USB wireless device must comply with the requirements specified in Chapter 7, "USB."

13.30. IR device supports dynamic resource configuration
Required

The adapter must provide flexible resource configuration and complete dynamic disable capabilities following the specifications for the bus or legacy port used. Resource configuration requirements are defined in the Plug and Play specification for the bus that the device uses. See also the related sections in this chapter that define configuration resource requirements for serial ports and parallel ports.

13.31. IR device meets USB guidelines for interfacing with IrDA Data and IrDA Control devices
Required

A USB working group is developing guidelines for how USB is to interface with both IrDA Data and IrDA Control devices. When these guidelines are finalized, they will become PC 99 requirements for USB IR implementations.

13.32. System supports standard input speeds of 4 Mb/s
Required

Device support is required for Fast IR (FIR) input speeds of 4 Mb/s for all IrDA Data devices.

13.33. System provides a separate, physically-isolated transceiver for each IR protocol supported

Required

This requirement ensures correct implementation for a system that includes IR support for any combination of devices that use the IrDA Data protocol, the IrDA Control protocol, or the universal consumer-IR approach to legacy remote control, each of which use different device signals. A system that uses only a specific IR device protocol will restrict the ability to use multiple input devices and might also restrict other capabilities.

A PC 99 system that advertises itself as supporting all three IR solutions—IrDA Data protocol, IrDA Control protocol, and legacy remote control IR—must provide a separate transceiver for each solution. The system must also expose each separate transceiver to the operating system.

The transceivers must be physically isolated from each other; an example is placing each transceiver on a different edge of the system case. Although some IrDA member companies have tested IrDA Data, IrDA Control, and legacy remote control IR transceivers without spatial separation and demonstrated adequate performance, interference-free operation cannot be assured without physical isolation.

If multiple IR protocols are supported, controllers must provide separate data connections into the PC using USB. The IrDA and USB industry associations define guidelines for how to build and interface such devices. Contact information can be found in "References for I/O Ports and Devices" later in this chapter.

13.34. System supports RF capabilities

Optional

If RF is included in a system, the implementation must meet the general device requirements defined in "System Requirements for I/O Ports and Devices" earlier in this chapter.

Manufacturers of Consumer PC systems and cordless consumer peripherals such as PC-enhanced cordless telephones or RF wireless data devices are encouraged to join the HomeRF Working Group (HRFWG) to obtain information about the Shared Wireless Access Protocol (SWAP) specification. For more information, see "Wireless Design Issues" in Chapter 2, "PC 99 Design Issues."

The SWAP specification and components required for its implementation are expected to be available in late 1998; until the specification is available, the following recommendations are offered to help designers make appropriate choices if RF solutions are to be implemented in a particular system design.

13.35. RF implementation uses a low-power RF alternative

Recommended

For relatively short-range wireless devices that cannot use IR, it is possible to use low-power RF. Use an RF solution appropriate to the application. For example, cordless keyboard and trackball devices that need RF instead of Control IR require a maximum range of only 15 to 20 feet.

13.36. RF implementation provides a method to defeat noise and conflict with other RF devices

Recommended

RF devices should be able to defeat noise such as electromagnetic interference (EMI). Also, programmable channel selection, carrier sensing, or the relatively expensive spread-spectrum or frequency-hopping techniques can be used to share the RF medium with other RF devices that might be in the environment.

Many of the issues discussed in this recommendation are addressed by the governing regulatory agencies.

13.37. System and RF device have separate local certification

Recommended

Rules for certifying low-power, short-range, unlicensed RF devices vary greatly from country to country. By configuring the RF device as a system add-on, local certification of the system will not be blocked while waiting for certification of the RF device, which might take longer. Configuring the RF device as a system add-on also enables adding RF support to legacy hardware.

Smart Card Requirements

This section defines requirements for smart card devices. Such devices are not required, but if implemented, must comply with the requirements defined in this section. The general device requirements are defined in "System Requirements for I/O Ports and Devices" earlier in this chapter.

13.38. Smart card reader complies with ISO 7816

Required

A smart card reader must comply with the following ISO specifications:

- ISO 7816-1:1987 Identification cards—Integrated circuit(s) cards with contacts—Part 1: Physical characteristics

- ISO 7816-2:1988 Identification cards—Integrated circuit(s) cards with contacts—Part 2: Dimensions and location of the contacts

- ISO/IEC 7816-3:1997 Information technology—Identification cards— Integrated circuit(s) cards with contacts—Part 3: Electronic signals and transmission protocols

13.39. Smart card reader supports ISO 7816 T=0 and T=1 protocols
Required

A smart card reader must support the asynchronous protocols T=0 and T=1 as described in ISO 7816-3, either in hardware or in the driver for the operating system. Both protocols must be fully supported. The smart card reader and the driver must support cards that can handle both protocols.

The following protocol rules apply for the T=1 protocol:

- A transmission is defined as sending a command to a smart card using one or more T=1 blocks and receiving the corresponding answer using one or more T=1 blocks as defined in ISO 7816-3.
- The very first transmission—after a reset of the smart card—should start with an Information Field Size Device (IFSD) request, as defined in ISO 7816-3, Amendment 1, Section 9.5.1.2.

  If the current card does not support an IFSD request (the card should reply with an R-Block indicating "Other error"), the transmission should continue with an I-Block.

After a successful RESYNCH request, the transmission must restart from the beginning with the first block with which the transmission originally started.

Support for protocols other than T=0 and T=1 is optional.

13.40. Smart card reader supports inverse-convention smart cards
Required

A smart card reader must support inverse-convention smart cards either in hardware or in the driver for the operating system.

13.41. Smart card reader supports 258-byte packets in T=0 and 259-byte packets in T=1
Required

A smart card reader must support the exchange of the following in a single transmission:

- 258 byte packets in T=0—that is, 256 data bytes plus the two status words SW1 and SW2
- 259 byte packets in T=1—that is, 254 INF bytes plus NAD, PCB, LEN, and two EDC bytes

13.42. Smart card reader supports a smart card insertion/removal monitor

Required

A smart card reader must be able to detect and report smart card insertions and smart card removals without any user intervention other than removing or inserting the smart card itself. Preferably, the reader uses an interrupt mechanism to report the smart card insertion/removal to the system. A driver polling method to detect smart card insertion and removals is not recommended.

13.43. Smart card reader supports PTS

Required

To support multi-protocol smart cards and smart cards using higher data rates and higher clock frequencies, the reader must support protocol type selection (PTS) according to ISO 7816-3 Amendment 2.

13.44. Smart card reader supports 3.5795 MHz minimum clock frequency

Required

A smart card reader must support a minimum clock frequency of 3.5795 MHz.

Recommended: The reader supports higher clock frequencies.

13.45. Smart card reader supports 9600 bps minimum data rate

Required

A smart card reader must support a minimum data rate of 9600 bits per second.

Recommended: The reader supports data higher rates: 3.5795 MHz with default communications settings.

13.46. Smart card reader supports the Power Down command

Required

A smart card reader must support the Power Down command to turn off power of a smart card, as defined in ISO 7816-3 Section 4.1.

13.47. Smart card reader does not use an additional power supply

Recommended

A smart card reader should use power provided by the system for the smart card and the smart card reader. The reader should not use an external power supply or battery.

PC 99 Design Features for Ports

This section summarizes requirements related to the design initiatives defined in Part 1 of this guide.

Plug and Play and Bus Design for I/O Ports and Devices

The items in this section are requirements for Plug and Play capabilities.

13.48. Each device has a unique Plug and Play device ID
Required

For a non-bus–specific system-board device, there must be a device-specific ID.

Each bus-specific device must have a Plug and Play device ID as required for the bus it uses, as defined in Part 3 of this guide. For example, a PCI device must comply with PCI 2.1 and also must provide a Subsystem ID and Subsystem Vendor ID, as defined in Chapter 9, "PCI." A USB device must comply with the *Universal Serial Bus Specification, Version 1.0* or later, and also must provide a unique ID.

13.49. Dynamic resource configuration is supported for all devices
Required

The system must be capable of automatically assigning, disabling, and relocating the resources used by this device when necessary, using the method required for the related bus class. When the end user changes this device or adds it to the system, setting resource assignments must not require changing jumpers or switches on either the adapter or the system board.

In the event of an irreconcilable conflict with other devices on the system, the system must be able to disable the device to prevent the system from stalling. If there is a conflict where more than one port or device of the same type is detected on the system, then one of two methods can be used to resolve it:

- Method 1: Completely disable the built-in port or device. For example, if there is a conflict when a second serial port is added to a desktop system, the expansion card overrides the system-board device. Using this method, the system disables the device on the system board and enables the expansion card only. This is the recommended conflict-resolution method for add-on serial, parallel, Musical Instrument Digital Interface (MIDI), and joystick devices.

  Or if an expansion card, such as a display adapter with a built-in pointing-device port, is added to a desktop system that has a system-board pointing-device port, then the expansion card overrides the system-board pointing-device port. Using this method, the system disables the pointing-device port on the system board and only accepts pointing-device input from the expansion card.

- Method 2: Both ports and devices remain active while resolving any conflict by relocating the resources of one or both devices. Using this method, either device can be used. For example, in a docking system, the pointing device on a mobile PC and the pointing device on a docking station can be allowed to share pointing responsibilities. Either pointing device can be used, although the software will use only one.

Note: Fixed (static) resource devices can exist to support standard devices, including the 8042 keyboard controller. For a system based on Intel Architecture, these fixed resources are located at I/O addresses under 100h. Standard system-board devices should use their ISA-compatible addresses. For a system based on Intel Architecture, this includes devices with I/O port addresses within the reserved range 0h–0ffh. For more information about legacy resources and ISA-compatible addresses, see Appendix D, "Legacy Support."

Power Management for I/O Ports and Devices

This section summarizes the specific power management requirements for I/O ports and devices.

13.50. Each device complies with its device class power management reference specification

Required

The related device class power management reference specification applies for each specific type of device. For example, for an input device, the *Input Device Class Power Management Reference Specification* is the relevant specification. These specifications also cover device functionality expected for each power state and possible wake-up event definitions for each class. Power states D0 and D3 are required.

13.51. Device supports wake-up events

Required for wireless input; optional for other devices

The ability to cause a wake-up event as defined in the device class power management reference specification is required for wireless input devices. It is optional for other devices.

Device Drivers and Installation for I/O Ports and Devices

This section summarizes device driver requirements for I/O ports and devices. The items in this section are requirements for all PC 99 systems.

13.52. Device drivers and installation meet PC 99 requirements

Required

The manufacturer does not need to supply a driver if a PC 99-compliant driver provided with the operating system can be used. If the manufacturer supplies a driver, the requirements for the device driver and installation are defined in requirement 3.11, "Each device and driver meets PC 99 device requirements."

The basic requirements include driver support for unattended installation and Help file support if special driver parameters are used.

For input devices that use USB connections, driver support must be implemented as a minidriver under the WDM HID support provided in the Windows 98 and Windows NT operating systems.

13.53. All PC 99 input devices support Microsoft DirectInput and work simultaneously

Required

All input devices implemented in a PC 99 system must have drivers that support Microsoft DirectInput if they do not use drivers that are built into the operating system. All input devices must also be able to correctly provide simultaneous input. This means that no input device is automatically disabled when another input device is in use.

Note: The built-in drivers provided with Windows 98 and Windows NT 5.0 meet this requirement. For information about implementing drivers that support simultaneous use of devices, see the Microsoft DirectX DDK, available through MSDN Professional membership.

References for I/O Ports and Devices

The following represents some references, services, and tools available to help build hardware that is optimized to work with Windows operating systems.

Device class power management reference specifications
    http://www.microsoft.com/hwdev/onnow.htm

HomeRF Working Group
    http://www.homerf.org

IBM Personal System/2 Common Interfaces, Part No. S84F-9809
IBM Personal System/2 Mouse Technical Reference, Part No. S68X-2229
   International Business Machines Corporation
   Order from IBM Customer Publications Support: (800) 879-2755
   Or contact an IBM sales representative

IEEE specifications
   ASK*IEEE
   Phone: (800) 949-4333
   Fax: (212) 310-4091
   E-mail: askieee@ieee.org
   http://www.ieee.org

   Global Engineering Documents
   Fax: (303) 397-2740
   Phone: (800) 854-7179 (US)
                  (613) 237-4250 (Canada)
                  (303) 792-2181 (Outside North America)

ISO/IEC DIS 7816 Identification Cards—Integrated circuit(s) cards with contacts
   Part 1: Physical characteristics
   http://www.iso.ch/cate/d29257.html

   Part 2: Dimensions and location of the contacts
   http://www.iso.ch/cate/d26536.html

   Part 3: Electronic signals and transmission protocols
   http://www.iso.ch/cate/d14735.html

Microsoft Windows 95 DDK, Windows 98 DDK, and Windows NT 5.0 DDK
   MSDN Professional membership

Network PC System Design Guidelines, Version 1.0b
   http://www.microsoft.com/hwdev/netpc.htm

New Key Support for Microsoft Windows Operating Systems and Applications
   http://www.microsoft.com/hwdev/desinit/scancode.htm

PC/Smart Card (PC/SC) Workgroup
   http://www.smartcardsys.com

Plug and Play specifications
   http://www.microsoft.com/hwdev/respec/pnpspecs.htm

Serial Infrared (SIR) Physical Layer Specification
Control IR (CIR or IrBUS) Specification
Other Infrared Data Association documents (available only to IrDA members)
   Infrared Data Association
   PO Box 3883
   Walnut Creek, CA 94598 USA
   Phone: (510) 943-6546
   Fax: (510) 943-5600
   E-mail: irda@netcom.com

Universal Serial Bus PC Legacy Compatibility Specification, Version 0.9
    http://www.teleport.com/~usb/data/usb_le9.pdf

USB HID Usages Table
Other USB specifications
    http://www.usb.org

White papers and guidelines for Microsoft operating systems
    http://www.microsoft.com/hwdev/drvrinfo.htm

Checklist for I/O Ports and Devices

If a recommended feature is implemented, it must meet the requirements for that feature as defined in this document.

Consumer	Office	Mobile	Workstation	Entertainment

13.1. System includes connection for external serial devices
Required for all system types

13.2. System includes connection for external parallel devices
Required for all system types

13.3. System includes external connection for keyboard
Required for all system types

13.4. System includes pointing-device connection and pointing device
Required for all system types

13.5. System includes USB game pad or joystick
Required for all system types; wireless recommended for Entertainment PC

13.6. System includes built-in wireless capabilities
Recommended for all system types

13.7. Devices use USB or external bus connections rather than legacy serial or parallel ports

Consumer	Office	Mobile	Workstation	Entertainment
Required	*Recommended*	*Recommended*	*Required*	*Required*

13.8. All devices meet PC 99 general device requirements
Required

13.9. Serial port meets device class specifications for its bus
Required

13.10. Legacy serial port is implemented as 16550A UART or equivalent and supports 115.2K baud
Required

13.11. Legacy serial port supports dynamic resource configuration
Required

13.12. Conflict resolution for legacy serial port ensures availability of at least one serial port
Required

13.13. Parallel port meets device class specifications for its bus
Required

13.14. Flexible resource configuration supported for each parallel port
Required

13.15. EPP support does not use restricted I/O addresses
Required

13.16. Compatibility, nibble mode, and ECP protocols meet IEEE 1284-1994 specifications
Required

13.17. Port connectors meet IEEE 1284-I specifications, minimum
Required

13.18. IEEE 1284 peripherals have Plug and Play device IDs
Required

13.19. Device identification string provides a Compatible ID key
Recommended

13.20. Daisy-chained parallel port device is Plug and Play capable
Required

13.21. Pointing-device connection meets requirements for its bus class
Required

13.22. Remote control pointing device provides PC 99 minimum support
Recommended

13.23. Keyboard connection meets requirements for its bus class
Required

13.24. No interference occurs between multiple keyboards
Required

13.25. Keyboard includes Windows and Application logo keys
Recommended

13.26. Device meets USB HID class specification requirements
Required

13.27. IR device uses NDIS 5.0 miniport driver
Required

13.28. IR device meets IrDA specifications
Required

13.29. IR device meets PC 99 bus and port specifications
Required

13.30. IR device supports dynamic resource configuration
Required

13.31. IR device meets USB guidelines for interfacing with IrDA Data and IrDA Control devices
Required

13.32. System supports standard input speeds of 4 Mb/s
Required

13.33. System provides a separate, physically-isolated transceiver for each IR protocol supported
Required

13.34. System supports RF capabilities
Optional

13.35. RF implementation uses a low-power RF alternative
Recommended

13.36. RF implementation provides a method to defeat noise and conflict with other RF devices
Recommended

13.37. System and RF device have separate local certification
Recommended

13.38. Smart card reader complies with ISO 7816
Required

13.39. Smart card reader supports ISO 7816 T=0 and T=1 protocols
Required

13.40. Smart card reader supports inverse-convention smart cards
Required

13.41. Smart card reader supports 258 byte packets in T=0 and 259 byte packets in T=1
Required

13.42. Smart card reader supports a smart card insertion/removal monitor
Required

13.43. Smart card reader supports PTS
Required

13.44. Smart card reader supports 3.5795 MHz minimum clock frequency
Required

13.45. Smart card reader supports 9600 bps minimum data rate
Required

13.46. Smart card reader supports the Power Down command
Required

13.47. Smart card reader does not use an additional power supply
Recommended

13.48. Each device has a unique Plug and Play device ID
Required

13.49. Dynamic resource configuration is supported for all devices
Required

13.50. Each device complies with its device class power management reference specification
Required

13.51. Device supports wake-up events
Required for wireless input; optional for other devices

13.52. Device drivers and installation meet PC 99 requirements
Required

13.53. All PC 99 input devices support Microsoft DirectInput and work simultaneously
Required

C H A P T E R   1 4

Graphics Adapters

This chapter presents the requirements and recommendations for graphics adapters.

The key design goal is to ensure that graphics hardware behaves consistently across a wide range of applications, based on the need of the system to provide fast, high-quality graphics rendering.

Requirements for OpenGL support are defined in Chapter 4, "Workstation PC 99." Requirements for MPEG and DVD playback, video input and capture devices, and display monitors are defined in Chapter 15, "Video and Broadcast Components," and Chapter 16, "Monitors."

Contents

System Requirements for Graphics Adapters

This section summarizes the PC 99 system requirements for graphics adapters.

Mobile PC Note   For exceptions and guidelines for the internal graphics subsystem on mobile PCs, see Chapter 6, "Mobile PC 99," as well as notes in the individual sections of this chapter.

14.1. Graphics adapter uses PCI, AGP, or another high-speed bus
Required for all system types

Recommended: Accelerated Graphics Port (AGP) attachment with optional sideband addressing and double-clocked data transfer mode, as defined in *Accelerated Graphics Port Interface Specification*, *Revision 1.0* or later, plus PC 99 requirements defined in "AGP Requirements" later in this chapter.

Note: It is anticipated that AGP, or an integrated graphics subsystem that meets or exceeds AGP performance levels, will be required for all system types in the next version of this design guide.

In all cases, PCI adapters can be used as secondary graphics adapters.

14.2. System provides hardware-accelerated 3-D graphics

Consumer	Office	Mobile	Workstation	Entertainment
Required	Recommended	Recommended	Required	Required

The graphics adapter requirements on PC 99 systems that implement 3-D acceleration are defined in "Hardware Acceleration for 3-D Graphics" later in this chapter.

For most systems, 3-D acceleration is based on Direct3D capabilities provided in the operating system.

Systems designed as Windows NT graphics workstations must provide a 3-D accelerator that supports either OpenGL or Direct3D acceleration. Support for Direct3D on OpenGL accelerators is recommended for Windows NT 5.0. OpenGL support can be implemented under Windows NT as a Mini Client Driver (MCD) or Installable Client Driver (ICD). OpenGL driver support for Windows 98 is optional and can only be implemented as an ICD.

For implementation details for OpenGL, see the Windows 95 DDK and the Windows NT 5.0 DDK.

14.3. System uses WC with higher-performance processors
Required for all system types

Write combining (WC) of successive stores to the frame buffer is a requirement for systems with processors that support write combining.

14.4. Primary graphics adapter works normally with default VGA mode driver

Required for all system types

The default video graphics array (VGA) driver is required for installing the operating system. The primary adapter must support 4-bit planar VGA mode as described in the Windows 95 DDK and the Windows NT 5.0 DDK.

14.5. Adapter and driver support multiple adapters and multiple monitors

Consumer	Office	Mobile	Workstation	Entertainment
Required	Required	Recommended	Required	Required

System expansion buses that allow graphics adapters such as PCI and AGP can support the simultaneous use of more than one graphics adapter in the system. Each graphics adapter can support one or more attached monitors, but this is not a requirement. Although only a single AGP device can be implemented in a system, multiple-monitor support can be implemented using add-on PCI graphics adapters.

The device drivers for each graphics adapter must provide the required support to allow the presence of multiple adapters and multiple monitors. The hardware and BIOS support consist of Plug and Play-related configuration and resource require-ments that ensure automatic support for use of more than one graphics adapter and for simultaneous display on two or more monitors. For details, see "Multiple-Adapter and Multiple-Monitor Support" later in this chapter.

Mobile PC Note   For mobile PCs, multiple adapter support is not required unless the mobile system supports a full docking station. For information, see requirement 6.20, "Mobile system meets Mobile PC 99 requirements for supporting multiple adapters and multiple monitors."

14.6. Adapter supports television output if system does not include large-screen monitor

Recommended for all system types

Recommended: Support both National Television System Committee (NTSC), Phase Alternation Line (PAL) output, or both.

Support for television output is especially recommended for Entertainment PC systems that do not include a large-screen entertainment monitor. The ability to connect to and use a standard NTSC or PAL television as a large display surface is key to the ability to deliver realistic television, movie, and game experiences.

For mobile PCs, television-output capabilities can be used to enable on-screen presentation graphics in the conference room.

The NTSC system must support 640 × 480 at 60 Hz. The PAL system must support 640 × 480, 800 × 600, or both at 50 Hz. For information about the related requirements, see "Television Output Requirements" later in this chapter.

The following items are recommended:

- Provide composite, S-Video, and component outputs. Component outputs are especially important in Europe and will become important in North America in the 1999–2000 timeframe.

- A second display controller to drive television output. This allows a separate pixel surface, which is supported under Windows NT and Windows 98. Including a second display controller lets a home PC drive its monitor at 75 Hz for word processing while a DVD movie or broadcast program shows simultaneously on the television at 60 Hz.

  Referring to two display controllers merely indicates functionality. It is not intended to preclude other implementations that achieve the same result. The desired result is two independently timed outputs to different displays.

Graphics Adapters Basic Features

This section defines basic feature requirements for graphics adapters.

14.7. Adapter meets PC 99 general device requirements

Required for all system types

This includes the requirements for Plug and Play device IDs, automated software-only settings for device configurations, device drivers and Windows-based installation, and icons for external connectors. For information, see "PC 99 General Device Requirements" in Chapter 3, "PC 99 Basic Requirements."

14.8. Screen resolution and local memory capacity meet PC 99 minimum requirements

Required for all system types, with exceptions for mobile PCs

The adapter must support all required resolutions, including:

640 × 480 × [8, 15 or 16, 24 or 32] bpp
800 × 600 × [8, 15 or 16, 24 or 32] bpp
1024 × 768 × [8, 15 or 16] bpp

The following resolutions are recommended:

1024 × 768 × 24 bpp
1280 × 1024 × [8, 15 or 16, 24 or 32] bpp

It is acceptable to implement either 15-bit or 16-bit color mode, and it is also acceptable to implement either 24-bit or 32-bit color mode. Notice that in the later case, the 32-bit mode is preferred because it provides more spare bits for alpha blending capability.

All PC 99 systems, except Office PC and the Mobile PC built-in graphic subsystem, must provide for rendering buffers up to $800 \times 600 \times 16$-bit bpp (double-buffered), 16-bit Z-buffering, and a 1.25 MB texture cache. This requires an effective memory footprint of approximately 4 MB. For AGP-enabled systems, which store and execute textures directly from AGP system memory, there is no texture cache requirement.

Mobile PC Note   Mobile PC capabilities for external monitor support are also limited to the degree they can be supported by the graphics controller capabilities and frame buffer size. For complete details, see "Mobile PC Graphics Requirements" in Chapter 6, "Mobile PC 99."

Designs for systems that will support Direct3D applications should provide sufficient 3-D texture access to meet the 3-D performance recommendations defined in requirement 14.34, "Hardware meets PC 99 3-D accelerator performance requirements."

Texture compression can provide additional effective texture memory; it also increases the effective memory bandwidth that is available.

14.9. Adapter meets VESA specifications for ergonomic timing rates
Required for all system types, with exceptions for mobile PCs and flat panel desktop displays
Recommended: 85 Hz for 1024×768, non-interlaced.

The graphics adapter must support, at a minimum, the 75 Hz ergonomic timings for all resolutions supported by the monitor up to 1024×768, as documented in the current version of *VESA and Industry Standards and Guidelines for Computer Display Monitor Timing*. Higher timings and resolutions are preferable under standards published by Video Electronics Standards Association (VESA).

For TV-enabled systems, in addition to the standard VESA timings, it is also necessary to support the 59.94-Hz variants of the 60-Hz timings. This is important for smooth frame delivery in TV video applications.

Mobile PC Note   For flat panel displays for desktop or mobile use, it is not necessary to implement refresh rates higher than 60 Hz. For additional exceptions and requirements for mobile PC systems, see "Mobile PC Graphics Requirements" in Chapter 6, "Mobile PC 99."

When the user selects 1024×768 resolution, the graphics adapter must default to a non-interlaced refresh rate. A graphics adapter can default to 1024×768 interlaced mode in either of the following situations:

- The attached monitor is not DDC-compatible and the user has not selected a monitor type in the display control panel.

- The monitor does not support 1024×768 non-interlaced mode, as determined from the Extended Display Identification Data (EDID) or registry settings.

14.10. All supported color depths are enumerated
Required for all system types

The driver must enumerate all modes supported so that applications can choose their preferred color depth. The driver must comply with the following guidelines for enumeration:

- For 16 bpp, either the 5:5:5, 5:6:5, or both modes must be supported.

- If only the 5:5:5 mode is supported, the driver must also enumerate this as 16-bpp mode. This is required because some applications only look for 16-bpp support and will run in 8-bit mode if they fail to find a 16-bit mode.

- If both 5:5:5 and 5:6:5 modes are supported, both modes must be enumerated.

For each color depth supported, color ordering must be implemented as shown in the following list. Color ordering is shown in the following list from the most-significant bit (MSB) to the least-significant bit (LSB.)

Mode	Color ordering
15 bpp	1 undefined, 5 red, 5 green, 5 blue (URRR RRGG GGGB BBBB)
16 bpp	5 red, 6 green, 5 blue (RRR RRGGG GGGB BBBB)
24 bpp	8 red, 8 green, 8 blue (RRRR RRRR GGGG GGGG BBBB BBBB)
32 bpp	8 alpha, 8 red, 8 green, 8 blue (AAAA AAAA RRRR RRRR GGGG GGGG BBBB BBBB)

14.11. Graphics operations use relocatable registers only
Required for all system types

VGA registers must not be used to perform graphics operations such as bit blting, palette setting, and pointer movement. The registers used for these graphics operations can be either I/O locations or memory-mapped locations, but must be relocatable. Normal system operation should never require use of base VGA registers, except for system startup and mode setting.

DirectDraw and Direct3D functionality must be independent of VGA. This means that graphics require VGA only for initialization.

14.12. Adapter supports downloadable RAMDAC entries for integrated color management

Required for all system types

For graphics adapters that support 24-bit or higher displays, downloadable RAM digital-to-analog converter (RAMDAC) entries should be included to perform gamma correction in hardware. This capability supports the related requirement to use VGA only for system initialization defined in requirement 14.11, "Graphics operations use relocatable registers only."

Integrated Color Management (ICM) uses this capability to ensure that gamma is correct in the monitor and to allow game applications to switch palettes. This capability also supports transition effects in Internet Explorer and other applications.

14.13. Adapter supports DDC monitor detection

Required for all system types, with exceptions for mobile PCs

This requirement is based on the *Display Data Channel Standard, Version 3.0* (DDC), which defines the communication channel between the display and host system. The software can use this information to properly manage output to the various displays and to prevent the disabling of television output if no monitor is attached.

Mobile PC Note   Mobile systems are not required to support DDC monitor detection of the display if the display is permanently attached and connected using an internal interface. However, such systems must support DDC for the external monitor interface port.

Hardware Acceleration for Video Playback

This section presents the video playback requirements for graphics adapters created for systems that support TV or DVD video playback.

14.14. Hardware supports video overlay surface with scaling

Required for systems that support TV or DVD video playback, with exceptions for mobile PCs

It is envisioned that the overlay surface will be implemented using one of the required YUV formats. The graphics adapter must be able to support a minimum of one off-screen video overlay surface that has following characteristics:

- **14.14.1 Size.** Support for 720×576 or larger.

  To support the HD0 formats for DTV—notably 720p24—it is required to support 1280×720 on the Entertainment PC.

- **14.14.2 Screen Resolutions.** The video overlay must be fully operative at a minimum screen resolution of 1024×768 at 60 Hz and color depths of 8 bpp and 16 bpp.

  Recommended: Full support at 1280×1024, with color depths of 8, 16, 24, and 32 bpp.

Mobile PC Note   For mobile systems, screen resolutions are defined in Chapter 6, "Mobile PC 99."

- **14.14.3 Color formats.** The required formats must include the following:

  - YUV 4:2:2 YUY2: A packed-pixel byte stream for every pixel in the order of Y1, U, Y2, V is required in both the primary and secondary overlay surfaces.

    Recommended: Support for YUV 4:2:2 UYVY: A packed-pixel byte stream for every pixel in the order of U, Y1, V, Y2 is recommended in both the primary and secondary overlay surfaces.

  - YUV 4:2:0 YV12: A system-board byte stream for the entire plane in the order of Y plane, V plane, U plane is required in the secondary overlay surface when double-buffering is supported.

    If double buffering is not supported, YV12 support must be provided in the primary overlay surface.

    Support for the YUV 4:2:0 format is not a requirement if the graphics chip supports on-chip MPEG decoding (that is, 75 percent hardware implementations such as motion compensation and iDCT in hardware solutions, or the equivalent). In this situation, YUV 4:2:0 capability is only a recommendation, although it is still strongly recommended to support software MPEG decoding for secondary video windows.

Mobile PC Note   Mobile PCs and Office PCs that implement TV or DVD video playback features are not required to support the YUV 4:2:0 format.

The YUV color space and intensity range are defined by the ITU-R BT.601-4 standard (previously called CCIR-601), where U is CB and V is CR. These formats use less memory while maintaining high quality, and YUV is the native format for many image and video compression standards.

- **14.14.4 Scaling.** Upscaling and downscaling to any size window. The higher quality video scaling can occur anywhere between the video input to the chip, on the AGP, PCI, or side port, and the video appearing on the screen.

  Video scaling must be implemented using the existing DirectDraw and DirectShow APIs.

For PCs to effectively compete with dedicated consumer electronics video devices, it is necessary to raise the quality of video scaling on the PC. Specifying scaling quality is hard because of the difficulty of quantifying viewer-perceived video quality. In the absence of anything better, guidelines for the quality of the video filter used in the resizing operations are specified for each system type in the following lists.

Scaling requirements for video-enabled Office PC or Mobile PC systems:

- Hardware scaling is not a requirement, but bi-linear scaling (two taps vertically and two taps horizontally) is recommended. However, considerable user and marketplace benefits can be gained by implementing the video playback requirements defined for Entertainment PC systems.

- Any hardware scaling engine present on a non-DTV–enabled Office PC is required to be able to accept a standard definition video input (480i or 576i), such as might come from a DVD or NTSC source. For a DTV-enabled Office PC, the requirement is that the scaling engine, if one is present, must be able to accept an input with a rate of 480p60 (720 horizontal pixels) and 720p24 (1280 horizontal pixels).

Scaling requirements for video-enabled Consumer PC system:

- The minimum requirement is to use bi-linear scaling; a filter with two vertical taps and two horizontal taps is required. Recommended: a minimum of three taps vertically and four taps horizontally be implemented and, ideally, four or five vertical and seven or eight horizontal taps.

- The ability to shrink or zoom by a variable factor of up to 8:1 in one-pixel increments is required.

- The image quality should not be perceptibly degraded when shrinking by factors up to 2:1. Some image degradation is acceptable for the larger shrink ratios, although market acceptance of the product will suffer if image quality is excessively degraded.

- The scaling engine on a non-DTV–enabled Consumer PC must be able to accept a standard definition video input (480i or 576i), such as input that might come from a DVD or NTSC source. For a DTV-enabled Consumer PC, the scaling engine must be able to accept an input with a rate of 480p60 (720 horizontal pixels) and 720p24 (1280 horizontal pixels).

- The ability to upscale must be implemented in hardware. Downscaling should be implemented in hardware. Future versions of this design guide are likely to exclude the practice of being able to downscale in the driver.

Scaling requirements for Entertainment PC systems:

- The scaling filter (interpolator) is required to implement a minimum of three taps vertically and four taps horizontally.

Recommended: a minimum of three taps vertically and five taps horizontally be implemented and, ideally, four or five vertical and seven or eight horizontal taps.

- The ability to shrink or zoom by a variable factor of up to 8:1 in one-pixel increments and the ability to shrink by a variable factor of up to 16:1 in one-pixel increments is required.

- The image quality should not be perceptible degraded when shrinking by factors up to 4:1. Image degradation is acceptable for the larger shrink ratios, although market acceptance of the product will suffer if image quality is excessively degraded.

- The scaling engine on a non-DTV–enabled Consumer PC is required to be able to accept a standard input with a rate of 480p60 (720 horizontal pixels) and 720p24 (1280 horizontal pixels).

- Both upscaling and downscaling must be implemented in hardware.

The term "tap" is defined here as the number of input pixels that contribute to the building of each output pixel. A bi-linear filter is two taps, and a three tap filter is a filter better than bi-linear. For filter designs employing three or more taps, it is desirable to use a "windowed sinx/x" function. However, the "windowing" process needs particular attention, especially when small numbers of taps are used to achieve the best subjective picture quality.

To allow optimization, it is sensible for filter coefficients to be stored in a look-up table with values that are downloadable from the driver. For shrinks greater than a 2:1 ratio, larger numbers of taps are needed.

An example would be putting shrink factors, such as a halving factor in series with the variable shrink factor specified earlier. When doing shrinks, great care needs to be taken with the filter coefficients to minimize spatial aliasing. High-frequency components in the source should ideally be attenuated by either pre-filtering or adjusting the interpolation filter characteristics.

When scaling 4:2:2 or 4:2:0 YUV video, scaling is only acceptable with two-pixel granularity. A method must be employed to present this as one-pixel granularity on window size because users will resize windows with one-pixel granularity. One acceptable method would be to crop a one-pixel strip from the resized video where necessary.

Recommended: Additional independent and resizable overlays for support of picture-in-picture (PIP) video features and multiple video conferencing windows are recommended on all system types.

Future versions of these guidelines are likely to specify higher quality scaling. A particular area of focus is likely to be the quality of back-end upscalers, which will need to increase. An example is an increase to a three-tap by five-tap interpolator for all video-enabled desktop PCs.

14.15. Hardware supports VGA destination color keying for video rectangle

Required for systems that support TV or DVD video playback

This is a requirement for video overlays. The hardware must be capable of independently controlling the VGA pixels for compositing the video plane under the VGA plane. This VGA destination color keying must function in all video modes using either or both of the following:

- A specific color/color range, for example, on 4-bit, 8-bit, 15-bit, and 24-bit SVGA modes
- Additional alpha blending bits in the color plane bits on 16-bit and 32-bit SVGA modes

Color keying the VGA allows certain VGA pixels to be replaced by the underlying video pixels on a pixel-by-pixel basis. This feature enables VGA video overlays, controls, Windows pop-up menus, dialog boxes, and so on, and it allows for irregular-shaped graphics compositing. Color keying must work simultaneously with any vertical/horizontal scaling active for the underlying video.

14.16. Hardware supports alpha blending of graphics and video

Required for systems that support TV or DVD video playback, with exceptions for mobile PCs and Office PCs

Mobile PC Note This capability is recommended for mobile PCs and Office PCs, and it is required for all other system types that support TV or DVD video playback.

The hardware must support alpha blending for DVD-Subpicture and the user interface (UI) for data-enhanced television.

The DVD-Subpicture stream has 4 bits of alpha information per pixel that indicate how the subpicture should be composited with the main picture. In the future, data-enhanced television streams will also require alpha-composited UI functionality with 8-bit control. With 8 bits, the translucency can be faded in and out, which is important to the creative community. This type of control is currently provided by set-top boxes such as WebTV® service.

In color modes that support alpha blending, such as ARGB8888, the blend level is controlled on a per-pixel basis. Color modes that do not support alpha blending, such as RGB 565, should allow an overall constant alpha blend value for the overlay.

A minimum of 4 bits of alpha blending must be provided in any secondary overlay surface when in 32-bit mode, such as ARGB8888. In other color modes, it is acceptable within the 1999–2000 timeframe to synthesize the effect within the secondary overlay surface. This can be done using methods such as screen-door dithering using the overlay color key or 1-bit alpha control. Full 8-bit alpha control is defined as a 256-level linear translucency state from 0 percent (value of 0) to 100 percent (value of 255). When fully implemented, linearity should be monotonic with an accuracy within 0.5 bits.

Whatever alpha-blending scheme is implemented, the driver should present it as an 8-bit control.

It is likely that future versions of this guide will require full 8-bit alpha blending within any secondary overlay surface.

14.17. Video port meets PC 99 specifications if present on graphics adapter
Required

Support for a video side port is recommended. If implemented, this requirement applies to all graphics adapters that use a video port connection or that enable end users to make such a connection to a video device. The video port is a dedicated connection between video devices, such as the graphics adapter and an MPEG-2, NTSC, or PAL decoder. A video port can be implemented as a hard-wired connection on the same board as the graphics adapter or implemented between separate devices using a cable connection.

Video side ports that have host port or bi-directional capability provide a useful way to attach additional functionality to the graphics chip. In addition to the obvious case of NTSC/PAL decoders, this is useful for optional functions and for functions that would not fit on the graphics chip, such as MPEG decoders and high quality de-interlacers.

It is expected that most implementations of graphics adapters will have a single MPEG decoder on the graphics adapter. Providing a side port connector on the card allows addition of other decoders.

For a graphics adapter that includes a video port, the following requirements must be met:

- **14.17.1 Autoflipping.** The video port must support automated overlay and video port buffer flip on video port vertical synchronization (Vsync).

- **14.17.2 IRQ.** The video port must generate an IRQ when Vsync occurs. The kernel-mode video transport component of DirectDraw version 5.0 and later can use this IRQ to perform autoflips. This capability allows fields to be skipped by the video port and also prevents an irregular synchronization from overwriting its buffers. This also enables capture of vertical blanking interval (VBI) and video port data.

Mobile PC Note   This IRQ is not required for mobile PCs.

- **14.17.3 Driver.** The driver must support DirectDraw Video Port Extension (VPE), which provides a key element of video playback support in DirectX 5.0. This support must be incorporated to ensure that the graphics adapter and video port take advantage of VPE capabilities in the operating system.

  For information about implementing DirectX support, see the Windows NT 5.0 DDK. See also the white paper on DirectDraw VPE and kernel-mode video transport at http://www.microsoft.com/hwdev/devdes/vpe.htm.

  For additional requirements related to implementing video ports, see "System Requirements for Video and Broadcast Components" in Chapter 15, "Video and Broadcast Components."

Recommended: The following guidelines for video ports are recommended to support high-quality TV or DVD video playback:

- **Maximum height.** The graphics adapter should support a register that limits the maximum height of the field that gets written into memory.

- **Separate pitch and start addresses.** The overlay and the video port should support separate pitch and start addresses. This allows the bob algorithm to be used while the video is interleaved, which makes switching between bob and weave modes possible.

14.18. Hardware supports MPEG-2 motion compensation acceleration
Recommended
For products that use MPEG-2 software decoders, MPEG-2 motion compensation acceleration is recommended.

Specifically, this recommendation refers to, but is not limited to, the following:

- Motion compensation of YUV 4:2:0 planar surfaces (versus YUV 4:2:2 packed pixel surfaces) to decrease system memory bandwidth requirements

- Full-precision motion compensation (for example, use 9 bits for an 8-bit signed error term) to prevent degradation of video quality

- Bus mastering of error terms, and vectors to and from AGP memory (versus system memory), to increase memory bandwidth and CPU cache efficiencies

For more guidelines, see "MPEG-2 Video Playback Requirements" in Chapter 15, "Video and Broadcast Components."

14.19. Hardware supports scanning at the same frequency as the incoming video

Consumer	Office	Mobile	Workstation	Entertainment
Recommended	*Recommended*	*Recommended*	*Recommended*	*Required*

Frames must not be dropped or repeated for synchronization any more frequently than once every 60 seconds when there is a stable video source. It must be possible to set the refresh rate on the card to be the same as the video being displayed in the primary window. If the video is 59.94 Hz, then the PC refresh rate should be 59.94 Hz +/–0.025 percent. Trying to use a 60 Hz rate when the source video is 59.94 Hz is not acceptable and will cause a "jump" every 17 seconds.

Note: PAL requirements will be addressed in a future document.

Mobile PC Note The 59.94 Hz requirement does not apply to LCD screen devices for the 1999–2000 time frame.

An effective way to achieve this is with some form of genlocking using a phased-locked loop with a time constant of many seconds to avoid problems with noisy signals and changing television channels. When the source is or has been unstable or if the source has been changed, then greater frame dropping or repeating is allowed for the first three minutes after the source becomes stable.

It is recognized that there is an inconsistency with VESA specifications for ergonomic timing rates; VESA timings don't currently include 59.94 Hz. Support of the 59.94 Hz variant of the specified 60 Hz VESA timing is essential for TV video.

As an alternative to providing the ability to scan at the same frequency as the incoming video, it is possible to use motion vector-steered temporal rate conversion. In the long term, this is a very good solution to CRT displays. However, solutions able to meet the necessary video quality requirements at economical price points are likely to be rare in the 1999–2000 time frame.

Multiple-Adapter and Multiple-Monitor Support

This section defines the requirements for ensuring system support for multiple adapters and multiple monitors. This support ensures that if the user adds a second adapter, resources will automatically be available and the operating system can automatically manage multiple display adapters.

The actual implementation a user might employ could be one of the following:

- Multiple adapters added to the PC system
- A single adapter with a single controller supporting two monitors
- A single adapter with multiple controllers supporting multiple monitors
- Any combination of these scenarios

The support in both Windows and Windows NT requires multiple-adapter/ multiple-monitor compatibility in the BIOS, plus the graphics adapter and its driver. This support also requires allowing any secondary graphics adapters to be enabled in VGA mode, thus requiring that VGA for the previous adapter be temporarily disabled.

With this support, a single adapter that supports multiple monitors can display independent screen images. The operating system support therefore also assumes that the different displays might have differing X, Y resolutions, color depths, refresh rates, and display capabilities.

For technical details about implementing driver support for multiple adapters and multiple monitors, see the Windows 98 DDK and the Windows NT 5.0 DDK.

14.20. Extended resources can be dynamically relocated after system boot
Required

To ensure Plug and Play for multiple-adapter/multiple-monitor capabilities, all non-VGA standard display resources, also known as extended resources, such as register sets and so on, must be capable of being dynamically relocated after system boot.

This is an extension of requirement 14.11, "Graphics operations use relocatable registers only," plus the requirements defined in "General Plug and Play Requirements" later in this chapter.

14.21. VGA resources can be disabled by software
Required

A means must be provided to allow a driver to disable its adapter from decoding standard VGA addresses to ensure that the adapter is independent of all other graphics adapters in the system. The adapter must remain fully functional without the VGA addresses. See also requirement 14.11, "Graphics operations use relocatable registers only."

Hardware Acceleration for 2-D Graphics

This section summarizes guidelines related to 2-D DirectDraw graphics features, which can be implemented as hardware acceleration features.

All PC 99 systems require hardware acceleration for 2-D graphics. Robust DirectDraw support is also required to allow 3-D hardware accelerators to take full advantage of the DirectX architecture.

14.22. Frame buffer can be accessed directly by applications
Required for all system types

The visible frame buffers must be accessible. It must be possible for applications to perform direct frame buffer accesses at any time, even while asynchronous accelerator operations are being executed. Without this capability, drivers cannot support DirectDraw or Direct3D on Windows NT, and operations on Windows 98 will not be fully robust.

Some hardware keeps the information in its frame buffers in a format that does not correspond to the linear format standard in DirectDraw, such as tiling the pixels to exploit the 2-D coherence of image data. If this is the case, the hardware must perform translations so that DirectDraw surfaces being accessed directly appear linear. The hardware performing this translation might be a limited resource, but it must be able to perform translations on at least seven DirectDraw surfaces simultaneously. Support for eight or more surfaces is recommended.

14.23. Adapter and driver support linear-mapped, low-resolution modes
Required for all system types

All graphics adapters currently support linear-mapped low-resolution modes, with minimal driver work needed to support this requirement. Decreasing the size of the frame buffer decreases the average polygon size and increases the frame rate for a given scene. These additional modes provide support software rendering for games and software Direct3D.

If low-resolution support is implemented in the hardware, the following low-resolution modes are required:

$320 \times 200 \times 16$ bpp	$320 \times 240 \times 16$ bpp	$640 \times 400 \times 16$ bpp
$320 \times 200 \times 8$ bpp	$320 \times 240 \times 8$ bpp	$640 \times 400 \times 8$ bpp

The following low-resolution modes are recommended:

$400 \times 300 \times 16$ bpp	$512 \times 384 \times 16$ bpp
$400 \times 300 \times 8$ bpp	$512 \times 384 \times 8$ bpp

Note: In Windows 98, low-resolution capabilities must not be defined in the registry so that they do not appear in the display control panel. In Windows NT, the control panel automatically filters out these modes.

14.24. Hardware supports transparent blter

Required for all system types

There is no restriction on source size. A transparent blter can perform a blt with a source key transparent color. This assumes that the blter is asynchronous with the host processor.

14.25. Hardware provides support to prevent tearing

Required for all system types

This must be performed in synchronization with the VBI.

The hardware must support a mechanism for preventing visible artifacts such as "tearing." The mechanism for doing this is at the discretion of the hardware designer, but it should support tear-free capabilities for both full-screen and non-occluded windowed applications.

Blts must be performed in synchronization with the vertical scan line to avoid tearing. The ability to read the current scan line supports blting or writing to the screen without tearing. In some contexts, such as video playback, this support eliminates the need for the secondary overlay buffer.

For information about the upper limits of resolution to be supported, see requirement 14.8, "Screen resolution and local memory capacity meet PC 99 minimum requirements."

14.26. Hardware supports programmable blter stride

Required for all system types

This is required as part of the support for textures. A programmable blter stride ensures that Windows can use linear memory. A fixed stride forces Windows to use rectangular memory management, with all the related inefficiencies. It must be possible to specify different strides for the source and destination on blts.

Hardware Acceleration for 3-D Graphics

This section summarizes guidelines related to Microsoft Direct3D technologies that can be implemented as hardware acceleration features. Supporting the items in this section can result in improved performance and improved memory use.

Support for 3-D graphics is required by mainstream business applications plus educational, entertainment, and other applications including the Internet Explorer shell for both Windows 98 and Windows NT 5.0.

All systems except Office PC and mobile PC systems are required to support 3-D acceleration in the graphics subsystem. Each entry in this section indicates by system type whether a particular feature must be implemented if the graphics adapter includes 3-D support.

Mobile PC Note   For exceptions and requirements for mobile PCs that implement 3-D hardware acceleration, see "Mobile PC Graphics Requirements" in Chapter 6, "Mobile PC 99."

14.27. Hardware supports PC 99-required RGB rasterization
Required for all system types, with exceptions for mobile PCs

In RGB mode under Direct3D, shading across a surface is accomplished by independently interpolating all color components. The following capabilities are required for red-green-blue (RGB) rasterization:

- **14.27.1 Basic 3-D requirements.** To meet basic 3-D requirements, the adapter and driver must do the following:
  - Support $800 \times 600 \times 16$ bpp, double buffered, with 16-bit Z buffer at 75 Hz in full-screen, 3-D graphics mode
  - Make all required features available at the same time; for example, it is not acceptable to turn off specular highlights in order to enable fog
  - Conform to Direct3D rasterization rules

- **14.27.2 Textures.** These include the following:
  - MIP-mapped textures
  - Bilinear or better filtered textures, rather than point-sampled, with perspective correction

- **14.27.3 Alpha blending.** Source alpha blending, and destination alpha blending is recommended. The following modes are defined for Direct3D in the DirectX 5.0 DDK:

Required	Recommended
D3DBLEND_DESTCOLOR	D3DBLEND_BOTHINVSRCALPHA
D3DBLEND_INVDESTCOLOR	D3DBLEND_BOTHSRCALPHA
D3DBLEND_INVSRCALPHA	D3DBLEND_DESTALPHA
D3DBLEND_INVSRCCOLOR	D3DBLEND_INVDESTALPHA
D3DBLEND_ONE	D3DBLEND_SRCALPHASAT
D3DBLEND_SRCALPHA	
D3DBLEND_SRCCOLOR	
D3DBLEND_ZERO	

For source RGB alpha blending, transparent primitives are blended with the background, but the background transparency is not updated. This method provides good visual accuracy if there are not too many overlapping transparent objects.

- **14.27.4 Lighting and fogging.** These requirements include the following:

  - Flat and Gouraud shading.

  - Depth-based (Z-based) fog of an arbitrary color, calculated on a per-vertex basis. Depth is defined as distance perpendicular to the screen.

  - Specular highlighting.

The Direct3D reference rasterizer provided in DirectX 5.0 and later supports all of these capabilities.

There is no requirement for edge anti-aliasing. See the following recommendation.

14.28. Hardware supports recommended RGB rasterization features
Recommended for all system types, with exceptions for mobile PCs
The recommended RGB rasterization features include the following:

- Range-based and table-based fog

- Hardware support for triangle strips and fans

- Sort independent edge anti-aliasing

- Precision line drawing (Bresenham line drawing algorithm recommended)

14.29. Hardware supports multi-texturing

Consumer	Office	Mobile	Workstation	Entertainment
Recommended	Recommended	Recommended	Required	Required

Multi-texturing hardware can apply multiple textures to a polygon. The most common application of multi-texturing is with map-based techniques for diffuse lighting and specular reflections.

Implementing this capability requires supporting two or more sets of independent texture coordinates. It is recommended that hardware supports combining at least two textures in a single pass.

The following texture combination operations are required:

- MODULATERGB: Component-wise multiplication of both texture colors.

- MODULATELPHA: Multiply colors of one texture by the alpha of the other.

- ADD: Component-wise addition of both textures.

- BLEND: Linear combination of textures weighted by a scalar specified in a register or in a polygon alpha.

Multi-texturing is used to compute the texture value that participates in the pixel pipeline implemented in Direct3D in DirectX 5.0. It is independent of the alpha blending stage in a previous version of Direct3D.

This technique should work in combination with fogging and alpha blending, but it need not operate at the same time as other advanced filtering.

For more information, see the paper on multi-texturing and DirectX available on the web site at http://www.microsoft.com/hwdev/video/.

14.30. Hardware supports texture formats

Required for all system types, with exceptions for mobile PCs

Hardware that implements 3-D acceleration must support palletized textures. Pallet entries use the corresponding nonpalletized formats shown in the following table.

Required	Recommended
1:5:5:5 ARGB	4-bit palletized
4:4:4:4 ARGB	8-bit palletized
	8:8:8:8 ARGB
	0:5:6:5 ARGB
	4:2:2 YUV

14.31. Hardware complies with texture size limitations

Consumer	Office	Mobile	Workstation	Entertainment
Required	*Recommended*	*Recommended*	*Required*	*Required*

MIP mapping requires that textures of size 1×1 be supported. To meet PC 99 requirements, a 3-D accelerator must support this lower limit on texture size.

The texture units must support square and non-square power-of-two textures $(2^n \times 2^m)$ up to 256×256.

Recommended: The texture unit should support non-power-of-two width and height. This enables the texture mapping unit to be used to emulate blts. Also, it is recommended that the texture unit support an upper limit of 2048×2048 rather than the required 256×256.

14.32. Hardware supports destination RGB alpha blending

Recommended for all system types

For destination RGB alpha blending, primitives are blended with the background, updating not only the colors in the frame buffer but also a cumulative transparency that can affect the rendering of subsequent primitives.

See the list of required and recommended alpha blending modes as defined for Direct3D in requirement 14.27, "Hardware supports PC 99-required RGB rasterization."

14.33. Hardware supports Z comparison modes and Direct3D-compatible formats

Consumer	*Office*	*Mobile*	*Workstation*	*Entertainment*
Recommended	*Recommended*	*Recommended*	*Required*	*Required*

The 3-D hardware should support 16-bit minimum, unsigned, lockable Z buffer format and all Z comparison modes.

Hardware that supports Z buffering must support clearing of the Z buffer through the DirectDraw depth-fill blt mechanism. However, DirectX 5.0 enables Z buffers to be cleared at the same time as destination surfaces. It is recommended that hardware support simultaneous clearing of color and Z buffers using the DirectX 5.0 mechanism.

14.34. Hardware meets PC 99 3-D accelerator performance requirements

Consumer	*Office*	*Mobile*	*Workstation*	*Entertainment*
Recommended	*Recommended*	*Recommended*	*Required*	*Required*

The 3-D rendering subsystem should have triangle setup capability implemented in hardware that is capable of processing triangles at a sustained rate in excess of 1 million triangles per second.

Each triangle is assumed to be 1 visible pixel in area, front facing, textured, and composed of three vertices, where each vertex contains a diffuse and specular color component. Rendering conditions should be 16 bpp, bilinear textured, Z buffered, and alpha blended. Triangles should be ordered such that the Z check always passes (the current triangle is in front of all previously rendered triangles).

The 3-D rendering subsystem should be capable of filling triangles at a sustained rate in excess of 40 million pixels per second. Each triangle is assumed to be 10,000 visible pixels in area, with the same attributes as described for triangle setup in the previous paragraph. Rendering conditions are also the same as for triangle setup. Supporting 60 million pixels per second is recommended.

Television Output Requirements

This section summarizes the key design issues and requirements for television output capabilities, which are recommended for all PC 99 system types, particularly any Entertainment PC system that does not include a large-screen entertainment monitor.

The required support allows an NTSC or PAL television to be used as a primary or secondary display surface for the Windows operating system and for Windows-based applications. Such a display surface allows more realistic game, video, and multimedia experiences for users who want to use a large-screen television that they already own.

With built-in operating system support, using a separate television resolution display controller for driving the NTSC encoder, which is typically sited on the same graphics adapter, has the following advantages:

- Provides a larger pixel working area.
- Ensures that the PC can be used in one room with a monitor running at 75 Hz for an application such as word processing or games, while it simultaneously drives a television at 60 Hz in another room to show a DVD movie or television program.
- Provides support that is ideal for editing home videos, allowing the user to view the content and the edit time lines simultaneously.
- Eliminates the need for the user to continuously change the display resolution between the high-resolution, high-refresh rate needed for PC applications and the low-resolution, television-resolution mode.
- Eliminates the PC monitor flicker that occurs if the monitor is driven by the same display controller as the television.

If television output capabilities are provided in a PC 99 system, support is required for either NTSC or PAL standards. NTSC refers to the television standards first developed in the United States and used in Canada, Japan, and Mexico. PAL refers to the television standards first developed in Germany and used in Austria, Belgium Brazil, Denmark, Finland, the Netherlands, Norway, Sweden, Switzerland, and the United Kingdom.

For more information about world television standards, see the web site at http://www.bbc.co.uk/aberdeen/eng_info/.

Note: The requirements in this section apply only if the television output capability is present on a PC 99 system or on a graphics adapter that supports television output capabilities. Some television output capabilities listed in this section are required only for Entertainment PC systems.

14.35. Adapter supports both NTSC and PAL output

Recommended for all system types

The television output adapter should support both output standards. If NTSC is supported, then the NTSC system must support 640 × 480 at 60 Hz. If PAL is supported, then the PAL system must support 640 × 480, 800 × 600, or both at 50 Hz.

Whether either or both output standards are supported, software must be capable of independently enabling and disabling television and VGA output.

Note: For NTSC, the 60-Hz mode described in this section is actually 59.94 Hz.

14.36. Default boot mode supports appropriate locale

Required for all system types

If television output capability is present on a PC 99 system, the system and the graphics adapter must enable television output automatically as the primary display if a VGA monitor is not attached. The system must default to modes compatible with television output in the geographic region for which the adapter was localized. NTSC adapters should default to 60-Hz modes; PAL adapters should default to 50-Hz modes. Ideally, an adapter would support both modes and provide a safe means for the default selection to be changed by a user.

Mobile PC Note   For mobile PCs, it is acceptable for television output to be enabled manually.

14.37. Adapter supports underscan scaling

Consumer	Office	Mobile	Workstation	Entertainment
Required	*Recommended*	*Recommended*	*Recommended*	*Required*

For Consumer PC and Entertainment PC systems, the television output adapter must be able to correct horizontal and vertical overscan using hardware scaling. This allows 640 × 480 resolution modes to fit onto NTSC displays and 800 × 600 resolution modes to fit onto PAL displays.

Driver software must be capable of enabling and disabling scaling and also of adjusting scaling for compatibility with a variety of television monitors. As television monitors age, overscan reduces, so less scaling is required.

14.38. Adapter supports flicker filter

Required for all system types, with exceptions for mobile PCs

The television output adapter must use multi-line (3-tap minimum) hardware filtering techniques for flicker reduction. Enable, disable, and adjust capabilities for the flicker filter must be software controllable. Also, overscan should be software-enabled when the PC is playing full-screen video.

Mobile PC Note   For mobile PCs, the television output adapter must use 2-tap minimum hardware filtering techniques or better.

14.39. Adapter provides proper termination

Required

Proper termination is required so that optimal picture quality from any connector does not require displays to be attached to other connectors. For example, a VGA monitor must not be required in order for the S-Video output to appear properly.

14.40. Adapter supports composite video and S-Video connectors

Consumer	Office	Mobile	Workstation	Entertainment
Recommended	*Recommended*	*Recommended*	*Recommended*	*Required*

Support for both composite video and S-Video is required for Entertainment PCs and is recommended for other system types.

Compared to composite video, S-Video dramatically improves the picture quality of the NTSC or PAL scan converter. This standard is designed to reduce cross talk between chrominance and luminance signals, and to increase the luminance bandwidth capability of the television. A further increase in quality is obtained by using component video, which is common in Europe and will become so in North America.

For information about these standards, see the web site available at http://www.bbc.co.uk/aberdeen/eng_info/.

14.41. Adapter with television output supports both VGA and television output

Required for all system types

In addition to television output, the PC 99 system must also support VGA output to ensure that users with large-screen VGA monitors can use this output capability.

It is recommended that the adapter supports the following:

● Simultaneous output to VGA monitor and television.

● Two display controllers or an implementation that provides the desired result of two independently timed outputs to different monitors.

  With a single controller, both the monitor and television must use a 60 Hz, low-resolution format; which is not desirable.

14.42. Software supports positioning

Consumer	Office	Mobile	Workstation	Entertainment
Required	*Recommended*	*Recommended*	*Recommended*	*Required*

Software must be able to program the television output hardware to position the television image in increments of 4 pixels horizontally and 4 scan lines vertically.

14.43. Software supports detection of television connection

Consumer	Office	Mobile	Workstation	Entertainment
Required	*Recommended*	*Recommended*	*Recommended*	*Required*

For Consumer PC and Entertainment PC systems, software must be able to detect whether a television is attached to S-Video or composite output connectors. Detection of a VGA monitor is based on requirement 14.13, "Adapters supports DDC monitor detection."

Detection of a television connection is required to allow the operating system and graphics drivers to correctly support display output during the startup sequence, for example, determining what resolution and refresh rate to use, and to allow applications to adjust their user interfaces appropriately to the screen capabilities.

14.44. Analog video outputs, such as NTSC, have copy protection on DVD-enabled platforms

Required for all system types

The use of an appropriate copy protection system is necessary to stop DVD discs from being played on the PC and then recorded on a VCR. Details for MacroVision protection for DVD are available at http://www.macrovision.com.

PC 99 Design for Graphics Adapters

This section summarizes requirements related to the PC 99 design initiatives defined in Part 1 of this guide.

Plug and Play and Bus Design for Graphics Adapters

The items in this section summarize requirements for Plug and Play and other resource- and bus-related capabilities. The specifications in this section are required for all PC 99 systems.

See also requirement 14.11, "Graphics operations use relocatable registers only."

General Plug and Play Requirements

The requirements in this section ensure easy configuration.

14.45. Each device has a Plug and Play device ID

Required

The device must have a unique device ID using the format required for its bus. For example, a PCI device must comply with PCI 2.1 and provide a Subsystem ID and Subsystem Vendor ID, as defined in Chapter 9, "PCI."

Note: Multiple-monitor support allows Display class devices to be initialized independent of the system initialization process. For this reason, system-board and add-on display devices cannot use the VGA BIOS POST routine to populate the Subsystem Vendor ID because the device's POST code might not be executed until later in the process, after device enumeration occurs. For system-board devices, the system BIOS should populate the Subsystem Vendor ID at power on. Add-on display adapters should provide a method for populating the Subsystem Vendor ID at the point when power is applied and the device is initialized to the state that is ready for POST.

14.46. System supports conflict resolution, VGA compatibility, and extended registers

Required

When the end user changes or adds a graphics adapter to the system, setting resource assignments must not require changing jumpers or switches on either the card or the system board. The system must be able to automatically relocate the resources used by a graphics adapter on the system board when a graphics adapter expansion card is added to the system. In the event of an irreconcilable conflict with other devices on the system, the system must be able to disable one of the adapters in order to prevent the system from stalling.

The system must support the VGA graphics standard for application compatibility and for the Windows clean-boot error-recovery process. If a VGA BIOS exists on the graphics adapter, it must be able to configure its base address to C0000h and one alternate address, at a minimum, to prevent conflicts.

Extended resources are additional I/O ports, direct-access frame buffers, or data transfer areas on a graphics adapter that use more resources than does standard VGA. The Windows configuration manager must be able to map the resources to avoid conflicts with other system devices. At least one alternate configuration must be provided for each non-VGA display resource in the event of conflict during the IPL boot.

The software drivers and VGA BIOS (if used) must be able to use alternate configuration register addresses. The system must be able to dynamically disable or relocate VGA resources from C0000h. It must also be possible to re-enable these resources upon system reboot or reset.

For additional related requirements for multiple monitor support, see "Multiple-Adapter and Multiple-Monitor Support" earlier in this chapter.

BIOS and Option ROM Requirements for Graphics Adapters

The requirements in this section relate to BIOS support for graphics adapters.

14.47. Chips support linear packed-pixel frame buffer, relocatable above 16 MB

Required

Note: For DirectDraw, the graphics adapter's chip set must support linear access to the frame buffer by the host.

Windows operating systems are optimized for a graphics adapter with a packed-pixel frame buffer at all supported resolutions. Memory-mapped packed-pixel frame buffers also provide a fast and simple interface between Windows and the graphics adapter. The Windows DIB engine provides a very fast display by writing directly to packed-pixel frame buffers; this architecture requires that the hardware developer write only a small, simple device driver.

For optimized support with Windows, a linear packed-pixel frame buffer is required over a bank-switched frame buffer. Use 32-bit addresses to allow the linear frame buffer to be placed above the 16-MB ISA boundary, which enables a system to be populated with large amounts of RAM.

If memory or other resources conflict with the frame buffer being mapped into a linear address space, the page frame address can be used with minimal degradation of performance.

14.48. Option ROM supports DDC2B

Required, with exceptions for Mobile PCs

This requirement does not apply for systems that use RISC-based processors.

The option ROM for the graphics adapter must meet current DDC2B host requirements documented in *Display Data Channel Standard, Version 3.0*, Level 2B protocol (DDC2B), published by VESA. This standard defines the functions that support the data channel between the graphics adapter and a DDC monitor.

Mobile PC Note   For information about exceptions for permanently attached display monitors, see requirement 6.21, "External graphics adapter interface supports DDC monitor detection."

14.49. BIOS setup utility provides option to force use of system-board graphics

Recommended

The OEM should provide an option in the system BIOS setup utility to force the system-board graphics device to be used, ignoring and disabling any PCI graphics adapters. This option would ensure that a user with a PCI hot-docking system is always able to undock because the VGA device will be in the mobile unit.

14.50. BIOS supports large frame buffers for graphics adapters

Required

The BIOS must support large frame-buffer graphics adapters that have up to 256 MB of frame buffers.

AGP Requirements

This section defines the requirements for systems that implement AGP.

AGP technology allows textures to be stored in system memory, enabling larger, detailed texture maps in consumer applications. Effective AGP implementations can eliminate the need for a local memory texture cache, as defined in requirement 14.8, "Screen resolution and local memory capacity meet PC 99 minimum requirements."

14.51. AGP meets PC 99 implementation guidelines

Required

The following is required for implementing AGP:

- Comply with the PCI Bus Power Management Interface Specification, Revision 1.0 or later, including the Configuration Space registers and the device state (Dx) definitions

- Comply with PCI 2.1 software interface layers, including the PC 99 requirements for Subsystem ID and Subsystem Vendor ID

- Comply with *Accelerated Graphics Port Interface Specification, Revision 1.0* or later. This means the card has an AGP capability pointer with a working AGP capability structure that has the following characteristics:

  - A minimum request-queue depth of 1 DWORD (RQ value of 0)

  - A workable AGP_ENABLE

  - A minimum speed of 2x, system implementation of GART, and support for non-local video memory are required for all system types except mobile PCs

Mobile PC Note   For mobile PCs, 1x is an acceptable speed and GART is recommended, rather than required. For more information, see Chapter 6, "Mobile PC 99."

Requirements for PCI Graphics Adapters

The requirements in this section apply for graphics adapters that use the PCI bus.

14.52. PCI graphics device supports IRQ and correctly populates PCI BARs

Consumer	Office	Mobile	Workstation	Entertainment
Required	Recommended	Recommended	Required	Required

Proper IRQ support is needed for optimal support of video playback. The display driver queries the actual device to find its register locations and so on. The PCI base address registers (BARs) must be populated correctly for this information to be correct in the registry.

On adapters that do not support an IRQ, the Interrupt Pin Register (3Dh) should be zero (0).

14.53. PCI system-board graphics device is not hidden from Plug and Play enumeration

Required for all system types

The system-board device must disable the PCI device rather than hiding it. Hiding the system-board graphics adapter from the PCI bus when another graphics adapter is detected in the system causes problems for supporting multi-monitor capabilities.

Power Management for Graphics Adapters

This section summarizes the specific power management requirements for graphics adapters.

14.54. Graphics adapter complies with device class power management reference specification

Required

The *Display Device Class Power Management Reference Specification, Version 1.0* or later, provides definitions of the OnNow device power states (D0–D3) for display and graphics devices. The specification also covers device functionality expected in each power state and the possible wake-up event definitions for the class, if any. Power states D0 and D3 are required; D1 and D2 are optional for graphics adapters.

14.55. Graphics adapter complies with VBE/Core 2.0 extensions for power management

Required

The *VESA BIOS Extension Standard/Core Functions 2.0* (VBE/Core 2.0) specification defines extensions to VGA ROM BIOS services for power management.

Device Drivers and Installation for Graphics Adapters

This section summarizes the requirements for graphics adapters. The specifications in this section are required for all PC 99 systems.

For additional driver-related requirements for multiple-monitor support, see "Multiple-Adapter and Multiple-Monitor Support" earlier in this chapter.

Note: Software provided with graphics adapters designed for use with Windows NT 5.0 must comply with the requirements defined in the drivers section of the Windows NT 5.0 DDK.

14.56. Device drivers and installation meet PC 99 requirements
Required

The manufacturer does not need to supply a driver for a device if the device passes PC 99 compliance testing using a driver provided with the operating system. If the manufacturer supplies a driver, it must comply with requirement 3.16, "Device driver and installation meet PC 99 requirements." The basic requirements include driver support for unattended installation and Help file support if special driver parameters are used.

Note: For Windows 98, the display driver (.DRV) component loaded and called by the operating system is a Win16 module.

14.57. Driver does not bypass any Microsoft-provided system components
Required

The driver must not bypass or patch any Microsoft-provided system components. For Windows, this includes Gdi.exe, Kernel.exe, User.exe, Dibeng.dll, Mmsystem.dll, Ddraw.dll, D3d*.dll, and so on.

For Windows NT, this requirement applies for all files normally installed in the System32 directory. These files include, but are not limited to, Win32k.sys, Ntoskrnl.exe, Gdi32.dll, User32.dll, and Mcdsrv32.dll.

14.58. Applications provided with device meet requirements for Win32-based applications
Required

Any Windows-based applications provided with the device must meet Microsoft requirements for software compatibility as defined in the Microsoft Platform SDK.

14.59. Driver supports dynamic color bit-depth change
Required

The graphics adapter must operate properly and must not fail when asked by the operating system to change the color depth.

Graphics Adapters References

The following represents some of the references, services, and tools available to help build hardware that is optimized to work with Windows operating systems.

Accelerated Graphics Port Interface Specification, Revision 1.0 or later
   http://developer.intel.com

ATSC DTV Specification
   http://www.atsc.org

Display Data Channel Standard, Version 3.0
   http://www.vesa.org

Display Device Class Power Management Reference Specification Display Version 1.0
   http://www.microsoft.com/hwdev/onnow.htm

Microsoft Windows 95 DDK, Windows 98 DDK, Windows NT 5.0 DDK, and DirectX 5.0 DDK
   MSDN Professional membership

PCI Local Bus Specification, Revision 2.1 (PCI 2.1)
PCI Bus Power Management Interface Specification, Revision 1.0
   Phone: (800) 433-5177
   http://www.pcisig.com

VESA BIOS Extension Standard/Core Functions 2.0 (VBE/Core 2.0)
VESA and Industry Standards and Guidelines for Computer Display Monitor Timing
   http://www.vesa.org

White papers and guidelines for DirectX, multiple-monitor/multiple-adapter support, and DirectDraw VPE and kernel-mode video transport
   http://www.microsoft.com/hwdev/video/

Checklist for Graphics Adapters

If a recommended feature is implemented, it must meet the requirements for that feature as defined in this document.

Consumer	Office	Mobile	Workstation	Entertainment
14.1. Graphics adapter uses PCI, AGP, or another high-speed bus				
Required for all system types				
14.2. System provides hardware-accelerated 3-D graphics				
Required	*Recommended*	*Recommended*	*Required*	*Required*
14.3. System uses WC with higher-performance processors				
Required for all system types				
14.4. Primary graphics adapter works normally with default VGA mode driver				
Required for all system types				

14.5. Adapter and driver support multiple adapters and multiple monitors
Required   Required   Recommended   Required   Required

14.6. Adapter supports television output if system does not include large-screen monitor
Recommended for all system types

14.7. Adapter meets PC 99 general device requirements
Required for all system types

14.8. Screen resolution and local memory capacity meet PC 99 minimum requirements
Required for all system types, with exceptions for mobile PCs

14.9. Adapter meets VESA specifications for ergonomic timing rates
Required for all system types, with exceptions for mobile PCs and flat panel desktop displays

14.10. All supported color depths are enumerated
Required for all system types

14.11. Graphics operations use relocatable registers only
Required for all system types

14.12. Adapter supports downloadable RAMDAC entries for integrated color management
Required for all system types

14.13. Adapter supports DDC monitor detection
Required for all system types, with exceptions for mobile PCs

14.14. Hardware supports video overlay surface with scaling
Required for systems that support TV or DVD video playback, with exceptions for mobile PCs

14.15. Hardware supports VGA destination color keying for video rectangle
Required for systems that support TV or DVD video playback

14.16. Hardware supports alpha blending of graphics and video
Required for systems that support TV or DVD video playback, with exceptions for mobile PCs and Office PCs

14.17. Video port meets PC 99 specifications if present on graphics adapter
Required

14.18. Hardware supports MPEG-2 motion compensation acceleration
Recommended

14.19. Hardware supports scanning at the same frequency as the incoming video
Recommended   Recommended   Recommended   Recommended   Required

14.20. Extended resources can be dynamically relocated after system boot
Required

14.21. VGA resources can be disabled by software
Required

14.22. Frame buffer can be accessed directly by applications
Required for all system types

14.23. Adapter and driver support linear-mapped, low-resolution modes
Required for all system types

14.24. Hardware supports transparent blter
Required for all system types

14.25. Hardware provides support to prevent tearing
Required for all system types

14.26. Hardware supports programmable blter stride
Required for all system types

14.27. Hardware supports PC 99-required RGB rasterization
Required for all system types, with exceptions for mobile PCs

14.28. Hardware supports recommended RGB rasterization features
Recommended for all system types, with exceptions for mobile PCs

14.29. Hardware supports multi-texturing
Recommended   Recommended   Recommended   Required   Required

14.30. Hardware supports texture formats
Required for all system types, with exceptions for mobile PCs

14.31. Hardware complies with texture size limitations
Required   Recommended   Recommended   Required   Required

14.32. Hardware supports destination RGB alpha blending
Recommended for all system types

14.33. Hardware supports Z comparison modes and Direct3D-compatible formats
Recommended   Recommended   Recommended   Required   Required

14.34. Hardware meets PC 99 3-D accelerator performance requirements
Recommended   Recommended   Recommended   Required   Required

14.35. Adapter supports both NTSC and PAL output
Recommended for all system types

14.36. Default boot mode supports appropriate locale
Required for all system types

14.37. Adapter supports underscan scaling
Required Recommended Recommended Recommended Required

14.38. Adapter supports flicker filter
Required for all system types, with exceptions for mobile PCs

14.39. Adapter provides proper termination
Required

14.40. Adapter supports composite video and S-Video connectors
Recommended   Recommended   Recommended   Recommended   Required

14.41. Adapter with television output supports both VGA and television output
Required for all system types

14.42. Software supports positioning
Required   Recommended   Recommended   Recommended   Required

14.43. Software supports detection of television connection
Required   Recommended   Recommended   Recommended   Required

14.44. Analog video outputs, such as NTSC, have copy protection on DVD-enabled platforms
Required for all system types

14.45. Each device has a Plug and Play device ID
Required

14.46. System supports conflict resolution, VGA compatibility, and extended registers
Required

14.47. Chips support linear packed-pixel frame buffer, relocatable above 16 MB
Required

14.48. Option ROM supports DDC2B
Required, with exceptions for Mobile PCs

14.49. BIOS setup utility provides option to force use of system-board graphics
Recommended

14.50. BIOS supports large frame buffers for graphics adapters
Required

14.51. AGP meets PC 99 implementation guidelines
Required

14.52. PCI graphics device supports IRQ and correctly populates PCI BARs
Required   Recommended   Recommended   Required   Required

14.53. PCI system-board graphics device is not hidden from Plug and Play enumeration
Required for all system types

14.54. Graphics adapter complies with device class power management reference specification
Required

14.55. Graphics adapter complies with VBE/Core 2.0 extensions for power management
Required

14.56. Device drivers and installation meet PC 99 requirements
Required

14.57. Driver does not bypass any Microsoft-provided system components
Required

14.58. Applications provided with device meet requirements for Win32-based applications
Required

14.59. Driver supports dynamic color bit-depth change
Required

C H A P T E R   1 5

Video and Broadcast Components

This chapter presents the requirements and recommendations for video playback, video input and capture devices, and technologies for broadcast-enabled computers.

For an overview of the key issues for these components, see "Video and Broadcast TV Design Issues" in Chapter 2, "PC 99 Design Issues."

Additional requirements related to video and broadcast components are defined in the following chapters:

- Requirements related to graphics adapters and television (TV) output capabilities are defined in Chapter 14, "Graphics Adapters"
- Requirements related to displays are defined in Chapter 16, "Monitors"
- Requirements related to digital cameras and other digital image input devices are defined in Chapter 22, "Digital Still Image Peripherals"

Contents

System Requirements for Video and Broadcast Components

This section summarizes the requirements for video and broadcast components. The aim of these guidelines is to help ensure that the PC adds features that compare to traditional consumer electronics TV and video devices, and that the PC also equals or exceeds the video quality available on the traditional devices. In particular, the assessment of picture quality includes image clarity, smooth resizing, and precision of frame delivery. Emphasis is placed on checking the accurate rendering of the highest motion content scenes.

Note: Some requirements in this chapter are designated as "required for all systems that support TV or DVD video playback." Because video playback is required for Entertainment PC systems, these requirements all apply for Entertainment PCs.

15.1. System meets PC 99 requirements for playback of MPEG-2 video from DVD-Video

Required for all systems that support TV or DVD video playback

Under Windows and Windows NT Workstation, operating-system playback support for MPEG-1 is provided through DirectShow. This requirement refers to built-in system support for DVD-Video playback or any other Main Profile at Main Level (MP@ML) MPEG-2 source, whether decoding is provided as a hardware decoder, a software decoder, or a combination of the two.

Related requirements are defined in "MPEG-2 Video Playback Requirements" and "DVD-Video Playback Requirements" later in this chapter.

15.2. System meets PC 99 requirements for playback of MPEG-2 video from digital TV broadcasts

Consumer	Office	Mobile	Workstation	Entertainment
Recommended	Recommended	Recommended	Recommended	Required

If a PC 99 system includes support for decoding and viewing video from digital TV broadcasts, whether provided as a hardware decoder, a software decoder, or a combination of the two, the system must deliver video quality that meets MPEG-2 playback requirements defined in "MPEG-2 Video Playback Requirements" later in this chapter.

15.3. System supports PC 99 analog video input and capture capabilities

Recommended for all system types

If video capture capability is implemented in a PC 99 system, it must meet the requirements defined in "Video Input and Capture Requirements" later in this chapter.

All video input sources and capture devices must implement driver support as defined for WDM Stream class in the Windows NT 5.0 DDK.

15.4. System includes analog TV tuner

Recommended for all system types

For an Entertainment PC system, the analog TV tuner can be implemented as a cable tuner or broadcast tuner, or ideally, as a tuner capable of both.

For information about the supporting tuner device, see "Analog TV Tuner/Decoder and VBI Capture Requirements" later in this chapter.

15.5. System includes digital satellite receiver module

Recommended for all system types

If this capability is included in a PC 99 system, the implementation must include a satellite tuner, demodulator, de-scrambler, and drivers, and possibly a smart card that meet the requirements defined in "Digital Broadcast TV Requirements" later in this chapter.

15.6. System includes digital cable receiver module

Recommended for all system types

If a digital cable receiver module is included in a PC 99 system, the implementation must include a tuner, demodulator, de-scrambler, and drivers, and possibly a smart card that meet the requirements defined in "Digital Broadcast TV Requirements" later in this chapter.

The implementation should be in accordance with the OpenCable initiative and the de facto specifications established by cable companies.

15.7. System includes ATSC DTV support

Recommended for all system types

If this capability is included in a PC 99 system, it should include a receiver module with an 8-VSB tuner/demodulator required for terrestrial ATSC digital television (DTV) reception.

Receivers must support at least the ATSC formats of 480p60 and 720p24, otherwise known as HD0. Higher ATSC formats are allowed. Specifications and technical information are available at http://www.atsc.org.

Support for ATSC DTV includes meeting hardware and software requirements for a tuner/demodulator, MPEG-2 decode capabilities, and graphics adapters as defined in "Digital Broadcast TV Requirements" later in this chapter.

15.8. System includes DVB cable, satellite, or terrestrial receiver module

Recommended for all system types

If this capability is included in a PC 99 system, it should include a cable, satellite or terrestrial tuner, demodulator, an optional smart card or Digital Video Broadcasting (DVB) Common Interface, de-scrambler, de-multiplexer, and drivers that meet the requirements defined in "Digital Broadcast TV Requirements" later in this chapter.

Specifications and technical information are available at http://www.dvb.org. Support for DVB digital TV includes meeting hardware and software requirements for a tuner/demodulator, MPEG-2 decode capabilities, and graphics adapters as defined in "Digital Broadcast TV Requirements" later in this chapter.

15.9. System includes support for multiple digital TV delivery methods

Recommended for all system types

Digital TV services will be delivered by a multitude of different methods. All PCs, particularly Entertainment PCs, should have a good modularity scheme to allow the user to decide which delivery methods are used. This capability can be provided by external connectivity using the IEEE 1394 bus or by internal connectivity using Device Bay or other mechanical form factors.

15.10. System supports DV decoding and encoding

Recommended for all system types

A digital video compression codec is necessary for displaying video from digital camcorders and for compressing video from other sources. Typically the digital camcorder will supply digital video-encoded (DV-encoded) video to DirectShow. DirectShow includes a software DV codec that can provide the necessary functionality. Although this means that hardware DV decoding is not required, hardware decoding can be used to improve performance or lessen CPU loading. Other video data compression schemes can also be used.

Basic Features for Video and Broadcast Components

This section summarizes basic features required for all video and broadcast components.

Mobile PC Note   Exceptions for mobile systems are defined in Chapter 6, "Mobile PC 99."

15.11. MPEG sources such as DVD or a receiver module support bus mastering

Required for all system types, with exceptions for mobile PCs

This requirement for bus mastering applies for the DVD drive and any receiver of broadcast MPEG streams. Bus mastering minimizes the CPU bandwidth needed to move data from an input source, such as a DVD drive or digital TV receiver module, to a host, and then finally to an MPEG decoder.

This means that each stream must have a set of logical buffers (digital broadcast satellite and DVD require a minimum of 16 buffers) composed of physical data segments, with a minimum of 16 + 1 of up to 64K for each buffer. Each logical buffer can begin or end on any byte position in physical memory. Therefore, the first and last physical data segment can be smaller than a physical memory page, but the intervening segments will be contiguous multiples of the physical-memory page size.

As defined in Chapter 18, "Storage and Related Peripherals," DVD drives and other ATA storage controllers and devices must support bus master DMA transfers.

15.12. Separate MPEG-2 hardware decoder for high-definition video does not cause PCI bus contention
Required

This requirement applies for any MPEG-2 decoder implemented in hardware, separate from the graphics adapter. Solutions that use software MPEG decoding or a combination of hardware and software decoding are equally valid if they meet the video quality requirements defined in these guidelines.

Mobile PC Note   This requirement does not apply to mobile PCs.

It is expected that a hardware MPEG-2 decoder will typically be placed on the graphics adapter, either on the graphics chip itself, on the main graphics printed circuit board, or as a plug-on daughter card. This is because of the electrical problems with feeding uncompressed digital video at high-definition rates over ribbon cable and the potential bandwidth limitations associated with feeding it over the PCI bus.

Oversubscription Issues on PCI Bus. Great care must be used in configuring uncompressed video streams that run across the PCI bus. PCI does not have any preferential access management mechanisms or other isochronous features. It is entirely possible to create a configuration where the bus is oversubscribed. Although this presents no real problem to asynchronous transfer streams, oversubscription can cause serious errors in isochronous or real-time streams, such as video.

It is not possible to create an effective solution with simple configuration or usage limits because some configurations can easily support multiple "standard definition" raw video streams. Certain other configurations with PCI boards are known to be problematic for a single NTSC capture stream, even though the board itself operates fine.

For this reason, OEMs and system integrators must take special care to ensure that the PCI video configurations they create work in all PCI loading scenarios likely to be encountered by that configuration.

It is anticipated that, in time, PCI arbitration mechanisms will improve and the PCI bus will be used less for disk traffic, both items leading to greater usable PCI bandwith being available. It is not possible to give a hard limit on acceptable PCI bandwidth usage for video streams and the responsibility for creating a reliable system rests with the system integrator. It is, however, the responsibility of IHVs to ensure that mechanisms are in place that will allow the systems integrator to properly tune the system operation.

Filter and Subsample Solutions. One possible solution is for IHVs to provide a facility to filter and subsample their streams in accordance with an empirically determined PCI bandwidth limit. IHVs could implement a settings tab control with a slider to set the available bandwidth. The slider would be, for example, 10 MB per second minimum and 132 MB per second maximum (the theoretical PCI maximum bandwidth). The default setting would be 30 MB per second, which is enough for a single uncompressed standard definition stream. Systems integrators would be able to adjust the slider to optimize performance in their particular application.

To keep scaling costs to a minimum, it is expected that most implementers will only use horizontal scaling, reducing the number of horizontal pixels. In situations where only a small amount of PCI bandwidth is found to be useable, the video will be a bit soft, but it will work without producing annoying artifacts or a bad user experience.

When a system that routes uncompressed video over the PCI bus is implemented, there must be no artifacts associated with the process of transferring video across the bus. The only exception allowable is a slight softening of the picture, provided that the process of filtering and sub-sampling has not introduced any artifacts. Particular artifacts that could be related to the process of transferring uncompressed video over the PCI bus and that must be avoided include: dropped frames, frame jitter that is either noticeable or causes genlocking to not function correctly, and black streaking related to missing pixel data.

Video Side Port Solutions. The other way of avoiding PCI congestion is to use a video side port. Video side ports that have host port or bi-directional capability, such as those that comply with *VESA Video Interface Port (VIP) Specification*, provide a useful way to attach additional functionality to the graphics chip. In addition to the obvious case of NTSC/PAL decoders, this is useful for optional functions and for functions that would not fit on the graphics chip, such as MPEG decoders and high quality de-interlacers.

Systems with multiple video sources that use the video port on the graphics adapter, including MPEG decoder, TV tuner/decoder, and capture functions on the system board or multiple Zoomed Video (ZV) ports, should offer a way to control the flow of video from multiple video sources into a single video port. Systems that use the video port on the graphics adapter must provide a method to disable the decoder output. A separate external multiplexer (MUX) meets this requirement.

For video sources that have the ability to open circuit their output buffers, there should be a method for arbitrating among multiple devices to avoid bus contentions. At system power up, all devices must come up with their output buffers disabled.

It is advised that the video side port hardware implement a straightforward method for the software to command the device to disable its output buffers. In the future, this capability might be used by the operating system to avoid bus conflicts in the case of a soft restart.

Driver support for any video port implementation must be based on DirectDraw Video Port Extensions (VPE), as defined in the DirectX 5.0 DDK. For more information, see requirement 14.17, "Video port meets PC 99 specifications if present on graphics adapter." See also the white paper on DirectDraw VPE and kernel-mode video transport at http://www.microsoft.com/hwdev/devdes/vpe.htm.

Mobile PC Note   For mobile PCs, the ZV standard is recommended for CardBus peripherals. For more information, see Chapter 12, "PC Card," and Chapter 6, "Mobile PC 99."

15.13. PCI-based sources of uncompressed standard-definition digital video support bus mastering with scatter/gather DMA
Required

In the 1999–2000 timeframe, some generators of uncompressed digital video such as NTSC/PAL/SECAM decoders and some MPEG decoders, will be implemented on PCI cards. Some of these designs will want to send uncompressed video over the PCI bus. As noted earlier, great care must be taken to ensure that the sending of raw video over the PCI bus does not cause dropped video frames and that congestion on the bus does not stop other essential PC functions from being performed The practice of mild filtering and subsampling video to reduce the bit rate before sending it is an acceptable way of avoiding bus congestion.

PCI-based hardware for video display applications must support byte-aligned, multi-segment bus master DMA transfers. Devices that are sources (or sinks) for data must be capable of transferring data to or from multiple, non-contiguous host memory buffers that are byte aligned and odd sized. The device must support such byte-aligned, odd-sized, non-contiguous buffers using host memory-based buffer transfer descriptors. Bus mastering operations must also be able to operate on non-aligned, odd-length data.

15.14. All MPEG-2 decoders can accept an MPEG-2 elementary stream

Required

DirectShow provides the selection and de-multiplexing of MPEG transport streams and program streams. Stream filtering in hardware can be used to aid this process. DirectShow feeds the appropriate video stream such as Packetized Elementary Stream (PES) to the MPEG decoder. The decoder must be able to take MPEG in that form. PES format support without reliance on any packet sequence numbering is a requirement. Nonreliance on packet sequence numbering is necessary to support applications where packet sequence numbers cannot be created, for example, when audio and video come from separate sources, such as video from disc synchronized to audio from the Internet.

15.15. All MPEG transport stream information is available to the central host processor

Required

MPEG streams can come from a number of sources, including different PCI receivers, Device Bay-based receivers, a set-top box, a set-top computer, a network such as the Internet, or a video-conferencing camera, and so on. DirectShow provides support for selecting the required MPEG streams, de-multiplexing them, and feeding them to the appropriate decoder or subsystem. Stream filtering in hardware can be used to aid this process.

Recommended: When possible, the transport stream de-multiplexing is performed by the central host processor.

In the same way that it sends the video to the video decoder, the host software (comprising DirectShow and other components) also sends the audio to the audio decoder and the data services to the appropriate place. This is fundamental to the architecture for digital TV on PCs. On a particular PC, each subsystem could be implemented in software, hardware, or a combination of the two. The operating system needs to be able to manage all the different configurations.

It is not acceptable to implement an "around the side" hardware path from the receiver to the MPEG decoder. The requirement that all digital compressed video streams are routed using the central host software will also make it easier to migrate to video-capable home network environment, where the receiver functions and display functions will typically be in completely separate boxes. It is also fundamental for features such as automatic program recording.

15.16. Background tasks do not interfere with MPEG-2 playback

Consumer	Office	Mobile	Workstation	Entertainment
Required	*Recommended*	*Recommended*	*Required*	*Required*

This requirement applies to background tasks initiated by applications included with the PC. Video performance should be such that non-foreground tasks, such as downloading a web page or using answering-machine software, should occur without disrupting video playback from either TV or DVD sources.

When the user runs an application in the foreground that requires significant system resources, such as a game or video answering machine, the system must remain stable, avoiding a bad user experience.

For Consumer PC systems, this requirement applies only to applications that are started automatically by the pre-configured OEM software, such as programs in the Windows/Start Menu/Programs/Startup folder. This guarantees that the video experience "out of the box" is as good as or better than consumer TV and other A/V components.

For Entertainment PC systems, this requirement applies to all applications included with the system.

Examples of operations that must not interfere with MPEG-2 playback include the following:

- Answering the telephone to receive voice mail or fax. This applies only to telephony software included with the PC, not third-party software installed by the user. Notice that telephone answering must not be automatically disabled during MPEG-2 playback unless explicitly configured by the user.
- Running scheduled communications tasks such as automatic connection using the modem or ISDN to transfer e-mail and faxes, download cached Internet content, and so on.

Note: Programs that make intensive use of system resources or that are designed for interactive foreground operation are excluded from this requirement. This includes games, video and audio playback, speakerphone, and disk utilities such as error checking, defragmentation, and virus protection.

15.17. Video input, capture, and broadcast device support is based on DirectX foundation class and WDM Stream class
Required

The driver for any video or tuner/decoder device must use the DirectX foundation class to control all video data. The MPEG-2 decoder must support the current DirectShow APIs and must support the WDM Stream class driver architecture. The WDM Stream class must be used to support any data streaming. For information, see the DirectX 5.0 DDK and the Windows NT 5.0 DDK. See also "Device Drivers and Installation for Video and Broadcast Components" later in this chapter.

15.18. All components meet PC 99 general device requirements
Required

This includes the basic requirements for a Plug and Play device ID, automated software-only settings for device configuration, device drivers and Windows-based installation, and icons for external connectors. For more information, see "PC 99 General Device Requirements" in Chapter 3, "PC 99 Basic Requirements."

MPEG-2 Video Playback Requirements

The requirements in this section apply for MPEG-2 decoders. All requirements apply for both software and hardware decoders or any combination of both unless otherwise noted in a specific requirement. The requirements in this section apply for devices that support playback of an MPEG-2 stream from any source, including DVD, digital TV receiver modules, hard drives, and so on.

Any PC 99 system that includes the ability to play MPEG-2 video must meet the requirements listed here to ensure quality playback of MPEG-2 data.

It is envisioned that many systems will have a single MPEG-2 decoder that does the decoding of both DVD and DTV originated sources. This statement is in no way intended to discourage the use of multiple "universal" decoders in the system, each capable of decoding both DVD and DTV.

For decoder driver requirements, see "Device Drivers and Installation for Video and Broadcast Components" later in this chapter. For related MPEG-2 audio playback guidelines, see requirement 17.15, "CD, DVD, and broadcast audio playback meet PC 99 requirements."

Mobile PC Note   Exceptions for mobile systems are defined in Chapter 6, "Mobile PC 99."

15.19. MPEG-2 MP@ML playback meets PC 99 requirements
Required for all systems that support TV or DVD video playback, with exceptions for mobile PCs

All MPEG-2 decoder implementations, whether implemented as hardware, software, or a combination of both, must be capable of the following:

- **15.19.1 MPEG-2 MP@ML playback, with smooth motion portrayal.** Playback requirements include full-frame rate decode of MPEG-2 MP@ML input streams, up to and including the following frame sizes and rates:

  720×480 at 60 fields per second 720×480 at 24 frames per second

  720×576 at 50 fields per second 720×576 at 25 frames per second

Decoded frame rate is measured at the graphics frame buffer. The actual rate at which video is displayed (or rendered) is defined in requirement 15.21, "MPEG-2 video decode implementations meet PC 99 quality requirements."

The use of the term "smooth" includes ensuring that the frames are delivered with equal time between them. It is not sufficient to just produce the correct number of frames per second; they also need to be rendered at the correct times to produce smooth motion portrayal.

- **15.19.2 Rates for decoding and displaying data.** This requires MPEG-2 data rates with a peak rate of 15 Mb/s for Entertainment PC systems and a peak rate of 9.8 Mb/s for all other PC 99 system types. This applies to both hardware and software MPEG decoding implementations.

15.20. MPEG-2 playback for ATSC, DVB, or other digital TV systems meets PC 99 requirements

Consumer	Office	Mobile	Workstation	Entertainment
Recommended	*Recommended*	*Recommended*	*Recommended*	*Required*

All digital TV MPEG-2 video decoder implementations, whether implemented as hardware, software, or a combination of both, must support at least the ATSC formats of 480p60 and 720p24, otherwise known as HD0. Higher ATSC formats are allowed.

The formats required for an ATSC DTV receiver are contained in Table 3 of *ATSC Digital Television Standard* (A/53), available at http://www.atsc.org. A DVB receiver can be specified as either a SDTV or HDTV device at either 25 Hz or 30 Hz. The video formats required for each device are defined in ETR 154, available for DVB members at http://www.dvb.org. The viewing experience when decoding these formats must meet or exceed that obtainable on consumer digital TVs.

Because of the uncertainty surrounding the ATSC Table 3 formats, it is advised that MPEG decoders allow for 720 horizontal pixels for the 480 vertical lines formats in addition to the 704 horizontal pixels specified in Table 3.

An ATSC DTV receiver is not required to decode and display all video formats in native resolution. The MPEG-2 decoder and graphics adapter can process the video to convert the video to a higher or lower resolution to match the capabilities of the graphics adapter and display subsystem.

15.21. MPEG-2 video decode implementations meet PC 99 quality requirements

Required for all systems that support TV or DVD video playback, with exceptions for mobile PCs

The following are required for MPEG decoder implementations, whether they are just MP@ML MPEG decoders or full digital-TV MPEG decoders.

- **15.21.1 Smooth frame delivery.** Video frames must be displayed within one-half frame of the intended display time. All the video fields and frames from the MPEG source should be decoded: all 60 fields per second from a 480i source and all 60 frames per second from a 480p60 source.

  This requirement is satisfied for implementations in which video frames are completely rendered into a DirectDraw surface and flipped using the DirectDraw Flip API or a hardware autoflip within one-half frame of the intended display time.

  No frame dropping or repeating is allowed except for the dropping or repeating of a single frame for synchronization purposes, which must not occur more than once per minute for a stable source. When changing sources, frame dropping can occur more often for the first three minutes after the new source is present. This exception allows long-time constant phase-locked loops to acquire the new timing.

- **15.21.2 Synchronized audio and video.** Audio and video must be synchronized to within one and a half video frames. This synchronization must not be allowed to drift out over time.

- **15.21.3 No tearing.** This requires proper video buffering, such as double or triple buffering.

- **15.21.4 Correct display of multiple aspect ratio content.** The material must, by default, be displayed according to the aspect ratio information in the MPEG header. The option for the user to change the aspect ratio—stretch, shrink, or crop—can be provided.

- **15.21.5 Output of all remaining frames at the end of the data sequence.** This requirement ensures output of all remaining frames when the decoder receives one of the following:

  - A sequence_end_code message, which differs from an Ipin::EndOfStream() function call

  - A time discontinuity

- **15.21.6 Splicing MPEG.** Decoders must properly interpret the Closed_Gop flag by dropping B frames before the first I frame after either a data discontinuity is received or the Broken_Link flag is set.

See the related video and MPEG-2 support requirements for graphics adapters, such as YUV (4:2:0 and 4:2:2) off-screen overlay surface and up/down interpolated scaling, as defined in "Hardware Acceleration for Video Playback" in Chapter 14, "Graphics Adapters."

15.22. De-interlacing of standard-definition video meets PC 99 requirements
Required for all systems that support TV or DVD video playback
Standard-definition video is defined as 480i60(30) or 576i50(25), otherwise known as 525i/60 and 625i/50 if the blanking interval is included. These standard-definition signals must be properly de-interlaced to produce the required progressive output for mixing with graphics and sending to the PC monitor.

Because the PC monitor is typically capable of displaying high resolution, it is important to extract as much resolution as possible from the standard-definition interlaced signals. The minimum requirement is to use the weave method, which is typically used for film-originated material, and the bob method, which is typically used for video-originated material. Combined vertical spatial and temporal interpolation using at least two input fields is highly recommended for Entertainment PC systems.

Good quality de-interlacing is also required for video delivered by analog means. It is expected that most PCs will implement a single high-quality de-interlacer and will allocate it to either analog or digital sources.

15.23. MPEG-2 decoder supports the pull-down algorithm
Recommended
An MPEG-2 software or hardware decoder should be able to detect and behave accordingly when 3:2 pull down (or any other algorithm) is being used to display 24-fps video. The kernel-mode video transport component in DirectDraw 5.0 requires this information from the decoder in order to know when a particular redundant field algorithm is being used so it knows which fields to skip.

For more information, see the DirectX 5.0 DDK.

DVD-Video Playback Requirements

In addition to the requirements in the previous section, the following requirements apply for systems that provide DVD-Video playback software and hardware. The goal for DVD and other audio/video (A/V) playback is to ensure that the end-user experience is the same or better than with a stand-alone DVD player.

Mobile PC Note   Exceptions for mobile systems are defined in Chapter 6, "Mobile PC 99."

15.24. DVD decoder driver correctly handles media types, time discontinuity, and decode-rate adjustment
Required
Vendor-supplied minidrivers for DVD, MPEG-2, and AC-3 decoders must:

- Use the correct media types, including validation of all format block fields on connection and on every IPin::QueryAccept message.

- Query for IMediaSample2 on every received media sample to test for a time discontinuity bit.

  It is also acceptable to query on every video/audio frame to reduce CPU overhead.

- Adjust the decode rate in response to IPin::NewSegment() calls for video and subpicture.

For details about APIs, see the DirectShow documentation in the Microsoft Platform SDK.

15.25. DVD decoder supports subpicture compositing and closed captioning
Required for all system types, with exceptions for mobile PCs
The system must be capable of displaying subpicture data as well as providing closed-captioning support for all such data stored on the disc. This requires YUV offscreen overlay surface support as defined in requirement 14.14, "Hardware supports video overlay surface with scaling."

Subpicture streams must be supported as defined in *DVD Specification, Version 1.0,* from Toshiba Corporation.

Note: Alpha blending, or a driver-implemented simulation implemented in the driver, is required for static menus.

15.26. Subpicture decoder correctly handles subpicture properties and other functions
Required for all system types, with exceptions for mobile PCs
The minidriver for the subpicture decoder must be able to:

- Set the subpicture properties
- Turn the subpicture compositing on and off
- Set the highlight rect parameters

For more information, see the Microsoft DirectX 5.1 SDK and the DirectX 5.0 information in the Windows NT 5.0 DDK.

15.27. System supports seamless DVD-Video 1.0 navigation
Required
This requirement includes menu navigation, video selection, and language and subpicture track selection in support of the user's ability to navigate DVD-Video discs. Test sources must include, but are not limited to, the following:

- Matsushita Electronics Incorporated (MEI) test disc
- Joe Kane Productions Video Essentials disc

For any system capable of playing back a DVD-Video title, DVD playback must use the latest released version of the Microsoft DirectShow Navigator/Splitter filter. In particular, it must use the most recent versions of:

- IDvdGraphBuilder
- Microsoft DirectShow DVD Navigator
- Microsoft DirectShow Overlay Mixer

The requirement to use the DirectShow Navigator/Splitter filter is not intended to preclude the use of differentiating product features and enhancements.

15.28. All DVD video decoders must support Line21 closed-caption data
Required

All DVD video decoders must support Line21 closed-captioned data output compatible for use with the DirectShow Microsoft Line21 decoder filter. In addition to ensuring closed-captioned output for the hearing impaired, it enables applications that use the Line21 channel on DVD as a data channel for non-Line21 data.

15.29. System provides a licensed CSS copyright protection scheme
Required

The system must provide a licensed content scramble system (CSS) implementation and support for CSS-encoded DVD-Video discs to ensure proper protection for content produced in accordance with CSS, including regionalization and analog video protection/analog protection system (APS).

Playback of regionalized movies must be handled in accordance with the CSS requirements and the interfaces as defined in the Mt. Fuji 2.0 specification for Phase II regionalization (RPC II). Version 2.0 of the Mt. Fuji specification will be proposed to the Small Forms Factor committee as SFF 8090 Version 2.0 Revision 1.0. Implementations for PC 99 systems should conform to this specification if it is approved in the 1999–2000 time frame.

For more information about copyright protection requirements, see requirement 18.31, "DVD device supports copyright protection." For information about CSS or to obtain a CSS license, contact MEI at http://www.mei.co.jp/, or contact the CSS licensing entity when it is established.

Video Input and Capture Requirements

This section summarizes requirements based on capabilities that support video capture in the Windows 98 and Windows NT 5.0 operating systems. If analog video capture is implemented, the requirements in this section must be met.

For requirements related to digital cameras and other digital image input devices, see Chapter 22, "Digital Still Image Peripherals."

15.30. Analog video decoder such as NTSC/PAL/SECAM meets PC 99 quality requirements

Required

If an analog video decoder is implemented in a PC 99 system, it must meet this requirement.

The analog video decoder must provide proper separation of the luminance and chrominance portions of the signal by employing a 2-D line comb filter or equivalent design.

Video decoders such as those for NTSC or PAL must be capable of decoding full-resolution composite signals at 720 samples per line with 8-bit luminance and chrominance sampling. Support for decoding to YUV 4:2:2 data format is required, while support for decoding to the other video formats of YUV 4:2:0 or YUV 4:1:1 can also be provided as an alternative.

Recommended: Luminance and chrominance separation should be done by employing a 2-D line comb filter or other equivalent design. Future versions of this guide are likely to require the use of a 2-D line comb filter or an equivalent design.

15.31. Analog video capture device outputs video data at 3.7 MB/sec, minimum

Required

Recommended: Video capture devices support hardware or software compression for enhanced functionality.

Systems with capture devices must be capable of capturing 3.7 MB per second to disk.

15.32. Video input or capture device provides raw sampled VBI data

Required

The raw vertical blanking interval (VBI) data must be decoded in software to provide enhancement data, web pages, and information about elements such as video formats and time code.

15.33. Digital video camera uses external bus support

Required

Digital video cameras must provide connectivity using physical wire and driver support to new external buses with isochronous capabilities, particularly USB and IEEE 1394 for high frame-rate devices.

For video conferencing cameras intended for the upgrade market in the 1999–2000 timeframe, it is acceptable to use a direct connection to a purpose-built PCI card using a proprietary interface. This implementation is not preferred and is unlikely to be acceptable in future versions of this guide.

Mobile PC Note   On mobile PCs, it is acceptable to use Zoomed Video or CardBus solutions.

15.34. Video input image orientation identification meets PC 99 requirements

Required

RGB pixel formats must be described with a BITMAPINFOHEADER that has a negative biHeight value to indicate that the vertical orientation of the image is top-down, but using the sign of biHeight to indicate orientation is only valid for RGB (uncompressed) formats. The exception is that WDM minidrivers for capture devices are required to only advertise positive biHeight for RGB.

For other compression types described with a FOURCC code in the biCompression field, the FOURCC code uniquely identifies the compression and orientation. It is not valid to describe the orientation with the sign of biHeight.

Common YUV formats such as UYVY, YV12, and YUY2 are top-down oriented. It is invalid to store an image with these compression types in bottom-up orientation. The sign of biHeight for such formats must always be set positive by drivers producing such formats, and the sign must be ignored by any driver receiving such formats. For proprietary compression formats with an associated FOURCC, any orientation is acceptable, but must always be the same for all bitmaps of that FOURCC.

Analog TV Tuner/Decoder and VBI Capture Requirements

This section defines requirements for analog TV tuner/decoder capabilities and VBI data capture capabilities in support of the Windows Broadcast Architecture. This architecture is designed to enable a wide range of data broadcasting services, including the use of decoded data captured from broadcast TV signals during the VBI, as well as from video scan lines. All analog TV decoders must include VBI capture capabilities.

For more information about the Windows Broadcast Architecture and capabilities supported by Windows operating systems, see the Windows NT 5.0 DDK and the white papers available from http://www.microsoft.com/dtv/.

Some requirements in this section specify support related to National Association of Broadcast Transmission Standards (NABTS) data or other locale-specific formats. Devices designed for locales that support other standards do not have to meet these requirements. However, some requirements specify NABTS as an example data format; in these cases, the device must meet the requirements for relevant locale standards.

15.35. Analog TV tuner/decoder supports PC 99 audio and video performance

Required

The audio and video performance capabilities required for a TV tuner/decoder are similar to the MP@ML MPEG quality requirements defined in "MPEG-2 Playback Requirements" earlier in this chapter, including the following:

- Data is delivered at full field rate with smooth delivery and no duplicated or dropped fields
- Audio and video playback is synchronized to within one and a half video frames
- Video output quality includes proper de-interlacing as defined in requirement 15.22, "De-interlacing of standard-definition video meets PC 99 requirements"
- No tearing
- Multiple aspect ratio content is displayed correctly

15.36. Analog TV tuner/decoder includes stereo audio decoder and supports SAP

Recommended for all system types

It is expected that the market will strongly favor stereo implementations. This recommendation includes support for a secondary audio programming (SAP) channel.

For devices designed for use in Europe and South Africa, the device should support Near-Instantaneously Companded Audio Multiplex (NICAM 728) as the standard for digital multichannel sound transmission.

15.37. VBI capture oversamples VBI data at least four times

Required

To ensure accurate data reception, data transmitted on all lines of the VBI must be oversampled at least four times the NABTS data bit rate (or locale-specific data bit rate). For example, if there are 288 bits of NABTS data on a scan line, approximately 1,152 one-byte samples, plus the necessary margin, must be captured per scan line. This represents the number required for timing tolerances in the NABTS specification and also for timing uncertainties within the capture hardware.

15.38. VBI capture makes VBI data available to the CPU for processing

Required

Raw data samples from VBI lines must go into host memory for access by the CPU. This data is used to read data encoded into broadcast transmissions, such as closed captioning, V-chip information, NABTS, and Teletext.

Digital Broadcast TV Requirements

The requirements in this section apply for any type of system that implements a digital broadcast subsystem, whether receiving satellite, cable, or terrestrial broadcasts. Such capabilities are recommended, but not required, for all system types. These capabilities are especially recommended for Entertainment PC systems.

It is expected in the 1999–2000 timeframe that receiver modules will be implemented in the following form factors: Device Bay modules, PCI modules, external modules or set-top boxes using the IEEE 1394 bus, and solutions such as set-top computers. A receiver module that is limited to low bit-rate transmissions, less than 5 Mb/s, could be implemented using USB. Device Bay is a good solution for receivers requiring conditional access systems, but conditional access systems can also be implemented with any of the other receiver types.

Digital broadcast and satellite support as defined under these guidelines includes all the requirements for hardware decoder capabilities and driver support as defined in this chapter, plus support for the DirectX foundation class, as defined in the Windows NT 5.0 DDK.

15.39. Digital broadcast module can receive all streams contained in the particular transport stream

Required

This can be a receiver for cable, satellite, or terrestrial digital TV broadcasts. The receiver module must provide data tuning, demodulation, conditional access, and other network-specific functions.

The receiver module must be able to receive both normal broadcast network-related information, such as MPEG video, audio, and program guide information, as well as data-stream information.

The receiver card must provide a way to allow the host to obtain PCR and other transport stream fields, such as the discontinuity indicator bit, when the card is performing PES packet building. In this mode, the relevant information must be made available by the driver to the host. In addition, the receiver card must provide a mode in which the host can obtain full MPEG-2 transport or program stream headers, and data for selected elementary streams.

15.40. Digital broadcast module can receive full bandwidth from each frequency

Required

The receiver module must be able to receive all information transmitted on any tuner or transponder frequency. If de-multiplexing is performed on the receiver module, the stream selection and routing must be controlled by software running on the host processor.

15.41. Digital broadcast module can receive a minimum of 16 simultaneous elementary streams

Required

The receiver module must be able to simultaneously receive on the same carrier frequency and send to the host either a transport stream or the complete set of elementary streams and accompanying data. Any receiver doing transport stream splitting—a receiver that provides a proprietary conditional access scheme—must support a minimum of sixteen elementary streams being sent to the host. The streams can be of any type, such as sixteen simultaneous data streams. These streams, identified by unique service channel IDs (SCIDs) or program IDs (PIDs), are subdivisions of bandwidth on a single tuner frequency.

The receiver module must provide a means for the host processor to control the de-multiplexing of the transport stream (containing the multiple data streams) or pass the complete transport stream to the host processor for software de-multiplexing. The fundamental criterion is that the resulting MPEG elementary streams are routed by the software running on the host processor.

Recommended: More than 24 simultaneous elementary streams.

15.42. System can simultaneously receive two or more broadcast frequencies
Recommended
The ability to tune to multiple frequencies results in better concurrent data and video operation. With two tuners/decoders, the viewer could watch a video on one frequency and download web pages on the other. This also enables picture-in-picture or multiple data streams on different channels or transponders.

Two or more physically separate tuner/decoder modules can be used for this, but a better solution is to have a single receiver module capable of receiving multiple channels. This allows the possibility of using one conditional access smart card for multiple channels.

15.43. Digital broadcast module provides support for conditional access
Recommended
Receiver modules should support conditional access mechanisms for any subscriptions, pay-per-view events, and other network-specific access-control mechanisms available on the broadcast services for which they are designed.

In many cases, this is a removable smart card that has been paired with code and run on a secure processor on the card. Device Bay provides a convenient way of incorporating a smart card slot, but it is not the only way.

For the separate yet related issue of copy protection, the link from the receiver to the host must be a secure link. It must conform to whatever copy protection scheme is mandated in connection with the terms for the conditional access.

15.44. Digital broadcast module provides signal quality and other diagnostic information
Required
The receiver module must be able to self-test and provide diagnostic information such as signal strength, cable short-circuit events, and the status of any input fuse or circuit breaker.

Recommended: Error rate information should also be provided. Because these modules are connected to public networks, these capabilities are essential to the carriers who need to diagnose problems in the system.

It should be possible to easily replace a faulty module. Device Bay provides a convenient way of achieving this without having to open the PC's enclosure, but it is not the only way to meet the requirement.

Systems should provide a simple method of aligning satellite dishes and terrestrial antennae. This might include some combination of signal strength, signal-to-noise ratio, and uncorrected Forward Error Correction (FEC) errors.

15.45. Digital broadcast receiver module supports general-purpose data cryptography
Recommended

The digital broadcast receiver module should be able to provide both symmetric and asymmetric encryption. If the receiver decrypts the broadcast data, it should re-encrypt for communication with other devices. Whatever conditional-access encryption is used should be supported. The asymmetric encryption, such as RSA public Key, or Elliptic Curve public Key, for the exchange of control information and data keys plus a high-speed symmetric encryption should be used for data transmission, such as data encryption standard (DES) or Blowfish block cipher. Hardware anti-tampering countermeasures should be implemented.

This capability is separate from, and completely independent of, other digital broadcast capabilities.

All private keys should be stored in protected RAM and ROM—stored within the device so that they cannot be easily read using physical means. The manufacturer also should sign the public keys, and the digital signature should be stored within the decryption hardware. Furthermore, there should be a capability for revocation. That is, when a key is known to be broken, that information will be broadcast; devices should be able to recognize whether it is connected to a device with a certification that has been revoked.

The cryptography device need not be directly on the receiver module; it can be a high-speed smart card or PCI device on the system board if it meets the functional specifications.

15.46. Digital broadcast receiver module supports stream filtering
Recommended

The digital broadcast receiver module should be able to filter out unneeded data streams in order to reduce bus activity and CPU usage. Streams allow data broadcasters to dynamically subdivide their broadcast bandwidth among many data streams of differing size.

15.47. ATSC DTV tuner/demodulator is fully implemented

Required

If an ATSC DTV tuner/demodulator is implemented, it must meet the requirements for packetized data transport structure, and modulation and transmission systems as specified in *ATSC Digital Television Standard* (A/53), available at http://www.atsc.org.

15.48. Stream splitting is supported using DirectShow filters

Recommended

This function should be provided using DirectShow. Stream splitting is done on the host CPU using DirectShow filters in the same manner as support is implemented for DVD video input data streams.

PC 99 Design for Video and Broadcast Components

This section summarizes requirements related to the design initiatives defined in Part 1 of this guide.

Plug and Play and Bus Design for Video and Broadcast Components

The items in this section summarize requirements for Plug and Play and other resource-related and bus-related capabilities.

15.49. Each hardware device has a Plug and Play device ID

Required

Each device must have a Plug and Play device ID as required for the bus it uses, as defined in Part 3 of this guide.

For video and broadcast hardware, a device can be implemented as a single function device or as part of a multifunction device. In the case of a multifunction device, all memory and register resources for this functionality must be distinct and separate from any other functions.

15.50. Dynamic resource configuration is supported for all devices

Required

The operating system must be capable of automatically assigning, disabling, and relocating the resources used by a device when necessary, using the method required for the related bus class. All configuration settings must be capable of being made through software, with no system reboot required.

When the end user changes a device or adds it to the system, setting resource assignments must not require changing jumpers or switches on either the adapter or the system board. In the event of an irreconcilable conflict with other devices on the system, the operating system must be capable of disabling the device to prevent the system from stalling. A disabled device must not claim any resources while disabled.

Video side port bus settings are an exception to this requirement. These settings might require jumpers to be moved for some sophisticated configurations.

15.51. Dependent video device is not independently enumerated
Required

If a video device is implemented as a dependent device on a multifunction adapter, it must not be independently enumerated. Instead, its parent must be responsible for installing and loading its driver and for updating the registry on its behalf. See also requirement 3.21, "Multifunction add-on devices meet PC 99 device requirements for each device."

Device Drivers and Installation for Video and Broadcast Components

This section summarizes the requirements for video and broadcast components.

15.52. Device drivers and installation meet PC 99 requirements
Required

The manufacturer does not need to supply a driver for a device if the device passes compliance testing for PC 99 using a driver provided with the operating system. If the manufacturer supplies a driver, it must comply with requirement 3.16, "Device driver and installation meet PC 99 requirements." The basic requirements include driver support for unattended installation and Help file support if special driver parameters are used.

All video components must use a WDM minidriver instead of a Video for Windows (VfW) driver. For information about WDM driver support, see the Windows NT 5.0 DDK. See also the related articles on WDM support at http://www.microsoft.com/hwdev/wdm/.

Drivers for hardware decoders and for the audio and video subsystems must be implemented as described in the Windows NT 5.0 DDK in order to support DirectShow, DirectDraw 5.0 VPE, and WDM.

15.53. Software drivers are installed during hardware driver installation
Required

Any additional required device-dependent software such as software codecs or NDIS transports must be installed during the device driver installation routine and must be included in the device INF file.

15.54. Applications provided with device meet Win32 requirements

Required

Video and image editing applications bundled with the device must support
DirectShow.

Any Windows-based applications provided with the device must meet software
compatibility requirements as defined by the Microsoft Platform SDK. Applications
installed with the device must use a standard Windows-based installation method as
defined in the Microsoft Platform SDK.

15.55. NDIS 5.0 miniport driver provided for digital broadcast receiver

Required

IP data carried in a transport stream, either encapsulated in the MPEG-2 private
section format or PES, must be available through the system IP stack using an
NDIS 5.0 miniport driver. Drivers for each device must be supplied by the device
vendor or network provider.

For information about NDIS 5.0 driver support, see the Windows NT 5.0 DDK.

Video and Broadcast Component References

The following represents some of the references, services, and tools available to
help build hardware that is optimized to work with Windows operating systems.

Advanced Television Systems Committee (ATSC) standards
    National Association of Broadcasters, (800) 368-5644
    Society of Motion Picture and Television Engineers, (914) 761-1100
    E-mail: mktg@smpte.org
    http://www.atsc.org

ANSI/SMPTE 12M
SMPTE Recommended Practice (RP) 136 and time-code standards
    Society of Motion Picture and Television Engineers
    http://www.smpte.org/stds/stsubj.html

DTV and broadcast architecture white papers
    http://www.microsoft.com/dtv/

DVD Specification, Version 1.0, Toshiba Corporation.
    http://www.toshiba.com

EIA Standard #ANSI/EIA-516-1988: "Joint EIA/CVCC Recommended Practice
    for Teletext: North American Basic Teletext Specification (NABTS)"
    Electronic Industries Association
    http://www.eia.org

IEC Publication 461
    http://www.iec.ch

Matsushita Electronics Incorporated (MEI) test disc
   http://www.mei.co.jp

Microsoft DirectDraw VPE and kernel-mode video transport white papers
   http://www.microsoft.com/hwdev/devdes/vpe.htm

Microsoft DirectShow
   http://www.microsoft.com/directx/pavilion/dshow/

Microsoft Windows 98 DDK, Windows NT 5.0 DDK, and
      DirectX 5.0 DDK and SDK
   MSDN Professional membership

PC Card Standard Guidelines, Volume 10 (PC Card standards)
   http://www.pc-card.com

SFF 8090 (Mt. Fuji specification) and other SFF specifications
   FaxAccess: (408) 741-1600 (fax-back)
   Fax: (408) 867-2115
   ftp://fission.dt.wdc.com/pub/standards/SFF/specs/

VESA Video Interface Port (VIP) Specification
   http://www.vesa.org/ve00013.html

Video Essentials test disc from Joe Kane Productions, Inc.
   http://www.videoessentials.com

WDM driver support white papers
   http://www.microsoft.com/hwdev/wdm/

White papers and guidelines for Microsoft operating systems
   http://www.microsoft.com/hwdev/bpc/

Checklist for Video and Broadcast Components

If a recommended feature is implemented, it must meet the requirements for that feature as defined in this document.

Consumer	Office	Mobile	Workstation	Entertainment

15.1. System meets PC 99 requirements for playback of MPEG-2 video from DVD-Video
Required for all systems that support TV or DVD video playback

15.2. System meets PC 99 requirements for playback of MPEG-2 video from digital TV broadcasts

Recommended	*Recommended*	*Recommended*	*Recommended*	*Required*

15.3. System supports PC 99 analog video input and capture capabilities
Recommended for all system types

15.4. System includes analog TV tuner
Recommended for all system types

15.5. System includes digital satellite receiver module
Recommended for all system types

15.6. System includes digital cable receiver module
Recommended for all system types

15.7. System includes ATSC DTV support
Recommended for all system types

15.8. System includes DVB cable, satellite, or terrestrial receiver module
Recommended for all system types

15.9. System includes support for multiple digital TV delivery methods
Recommended for all system types

15.10. System supports DV decoding and encoding
Recommended for all system types

15.11. MPEG sources such as DVD or a receiver module support bus mastering
Required for all system types, with exceptions for mobile PCs

15.12. Separate MPEG-2 hardware decoder for high-definition video does not cause PCI bus contention
Required

15.13. PCI-based sources of uncompressed standard-definition digital video support bus mastering with scatter/gather DMA
Required

15.14. All MPEG-2 decoders can accept an MPEG-2 elementary stream
Required

15.15. All MPEG transport stream information is available to the central host processor
Required

15.16. Background tasks do not interfere with MPEG-2 playback
Required   Recommended   Recommended   Required   Required

15.17. Video input, capture, and broadcast device support is based on DirectX foundation class and WDM Stream class
Required

15.18. All components meet PC 99 general device requirements
Required

15.19. MPEG-2 MP@ML playback meets PC 99 requirements
Required for all systems that support TV or DVD video playback, with exceptions for mobile PCs

15.20. MPEG-2 playback for ATSC, DVB, or other digital TV systems meets PC 99 requirements
Recommended   Recommended   Recommended   Recommended   Required

15.21. MPEG-2 video decode implementations meet PC 99 quality requirements
Required for all systems that support TV or DVD video playback, with exceptions for mobile PCs

15.22. De-interlacing of standard-definition video meets PC 99 requirements
Required for all systems that support TV or DVD video playback

15.23. MPEG-2 decoder supports the pull-down algorithm
Recommended

15.24. DVD decoder driver correctly handles media types, time discontinuity, and decode-rate adjustment
Required

15.25. DVD decoder supports subpicture compositing and closed captioning
Required for all system types, with exceptions for mobile PCs

15.26. Subpicture decoder correctly handles subpicture properties and other functions
Required for all system types, with exceptions for mobile PCs

15.27. System supports seamless DVD-Video 1.0 navigation
Required

15.28. All DVD video decoders must support Line21 closed-caption data
Required

15.29. System provides a licensed CSS copyright protection scheme
Required

15.30. Analog video decoder such as NTSC/PAL/SECAM meets PC 99 quality requirements
Required

15.31. Analog video capture device outputs video data at 3.7 MB/sec, minimum
Required

15.32. Video input or capture device provides raw sampled VBI data
Required

15.33. Digital video camera uses external bus support
Required

15.34. Video input image orientation identification meets PC 99 requirements
Required

15.35. Analog TV tuner/decoder supports PC 99 audio and video performance
Required

15.36. Analog TV tuner/decoder includes stereo audio decoder and supports SAP
Recommended for all system types

15.37. VBI capture oversamples VBI data at least four times
Required

15.38. VBI capture makes VBI data available to the CPU for processing
Required

15.39. Digital broadcast module can receive all streams contained in the particular transport stream
Required

15.40. Digital broadcast module can receive full bandwidth from each frequency
Required

15.41. Digital broadcast module can receive a minimum of 16 simultaneous elementary streams
Required

15.42. System can simultaneously receive two or more broadcast frequencies
Recommended

15.43. Digital broadcast module provides support for conditional access
Recommended

15.44. Digital broadcast module provides signal quality and other diagnostic information
Required

15.45. Digital broadcast receiver module supports general-purpose data cryptography
Recommended

15.46. Digital broadcast receiver module supports stream filtering
Recommended

15.47. ATSC DTV tuner/demodulator is fully implemented
Required

15.48. Stream splitting is supported using DirectShow filters
Recommended

15.49. Each hardware device has a Plug and Play device ID
Required

15.50. Dynamic resource configuration is supported for all devices
Required

15.51. Dependent video device is not independently enumerated
Required

15.52. Device drivers and installation meet PC 99 requirements
Required

15.53. Software drivers are installed during hardware driver installation
Required

15.54. Applications provided with device meet Win32 requirements
Required

15.55. NDIS 5.0 miniport driver provided for digital broadcast receiver
Required

C H A P T E R   1 6

Monitors

This chapter presents the requirements and recommendations for display monitors.

Requirements for graphics adapters and television output capabilities are defined in Chapter 14, "Graphics Adapters."

Mobile PC Note   For issues related to liquid crystal displays (LCDs) for mobile systems, see Chapter 6, "Mobile PC 99."

Contents

Monitor Basic Features

This section summarizes the basic design requirements for desktop, Mobile PC, and Entertainment PC monitors.

Note: Dot-pitch requirements are not specified in these guidelines because dot pitch depends on resolution and size. Also, design features other than dot pitch contribute to usability for PC applications, such as focus and phosphor. Monitors should be designed to provide a sharp and clear image across the full range of resolutions they are intended to support.

16.1. Color monitor is DDC2B-compliant with unique EDID identifier
Required

A monitor designed for or included with a PC 99 system must be compliant with *Display Data Channel Standard, Version 3.0,* Level 2B protocols (DDC2B), which defines the communications channel between the display and host system.

The monitor also must transmit an Extended Display Identification Data (EDID) structure containing unique ID Manufacturer Name and ID Product Code identifiers, plus all required fields, as defined in Section 3 of *Extended Display Identification Data Standard, Version 3.0* or later.

Mobile PC Note   Mobile computers do not need to support DDC between the graphics adapter and the display if both are in the same enclosure.

16.2. Monitor supports Integrated Color Management
Required

Windows 95/98 and Windows NT Workstation operating systems support using color profiles that comply with the International Color Consortium (ICC) Profile Format specification. The Integrated Color Management (ICM) APIs and functionality for Windows and Windows NT are described in the Microsoft Platform SDK and the Windows NT 5.0 DDK.

Mobile PC Note   Color-capable devices such as desktop CRT monitors, LCDs on mobile systems, color plasma and other flat-panel devices, printers, scanners, or still-image cameras are required to install one or more ICC profiles for ICC color management. A monitor color-calibration utility is recommended for generating, editing, and installing ICC profiles. The standard RGB (sRGB) profile will be distributed in Windows and Windows NT.

16.3. Monitor meets all PC 99 general device and driver requirements

Required

This includes the basic requirements for Plug and Play device IDs, automated software-only settings for device configuration, device drivers and Windows-based installation, and icons for external connectors. For more information, see "PC 99 General Device Requirements" in Chapter 3, "PC 99 Basic Requirements."

The manufacturer does not need to supply a driver if a PC 99-compliant driver provided with the operating system can be used. If the manufacturer supplies a driver, it must comply with requirement 3.16, "Device driver and installation meet PC 99 requirements." The requirements include driver support for unattended installation and Help file support if special driver parameters are used.

Note: Monitor support for Windows is installed using a monitor INF file, as defined in the Windows 95 DDK and Windows NT 5.0 DDK.

16.4. CRT-based monitor supports a mechanism for control from host software

Recommended

The control of brightness, contrast, screen offset, and so on, should be controllable from host software. This can be accomplished using USB or, when implemented, the proposed VESA DDC/CI standard.

Other controls, such as picture offset, are important since the system will need to switch between desktop refresh rates, such as 75 Hz, and video refresh rates, such as 60 Hz, to optimize video playback. Software control is also important in remote control applications such as IR/RF remote.

Desktop Monitor Requirements

This section lists the hardware requirements and features for desktop monitors.

16.5. Monitor meets minimum graphics resolution, based on monitor size

Required

With the following higher resolutions, a larger desktop area can be displayed, more applications can be shown on the display at once, individual windows can be larger, applications can be fully displayed side by side, and so on.

- 14-inch to 15-inch external monitor or built-in mobile PC display = 800 × 600, non-interlaced

- 17-inch external monitor or 13-inch to 15-inch LCD = 1024 × 768, non-interlaced

- 19-inch and larger monitors or LCDs larger than 15 inches = 1280 × 1024, non-interlaced

Note: These specific monitor sizes are not listed as recommended or required; they merely show the required resolution for a given size. Wide-format monitors and flat panel displays intended for entertainment applications must met the requirements contained in "Entertainment Monitor Requirements" later in this chapter.

16.6. CRT-based monitor supports ergonomic timing standards
Required
Recommended: 85 Hz

The monitor must, at a minimum, support the timings documented in *VESA and Industry Standards and Guidelines for Computer Display Monitor Timing Version 1.0, Revision 0.7* or later, for all resolutions supported by the monitor, as based on monitor size, as cited earlier in this section. The standards ensure a clear, flicker-free display for traditional PC computing.

It is also a requirement that monitors are able to operate with the 59.94 variant of the 60-Hz VESA timing. All references to 60-Hz timing in this chapter should be taken to also indicate the 59.94 variant.

16.7. CRT-based monitor synchronizes to a new format in a timely fashion
Recommended
When the scanning rate into the monitor is changed from one of its valid rates to another valid rate, it should resynchronize to the new format and produce a stable picture within three seconds from the graphics adapter becoming stable.

This capability is important because it will sometimes be necessary to change from a high refresh-rate graphics mode to a 60-Hz (or 59.94 variant) mode in order to optimize video playback.

It is preferred that the monitor be designed to minimize the noise emitted as it transitions between rates as this can be alarming to some users.

Entertainment Monitor Requirements

The Entertainment PC system requires a picture tube ideal for both PC graphics and television/movie video. This section defines the requirements for large-screen entertainment monitors.

Although an entertainment monitor is only a recommendation for Entertainment PC systems, a large-screen monitor that is sold with an Entertainment PC system must meet the requirements defined in this section.

16.8. Large-screen monitor is 20 inches (viewable diagonal) or larger if included with an Entertainment PC system

Required

Recommended: Monitor size of about 32 inches, measured on the diagonal.

16.9. Entertainment CRT-based monitor supports 800 × 600 at 60 Hz refresh rate

Required

Recommended refresh rate: 60 Hz (and 59.94 variant) for North America. Various rates are appropriate for Europe, such as 50, 60, or 75 Hz, depending on the video processing capabilities of the host PC.

It is acceptable to use 60 Hz (or the 59.94 variant) in North America because these types of monitor are intended to be viewed from at least a 6-foot distance, thus avoiding excessive flicker. Keeping the rate the same as the native video source will result in the best video quality because of the judder problems associated with using linear video processing to change refresh rates.

A display format of 800 × 600 at 60 Hz progressive (or the wide-screen equivalent) requires a refresh rate of about 38 kHz. This rate is commonly available in CRT-based large-screen TV-style monitors. A display format of 1024 × 768 at 60 Hz progressive (or the wide-screen equivalent) is preferable, but requires a scan rate of around 47 kHz. With the advent of good scaling on graphics adapters and program-enhancing additional data services, good use can be made of the higher resolution if it is available.

This requirement does not mean to imply the entertainment monitor needs to use CRT technology. The use of flat-panel alternatives is encouraged as soon as technology allows. The resolution and size, but not timing, requirements are the same as for CRT devices.

16.10. Entertainment monitor operates at the lower scan rates used by the operating system

Required

During system boot and in the event of an error, Windows 98 and Windows NT use lower resolution scanning formats such as 640 × 480, 640 × 400, and "text mode 3." The monitor must be able to display these important screens. It can be confirmed that a monitor compiles with this requirement by booting a PC and ensuring that the monitor is able to sync to all the screens displayed during the boot sequence.

This requirement applies to all monitor types, not just entertainment monitors, but is stated here because there is a potential problem on some large entertainment monitors.

16.11. Entertainment monitor's host control has digitally controlled geometry

Recommended

The host control of the monitor should be implemented using the same methods described in requirement 16.4, "CRT-based monitor supports a mechanism for control from host software."

Geometry control is necessary for adjustment of PC television images and includes the following controls: skew, pin cushion, size, brightness, contrast, and position. If implemented, geometry control must be provided through a software application rather than through dials on the monitor case. Controls must be revealed through a driver with a remote-controllable user interface.

Plug and Play Design for Monitors

The items in this section summarize requirements for Plug and Play.

16.12. External monitor meets DDC2B and EDID standards

Required

This requirement is based on DDC2B, which defines the communications channel between the display and host system, and on EDID Version 3.0, which defines data formats for configuration information. This requirement includes the identification string and other EDID data that the monitor sends to the system.

Use the established standard or (if necessary) detailed timings to indicate the maximum resolution that the monitor will support. Using either the established or the standard timings will result in greater flexibility when using detailed timing descriptor blocks.

The following items are particularly critical:

- EDID content must indicate the complete range of the monitor's capabilities.

  Do not use the EDID to indicate only the preset modes that the monitor supports. Take advantage of the established and standard timings to include as much information about the monitor's capabilities as possible.

- At least one piece of information must indicate the maximum resolution plus maximum timing at that resolution supported by the monitor. If this is not implemented using the established or standards timings, then a detailed timing can be used.

To enhance the Plug and Play functionality of monitors, the following monitor descriptor definitions are strongly recommended, as defined in the VESA EDID standard:

- **FD (monitor range).** This information is essential for enabling the operating system to calculate the optimal refresh rate for any selected resolution.

- **FC (monitor name).** Up to three detailed timing blocks can be used to incorporate the company and model name. These descriptors will be concatenated for a single string, and the blocks must be used in the order in which they are to be concatenated.

- **FF (monitor serial number).** If provided, this information will be placed into the registry for easy access by asset-management software.

Power Management for Monitors

This section summarizes the specific power management requirements for monitors.

16.13. Monitor complies with device class power management reference specification

Required

The *Display Device Class Power Management Reference Specification, Version 1.0* or later, provides definitions of the OnNow device power states (D0–D3) for graphics adapters and monitors. The specification also covers device functionality expected in each power state and the possible wake-up event definitions for the class, if any. CRT monitors must support the D0, D2, and D3 power states. The D1 power state is optional for monitors.

Mobile PC Note   Flat panel displays for mobile and desktop applications can implement just two states: on or off.

Monitors References

The following represents some of the references, services, and tools available to help build hardware that is optimized to work with Windows operating systems.

Display Data Channel Standard, Version 3.0, Level 2B protocols
Extended Display Identification Data (EDID) Standard, Version 3.0
VESA and Industry Standards and Guidelines for Computer Display
  Monitor Timing, Version 1.0, Revision 0.6
 Video Electronics Standards Association (VESA)
 Phone: (408) 435-0333
 Fax: (408) 435-8225
 http://www.vesa.org

Display Device Class Power Management Reference Specification, Version 1.0
 http://www.microsoft.com/hwdev/onnow.htm

International Color Consortium ICC Profile Format specification
 http://www.color.org

Microsoft Windows 95 DDK, Windows NT 5.0 DDK, DirectX DDK,
 and Microsoft Platform SDK
 MSDN Professional membership

Universal Serial Bus Monitor Control Class Specification, Version 1.0
 http://www.usb.org

Checklist for Monitors

If a recommended feature is implemented, it must meet the requirements for that feature as defined in this document.

16.1. Color monitor is DDC2B-compliant with unique EDID identifier
Required

16.2. Monitor supports Integrated Color Management
Required

16.3. Monitor meets all PC 99 general device and driver requirements
Required

16.4. CRT-based monitor supports a mechanism for control from host software
Recommended

16.5. Monitor meets minimum graphics resolution, based on monitor size
Required

16.6. CRT-based monitor supports ergonomic timing standards
Required

16.7. CRT-based monitor synchronizes to a new format in a timely fashion
Recommended

16.8. Large-screen monitor is 20 inches (viewable diagonal) or larger if included with an Entertainment PC system
Required

16.9. Entertainment CRT-based monitor supports 800 × 600 at 60 Hz refresh rate
Required

16.10. Entertainment monitor operates at the lower scan rates used by the operating system
Required

16.11. Entertainment monitor's host control has digitally controlled geometry
Recommended

16.12. External monitor meets DDC2B and EDID standards
Required

16.13. Monitor complies with device class power management reference specification
Required

C H A P T E R   1 7

Audio Components

This chapter presents the requirements and recommendations for audio devices.

For an overview of the design issues related to the audio requirements, see "Audio Design Issues" in Chapter 2, "PC 99 Design Initiatives."

Contents

Basic Audio Requirements

This section defines basic hardware feature requirements for audio components. These are system-based requirements, targeted for the entire PC solution as it ships, regardless of whether the audio components are separate add-on devices or are built into the system, for example, on the system board or the display monitor.

System Requirements for Audio

This section summarizes the system requirements for audio.

17.1. PC system includes PC 99 audio capabilities

Consumer	Office	Mobile	Workstation	Entertainment
Recommended	Recommended	Recommended	Recommended	Required

Although audio is a standard feature in most PC market segments, it is understood that certain SOHO and Office PC designs that focus heavily on cost will not require audio. For PCs that include audio, the requirements defined in this chapter must be met.

17.2. Audio device does not connect to ISA bus

Required for all system types

In 1999, the transition of audio away from ISA will be complete. Some of the reasons that ISA is not acceptable include the high overhead of transferring audio samples, the excessive requirements of resources such as IRQs, direct memory access (DMA), and I/O, plus limited power management capabilities.

17.3. Audio device does not use legacy hardware interfaces for MS-DOS–based applications

Required for all system types

If the audio device supports MS-DOS–based applications, it must use operating system-provided or operating system-compatible software emulation of legacy interfaces when the application is running. Legacy hardware does not meet PC 99 requirements if the legacy technique allows MS-DOS–based applications to communicate directly with ISA IRQ, DMA, or I/O hardware resources, such as PC/PCI or DDMA.

When running MS-DOS–based applications in a virtual MS-DOS box, the level of legacy compatibility provided by Windows 98 software emulation is comparable to hardware. Support for legacy hardware techniques in real mode MS-DOS, Windows 3.1, or Windows 95 is acceptable, as long as it does not interfere with Windows 98 operation.

Device support for direct access to legacy audio hardware prevents Windows 98 from simultaneously supporting multiple audio clients, breaks digital-ready USB audio, introduces potential resource conflicts, and degrades overall system performance. Because a typical legacy interface requires two DMA channels, two IRQ selections, and more than four I/O register sets, it is likely that conflicts with other hardware will occur or that current selected resources cannot accommodate a particular MS-DOS–based application.

Software emulation avoids legacy hardware problems because it uses "virtual" resources. This avoids conflicts with other hardware and the PCI device trying to allocate ISA resources that depend on core-logic chip sets and BIOS.

To make PCs easier to use, legacy hardware interfaces must not impact the Windows experience. Most users do not want to manipulate legacy resources. For those that do, Windows 98 offers MS-DOS mode, where the user has complete personal control and responsibility for the machine's hardware configuration, with no assistance from the operating system.

Audio Performance and Feature Requirements

This section summarizes the requirements for audio on PC 99 systems.

Several companies joined together to develop *Personal Computer Audio Quality Measurement* (PCAQM), a standard testing procedure for defining and measuring audio performance. Contributors to PCAQM include Audio Precision, Compaq Computer Corporation, Crystal Semiconductor, Intel Corporation, and Microsoft Corporation. PCAQM definitions and test methods are available from the web site at http://www.cirrus.com/products/papers/meas/meas.html.

17.4. Audio performance meets PC 99 requirements

Required, with exceptions for mobile PCs

The following table summarizes audio performance requirements for all audio-enabled PC 99 systems, with the exceptions noted for mobile audio. These requirements establish a minimum performance level for PCs, comparable to low-end consumer audio equipment. System designers are encouraged to exceed these minimum requirements, especially for Consumer PCs. Designers of integrated systems that include speakers are encouraged to ensure the availability of line out, USB ports, or both as attach points for speaker upgrades.

Mobile PC Note   Most specifications and tests isolate half-duplex play or record performance. Additional attention should be paid to full-duplex systems with an embedded microphone and speakers, such as mobile PCs and multimedia monitors, where acoustic coupling can significantly degrade microphone performance.

For precise definitions of the terminology used in the following table, please refer to the PCAQM test methodology paper cited earlier in this section.

PC 99 Audio Minimum Performance Requirements

Feature	Requirement	Value
Full-scale input voltage	FSIP (A-D-PC) line input	≥2.0 Vrms
	FSIP (A-D-PC) microphone input	≥100 mVrms
Full-scale output voltage	FSOP (PC-D-A) line output	≥1.0 Vrms[1]
Analog pass-through (A-A)	Line input to line output Frequency response (-3 dB) Dynamic range (SNR) THD+N (-3 dB FS)	 20 Hz to 20.0 kHz[4] ≥80 dB FS A[4] ≤–65 dB FS[4]
	Microphone input to line output Frequency response (-3 dB) Dynamic range (SNR) THD+N (-3 dB FS)	 100 Hz to 12.0 kHz ≥70 dB FS A[4] ≤–60 dB FS[4]
	Line input to speaker output with 8-ohm load[2] Frequency response (-3 dB) Dynamic range (SNR) THD+N (-3 dB FS)	 20 Hz to 20.0 kHz[4] ≥70 dB FS A[4] ≤–55 dB FS[4]
Digital playback (PC-D-A) for line output	Frequency response (-3 dB) 44.1 kHz source material 48.0 kHz source material	 20 Hz to 17.6 kHz[4] 20 Hz to 19.2 kHz[4]
	Dynamic range (SNR)	≥80 dB FS A[3,4]
	THD+N (-3 dB FS)	≤–65 dB FS[4]
Digital recording (A-D-PC) for line input	Frequency response 44.1 kHz destination 48.0 kHz destination	 20 Hz to 17.6 kHz[4] 20 Hz to 19.2 kHz[4]
	Dynamic range (SNR)	≥70 dB FS A[4]
	THD+N (-3 dB FS)	≤–60 dB FS[4]
Digital recording (A-D-PC) for microphone input	Frequency response (-3 dB) 22.05 kHz destination	 100 Hz to 8.8 kHz
	Dynamic range (SNR)	≥70 dB FS A[4]
	THD+N (-3 dB FS)	≤–60 dB FS[4]
Line output cross-talk	Channel separation between left and right line out channels (measured at 10 kHz)	≥60 dB[4]
Sampling frequency accuracy	Playback	0.1%
	Record	0.1%

[1] For mobile PCs with 3.3 V audio subsystems, the required Full Scale Output Voltage for line output is ≥0.7 Vrms.

[2] Line input to speaker output is a requirement only if a line output is not supported.

[3] Decibels relative to full scale (FS), measured using "A weighting" filters.

[4] For mobile PCs: The dynamic range requirements are relaxed by 10 dB FS A.
The THD+N requirements are relaxed by 10 dB FS.
The required frequency response is 20 Hz to 15 kHz, measured using 3 dB corners.
The cross-talk requirements are relaxed by 10 dB FS.

17.5. Audio subsystem supports basic data formats in full duplex
Required

The audio system must be capable of operating in half-duplex or full-duplex modes with both the input and output streams using 16-bit resolution at 8, 11.025, 16, 22.05, 32, 44.1, and 48 kHz.

- **17.5.1 Output.** The following is required:
  - The built-in or external audio codec hardware must support 16-bit stereo at 44.1 and 48 kHz at minimum.
  - For support of other sample rates (8, 11.025, 16, 22.05, 32 kHz, and so on) and formats (mono, 8-bit, and so on), it is acceptable to use the Sample Rate Conversion (SRC) and mixer services provided by Windows 98 and Windows NT Workstation 5.0.

- **17.5.2 Input.** The following is required:
  - The built-in or external audio codec hardware must support 16-bit stereo at 44.1 and 48 kHz at a minimum.
  - For support of other sample rates (8, 11.025, 16, 22.05, 32 kHz, and so on) and formats (mono, 8-bit, and so on), it is acceptable to use the SRC and format conversion services provided by Windows 98 and Windows NT 5.0.

Note: These audio hardware requirements support full bandwidth CD-quality audio (16-bit stereo at 44.1 and 48 kHz). The continued use of 8-bit data for games and multimedia content is discouraged. Higher SNR-per-bit alternatives, such as Adaptive Differential Pulse Code Modulation (ADPCM) or Intel Indeo® audio software, are available at low system overhead.

17.6. Audio subsystem supports full-duplex operation at independent sampling rates
Required

Speech recognition and audio/video conferencing require the audio system to simultaneously play back and record. Incoming and outgoing audio should be capable of operating at independent sampling rates. This requirement considers the entire system, including the possibility of USB speakers or microphones.

17.7. Analog microphone input meets PC 99 jack and circuit specifications
Required

This requirement provides a more detailed specification for the analog characteristics of the microphone input jack. This specification improves compatibility for applications such as speech recognition, speakerphone telephony, or conferencing.

The specification enables users with electret or dynamic microphones to connect the device to their PC and achieve consistent results. These requirements also maintain compatibility with the installed base of microphones. For information about optional close speaking headset microphones, see requirement 17.11, "Microphone meets performance recommendations for PC 99 speech-recognition microphones."

If the PC has an analog microphone input, it must meet the following specifications:

- Three-conductor 1/8-inch (3.5 mm) tip/ring/sleeve microphone jack with bias on the ring to support both three-conductor electret microphones or tip and ring shorted together for two-conductor dynamic microphones. In either case, the sleeve connects to ground.

- Minimum AC input impedance between tip and ground: 10 kOhm.

- Input voltages of 10–100 mV deliver full-scale digital input, using software-programmable $\geq$20 dB gain for low output microphones.

- Maximum 5.5 V with no load, minimum 2.0 V with 0.8 mA load, DC bias for electret microphones.

- Minimum bias impedance between bias voltage source and ring: 2 kOhm.

- AC coupled tip.

It is recommended that the PC analog microphone input also meet the following specifications:

- Input voltage of mV delivers full-scale digital input, using software programmable $\geq$30 dB gain for low output microphones.

- AC-coupled tip to implement analog (external to ADC) 3 dB rolloffs at 60 Hz and 15 kHz.

Note: These specifications are designed to ensure that when capturing a 100 mV signal from the microphone input at 22.050 or 44.1 kHz, the audio system delivers a digitized $\geq$8.8 kHz bandwidth input signal with $\geq$70 dB FS A weighted dynamic range (SNR) and $\leq$-60 dB FS unweighted THD+N. See also 17.4, "Audio performance meets PC 99 requirements."

17.8. Audio driver reports sample position for stream synchronization
Required

The driver must be capable of reporting within 1 ms the current position of the buffer being rendered, in relation to the samples given to the codec. This requirement applies for both compressed and uncompressed data.

For information about WDM device driver support for streaming capabilities, see the Windows NT 5.0 DDK. See also the related articles available on the web at http://www.microsoft.com/hwdev/desinit/csa1.htm.

17.9. Audio connectors use icons with color coding
Required

To reduce user confusion, the external connections must use a consistent set of symbols and color coding, preferably based on the standard artwork defined in Appendix A, "Icons," and the recommended color coding defined in requirement 3.18, "Connections use icons, plus keyed or shrouded connectors, with color coding."

Advanced Audio Recommendations

This section outlines the future direction of PC audio. It offers a view of the market requirements to come for PC audio, describing a number of directions that the industry is taking.

17.10. Audio subsystem provides sufficient externally accessible inputs and outputs
Recommended

At a minimum, the audio system should have the following analog audio connections:

- Monaural microphone input, stereo line input, or both
- Stereo line-level output, headphone output, or both

USB and IEEE 1394 ports provide the ability to connect high-quality digital audio input and output devices.

17.11. Microphone meets performance recommendations for PC 99 speech-recognition microphones
Recommended

Most PCs include a far-speaking microphone, either standalone or embedded. However, for optimal performance of speech-recognition applications, the best results are achieved with a close-speaking headset microphone as defined by these recommendations.

These guidelines represent a group consensus of the optimal characteristics for close speaking headset electret microphone used for speech recognition. They should enable developers of speech-recognition software to provide the OEM or retail customer with a list of devices designed to work optimally with a PC 99-compliant microphone input jack.

These guidelines are compatible with most of the installed base of sound cards and audio-enabled system boards. For more information about the microphone jack requirements, see requirement 17.7, "Analog microphone input meets PC 99 jack and circuit specifications."

The recommended guidelines for a PC 99 speech-recognition microphone are:

- Close speaking headset design (within four inches of the speaker's mouth)
- Full scale output voltage: 100 mV (0 dB FS)
- Three-conductor 1/8-inch (3.5 mm) tip/ring/sleeve plug with either of the following:
  - Tip carrying the audio signal and ring receiving the bias voltage, or
  - Tip and ring internally shorted together to carry the audio signal and bias voltage

  In either case, the sleeve connects to the ground.
- Operating bias voltage from 2.0–5.0 Volts Direct Current (VDC) with a maximum current drain of 0.8 mA
- Capable of sustaining a maximum voltage of 10 VDC on tip or ring without damage

It is also recommended that a PC 99 speech-recognition microphone meet the following specifications:

- Frequency response:
  - ±5 dB from 100 Hz to 10 kHz
  - ±3 dB from 300 Hz to 5 kHz
  - 0 dB at 1 kHz
- Minimum sensitivity of –44 dB relative to 1V/Pa
- THD+N less than –34 dB FS

- Noise cancellation (signal on axis versus signal at 180 degree off axis) with the following minimums:

19 dB at 250 Hz	4 dB at 2000 Hz
14 dB at 500 Hz	0 dB at 3500 Hz
9 dB at 1000 Hz	

- Maximum wind noise sensitivity of –65 dB with 0 dB = 1 V (measured with wind speed of 1m/s at the microphone element)

- Maximum output impedance of 1 kOhm (using a 1 kHz full-scale test tone with 2.0 VDC bias)

17.12. Audio subsystem provides hardware or software support for DLS
Recommended

Support for Downloadable Sounds specification (DLS), as defined by the MIDI Manufacturers Association, is recommended. For more information, see *DLS Specification, Version 1.0* or later, at http://www.midi.org.

17.13. Audio subsystem supports AEC reference inputs
Recommended

Full-duplex internal or external audio codecs that introduce additional digital or analog audio sources into the final mix are recommended to support simultaneous capture of microphone and acoustic echo cancellation (AEC) reference inputs. One analog-to-digital converter (ADC) is used to capture the microphone input and another ADC is used to capture a monophonic representation of the final output mix, which includes all digital and analog sources.

It is possible to use a single stereo ADC to capture the two monaural streams. The AEC reference should be time-synchronized and available at the same sample rate as the microphone input.

For more information, see Section 6.2 of *Audio Codec '97 Component Specification* from Intel Corporation, which describes one possible implementation. This specification is available on the web at http://developer.intel.com/pc-supp/platform/ac97/.

17.14. Audio subsystem provides hardware filtering of 3-D localization filters
Optional

For those solutions that provide hardware acceleration of 3-D filters, the designer can choose to incorporate eight separate audio sources.

17.15. CD, DVD, and broadcast audio playback meet PC 99 requirements

Required with systems that support video playback

These capabilities are specified to ensure quality playback of MPEG-2 audio from any source, including DVD, digital broadcast or satellite systems, hard drives, and so on. The goal for DVD and other audio/video playback is to ensure that the end-user experience is the same or better than from a stand-alone DVD player.

For those PCs that support software or hardware decoding and playback of DVD-Video or MPEG-2 video, it is required that the audio decoder must be capable of supporting one or both of the following formats, depending upon the local requirements for DVD audio:

- AC-3 (Dolby Digital) less than or equal to 5.1 channels, at 48 kHz less than or equal to 448 Kbps
- MPEG-2 multichannel less than or equal to 5.1 channels, at 48 kHz less than or equal to 912 Kbps
- MPEG-1 Layer 2 stereo, at 44.1 and 48 kHz less than or equal to 448 Kbps
- LPCM less than or equal to 8 channels, 16-bit, 20-bit, and 24-bit at 48 or 96 kHz less than or equal to 6.144 Mb/s

Note: Conversion to 44.1-kHz or 48-kHz 16-bit stereo is acceptable when the content exceeds the available resolution, sampling rates, or number of output channels.

17.16. Audio subsystem provides consistent volume levels for different devices

Optional

In cases where each audio channel is set to the same position on the Windows mixer panel, it is suggested that each channel provide a comparable volume level. Users should not need to have radically different settings on the control panel to balance the relative volume of each audio channel.

17.17. Audio subsystem does not provide a DB-15 analog joystick/MIDI port

Recommended

USB offers substantial benefits in connecting joysticks and MIDI adapters. Support for the DB15 analog game port and legacy peripherals such as polled analog joysticks adds cost, impacts ease of use, and degrades overall system performance.

PC 99 Design for Audio

This section summarizes requirements related to the PC 99 design initiatives as defined in Part 1 of this guide.

Plug and Play for Audio

The items in this section are requirements for all audio components.

17.18. Each hardware device has a unique Plug and Play device ID

Required

Each bus-specific device must have a Plug and Play device ID for the bus it uses, as defined in Part 3 of this guide. For example, a PCI device must comply with PCI 2.1 requirements and also provide a Subsystem ID and Subsystem Vendor ID as defined in Chapter 9, "PCI." A USB device must provide a unique ID as defined in the *Universal Serial Bus Specification, Version 1.0* or later.

Note: Each separate device or function enumerated by the BIOS on an audio adapter must have a separate Plug and Play device ID and resource configuration. If a game port or CD-drive interface is supplied, resources must be allocated in addition to those required for the audio device. Such devices must also have independent dynamic disable capabilities. For information about requirements for multifunction cards, see requirement 3.21, "Multifunction add-on devices meet PC 99 device requirements for each device."

17.19. Dynamic resource configuration is supported for all devices

Required

The system must be capable of automatically assigning, disabling, and relocating the resources used by this device when necessary, using the method required for the related bus class. All configuration settings must be capable of being made through software, with no system reboot required.

When the end user changes this device or adds it to the system, setting resource assignments must not require changing jumpers or switches on either the adapter or the system board. In the event of an irreconcilable conflict with other devices on the system, the system must be able to disable the device in order to prevent the system from stalling. The device must not claim any resources while disabled.

Bus Design for Audio

This section defines the requirements for bus-specific design for PC 99 audio.

Requirements for PCI Audio Devices

For audio devices that connect to the PCI bus, the following requirements apply.

17.20. PCI device conforms to PCI 2.1 and additional PC 99 requirements
Required

If the device uses PCI, it must meet the requirements defined in Chapter 9, "PCI," including requirements for complying with PCI 2.1, providing a Subsystem ID and Subsystem Vendor ID, and complying with the Maximum Completion Time ECN.

17.21. PCI device supports initiator, target, and block transfer
Required

For complete implementation details, see PCI 2.1.

Full-duplex audio sample transport must be supported using separate PCI bus mastering hardware for playback and capture sample streams.

It is desirable for sample transport mastering hardware to support burst capabilities in order to read or write multiple samples within the same PCI bus transaction. This will lessen the impact of sample transport on other agents in the system, which will have a positive effect on the system's responsiveness.

17.22. PCI device supports non-DWORD-aligned audio buffers
Required

To achieve optimal efficiency and latency when transferring audio data, the hardware must move pulse code modulation (PCM) format audio buffers directly between memory and the audio device without introducing buffer copies to re-align the data. Although the recommended programming practice is to use DWORD-aligned, DWORD-multiple length buffers, it is not possible to guarantee that all audio buffers will conform. Depending on the data format, the following cases can occur:

- The first sample of the audio buffer might not start on a DWORD boundary
- The last sample of the audio buffer might not end on a DWORD boundary

It is recommended that all PCI audio devices support buffers with arbitrary byte alignments and lengths. If a PCI device does not support arbitrary byte alignment and length, it must support buffer alignments and lengths that correspond to the smallest supported sample size it accepts. The following present examples.

- A device supports 8-bit monaural audio. This data could appear in memory on byte boundaries. The transfer length could be an integer number of bytes. To meet the PC 99 requirements, this device must correctly play audio data that is aligned on a byte boundary and has a length that is an integer number of bytes. It must not play non-audio data that either precedes or follows the audio data, nor can its device driver copy the audio data to a second buffer with an alignment or length of larger granularity and then play the second buffer through the device.

- A device supports only 16-bit audio formats. To meet the PC 99 requirements, this device must correctly play audio data that is aligned on a 16-bit boundary and has a length that is an integer number of 16-bit words. It must not play non-audio data that either precedes or follows the audio data, nor can its device driver copy the audio data to a second buffer with an alignment or length of larger granularity and then play the second buffer through the device.

Note: For maximum efficiency, Microsoft recommends that audio buffers allocated by DirectX clients, WDM kernel services clients, and WDM minidrivers be DWORD aligned and DWORD multiples in length whenever possible.

17.23. PCI device does not use ISA-based resources
Required
Whether Windows-based or MS-DOS–based applications are running, the PCI device must not allocate or use ISA IRQs, DMAs, or hard-coded I/O locations. The BIOS and Windows driver must not contain any options to select the use of ISA resources for the audio device.

If a device supports real-mode operation, the only acceptable manner for acquiring ISA resources is to use a real-mode configuration utility.

17.24. PCI device is digital ready
Required
To transfer digital audio to USB or IEEE 1394 devices, all digital audio data created in the PC must be available to the operating system for mixing and streaming. All PCI audio devices must be able to route the final mix of all digital audio data created or processed on-chip to the host using bus master transfers.

For example, a PCI audio device provides HRTF 3-D filtering and wave-table synthesis. After mixing all of the separate 3-D sources and wave-table channels down to a single stereo stream, the device transfers the data to host memory.

PC 99 requires, at a minimum, that a stereo mix be available to the host for redirection. If the device supports more than two output channels, for example, four or six, it is recommended that all output channels be accessible to the host.

Requirements for USB Audio Devices

For audio devices that connect to a USB port, the following requirements apply.

17.25. Audio meets USB specification and USB audio device class specification

Required

The device must comply with *Universal Serial Bus Specification, Version. 1.0* or later, and with *USB Device Class Definition for Audio Devices, Version 0.9* or later. This ensures that all Plug and Play requirements are met and that drivers provided with the operating system support this device.

17.26. USB audio device uses MMHID for control of basic functions

Required

If the USB audio device implements a volume or pan control, it must use the Multimedia Human Interface Device (MMHID) protocol to communicate these changes to and from the host.

Requirements for IEEE 1394 Audio Devices

This section defined requirements for audio devices that connect using IEEE 1394.

17.27. Audio meets PC 99 requirements for IEEE 1394

Required

IEEE 1394 audio peripherals must meet the requirements defined in Chapter 8, "IEEE 1394."

Power Management for Audio

This section summarizes the power management requirements for audio components.

17.28. System and device comply with PCI bus power management specification

Required

PCI-based audio controllers and add-on devices must comply with the *PCI Bus Power Management Specification, Revision 1.0* or later (PCI PM). Audio devices implemented on the system board must comply fully with the ACPI 1.0 specification.

17.29. Audio device complies with device class power management reference specification

Required

Audio devices must comply with *Audio Device Class Power Management Reference Specification, Version 1.0* or later, which provides definitions of the OnNow device power states (D0–D3) for these devices. The specification also covers the device functionality expected in each power state and the possible wake-up event definitions for the class. The device and driver are required to implement support for power states D0, D2, and D3. Other power states are optional.

Device Drivers and Installation for Audio

This section summarizes requirements for audio device drivers.

17.30. Device drivers and installation meet PC 99 requirements

Required

The manufacturer does not need to supply a driver if a PC 99-compliant driver provided with the operating system can be used. If the manufacturer supplies a driver, it must comply with requirement 3.16, "Device driver and installation meet PC 99 requirements." The basic requirements include driver support for unattended installation and Help file support if special driver parameters are used.

17.31. Audio meets PC 99 requirements for WDM driver support

Required

All audio devices must have drivers that use the WDM architecture exclusively. Audio devices must not use VxDs. The manufacturer can either supply a WDM driver with the audio device or rely on a WDM driver provided with Windows and Windows NT. For information, see the Windows NT 5.0 DDK.

17.32. Applications provided with device meet Win32 requirements

Required

Any Windows-based applications provided with the device must meet software compatibility requirements as defined in the Microsoft Platform SDK.

Audio References

The following represents some of the references, services, and tools available to help build hardware that is optimized to work with Windows operating systems.

Advanced Configuration and Power Interface Specification, Revision 1.0
   http://www.teleport.com/~acpi/

Audio '98 Roadmap
Audio Codec '97 Component Specification
Audio Codec '97 Design Guide papers
   http://developer.intel.com/pc-supp/platform/ac97/

Audio design for Windows operating systems white papers
    http://www.microsoft.com/hwdev/audio/

Audio Device Class Power Management Reference Specification, Version 1.0
    http://www.microsoft.com/hwdev/onnow.htm

DLS Specification, Version 1.0 or later
Downloadable Sounds (DLS) specification
    MIDI Manufacturers Association
    Fax: (714) 736-9775
    E-mail: mma@midi.org
    http://www.midi.org/abtdls.htm

Microsoft Windows 98 DDK, Windows NT 5.0 DDK (with DirectX 5.0 DDK),
    and Microsoft Platform SDK
    MSDN Professional membership

PCI Local Bus Specification, Revision 2.2 (PCI 2.2)
PCI Bus Power Management Specification, Revision 1.0 (PCI PM)
    http://www.pcisig.com

Personal Computer Audio Quality Measurement Definitions
        by Dr. Steven Harris and Cliff Sanchez, Crystal Semiconductor
    http://www.cirrus.com/products/papers/meas/meas.html

Plug and Play specifications
    http://www.microsoft.com/hwdev/respec/pnpspecs.htm

Universal Serial Bus Specification, Version 1.0
USB Device Class Definition for Audio Devices, Version 0.9
    http://www.usb.org

WDM device driver support white papers
    http://www.microsoft.com/hwdev/wdm/

Checklist for Audio Components

If a recommended feature is implemented, it must meet the requirements for that
feature as defined in this document.

Consumer	Office	Mobile	Workstation	Entertainment
17.1. PC system includes PC 99 audio capabilities				
Recommended	Recommended	Recommended	Recommended	Required
17.2. Audio device does not connect to ISA bus				
Required for all system types				
17.3. Audio device does not use legacy hardware interfaces for MS-DOS–based applications				
Required for all system types				
17.4. Audio performance meets PC 99 requirements				
Required, with exceptions for mobile PCs				

17.5. Audio subsystem supports basic data formats in full duplex
Required

17.6. Audio subsystem supports full-duplex operation at independent sampling rates
Required

17.7. Analog microphone input meets PC 99 jack and circuit specifications
Required

17.8. Audio driver reports sample position for stream synchronization
Required

17.9. Audio connectors use icons with color coding
Required

17.10. Audio subsystem provides sufficient externally accessible inputs and outputs
Recommended

17.11. Microphone meets performance recommendations for PC 99 speech-recognition microphones
Recommended

17.12. Audio subsystem provides hardware or software support for DLS
Recommended

17.13. Audio subsystem supports AEC reference inputs
Recommended

17.14. Audio subsystem provides hardware filtering of 3-D localization filters
Optional

17.15. CD, DVD, and broadcast audio playback meet PC 99 requirements
Required with systems that support video playback

17.16. Audio subsystem provides consistent volume levels for different devices
Optional

17.17. Audio subsystem does not provide a DB-15 analog joystick/MIDI port
Recommended

17.18. Each hardware device has a unique Plug and Play device ID
Required

17.19. Dynamic resource configuration is supported for all devices
Required

17.20. PCI device conforms to PCI 2.1 and additional PC 99 requirements
Required

17.21. PCI device supports initiator, target, and block transfer
Required

17.22. PCI device supports non-DWORD-aligned audio buffers
Required

17.23. PCI device does not use ISA-based resources
Required

17.24. PCI device is digital ready
Required

17.25. Audio meets USB specification and USB audio device class specification
Required

17.26. USB audio device uses MMHID for control of basic functions
Required

17.27. Audio meets PC 99 requirements for IEEE 1394
Required

17.28. System and device comply with PCI bus power management specification
Required

17.29. Audio device complies with device class power management reference specification
Required

17.30. Device drivers and installation meet PC 99 requirements
Required

17.31. Audio meets PC 99 requirements for WDM driver support
Required

17.32. Applications provided with device meet Win32 requirements
Required

C H A P T E R   1 8

Storage and Related Peripherals

This section presents the requirements for storage and related peripherals, including DVD devices. Specific requirements for SCSI, ATA, and ATAPI peripherals are defined in the related chapters in Part 3 of this guide.

For specific information about implementation details related to storage devices under the Windows 98 and Windows NT Workstation operating systems, see the articles at http://www.microsoft.com/hwdev/storage/.

Contents

Storage Controller and Peripherals Basic Features

This section summarizes the hardware requirements for storage peripherals. For related acoustical requirements for storage devices, see requirement 3.7, "Audible noise meets PC 99 requirements."

18.1. Storage controller and hard disk devices support bus master capabilities
Required

The host controller and hard disk devices must support bus mastering, and bus mastering must be enabled by default. When correctly implemented, bus master support ensures improved 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 *ATA/ATAPI-4 Revision 17* or later standard and also in Small Form Factor (SFF) 8038i.

Note: This requirement does not apply to legacy floppy disk controllers (FDCs) and will not become a requirement for legacy FDCs.

18.2. Removable media devices support media status notification
Required

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

Device type	Media status notification implementation
CD and DVD devices	Required. Comply with *ANSI NCITS T10 Multi-Media Command Set-2 (MMC-2)* standard for Media Status Event Notification.
ATAPI floppy/optical direct access drives	Required. Comply with either MMC-2 standard or SFF 8070i Version 1.1.
IEEE 1394 storage devices	Required. Comply with *NCITS Reduced Block Commands* (RBC; T10/97-260r0) standard.
ATA and non-ATAPI storage devices	Required. Comply with *Media Status Notification Support, Version 1.03*.
Other ATA/ATAPI devices, including tape drives	Recommended. If implemented, comply with *Media Status Notification Support Specification, Version 1.03,* or SFF 8070i.
Other types of SCSI removable devices	Recommended. If implemented, support based on *NCITS Reduced Block Commands* standard is recommended.

18.3. Device meets PC 99 general device requirements
Required

These include the requirements for Plug and Play device IDs, automated software-only settings for device configuration, device drivers and Windows-based installation, and icons for external connectors. For more information, see "PC 99 General Device Requirements" in Chapter 3, "PC 99 Basic Requirements."

18.4. Device meets PC 99 requirements for ports or buses
Required

The device must meet all requirements for the port or bus to which it is attached. A drive that uses the parallel port must meet all the requirements defined for legacy Plug and Play parallel peripherals, including requirements for ECP mode, as defined in "Parallel Port Requirements" in Chapter 13, "I/O Ports and Devices." If the device uses a USB, IEEE 1394, PCI, ATA, or SCSI connection, the device must meet the related requirements defined in Part 3 of this guide.

18.5. Device Bay storage device meets PC 99 requirements
Required

Device Bay is not required for PC 99 systems.

All Device Bay controllers and devices included with a PC 99 system or provided as retail devices must meet the requirements defined in *Device Bay Interface Specification, Version 1.0.* Any storage device designed as a Device Bay peripheral must also interface with either USB, IEEE 1394, or both. If it interfaces with USB, the device must support the *Universal Serial Bus Device Class Definition for Mass Storage Devices, Version 1.0* or later.

18.6. ATA controllers and devices support Ultra DMA
Required

All ATA devices and controllers must support Ultra DMA at transfer rates up to 33 MB per second as defined in the ATA/ATAPI-4 or SFF 8038i standard, and as described in requirement 10.7, "Controller and peripherals support Ultra DMA."

A peripheral that does not support the Ultra DMA transfer protocol must, at a minimum, implement the termination scheme required by this protocol in order to be tolerant of Ultra DMA.

18.7. USB-based mass storage device meets PC 99 requirements for USB
Required

If a USB-based mass-storage device, which could be a tape drive, UHD floppy drive, or CD drive, is implemented in a PC 99 system, it must meet the requirements defined in Chapter 7, "USB." It must also meet the requirements defined in *Universal Serial Bus Device Class Definition for Mass Storage Devices, Version 1.0* or later.

18.8. System BIOS or option ROM supports El Torito No Emulation mode
Required
For PC systems that include CD or DVD drives, the system BIOS or option ROM must support the No Emulation mode defined in the specification *El Torito—Bootable CD-ROM Format Specification, Version 1.0,* published by IBM and Phoenix.

A removable USB mass storage device must not be the primary boot device.

18.9. System BIOS or option ROM supports bootable ARMD
Recommended
For PC systems that include ATAPI floppy drives, the system BIOS or option ROM should support the *ATAPI Removable Media Device (ARMD) Specification, Version 1.0* or later.

18.10. Host controller for secondary storage uses IEEE 1394
Recommended
The IEEE 1394 bus is recommended as the connection for the host controller for secondary storage. Any IEEE 1394 implementation must meet all requirements defined in Chapter 8, "IEEE 1394," including the requirement that controllers comply with *1394 Open Host Controller Interface Specification, Revision 1.0* (OpenHCI).

A removable IEEE 1394 mass storage device must not be the primary boot device.

Floppy Disk Controller and Drive

This section describes the specific requirements for any FDC provided with a PC 99 system. The device must also meet the general requirements defined in "Storage Controller and Peripherals Basic Features" and "PC 99 Design for Storage Components" in this chapter.

A PC 99 system is not required to include an FDC of any type. Although most systems include some form of floppy disk drive, some Office PC systems might not need one.

18.11. Floppy disk capabilities, if implemented, do not use legacy FDC
Recommended for all system types
To support migration away from legacy devices, it is recommended that support for floppy disk drives be provided by using a solution other than a legacy FDC. Solutions could include an MMC-2-compliant ATAPI floppy drive, USB, PC Card, SCSI, or ATA expansion card.

Any floppy disk implementation or legacy FDC that is included on a PC 99 system must meet the requirements specified in this chapter. Requirements for ATAPI peripherals are defined in Chapter 10, "ATA and ATAPI." See also the related recommendation for BIOS or option ROM boot support in requirement 3.5, "BIOS meets PC 99 requirements for boot support," plus requirement 18.9, "System BIOS or option ROM supports bootable ARMD."

18.12. Legacy FDC device meets resource configuration requirements, if present

Required

A legacy FDC is optional for PC 99 systems. If implemented, the following resource requirements must be met for each legacy FDC device on the system:

● Use static I/O addresses 3F2h, 3F4h, and 3F5h. Additional addresses can be provided in the event of conflict

● Use IRQ 6

● Use DMA Channel 2 if FDC supports block data transfers to memory using DMA controllers

These resources cannot be shared among devices of the same type.

18.13. System supports dynamic configuration of legacy FDC

Required

If a legacy FDC is included in the system, the FDC must be capable of being configured, relocated, and disabled. For example, if the legacy FDC is located on the system board and an adapter that includes an FDC is added to the system, the system-board FDC must be capable of being disabled to prevent conflicts with the new adapter.

If the legacy FDC is located on an expansion card, the expansion card must allow independent dynamic disabling of the FDC and the hard disk controller. In this case, the adapter will continue to function if the FDC is disabled because of conflicts.

Hard Disk Drives

This section summarizes specific requirements for hard disk drives. The device must also meet the general requirements defined in "Storage Controller and Peripherals Basic Features" and "PC 99 Design for Storage Components" in this chapter.

Note: BIOS support is required for LBA for all read and write operations to ATA disk drives that have capacities greater than 528 MB. For more information, see requirement 10.5, "System BIOS and devices support LBA."

18.14. Operating system recognizes the boot drive in a multiple-drive system
Required

The implementation of boot-drive determination in multiple-drive systems is defined in Section 5.0 of the *Compaq, Intel, Phoenix BIOS Boot Specification, Version 1.01*. This is the format that both Windows and Windows NT operating systems use for determining the boot drive when new bootable devices are introduced to a PC. The system designer can use an equivalent method for boot-drive determination but the method must ensure that the Windows and Windows NT operating systems recognize the boot drive.

18.15. Hard drive is SMART-compliant and uses SMART IOCTL API
Optional

The Self-Monitoring, Analysis, and Reporting Technology system (SMART) is an industry term used to describe technology that monitors and predicts device performance.

The *SMART IOCTL API Specification, Version 1.1* or later, published by Compaq Computer Corporation and Microsoft Corporation, describes the API used by an application to issue SMART commands to a hard drive under Microsoft Windows operating systems. If SMART compliance is implemented, the driver must support the SMART IOCTLs.

CD Devices

This section summarizes the requirements for CD peripherals. The device must also meet the general requirements defined in "Storage Controllers and Peripherals Basic Features" and "PC 99 Design for Storage Components" in this chapter, including requirement 18.1, "Storage controller and devices support bus master capabilities."

18.16. CD device provides 8x minimum transfer rate or better performance
Required

The minimum CD device media transfer rate for read operations must be no less than 1200 KB per second when running in the fully on power state.

18.17. CD drive is CD-Enhanced compatible
Required

The CD drive must be able to mount multisession CD-ROM discs, even if track 1 is Red Book audio. Microsoft recommends use of the Sony ReadTOC method for SCSI-2 multisession support as defined in the MMC-2 standard or SFF 8020i, Version 2.5 or later.

CD-Enhanced support must be Blue Book compliant, as defined in *Enhanced Music CD Specification, Version 1.0.*

18.18. CD drive supports specified logical and physical CD formats
Required

At a minimum, the CD drive must be compatible with the following formats to ensure cross-media compatibility, based on compliance with the *Optical Storage Technology Association (OSTA) MultiRead Specification for CD-ROM, CD-R, CD-R/RW, and DVD-ROM Devices, Version 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 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 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.

18.19. ATA/ATAPI CD drive complies with SFF 8020i v. 2.6
Required

CD drives attached to the system using the ATA interface must support the hardware and protocols documented in *ATA Packet Interface for CD-ROMs, SFF 8020i, Version 2.6 or later.*

Note: Support for the READ CD-DA command as defined in the MMC-2 standard is recommended. This might become a requirement in future versions of these guidelines.

For DVD drives, see requirement 18.28, "DVD device complies with the MMC-2 standard," later in this chapter.

18.20. CD drive supports multisession and compatibility forms of the READ_TOC command
Required

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

For more information about ATAPI peripheral supporter for CD-I content, see requirement 18.18, "CD drive supports specified logical and physical CD formats."

18.21. ATA/ATAPI CD changer complies with the MMC-2 standard

Required

If an ATAPI-compatible CD changer with a capacity for seven or fewer discs is present, the changer must comply with the MMC-2 standard or with SFF 8070i.

18.22. CD device supports digital audio detection

Required

CD drives must support the bit "CD Capabilities and Mechanical Status Page" (2Ah), as defined in the MMC-2 standard. The bit "CD-DA Commands Supported" must be set if the drive can provide digital audio streams. This bit must be unset if the drive is not capable of digital audio.

The bit "CD-DA Stream is Accurate" of "CD Capabilities and Mechanical Status Page" can be set only if either the READ_CD command or READ_RAW command provides sector-accurate reads, as defined in MMC-2. Data alignment accuracy should 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. This bit must be unset if the conditions are not met.

18.23. CD device uses push-to-close design

Recommended

A motorized design is not required, but if it is implemented, the device must be designed so the user has three options for closing the device when inserting a disc:

- Physically pushing on the bay
- Physically pushing the close button on the bay housing
- Selecting a software-supported option to close the device

Rewritable Optical ATAPI Devices

This section summarizes specific requirements for rewritable optical storage devices. The device must also meet the general requirements defined in "Storage Controller and Peripherals Basic Features" and "PC 99 Design for Storage Components" in this chapter.

18.24. Block rewritable optical ATAPI device complies with SFF 8070i

Required

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

DVD Devices

This section summarizes specific requirements for DVD devices. The device also must meet the general requirements defined in "Storage Controller and Peripherals Basic Features" and "PC 99 Design for Storage Components" in this chapter.

For information about the requirements for DVD-Video and MPEG-2 playback performance, see Chapter 15, "Video and Broadcast Components." For more information about DVD support under Windows and Windows NT operating systems, see the articles at http://www.microsoft.com/hwdev/devdes/dvdwp.htm.

18.25. DVD device provides 2x minimum transfer rate or better performance anywhere on the disc
Required

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

Recommended: A 4X DVD-ROM at 4 MB per second sustained from the DVD disc.

18.26. DVD drive and controller support bus master DMA transfers
Required

The drive and controller must support byte-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 system-board implementations must support DMA as specified in the ATA/ATAPI-4 standard or SFF 8090.

18.27. DVD drive meets minimum compatibility requirements
Required

DVD drives must support all the functionality of CD drives as outlined in "CD Devices" earlier in this chapter. Specifically, the DVD device must be compatible with the following formats to ensure that the DVD device can read earlier media:

- Logical formats: CD Red Book (CD-Audio), Yellow Book (CD-ROM), White Book, Orange Book parts II and III (packet writing), Blue Book, UDF versions 1.5 and 2.0, and DVD video if applicable.
- Physical formats: ROM (stamped), Orange Book part II (CD-R) and part III (CD-RW), and ECMA-267 and ECMA-268 (DVD-ROM).

Recommended: Support for ECMA-274 (PC+RW) and ECMA-272, 273 (DVD-RAM 1.0 and DVD-R).

Conforming to *OSTA MultiRead Specification, Version 1.11* indicates compliance with all of these compatibility requirements.

18.28. DVD device complies with the MMC-2 standard
Required

A DVD device must comply with the MMC-2 standard, which defines the implementation requirements that the Windows operating system supports. The drive must support the following commands:

Beh	Read CD	08h	Device reset
B9h	Read CD MSF	A0h	Packet
4Bh	Pause/resume	A1h	Identify packet device
E5h	Check power mode	Efh	Set features
90h	Execute device diagnostic	E6h	Sleep
E1h	Idle Immediately	E0h	Standby immediate
00h	NOP		

DVD devices must also support the following:

- Timeout model as designed and documented in MMC-2.

- Get Event Status command (Media Event Status class) and all related commands, including Persistent Prevent/Allow, as defined in MMC-2.

- Get Configuration command for Morphing class devices (Class 2), as defined in MMC-2. Windows 98 uses the Get Configuration command to determine whether media event status is supported correctly.

18.29. DVD device uses push-to-close design
Recommended

A motorized tray design is not required, but if it is implemented, the device must be designed so the user has three options for closing the device when inserting a disc:

- Physically pushing on the bay

- Physically pushing the close button on the bay housing

- Selecting a software-supported option to close the device

18.30. DVD device supports defect management
Required

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.

18.31. DVD device supports copyright protection
Required

The drive must support a licensed implementation of the CSS copyright-protection scheme and support CSS-protected discs to ensure proper protection for prerecorded video content as defined in the DVD specification.

Software is provided as part of the Windows and Windows NT operating system support for DVD in order to facilitate the authentication process required by this scheme. This allows a DVD drive to authenticate and transfer keys with a CSS content decrypter. Windows and Windows NT operating system software will act as the agent to allow either hardware or software decrypters to be authenticated.

PC 99 Design for Storage Components

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

Plug and Play and Bus Design for Storage Components

The items in this section are requirements for Plug and Play capabilities.

18.32. Each device has a Plug and Play device ID
Required

For each system-board device, there must be a device-specific ID.

Each device must provide Plug and Play device IDs in the manner required for the bus it uses as defined in Part 3 of this guide. For example, a PCI add-on device must comply with PCI 2.1 requirements and also must provide a Subsystem ID and Subsystem Vendor ID, as defined in Chapter 9, "PCI."

18.33. Dynamic resource configuration is supported for all devices
Required

To ensure conflict resolution for resource allocation, the device must conform to the Plug and Play specifications for the bus it uses, as described in Part 3 of this guide. The system must be able to automatically configure, relocate, or disable the resources used by the device if conflicts occur when an expansion card is added to the system.

Devices must be capable of being disabled with software settings only. Configuring or adding a device must not require rebooting or jumper setting changes. Disabling the device must result in freeing all its resources for use by other devices. DIP switches on boot devices can be used for an initial power-on default state or for non-Plug and Play system compatibility, but must be able to be overridden by software configuration after system power up.

The primary hard disk controller is not required to support dynamic disable capabilities.

Note: This requirement does not apply to jumper settings used by the OEM to make basic system-related settings in the factory. This requirement applies only to settings that the end user must make to configure the hardware.

18.34. 3F7h and 377h are unclaimed by devices
Required

To avoid having two devices in the system claim 3F7h and 377h, these addresses must not be claimed for device registers by ATA devices.

It is recognized that some FDC devices claim this range. Such devices can be implemented in a PC 99 system; however, the system manufacturer must ensure that only a single device in the system claims this range.

18.35. Physical security is provided for storage devices
Recommended

External drive devices should have locking capabilities. Each removable media device should be capable of being locked to prevent unauthorized access to data. This means that the device is rendered useless, either electronically or mechanically.

18.36. Option ROMs support Int 13h Extensions
Required

The Int 13h Extensions ensure correct support for high-capacity drives, consistent drive-letter mapping between real and protected modes, and other capabilities for both Windows and Windows NT operating systems. Support for the fixed-disk access subset of Int 13h Extensions must be provided in the system BIOS and in any option ROMs for storage devices that include BIOS support.

The Int 13h Extensions are defined in the "Layered Block Device Drivers" section of the Windows 95 DDK and in the Windows NT 5.0 DDK.

In addition, it is recommended that BIOS interrupt services should provide a protocol-independent method using the Int 40h extension to support ATAPI floppy drives as specified in the ARMD Specification, Version 1.0.

Power Management for Storage Components

This section summarizes specific power management requirements for storage devices.

18.37. Device and controller comply with device class power management reference specification

Required

The *Storage Device Class Power Management Reference Specification, Version 1.0* or later, 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 wake-up 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. Support for the D1 state is not required for floppy disk devices.

Mobile PC Note   For mobile hard drives, it is recommended that a Read operation typically be completed within 5 seconds of applying power or leaving the D1 state and transitioning to D3. For desktop systems, the recommendation is 10 seconds.

The drive spinup time recommendation is not expected to become a requirement in future versions of this guide.

18.38. Device supports wake-up events

Optional

The ability to cause a wake-up event as defined in the *Storage Device Class Power Management Reference Specification, Version 1.0* or later, is an optional feature.

Device Drivers and Installation for Storage

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

18.39. Device drivers and installation meet PC 99 requirements

Required

The manufacturer does not need to supply a driver if a PC 99-compliant driver provided with the operating system can be used. If the manufacturer supplies a driver, it must comply with requirement 3.16, "Device driver and installation meet PC 99 requirements." The basic requirements include driver support for unattended installation and Help file support if special driver parameters are used.

Ease-of-use requirements for installation and configuration are defined for SCSI peripherals and for ATA and ATAPI devices in Part 3 of this guide. For information about WDM support for devices that use the USB or IEEE 1394 bus, see the Windows NT 5.0 DDK. See also the related articles on the web site at http://www.microsoft.com/hwdev/wdm/.

18.40. Device driver runs in protected mode following installation
Required

The device driver must be running in 32-bit protected mode, not compatibility mode, immediately following installation.

Note: Although it is preferred that a system reboot not be required as part of device installation, it is recognized that installation of boot devices presents a special situation. It is acceptable that installation of a boot device includes restarting the system.

18.41. Applications provided with the device meet Win32 requirements
Required

Any Windows-based applications provided with the device must meet requirements for software compatibility as defined in the Microsoft Platform SDK. However, any software applications included with the device can be installed using an alternate Windows-based installation method as defined in the Microsoft Platform SDK.

18.42. Device driver for partitioned media supports all Windows and Windows NT partition types
Required

Device drivers that support partitioned media must support all Windows and Windows NT partition types, which include but are not limited to FAT16, FAT32, and NTFS, plus UDF 1.5 and 2.0 for CD and DVD.

18.43. Device driver for block-mode device supports extended BPBs
Required

Storage subsystems that include an MS-DOS–based block-mode device driver, for example, Aspidisk.sys, must support Extended BIOS Parameter Blocks (BPBs) in the Build BPB device driver function call, and must support category=48 in the generic IOCTL device driver interface calls, as specified in the 1996 update to the Windows 95 DDK.

Storage References and Resources

This section lists resources for building storage hardware that works with the Windows and Windows NT operating systems.

1394 Open Host Controller Interface Specification, Revision 1.0
    ftp://ftp.austin.ibm.com/pub/chrptech/1394ohci/

ATA/ATAPI-4 Revision 17 Working Draft Standard (ATA/ATAPI-4)
ATA Packet Interface for CD-ROMs (SFF 8020*I*)
Other ATA and SCSI standards
    Global Engineering Documents
    Fax: (303) 397-2740
    Phone: (800) 854-7179 (U.S.)
              (613) 237-4250 (Canada)
              (303) 792-2181 (Outside North America)

    ATA and ATAPI draft standards and other working documents are available at
    ftp://fission.dt.wdc.com/pub/standards/ and
    ftp://ftp.symbios.com/pub/standards/io/

Compaq, Intel, Phoenix BIOS Boot Specification, Version 1.01
El Torito—Bootable CD-ROM Format Specification, Version 1.0
    http://www.ptltd.com/techs/specs.html

Device Bay Interface Specification, Version 1.0
    http://www.device-bay.org

Device driver support for storage devices and DVD white papers
    http://www.microsoft.com/hwdev/drvrinfo.htm

DVD Specifications for Rewritable Disk, Part 1: Physical Specifications,
        Toshiba Corporation
    http://www.toshiba.com

ECMA Standards ECMA-267 (DVD-ROM), ECMA-274 (DVD+RW)
        and ECMA-272, 273 (DVD-RAM)
    http://www.ecma.ch

FAT32 partition device driver support
    http://www.microsoft.com/hwdev/storage/

Media Status Notification Support Specification, Version 1.03
Plug and Play specifications
SMART IOCTL API Specification, Version 1.1
    http://premium.microsoft.com/msdn/library/specs/d4/iocltapi.htm

Microsoft Windows 95 DDK, Windows 98 DDK, Windows NT 5.0 DDK,
        and Microsoft Platform SDK
    MSDN Professional membership

MMC-2 Multi-Media Command Set-2
    ftp://ftp.symbios.com/pub/standards/io/t10/drafts/mmc2/mmc*xxxx*.pdf

Multisession Compact Disc Specification 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

National Committee for Information Technology Standards (NCITS) Reduced Block Commands (RBC)
ftp://ftp.symbios.com/pub/standards/io/t10/drafts/rbc/

OSTA MultiRead Specification for CD-ROM, CD-R, CD-R/RW, and DVD-ROM Devices, Version 1.11
Universal Disk Format Specification, Version 1.5 and 2.0
http://www.osta.org

SFF Committee publications
FaxAccess: (408) 741-1600 (fax-back)
Fax: (408) 867-2115

Storage Device Class Power Management Reference Specification, Version 1.0
http://www.microsoft.com/hwdev/onnow.htm

Universal Serial Bus Device Class Definition for Mass Storage Devices, Version 1.0
http://www.usb.org

WDM device driver support white papers
http://www.microsoft.com/hwdev/wdm/

Checklist for Storage and Related Peripherals

If a recommended feature is implemented, it must meet the PC 98 requirements for that feature as defined in this document.

18.1. Storage controller and hard disk devices support bus master capabilities
Required

18.2. Removable media devices support media status notification
Required

18.3. Device meets PC 99 general device requirements
Required

18.4. Device meets PC 99 requirements for ports or buses
Required

18.5. Device Bay storage device meets PC 99 requirements
Required

18.6. ATA controllers and devices support Ultra DMA
Required

18.7. USB-based mass storage device meets PC 99 requirements for USB
Required

18.8. System BIOS or option ROM supports El Torito No Emulation mode
Required

18.9. System BIOS or option ROM supports bootable ARMD
Recommended

18.10. Host controller for secondary storage uses IEEE 1394
Recommended

18.11. Floppy disk capabilities, if implemented, do not use legacy FDC
Recommended for all system types

18.12. Legacy FDC device meets resource configuration requirements, if present
Required

18.13. System supports dynamic configuration of legacy FDC
Required

18.14. Operating system recognizes the boot drive in a multiple-drive system
Required

18.15. Hard drive is SMART-compliant and uses SMART IOCTL API
Optional

18.16. CD device provides 8x minimum transfer rate or better performance
Required

18.17. CD drive is CD-Enhanced compatible
Required

18.18. CD drive supports specified logical and physical CD formats
Required

18.19. ATA/ATAPI CD drive complies with SFF 8020i v. 2.6
Required

18.20. CD drive supports multisession and compatibility forms of the READ_TOC command
Required

18.21. ATA/ATAPI CD changer complies with the MMC-2 standard
Required

18.22. CD device supports digital audio detection
Required

18.23. CD device uses push-to-close design
Recommended

18.24. Block rewritable optical ATAPI device complies with SFF 8070i
Required

18.25. DVD device provides 2x minimum transfer rate or better performance anywhere on the disc
Required

18.26. DVD drive and controller support bus master DMA transfers
Required

18.27. DVD drive meets minimum compatibility requirements
Required

18.28. DVD device complies with the MMC-2 standard
Required

18.29. DVD device uses push-to-close design
Recommended

18.30. DVD device supports defect management
Required

18.31. DVD device supports copyright protection
Required

18.32. Each device has a Plug and Play device ID
Required

18.33. Dynamic resource configuration is supported for all devices
Required

18.34. 3F7h and 377h are unclaimed by devices
Required

18.35. Physical security is provided for storage devices
Recommended

18.36. Option ROMs support Int 13h Extensions
Required

18.37. Device and controller comply with device class power management reference specification
Required

18.38. Device supports wake-up events
Optional

18.39. Device drivers and installation meet PC 99 requirements
Required

18.40. Device driver runs in protected mode following installation
Required

18.41. Applications provided with the device meet Win32 requirements
Required

18.42. Device driver for partitioned media supports all Windows and Windows NT partition types
Required

18.43. Device driver for block-mode device supports extended BPBs
Required

C H A P T E R   1 9

Modems

This chapter presents the requirements for modems, fax modems, voice modems, voice/data modems, wireless and cellular modems, and serial Integrated Service Digital Network (ISDN) adapters.

For an overview of the design issues related to the modem requirements, see "Modem Design Issues" in Chapter 2, "PC 99 Design Initiatives."

Note: Communications standards mentioned in this chapter are available through Bellcore, European Telecommunication Standards Institute (ETSI), International Telecommunication Union (ITU) Sales, Telecommunications Industry Association (TIA), or Global Engineering Documents, as described in "Modem References" later in this chapter.

Notice also that, as for all PC 99 requirements, it is specifically noted in the text whether it is planned that a specific recommended feature will become a requirement in future versions of these guidelines.

Contents

System Requirements for Modems

This section summarizes the PC 99 system requirements for modems.

19.1. Modem device is provided with PC system

Consumer	Office	Mobile	Workstation	Entertainment
Required	Recommended	Required	Required	Required

Recommended: Internal modem, or use USB or PC Card as the external modem connection.

This requirement can also be met by including support for alternative digital or analog public network communications devices, including ISDN, Digital Subscriber Line (DSL) technology, or cable modem, as appropriate to customer demand and geographic locale. The recommended interface for these technologies is to use a Network Driver Interface Specification (NDIS) miniport, as described in Chapter 20, "Network Communications."

Mobile PC Note   The presence of a CardBus slot on the mobile PC meets the requirements for providing a modem. The minimum capabilities for an integrated modem are defined in Chapter 6, "Mobile PC 99."

Modem Basic Features

This section defines basic hardware feature requirements for modems.

19.2. Modem controller meets PC 99 requirements
Required
The modem controller must support the following:

- V.250 (formerly V.25 *ter)*
- AT command buffer of at least 60 characters
- Semicolon (;) character dial string modifier, except when the modem is configured for operation in those countries that prohibit this dial modifier
- Universal Modem Driver (Unimodem) Diagnostics command, AT#UD
- Capable of software-based feature upgrades; provide upgradable ROM or Windows driver-based modem

Recommended: For compatibility with legacy applications that are not based on the Windows Telephony API (TAPI), the ATW2 command should be supported. This command specifies that a string specifying the receiver line bit rate is appended to the CONNECT result code.

19.3. Modem supports V.250 AT command set

Required

International Telecommunications Union (ITU) Recommendation V.250 is a superset of the TIA-602 basic AT command set with significant and useful improvements. It includes these new components:

- A standard format for extending the AT command set, with standard means for the PC to test the range of supported values for each command. This enables adaptive modem installation.

- Standard extensions for modem ID, port control, modulation control and reporting, error control, and data compression control and reporting. This reduces or eliminates the need for data-modem INF files.

Related Recommendation V.251, formerly known as Annex A/V.25 *ter*, provides standard commands that enable the PC to use V.25, V.8, and V.8 *bis* call-control features for point-to-point data calls, voice/data/video calls, and voice-to-data transitions.

It is not required to implement every AT command, result code, and information text defined in V.250. If a particular function is not implemented in a modem or is not controllable by way of the AT command, then the corresponding V.250 AT command need not be implemented.

However, any modem function controllable by way of the AT command must be controllable by the appropriate V.250 command if one is defined in V.250 for that function. Optionally, the function can be controlled by a proprietary command. Similarly, any reportable modem event must use the report defined in V.250, if one exists.

The essential V.250 commands are the following:

- All basic mode commands from TIA-602 (no + prefix)
- Identification: +GMI, +GMM, +GMR
- Port control: +IPR, +ICF, +IFC, +ILRR
- Modulation: +MS, +MR, +MA
- Error control: +ES, +ER, +EB, +ESR, +ETBM
- Compression: +DS, +DR

The modem must also be able to generate appropriate V.250 responses enabled by the +ILRR, +MR, +ER, and +DR commands. The standard format allows a future modem installer to adaptively install and use a modem, with minimal need for INF-file minidrivers.

19.4. Data modem supports V.90 (1998) analog modem modulation

Required

ITU-T Recommendation V.90 modulation supports pulse-code modulation (PCM) connections to digitally-connected central sites, at data rates from 56 Kbps down to 28 Kbps.

V.90 support implies support for V.34, which is used for analog-to-analog connections and for connections to central sites from users whose telephone lines do not support V.90 operation, at speeds from 33.6 Kbps down to 2400 bps.

Mobile PC Note

For mobile PCs, if modem capabilities are integrated in the base platform, then V.34 or higher is required. All other requirements for modems must be met as defined in this chapter.

19.5. Data modem supports Annex A/V.34 (1998) SRC

Recommended

Seamless Rate Change (SRC) procedures defined in new Annex A/V.34 (1998) enhance performance during data mode, because data pump speed changes take place without blocking data flow. SRC is critical for IP-Telephony applications such as H.323/PPP or H.324 over a V.34 data modem; without SRC, rate changes interrupt voice channels for 10 or more seconds (for retrains) or approximately 1 second (for rate negotiations). SRC might also allow a faster startup procedure, because the data pump can then quickly converge on a sub-optimal slower initial speed, for example, to initiate ISP connection negotiations, and then change to higher speeds as the pump training is refined.

19.6. Data modem supports V.42 LAPM, V.42 *bis,* and V.80 Synchronous Access data protocols

Required

The V.42 Link Access Procedure for Modems (LAPM), which provides error control, together with the V.42 *bis* data compression procedures, are particularly well-suited to traditional bulk data delivery modem applications.

The Synchronous Access modes defined in Chapter 8 of V.80 allow the data protocols in the modem to be bypassed and allow any arbitrary, non-traditional protocol to be implemented in the host. For example, it allows host-based V.70 Simultaneous Voice/Data or host-based H.324 video telephony systems to be implemented. Chapter 8 of V.80 requires implementation of both Framed sub-Mode and Transparent sub-Mode.

Because V.42 LAPM is the default mode of operation in most modems, it is commonly used when accessing Internet Service Providers (ISPs). The asynchronous (character-oriented) form of the Point-to-Point Protocol (PPP) runs on top of LAPM.

For enhanced, lower-latency performance for such applications as Internet telephony, V.80 can be used together with the synchronous form of PPP. V.8 *bis* can be used to negotiate the use of V.80. In particular, the AT+ITF command defined in V.80 is useful in reducing the buffering delays in the modem transmitter.

19.7. Modem supports call control signaling, controlled using V.251 modem commands

Required

To comply with PC 99 requirements, V.90 and V.34 modems must support ITU Recommendations V.8, V.8 *bis*, and Recommendation V.251.

ITU Recommendation V.8 *bis* provides for the negotiation and selection of call functions between end points, and enables smooth voice-to-modem transitions during a call. V.8 *bis* is required for multimedia modes such as V.61 Analog Simultaneous Voice and Data (ASVD) and V.70 Digital Simultaneous Voice and Data (DSVD). V.8 *bis* is also used to negotiate the use of manufacturer-specific modulations and features. V.8 *bis* defines code points for V.42 and V.80 modes of operation. It enhances the basic call function selection embodied in the recommendations for V.25 and V.8.

ITU Recommendation V.251 enables the PC to participate in call control, allowing flexibility and a visual user interface as well as saving modem complexity. At a minimum, the V.251 implementation must:

- Support V.8 operation that is controlled by Data Circuit Terminating Equipment (DCE) with Data Terminal Equipment (DTE) notification
- Support DTE-controlled V.8 *bis* operation
- Support backward compatibility for media detection with terminals using V.25 signaling, for example, data calling tone and fax calling tone
- Support backward compatibility for media detection with older modems, for example, V.32 and V.32 *bis*
- Provide a means for turning on the V.8 Calling Indicator (CI) signal for originating calls

Video-Ready Modem Handbook specification from Intel Corporation describes an example using V.251 for call control and call function selection. The specification also gives implementation guidance for the use of V.80 in low-latency applications.

To support media detection in future Microsoft Back Office® family of products, it is recommended that the V.251 modem implement the <a8a> codepoints for DTE-controlled operations (2, 3, and 4).

19.8. Fax modem supports 14.4 Kbps (V.17) with Class 1 (TIA-578-A) command set
Required

Fax capabilities are required. The fax modem must support 14.4 Kbps (V.17) with the Class 1 (TIA-578-A) command set.

In addition to the required fax capabilities, the following enhanced capabilities are recommended for fax modems:

- Class 1.0 (ITU T.31) with +FAR support, which allows the hardware to perform adaptive carrier detection
- Class 2.0 (ITU T.32 or TIA-592) for rack-mounted server modems
- Adaptive DATA/FAX call classification based on the Class 2.0 +FAA command or equivalent (for example, +FAE), particularly for rack-mounted server modems
- V.34 half-duplex (33.6 Kbps) modulation, controlled by Annex B/T.31 procedures

Windows includes fax modem support. Windows NT Workstation 5.0 and future versions of Microsoft BackOffice family of products will support Class 1.0 and Class 2.0 fax modems and adaptive FAX/DATA call classification. To benefit from this support, modem vendors should extend their modem INF files to support the registry keys for these features, as defined in the Windows Modem Developers Kit (MDK).

19.9. Modem supports delayed and blacklisted number clearing
Recommended

This support is recommended for modems supporting delayed and blacklisted number tables. The modem should clear its delayed and blacklisted number tables if the associated handset goes off hook.

During certain international Post, Telephone, and Telegraph (PTT) certification processes, modems must support the delayed and blacklisted numbers feature. That means that when the modem fails to connect to a specific number for a certain number of times, the dialed number is stored in an internal list. Subsequent automated dialing operations to this number are then either delayed for a time or might be forbidden until some form of manual intervention occurs (blacklisted). The international certification processes specify that manual intervention using an external device is required in order to clear these numbers.

Windows provides error messages corresponding to delayed and blacklisted error reports in order to reduce customer confusion.

19.10. Modem supports TDD, meeting V.18-1996 with V.250 AT commands
Recommended

People who are deaf or hard of hearing can use Telephone Device for the Deaf (TDD), also known as Text Telephones, to communicate over phone lines. The U.S. Americans with Disabilities Act (ADA) requires all businesses of a certain size or larger to have Text Telephone services available and to be able to receive calls from people using Text Telephones.

It is recommended to include Text Telephone capability for the type commonly used in the country of sale and use, for example, Baudot in the United States, Minitel in France, and so on. In North America and Europe, the following types of Text Telephones are used:

- Baudot: 45 or 50 bps Frequency-Shift-Keyed (FSK) and 5-bit Baudot coding
- ASCII: 300 bps Bell 103 and 7-bit ASCII coding
- European Deaf Telephone (EDT): 110 bps half-duplex V.21 and 7-bit coding
- Minitel: V.23 modems and 7-bit coding
- Modems and 7-bit coding
- Dual-tone multifrequency (DTMF): 2-digit or 3-digit character coding

ITU Recommendation V.18 codifies how all these devices work and how to adaptively connect to all of them. ITU Recommendation V.250 contains these AT commands for control of V.18 features in a modem: +MV18S, +MV18R, +MV18AM, +MV18P.

Voice Modem Requirements

Voice capabilities are not required for PC 99 modems, but if implemented, the requirements defined in this section must be met.

A separate category of voice-only device can be integrated with a telephone. These voice-only devices are not required to support modem data or fax, but must comply with the requirements defined in this section.

19.11. Voice modem supports ITU V.253 (AT+V)

Required in modems supporting voice

TIA IS-101-1994, the interim standard for Voice DCE, has been superseded by TIA-695. TIA-695 adds voice formats and speakerphone control commands. ITU-T V.253 (formerly V.voice) was completed in January 1998 and is a superset of the TIA-695 U.S. standard. V.253 includes small corrections to TIA-695 and adds provisions for bi-directional, digitized voice over the serial port.

The following voice modem features are required:

- Voice recording and playback (+VTX, +VRX)
- DTMF generation and detection during voice I/O
- Voice I/O support of 8-bit, 8-kHz PCM formats: unsigned linear, G.711
- Programmable gain control for all audio channels
- Support for speakerphone operation (+VTR)

Voice-only devices—AT command set devices that do not implement data or fax functions—must also support voice I/O to the handset.

19.12. Voice modem support includes PC 99 recommendations

Recommended

The following voice modem features are recommended:

- Sense local telephone line state (on hook/off hook) without the modem going off hook
- Extension (parallel) telephone answer and hang-up detection and reporting
- Programmable gain control for all audio channels
- Remote (far end) telephone answer and hang-up detection and reporting
- Message waiting signal (stuttered dial tone) detection reporting

- Special Information Tone (SIT) detection and reporting
- Distinctive ring detection and reporting
- Powered interface to the local telephone to support voice I/O and DTMF I/O

It is not required for a voice modem that implements any recommended feature to implement every feature in this list.

19.13. Voice modem supports Caller ID Detection and Reporting
Recommended
Caller ID reporting is controlled with the AT+VCID and AT+VRID commands. As specified in V.253, Caller ID reporting is available in operating modes other than FCLASS 8 (Voice Mode). Therefore, it is recommended that the modem support the AT+VCID and AT+VRID commands even if Voice Mode is not supported.

19.14. Voice modem supports speakerphone
Required in modems supporting voice
Audio I/O for speakerphone can be implemented in any of the following ways. At least one of the following methods is required for voice modems:

- Simultaneous, bi-directional digitized audio to host, using the host modem asynchronous port. This method is defined in V.253, and allows speakerphone operation with PC audio peripherals, as well as host-based acoustic echo cancellation.

  This method is essential for speakerphone operation with PC Card modems, which lack the connectors for external audio I/O. Because this method requires the least amount of hardware components in the modem and is therefore the lowest-cost solution, it is the preferred speakerphone implementation.

- Internal analog connection to the PC audio system. Some OEM internal voice modems incorporate an audio codec, which connects using an internal cable to the host studio peripherals. This allows speakerphone operation with PC audio peripherals, but it requires additional hardware components in the modem and a cumbersome, proprietary analog cable connection inside the PC.

- Jacks to external audio I/O. I/O jacks such as microphone, speaker, or handset jacks are optional, but if they are included on the modem, speakerphone operation should be supported through them.

- Built-in audio I/O. Microphone and speaker support are appropriate for voice-only non-modem devices, such as PC-connected phones.

Wireless and Cellular Modem Requirements

This section provides requirements and recommendations for wireless and cellular modems.

19.15. Wireless support is implemented for modems
Recommended

There are a variety of wireless modems and look-alike modems. These include the common types: North American analog cellular, cellular digital packet data (CDPD), global system for mobile communications (GSM) and other digital cellular systems, and so on. However, there are several other types, such as the Ricochet modem from Metricom.

For all wireless and cellular modems, the commands in TIA-678 are recommended. The +WS-46 command, which selects the wide area network (WAN), is required.

Windows has registry keys that support analog cellular modems. Windows also supports data access in GSM and other wireless modem types. Participants in the Mobile Data Initiative are developing extensions for other services on digital cellular modems, as described in the following requirement.

19.16. Digital cellular phone support is implemented for modems
Recommended

Digital cellular support is not a requirement, but if implemented, the following appropriate digital cellular control standards must be supported:

TIA-678 +WS-46 selector command	Class 2.0 facsimile services, per appropriate standard
+CBC battery power monitoring command	
+CPAS phone activity status	For GSM modems, +CBST protocol selection command
+CSQ signal quality monitoring command	

To allow software applications to specify settings and manipulate Short Messaging Service (SMS) through a GSM modem card, it is recommended that the card support the following GSM 07.05 commands.

+CMGF: Message Format	+CPMS: Preferred Message Storage
+CMGL: List Messages	+CRES: Restore Settings
+CMGR: Read Messages	+CSAS: Save Settings
+CMGS: Send Messages	+CSCA: Service Center Address
+CMGW: Write Messages	+CSCS: TE character set selection
+CNMI: New Message Indications to terminal equipment (TE)	+CSMS: Select Messaging Service

Unlike wireline data modems, these devices are not required to support V.34 signaling; it is not available. 9600 bps capability is required; higher speeds are recommended where available.

Class 1.0 fax support is available on some of these devices, but it is not required; the error rates with transparent modem faxes are often very high.

Cellular telephone systems are widely deployed in the industrialized world and are now being deployed internationally. In North America, analog cellular systems (TIA-553) are currently predominant, although two types of digital cellular systems can also be deployed: code division multiplexed access (CDMA; TIA IS-95) and time division multiplexed access (TDMA; IS-136).

In Europe and the rest of the world, the GSM digital cellular system is widely deployed. In Europe, the infrastructure for data, fax, and short messaging is now in place.

For all three digital cellular systems, the system design has been extended to offer data, fax, voice, and SMS to mobile users. In all cases, a modem pool is added to the ground stations, where connection is made to the Public Switched Telephone Network (PSTN). Access to the logical serial ports of these modems is made using the digital error-controlled radio link to the equipped mobile phone and is exposed on a serial port or associated PC Card device.

Digital cellular communications equipment should default to using error correction on the radio link. For example, for GSM 7.07, the modem should initialize to +CBST=,,1 (which selects a "nontransparent" air interface).

To allow data cards to use GSM/ISDN V.110 "fast access" where available in the network, +CBST=71,, (9600 bps V.110) should be a valid setting.

The AT command sets for these digital cellular phone systems are contained in the following standards.

Standard	Command set
GSM 7.07	GSM system: data, fax, voice
GSM 7.05	GSM SMS
TIA IS-707	North American CDMA: data and fax
TIA IS-135	North American TDMA: data and fax

The TIA-678 +WS46 command has codes to indicate which system the modem is capable of. For example, the following values, quoted from Table 4 of the standard, are useful.

Value	System
1	Public telephone network (that is, a normal wireline modem)
4	CDPD
7	TIA-553 analog cellular system
10	Metricom Ricochet network
12	GSM digital cellular system
13	TIA IS-95 CDMA digital cellular
14	TIA IS-136 TDMA digital cellular (Personal Communications System [PCS])

ISDN Modem Requirements

There are two classes of ISDN adapters: parallel bus devices, supported by NDIS WAN drivers, and serial port devices, supported by Unimodem with INFs. This section addresses serial ISDN adapters, colloquially referred to as ISDN modems.

For a general discussion of ISDN and a list of requirements related to parallel bus devices based on NDIS under Windows and Windows NT, see Chapter 20, "Network Communications."

ISDN modems share the following features:

- ISDN Basic Rate interface (2B+D)
- Serial AT command language, with proprietary ISDN extensions

ISDN modems also share the following differences from wireline PSTN modems:

- User (or device) must configure for switch type and service profile ID (SPID)
- Data only, in increments of one or two 64,000 bps B channels
- Fax not available
- V.42 and V.42 *bis* usually not available

This section defines the requirements for ISDN modems.

19.17. ISDN driver supports unattended installation, with limitations

Required

In general, the driver must meet the PC 99 requirements for drivers and installation, as defined in requirement 3.16, "Device driver and installation meet PC 99 requirements." However, configuration of the dependent parameters, such as SPIDs and switch-type IDs, must be done using the ISDN Configuration Wizard included in the operating system.

19.18. ISDN modem supports required command set

Required

An ISDN modem must support the following:

- Basic AT commands, such as TIA-602, which is a subset of ITU V.250

- Commands to select the end-to-end protocol used over the ISDN, for example, synchronous PPP, V.110, V.120, and so on

- Commands to set the switch type, subscriber numbers, or directory numbers

- SPID or EAZ (where applicable) for user selection or if auto-detection fails, must be included, implemented in the device or in the communications driver

19.19. ISDN modem exposes both B channels

Recommended

ISDN modems should expose both B channels so that they can leverage the multilink PPP support included in the operating system. Multilink PPP, as defined in RFC 1717, combines several ISDN B channels to increase the bandwidth of PPP links.

When using ISDN modems connected to the PC by way of a single serial port, these capabilities included in the operating system cannot be leveraged and the users might not be able to fully benefit from the features in the ISDN device, such as supporting two B-channels and combining them into one fast link. This is because Windows cannot see both B channels of the ISDN connection unless each B channel is exposed to the operating system either as a COM port or by way of NDIS.

External ISDN modems should be connected on a port such as USB that is fast enough to expose the full bandwidth of both B channels. Providing two separate COM-port cables is not an acceptable solution.

19.20. ISDN modem supports asynchronous-to-synchronous conversion
Required

These types of ISDN devices are treated as modems, not as internal ISDN devices supported using NDIS WAN miniports. In the external case, the primary implication is that the operating system will send byte-level PPP (also known as asynchronous PPP). In the NDIS WAN case, the implication is that the operating system will send bit-level PPP (also known as synchronous PPP).

Because ISDN is a synchronous service and an ISDN modem connects to an asynchronous port on the PC, the device must provide some means of converting asynchronous data to synchronous data.

19.21. ISDN modem defaults to HDLC PPP after INF installation
Recommended

High-level data link control (HDLC) framing is a standard for sending synchronous data. An ISDN modem can support multiple end-to-end protocols, but it should default to synchronous PPP (RFC 1662), which is used by the Microsoft Remote Access Services (RAS) and Dial Up Networking (DUN) protocol stacks.

19.22. ISDN modem uses high-speed port
Recommended

Because of speed limitations inherent in a PC's COM ports, the connection for ISDN modems should be by way of a high-speed bus such as USB or IEEE 1394. A specification for controlling an ISDN TA over USB is in development by the USB Communications Device Class working group.

Basic Modem Performance

This section presents performance-related recommendations and requirements. In the case of the first two tests, "modem pair" refers to the fact that the identical make or model of the modem under test is present on both ends of the connection.

19.23. Modem pair passes basic V.34 file transfer test
Required

TIA standard TSB-38 specifies test procedures for evaluating modems. Test file **4.TST** contains random data and does not benefit from data compression.

This requirement is a basic test of modem functionality and verifies that the modem is able to connect at 31.2 Kbps, stay connected, and transfer data on a clean line for at least a half hour, which is a typical time period for a modem session.

While operating in V.34 modulation on TIA TSB-37A line 18C2, the modems must be able to transfer 256 repetitions of the TSB-38 test file **4.TST** in 40 minutes or less, simultaneously in both directions, without hanging up or otherwise aborting the transfer. V.42 LAPM is enabled during this test. Data transmission runs directly on the modems without the use of an additional protocol such as Zmodem.

Impairment combination 18C2 in the TIA TSB-37A PSTN consists of very mild impairments. No V.34 modem should have difficulty operating on this line at least 31.2 Kbps.

Note: For modems certified for operation only in those countries outside of North America, impairment combination 2C4 as specified in ITU-T Recommendation V.56 *bis*, can be substituted for TSB-37A line 18C2. Recommendation V.56 *bis* is an international equivalent of TIA TSB-37A.

19.24. Modem pair passes basic call connect reliability test
Required

This requirement is a basic test of modem functionality and verifies that the modem can reliably connect a large number of times on good telephone channels.

While operating in V.34 modulation, the modems must be able to perform four repetitions of the Call Connect vs. Test Loop Combination test defined in TIA TSB-38 (476 total connection attempts), with an overall call completion success ratio of 97 percent, and with neither modem stalling in an unresponsive, inoperable state.

As specified in TSB-38, the test channels 17C1 though 17C7 are used in this test because impairment combination 17C represents more than 55 percent of the combinations in the PSTN model defined in TSB-37A.

At the conclusion of each connection or connection attempt during the test, the modem port will be closed and then reopened for the next attempt.

Note: For modems certified for operation only in those countries outside of North America, the Call Connect Reliability Test specified in ITU-T Recommendation V.56 *ter*, can be substituted for that in TSB-38. Recommendation V.56 *ter*, an international equivalent of TIA TSB-38, specifies use of the PSTN model defined in Recommendation V.56 *bis*.

19.25. Modem pair passes concurrency test
Required

In this series of concurrency tests, the modem runs while a series of representative communications applications are running on the PC, for example, e-mail, web browsing, and H.263+ video teleconferencing.

Driver-based Modem Guidelines

The following requirements and recommendations apply to Windows driver-based modems.

Note: These recommendations are intended to guide designers in the development of WDM-based software modem implementations. Instrumentation techniques suggested here might only be realizable by designers with access to driver source code. They might not be applicable to external "black box" testing of modem performance.

19.26. Driver-based modem uses a WDM-based driver solution
Required

Windows 98 and Windows NT 5.0 share WDM kernel calls. Driver-based modems must use the WDM kernel so that both operating systems can use a common driver binary. For Windows NT 5.0, these drivers must also support symmetric multiprocessors.

19.27. Driver-based modem processor usage is not excessive
Recommended

Processor usage guidelines refer to performance on the minimum processor required by this guide for Consumer PC systems, as defined in requirement 3.1, "System performance meets PC 99 minimum requirements." Performance guidelines are the following:

- **19.27.1 Driver minimum-maximum cycle times are appropriate.** The driver interrupt period or cycle time for computational processing needs to be short enough so that the signal processor can be responsive to line events, yet long enough so that system context switching overhead is not excessive.

  Cycle times in the range of 3 to 16 milliseconds are recommended. The 3-millisecond minimum ensures a reasonable bound on interrupts and task switching overheads. The 16-millisecond maximum establishes an upper bound for continuous execution at real-time thread priority, which can impact the minimum-sized audio buffer that can be used for low-latency audio during software modem sessions. Some manufacturers have cycle times as long as 20 milliseconds; this will impair low latency multimedia audio, such as G.729 audio on H.324 or H.323.

  In subsequent guidelines, the examples are based on the 16-millisecond maximum.

- **19.27.2 Average processor usage during data transmission does not exceed 25 percent.** In data transmission mode, the average processor usage by a driver-based V.34 or V.90 modem should not exceed 25 percent. For example, processor usage should not exceed 4 milliseconds during each 16-millisecond interval.

- **19.27.3 Total processor usage during data transmission does not exceed 50 percent.** In data transmission mode, the total processor usage by a driver-based modem should not exceed 50 percent of any period equal to the cycle time—for example, 8 milliseconds out of a 16-millisecond period. This accommodates back-to-back service of double-buffered tasks, while leaving adequate processing time available for low latency audio.

- **19.27.4 Average processor usage in retrain mode does not exceed 50 percent.** In (re)train mode, the average processor usage by a driver-based modem should not exceed 50 percent. For example, processor usage should not exceed 8 milliseconds in each 16-millisecond interval.

- **19.27.5 Total processor usage in retrain mode does not exceed 75 percent.** In retrain mode, the total processor usage by a driver-based modem should not exceed 75 percent of any period equal to twice the cycle time, for example, 24 milliseconds out of a 32-millisecond period. This percentage accommodates atypical usage peaks of very short duration, such as back-to-back service of double-buffered retrain mode tasks, while leaving adequate processing time available for low latency audio.

Implementers can verify that their driver meets these guidelines by using a profiling tool such as VTune or by instrumenting their code to use the processor time-stamp counter model-specific register or an equivalent. Because usage includes system calls made by the driver, as well as operating system overhead incurred to schedule deferred procedure calls (DPCs) and threads, profiling measurements should be made using differencing techniques that compare driver plus operating system usage in active and inactive states.

19.28. Driver does not disable interrupts for excessive periods of time
Recommended

The maximum time during which a driver-based modem disables interrupts should not exceed 100 microseconds. The total time during which a driver-based modem has disabled interrupts should not exceed 200 microseconds during any 1-millisecond interval. This percentage accommodates back-to-back interrupt servicing.

Implementers can verify that their driver meets this guideline by designing their code to use a processor performance monitoring counter with a "cycles interrupts masked" or equivalent event selected.

19.29. Driver handles thread priorities appropriately
Recommended

Under WDM, driver writers can take advantage of kernel-mode threads with real-time priorities to minimize any need to perform extended processing with thread scheduling disabled. Computation in WDM DPCs takes place with thread scheduling disabled and can not be preempted by other DPCs.

Such computation should be limited, maintaining system responsiveness and minimizing the DPC and thread latency experienced by the operating system and all drivers, including modem drivers. Furthermore, because a range of DPC priorities (High, Medium, and LowImportance) are available, it is desirable that the maximum execution time of a DPC be tightly bounded to ensure that high priority DPCs do not suffer unduly from priority inversion.

- **19.29.1 Driver uses thread priorities 28 and above.** Only kernel-mode threads have access to the priority range 27 through 30. This guide recommends that driver-based modems perform the bulk of their computation in kernel mode threads, using thread priorities in the range 28 through 30. Thread priority 31 should be reserved for short-duration time-critical processing by the operating system. Non-modem thread-based drivers should use thread priorities 27 and lower.

- **19.29.2 Driver limits execution of simultaneously queued DPCs.** At any instant in time, the total execution time required for all DPCs that have been queued by a WDM driver-based modem, but have not been executed, should not exceed 500 microseconds.

    Furthermore, DPCs requiring over 250 microseconds to execute should be initialized to low DPC priority (LowImportance) so as to bound the length of the priority inversion during which a driver-based modem prevents a higher-priority DPC from executing.

- **19.29.3 Driver does not disable thread preemption for excessive periods of time.** A WDM driver-based modem should not continuously disable thread preemption for more than 3.3 milliseconds. This guideline accommodates 300 microseconds of interrupts being disabled together with two back-to-back episodes of 1.5 milliseconds of extended processing at DISPATCH_LEVEL, as up to three 500-microsecond DPCs execute sequentially.

Implementers can verify that their driver meets these guidelines by designing code that uses the processor time-stamp counter model-specific register or an equivalent.

19.30. Driver tolerates reasonable operating system and bus latencies
Recommended
The following guidelines concern modem driver tolerance for hold-off from processing caused by the operating system, other drivers, or both. The recommended tolerances are designed to ensure minimum degradation in modem Quality of Service (QoS)—meaning effective throughput, connection rate, and line drop. It is strongly suggested that driver-based modems be designed to degrade gracefully in the event of a longer hold-off than recommended here, for example, by recovering from bit errors without either retraining or stepping down to a lower speed. The recommendations are:

- **19.30.1 Driver tolerates interrupt latency.** A driver-based modem should be able to tolerate a period of 2 milliseconds with interrupts disabled.
- **19.30.2 Driver tolerates DPC latency.** A driver-based modem should be able to tolerate a continuous period of 5 milliseconds during which a queued DPC is held-off from execution, possibly by other DPCs.
- **19.30.3 Driver tolerates thread latency.** A WDM driver-based modem should be able to tolerate a 12-millisecond period when thread scheduling is continuously disabled.
- **19.30.4 Driver tolerates PCI bus latency.** A WDM driver-based modem should be able to tolerate a 100-microsecond hold-off from access to the PCI bus caused by other bus masters.

19.31. Driver does not make excessive use of locked memory
Recommended

Use of page-locked memory by a V.34 or V.90 WDM driver-based modem should not exceed 5 percent of the minimum physical memory configuration required by this guide for a Consumer PC system: 1.6 MB out of 32 MB.

PC 99 Design for Modems

This section summarizes PC 99 requirements related to the design initiatives in Part 1 of this guide.

Plug and Play and Bus Design for Modems

This section defines requirements for Plug and Play capabilities.

19.32. Each hardware device has a unique Plug and Play device ID
Required

For a system-board device, there must be a device-specific ID.

Each bus-specific device must provide device IDs in the manner required for the bus it uses as defined in Part 3 of this guide. For example, PCI devices must comply with PCI 2.1 and must also provide a Subsystem ID and Subsystem Vendor ID as defined in Chapter 9, "PCI."

Note: The device must implement either a bus Plug and Play ID or a COM-port Plug and Play ID, but not both.

19.33. Each device has a Plug and Play compatible ID

Required

The various bus-specific Plug and Play specifications provide the means for reporting a Compatible ID as well as a device unique ID.

At least one Compatible ID is required for PC 99. Its primary use is for back up in case the driver or INF file associated with the unique ID is not available, for example, if the customer lost the disk. The goal is for the modem to retain essential data functionality.

The most useful Compatible IDs would point either to an earlier version of the same product, whose INF file is included in shipping versions of Windows, or point to a reference INF file, provided by the modem chip-set manufacturer.

19.34. Dynamic resource configuration is supported for all devices

Required

The system must be capable of automatically assigning, disabling, and relocating the resources used by this device when necessary, using the method required for the related bus class. When the end user changes this device or adds it to the system, setting resource assignments must not require changing jumpers or switches on either the adapter or the system board. In the event of an irreconcilable conflict with other devices on the system, the system must be able to disable the device to prevent the system from stalling.

19.35. PCI modem meets PC 99 requirements

Required

This device must comply with PCI 2.1 or later if PCI is used as the bus connection for the modem. The device must also meet all requirements defined in Chapter 9, "PCI," including compliance with the Maximum Completion Time ECN for devices based on PCI 2.1. Additional power management capabilities are defined for PCI devices in requirement 19.38, "Device complies with device class power management reference specification."

19.36. USB modem meets PC 99 specifications

Required

A modem that uses USB must comply with all related USB specifications, including:

- *USB Specification, Version 1.0* or later
- *Universal Serial Bus Device Class Definition for Communication Devices, Version 1.0* or later

For compatibility with Unimodem and Windows USB serial drivers, a USB modem that incorporates the modem controller function must support the mandatory and optional requests and notifications for Abstract Control Model Serial Emulation defined in section 3.5.1.2.1 of the *USB Class Definitions for Communication Devices Specification.*

19.37. Device Bay modem meets PC 99 requirements
Required

A modem designed as a Device Bay peripheral must interface with either USB, IEEE 1394, or both buses. If implemented to use the USB bus, the device must support relevant USB device class specifications. All Device Bay peripherals must meet the requirements defined in *Device Bay Interface Specification, Version 1.0* or later.

Power Management for Modems

This section summarizes the modem power management requirements. See also the specific power management requirements for each bus defined in Part 3 of this guide.

19.38. Device complies with device class power management reference specification
Required

The *Communications Device Class Power Management Reference Specification, Version 1.0* or later, provides definitions for the OnNow device power states (D0–D3) for modems. The specification also covers the device functionality expected in each power state and the possible wake-up event definitions for the class.

Power states D0 and D3 are required for modems on power-managed buses, including PCI, CardBus, and USB.

Modem adapters that use the PCI bus must be capable of generating a power management event (PME# assertion) from the D3 cold device state. It is recommended that modem adapters also support capture of Caller ID with hardware support for the AT+VRID "resend caller ID" voice modem command.

19.39. Device supports wake-up events
Required

A modem must be able to cause a wake-up event on an incoming ring as defined in *Communications Device Class Power Management Reference Specification.* This applies for modems on all power-managed buses, including PCI, CardBus, and USB.

The D2 power state is defined specifically for this purpose in the power management reference specification. The ability for a modem to cause a wake-up event from the D3 power state is also possible, and using the D3 state is recommend because it realizes better system power savings. To comply with this requirement, a modem must be able to cause a wake-up event from either the D2 state, the D3 state, or both states.

Because caller-ID reporting would be missed by PCs while in a sleep state, the ability for a modem to retain and repeat the last caller-ID reporting on demand is recommended. The mechanism for doing this is described in *Communications Device Class Power Management Reference Specification* and in the V.253 voice modem specifications.

Device Drivers and Installation for Modems

This section summarizes device driver requirements for modems. The items in this section are requirements for all PC 99 systems.

19.40. Device drivers and installation meet PC 99 requirements
Required

The manufacturer does not need to supply a driver if a PC 99-compliant driver provided with the operating system can be used. If the manufacturer supplies a driver, the requirements for the device drivers and installation are defined in Chapter 3, "PC 99 Basic Requirements." The basic requirements include driver support for unattended installation and Help file support if special driver parameters are used.

For information about WDM-based support for controllerless and software modems, see the Windows NT 5.0 DDK. See also the related articles at http://www.microsoft.com/hwdev/modem/. For guidelines about implementing driver and installation support for modems under the Windows operating system, see the Windows MDK.

19.41. Driver supports Unimodem
Required

The device driver must include Unimodem support. Typically, this requires a modem INF file, developed and verified using the MDK and pretested by the modem manufacturer.

19.42. Applications provided with device meet Win32 requirements
Required

Any Windows-based applications provided with the device, such as fax utilities, must meet requirements for software compatibility as defined in the Microsoft Platform SDK.

Telephony applications and service providers provided with PC 99 systems must be implemented using TAPI 2.0. Among other enhancements, applications can request, negotiate, and renegotiate QoS parameters with the network and receive indication of QoS on inbound calls and when QoS is changed by the network. For a summary of the TAPI 2.0 architecture and a description of how to write a TAPI service provider, see http://www.microsoft.com/win32dev/netwrk/tapiwp.htm. For implementation information, see the Microsoft Platform SDK.

Modem References

The following represents some of the references, services, and tools available to help build hardware that is optimized to work with Windows operating systems.

ANSI, TIA, and other standards
  Global Engineering Documents
  Phone: (800) 854-7179 (US)
                 (613) 237-4250 (Canada)
                 (303) 792-2181 (Outside North America)
  Fax: 1 (303) 397-2740
  ftp://ftp.symbios.com/pub/standards/io/

Bellcore Technical References
  Bellcore (Bell Communications Research)
  Phone: (800) 521-2673 (North America)
                 (908) 699-5800 (Outside North America)
  http://www.bellcore.com

Communications Device Class Power Management Reference Specification, Version 1.0
  http://www.microsoft.com/hwdev/onnow.htm

Device Bay Interface Specification, Version 1.0
  http://www.device-bay.org

European Telecommunications Standards Institute (ETSI) or Global System
      for Mobile (GSM) standards
  Phone: +33-92 94 42 00
  FAX: +33-93 65 47 16
  E-mail: secretariat@etsi.fr

ITU communications standards
  ITU Sales
  Phone: +41 (22) 730-6141

Fax: +41 (22) 730-5194
E-mail: sales@itu.ch
http://www.itu.ch

Microsoft Platform SDK, Windows DDK, and Windows NT DDK, including
information about WDM and NDIS
MSDN Professional membership

Microsoft Windows Modem Developer Kit (MDK) and related white papers
Unimodem Diagnostics Command Reference Specification
http://www.microsoft.com/hwdev/modem/

PCI Local Bus Specification, Revision 2.1 (PCI 2.1)
http://www.pcisig.com

Plug and Play specifications
http://www.microsoft.com/hwdev/respec/pnpspecs.htm

Telephony API (TAPI) overview and white papers
http://www.microsoft.com/communications/telephony.htm
http://www.microsoft.com/win32dev/netwrk/tapiwp.htm

USB specifications
http://www.usb.org

WDM device driver support white papers
http://www.microsoft.com/hwdev/wdm/

Video-Ready Modem Handbook Specification, Version 1.0
http://developer.intel.com/IAL/vidred.htm

Checklist for Modems

If a recommended feature is implemented, it must meet the PC 99 requirements for
that feature as defined in this document.

Consumer	Office	Mobile	Workstation	Entertainment

19.1. Modem device is provided with PC system
Required Recommended Required Required Required

19.2. Modem controller meets PC 99 requirements
Required

19.3. Modem supports V.250 AT command set
Required

19.4. Data modem supports V.90 (1998) analog modem modulation
Required

19.5. Data modem supports Annex A/V.34 (1998) SRC
Recommended

19.6. Data modem supports V.42 LAPM, V.42 bis, and V.80 Synchronous Access data protocols
Required

19.7. Modem supports call control signaling, controlled using V.251 modem commands
Required

19.8. Fax modem supports 14.4 Kbps (V.17) with Class 1 (TIA-578-A) command set
Required

19.9. Modem supports delayed and blacklisted number clearing
Recommended

19.10. Modem supports TDD, meeting V.18-1996 with V.250 AT commands
Recommended

19.11. Voice modem supports ITU V.253 (AT+V)
Required in modems supporting voice

19.12. Voice modem support includes PC 99 recommendations
Recommended

19.13. Voice modem supports Caller ID Detection and Reporting
Recommended

19.14. Voice modem supports speakerphone
Required in modems supporting voice

19.15. Wireless support is implemented for modems
Recommended

19.16. Digital cellular phone support is implemented for modems
Recommended

19.17. ISDN driver supports unattended installation, with limitations
Required

19.18. ISDN modem supports required command set
Required

19.19. ISDN modem exposes both B channels
Recommended

19.20. ISDN modem supports asynchronous-to-synchronous conversion
Required

19.21. ISDN modem defaults to HDLC PPP after INF installation
Recommended

19.22. ISDN modem uses high-speed port
Recommended

19.23. Modem pair passes basic V.34 file transfer test
Required

19.24. Modem pair passes basic call connect reliability test
Required

19.25. Modem pair passes concurrency test
Required

19.26. Driver-based modem uses a WDM-based driver solution
Required

19.27. Driver-based modem processor usage is not excessive
Recommended

19.28. Driver does not disable interrupts for excessive periods of time
Recommended

19.29. Driver handles thread priorities appropriately
Recommended

19.30. Driver tolerates reasonable operating system and bus latencies
Recommended

19.31. Driver does not make excessive use of locked memory
Recommended

19.32. Each hardware device has a unique Plug and Play device ID
Required

19.33. Each device has a Plug and Play compatible ID
Required

19.34. Dynamic resource configuration is supported for all devices
Required

19.35. PCI modem meets PC 99 requirements
Required

19.36. USB modem meets PC 99 specifications
Required

19.37. Device Bay modem meets PC 99 requirements
Required

19.38. Device complies with device class power management reference specification
Required

19.39. Device supports wake-up events
Required

19.40. Device drivers and installation meet PC 99 requirements
Required

19.41. Driver supports Unimodem
Required

19.42. Applications provided with device meet Win32 requirements
Required

C H A P T E R   2 0

Network Communications

This chapter presents requirements and recommendations for network adapters and related technologies.

Network communications requirements are based on Network Driver Interface Specification (NDIS) 5.0, which defines the networking requirements, services, terminology, and architecture for Windows 98 and Windows NT Workstation 5.0 operating systems. For background information about NDIS 5.0, see the web site at http://www.microsoft.com/hwdev/network/.

Note: References to adapters, network interfaces, and so on in this chapter should be taken to apply to add-on network adapter cards, network implementations on the system board, and external network interfaces equally and without preference for any of these types of implementation, unless otherwise noted.

Notice also that, as for all PC 99 requirements, if it is planned that a specific recommended feature will become a requirement in future versions of these guidelines, it is specifically noted in the text.

Contents

System Requirements for Network Communications

This section summarizes the network communications features required for PC 99 systems.

20.1. PC system includes network adapter

Consumer	Office	Mobile	Workstation	Entertainment
Recommended	Required	Recommended	Required	Recommended

It is recognized that OEMs supply Office PC systems to corporations for networking purposes in situations where the customer will insert network adapters at the end-user site. If a network communications device is present in the system, it must meet the minimum requirements for network adapters defined in this chapter. Office PC 99 systems submitted for compliance testing must include either a network adapter or a modem.

20.2. PC system includes internal or external ISDN device

Consumer	Office	Mobile	Workstation	Entertainment
Recommended*	Recommended	Recommended	Recommended	Recommended*

If an ISDN device is present in the system, it must meet the minimum requirements defined in "ISDN Requirements" in this chapter. For information about serial ISDN devices, see Chapter 19, "Modems."

Note: For items 20.2–20.6 marked with an asterisk (*) symbol, inclusion of either an asymmetric digital subscriber line (ADSL) modem, ISDN device, or home networking adapter for Internet access is recommended. For higher-speed multimedia networking, an ADSL modem, cable modem, or home networking adapter is recommended. Implementing these recommendations will provide a high-quality Internet connection, improving the user experience.

20.3. PC system includes cable modem

Consumer	Office	Mobile	Workstation	Entertainment
Recommended*	Recommended	Recommended	Recommended	Recommended*

A cable modem is not a required feature for any PC 99 system. However, if implemented, the device and driver must meet the guidelines defined in "Cable Modem Requirements" in this chapter.

20.4. PC system includes ATM adapter

Consumer	Office	Mobile	Workstation	Entertainment
Optional	Optional	Optional	Optional	Optional

An asynchronous transfer mode (ATM) adapter is not a required feature for any PC 99 system. However, if implemented, the device and driver must meet the guidelines defined in "ATM Adapter Requirements" in this chapter.

20.5. PC system includes ADSL adapter

Consumer	Office	Mobile	Workstation	Entertainment
Recommended*	Recommended	Recommended	Recommended	Recommended*

An ADSL device is a not required feature for any PC 99 system. However, if implemented, the device and driver must meet the guidelines defined in "ADSL Requirements" later in this chapter.

20.6. PC system includes satellite or broadcast receiver with NDIS driver

Consumer	Office	Mobile	Workstation	Entertainment
Recommended*	Recommended	Recommended	Recommended	Recommended*

For information about the requirements for supporting a broadcast receiver, which requires NDIS 5.0 support, see Chapter 15, "Video and Broadcast Components."

Network Adapter Requirements

This section defines basic hardware feature requirements for network adapters. Many of these requirements also apply to other network communications devices such as ISDN, cable modem, and ADSL. The applicable requirements for each device category are listed in the related sections later in this chapter.

20.7. Adapter uses NDIS 5.0 miniport driver

Required

The network adapter driver must be based on and comply with NDIS 5.0 in order to take advantage of new operating system capabilities. The driver must follow the NDIS miniport driver model defined in the Windows NT 5.0 DDK.

Important: The development of full MAC drivers is no longer supported. Support for full MAC drivers in the operating system will be removed in future versions of Windows operating systems.

If the network device is for connection-oriented media, such as ATM, ISDN, frame relay, or X.25, it must have a connection-oriented miniport driver that follows the connection-oriented model defined for NDIS 5.0 in the Windows NT 5.0 DDK. Also, for connection-oriented media, there needs to be an NDIS 5.0 call manager driver as defined in the DDK.

In some cases, such as ATM, the call manager driver is included in the operating system. Consequently, for an ATM adapter, the vendor needs to provide only an NDIS 5.0 connection-oriented miniport driver. For connection-oriented media such as ISDN or X.25, the vendor must provide a call manager driver with the hardware, because the call manager is not included in the operating system. Call manager support can be integrated in the connection-oriented miniport driver or implemented as a separate NDIS 5.0 call manager driver. Documentation for both integrated and separated call managers is included in the Windows NT 5.0 DDK.

An intermediate NDIS 5.0 miniport driver is required for network adapters that connect to the PC using IEEE 1394 or USB buses. This driver exposes its media type to NDIS at its upper edge, and it interfaces with the appropriate bus driver (IEEE 1394 or USB) at its lower edge.

20.8. Intermediate NDIS 5.0 miniport driver is deserialized
Recommended

NDIS 5.0 introduces support for deserialized miniports. This enables performance improvements and scalability on Windows NT multiprocessor systems.

For serialized miniports, NDIS simplifies the driver development by implementing the lock and queue management on behalf of the miniport driver. When these drivers are called, NDIS is always called before the miniport driver is entered, which enables NDIS to maintain the lock states and manage the queues of serialized miniport drivers.

This is not always the case with intermediate miniport drivers, where the driver can be called directly by another driver outside NDIS, such as the USB bus driver. Therefore, intermediate miniport drivers should be written as deserialized drivers implementing the lock and queue management in the driver.

20.9. Full-duplex adapter automatically detects and switches to full duplex mode
Required

If both the network adapter and switch port in a link pair support full duplex and there exists a standard way for each to detect and negotiate the duplex mode, then the network adapter must negotiate full duplex mode operation by default. Half duplex mode can be used if that is the only mode supported by one or both link partners, or it can be manually configured if warranted by special conditions. The goal is to configure this setting automatically without end-user intervention.

20.10. Adapter automatically senses presence of functional network connection
Required

Where the network allows it, the network adapter must be capable of dynamically determining whether it is functionally connected to a link partner such as a hub, switch, or router. The device must indicate the link state in the following cases:

- At boot time
- After returning to D0 power state
- When the link state changes while in the D0 power state (no time limit is specified for the required detection or status indication)

If the adapter is on an expansion card not used as a boot device, then the device drivers can determine the presence of the functional link. If the adapter is not functionally connected to a link partner, the miniport driver must provide appropriate NDIS status indication using support for cable sense in NDIS 5.0.

For information about NDIS status codes and indication mechanisms, see the Windows NT 5.0 DDK.

20.11. Adapter automatically senses transceiver type
Required

Network adapters that support multiple transceivers must be capable of automatically detecting which transceiver type is connected to the network unless detection is not possible with the network media available. The network adapter then must automatically drive the correct connection. In all cases, the user must not be required to set jumpers or manually enter information to inform the operating system of the transceiver type.

20.12. Adapter can transmit packets from buffers aligned on any boundary
Required

Buffer alignment refers to whether a buffer begins on an odd-byte, word, double word, or other boundary. Adapters must be able to transmit packets, any of whose fragments are on an odd-byte boundary.

For performance reasons, it is recommended that packets be received into contiguous buffers on a double word boundary.

20.13. Adapter communicates with driver across any bridge
Required

If the adapter uses a bridge, all communications must be free of errors across any bridge, such as a PCI bridge adapter.

20.14. Adapter supports filtering for at least 32 multicast addresses
Required

This requirement applies to networking technologies such as Ethernet that support multicast. This requirement does not apply to technologies such as Token Ring, which distributes Internet Protocol (IP) multicast traffic using the functional address as specified in RFC 1469.

This capability is needed to support push technology applications such as Microsoft NetShow™ server, Active Desktop™ interface, and Internet Explorer 4.0 or later version. The minimum required capability is for filtering 32 multicast addresses, also known as channels.

20.15. Adapter and driver support promiscuous mode
Required

Promiscuous mode ensures that the adapter can be used with Microsoft Network Monitor Agent. This requirement applies only to LAN (non-switched) media.

Notice that, by default, promiscuous mode is not turned on. Enabling promiscuous mode should be possible only by using the Microsoft Network Monitor Agent or another similar administrative application.

20.16. Adapter is compatible with remote new system setup capabilities if used as a boot device
Required

On a system that uses a network adapter to support installation of the operating system, the network adapter must be compatible with remote new system setup capabilities as defined in the *Network PC System Design Guidelines, Version 1.0b.*

An Office PC system must have a network adapter that meets this requirement and the necessary system BIOS capabilities to use the adapter as a boot device, as defined in requirement 3.5, "BIOS meets PC 99 requirements for OnNow support."

20.17. PCI network adapters are bus masters
Required

To improve the system performance by offloading the processor load, PCI network adapters must be bus masters.

20.18. Device Bay-type network adapter meets PC 99 requirements
Required

Any network communications device designed as a Device Bay peripheral must interface with either USB, IEEE 1394, or both, and must support relevant USB device class specifications. All Device Bay peripherals must meet the requirements defined in *Device Bay Interface Specification, Version 1.0.*

20.19. USB or IEEE 1394 device meets specifications for network communications devices
Recommended

USB network communications device vendors should participate in the USB Device Working Group's effort to define networking extensions to the USB Class Definitions for Communications Devices. Vendors also should implement their hardware to this specification when it is released.

Vendors are also encouraged to participate in the definition and implementation of similar IEEE 1394 efforts.

20.20. Network adapter and driver supports priority for IEEE 802-style networks

Recommended

Windows Quality of Service (QoS) components provide link layer priority information to NDIS 5.0 miniport drivers in each transmitted packet's NDIS_PER_PACKET_INFO structure. Priority values are derived by mapping IETF Integrated Services (intserv) service typed to IEEE 802.1p priority values, referred to as the "user priority" object in the draft available on the web at http://search.ietf.org/internet-drafts/draft-ietf-issll-is802-svc-mapping-01.txt, which is likely to be superceded by later draft or final specification. The intserv service type used for the mapping is determined by QoS-aware applications, or on behalf of the application, by QoS-aware operating system components.

IEEE 802.1p/q-capable Ethernet drivers are expected to use the priority level indicated in the NDIS_PER_PACKET_INFO structure to generate the responding field in the IEEE 802.1p/q MAC headers of transmitted packets. Similarly, these drivers are expected to extract the appropriate information from the MAC headers of received packets and to copy the priority to the NDIS_PER_PACKET_INFO structure before indicating the packet to higher protocol layers.

Notice that any link layer driver has the ability to interpret the priority information in the NDIS_PER_PACKET_INFO structure and use it as appropriate for the particular media.

For more information, see the Windows NT 5.0 DDK and "QoS: Assigning Priority in IEEE 802-style Networks," available on the web at http://www.microsoft.com/hwdev/devdes/qos.htm.

ISDN Requirements

This section summarizes the design features for ISDN devices.

In this section, "internal ISDN device" refers to the ISDN terminal adapter, which exposes raw access to its B channels using NDIS miniports. NDIS miniports could also be attached to the PC using WDM-supported bus classes such as USB or IEEE 1394, which would physically be an external device.

"ISDN modem" refers to an ISDN device that exposes itself as a modem controlled by the AT command set. To the operating systems, these devices look like modems and can be used as modems, the hardware manufacturer provides the following:

- A modem INF file for installing the device and for telling the Unimodem which commands to use to control the ISDN device.
- The ability to interpret the standard modem AT command in the ISDN device itself or in a serial port driver. For more information, see the TIA-602 specification, a subset of ITU V.250.

This section defines general requirements for ISDN and specific requirements for ISDN terminal adapters. For information about the requirements for ISDN modems, see Chapter 19, "Modems."

ISDN is recommended, but not required, for high-speed connections. If ISDN is implemented in a PC 99 system, it must meet the requirements defined in this chapter. For Plug and Play, power management, and driver support requirements, see "PC 99 Design for Network Communications" later in this chapter.

20.21. Internal ISDN device meets PC 99 network adapter requirements
Required
The ISDN device driver and its INF file must be based on NDIS 5.0. to ensure user-friendly installation and operation of the ISDN adapter.

The following requirements must be met, as defined in "System Requirements for Network Communications" earlier in this chapter:

- 20.7, "Adapter uses NDIS 5.0 miniport driver, with call manager support" for connection-oriented media
- 20.10, "Adapter automatically senses presence of functional network connection"
- 20.12, "Adapter supports quadword or smaller buffer alignment for receive and byte buffer alignment for send"
- 20.13, "Adapter communicates with driver across any bridge"
- 20.18, "Device Bay-type network adapter meets PC 99 requirements"
- 20.19, "USB or IEEE 1394 device meets specifications for network communications devices"

20.22. Internal ISDN device supports synchronous HDLC framing
Required
High-level data link control (HDLC) framing is a standard for sending synchronous data. Other framing methods are allowed if the miniport driver provides simple HDLC framed synchronous Point-to-Point Protocol (PPP) packets to NDIS.

20.23. NDIS interface and driver support raw unframed synchronous B channel I/O

Required

The internal ISDN device and the driver must support raw, unframed (non-HDLC) synchronous B channel I/O at 64 Kbps per B channel, with each B channel individually accessible. This will enable H.320 as well as voice calls over ISDN without audio breakup.

For these raw interfaces, the direct path to each B channel must support synchronous transmission and reception of H.221 frames, which are of 20 ms duration. To achieve this without additional latency to H.221, there must be support for overlapped I/O buffers at intervals of less than or equal to 20 ms in each direction. As underruns or overruns cause degraded audio, hardware buffering must be adequate to prevent B channel underruns and overruns. For Windows 98 and Windows NT 5.0, 20 ms is adequate.

This can be achieved by making buffering software configurable with adequate range to handle foreseeable real-world conditions. The miniport driver should make I/O completion callbacks to NDIS for each I/O buffer as soon as the I/O for that buffer is complete; it should not coalesce or delay callbacks.

20.24. ISDN driver supports unattended installation, with limitations

Required

Configuration of the dependent parameters, such as service profile IDs (SPIDs) and switch-type IDs, must be done through the ISDN Configuration wizard included in the operating system.

20.25. ISDN device with U-interface includes built-in NT-1 capability

Recommended

Note: This recommendation applies only in the United States.

NT-1 (network terminator) splits the duplexed transmit and receive signals from the ISDN line into separate transmit and receive components. An ISDN device with a built-in NT-1 can connect directly to the ISDN line. However, doing so prevents other devices from being attached to the ISDN line, because only one NT-1 can be connected to an ISDN line.

Therefore, if the ISDN device has built-in NT-1, it is also recommended that it has a connector for either an analog phone or another ISDN device (S/T-interface), such as ISDN phone. Adding an analog (POTS) port or S/T-interface to the ISDN device delivers convenience to the SOHO market, allowing customers to use one ISDN line to meet all telecommuting needs at minimal cost.

20.26. ISDN device includes software-selectable terminating resistors
Required

If the ISDN device has an S/T-interface for connecting additional ISDN devices, it must also have software-configurable terminating resistors that can be selected on or off. The default value of the termination is on in North America, but off in all other countries, where phone companies unconditionally provide the termination.

Cable Modem Requirements

A cable modem connected to a PC is one system component that cable-television operators use to deliver high-speed cable data services to customers.

Cable modem provides two-way services: Data flows downstream from the cable operator's head end and upstream from the customer's PC. At the head end, the cable data system is terminated by the cable modem termination system (CMTS), which terminates the upstream and downstream radio frequency (RF), MAC layer, and possibly Layer 3 protocols from the cable side. CMTS provides the internetwork connection between the cable system and the rest of the network at the head end. CMTS can be implemented on a proprietary hardware platform or a PC platform running Windows NT to provide different networking functions such as routing or QoS support, for example, RSVP.

Some implementations transmit upstream using narrow-band networks, such as ISDN or analog modem. But as cable companies upgrade their networks, an increasing number of RF return modems, for example, two-way modems, are being deployed. Two-way modems are preferred because they are always connected, perform better, and do not tie up phone lines or require modem banks.

The three current cable modem specifications are:

- Data-Over-Cable Service Interface Specification (DOCSIS), developed by the Multimedia Cable Network System (MCNS) consortium.

- IEEE 802.14, developed by IEEE.

- Digital Video Broadcasting/Digital Audio-Visual Council (DVB/DAVIC), developed by DAVIC and DVB and adopted by European Telecommunication Standards Institute (ETSI) and International Telecommunication Union (ITU).

Industry support for DOCSIS is growing rapidly in North America. In present form, its upper layers fully describe IP traffic encapsulated by 802.3/DIX Ethernet framing. ATM is left for future study.

External Ethernet DOCSIS cable modems provide IEEE 802.1d bridging for one or more Customer Premises Equipment. A PC attaches to the cable modems indirectly through its 10BASE-T network adapter. Integrated cable modems attach directly to the PC over buses such as USB, PCI, and IEEE 1394 and they require a vendor-supplied NDIS 5.0 miniport driver. This driver exposes an 802.3/DIX Ethernet adapter interface to the operating system and it interfaces to the cable modem hardware using the appropriate bus (PCI) or bus interface driver, USB or IEEE 1394 at its bottom edge.

In contrast to DOCSIS, both the IEEE 802.14 and the DVB/DAVIC efforts are focused on using ATM, typically implementing an ATM adapter interface and using an NDIS 5.0 ATM miniport driver.

20.27. Device is implemented as an integrated cable modem
Recommended

An integrated cable modem is recommended. This means integrating everything onto a single device, from the cable modem's physical interface layer (RF coax connector) up through a standard PC 802.3/DIX Ethernet or ATM adapter MAC interface. In other words, the PC software perceives the integrated cable modem as a standard Ethernet or ATM network adapter.

An example of this is a USB-attached DOCSIS implementation that integrates cable modem Physical Media Dependent (PMD), downstream convergence, cable MAC, link security, 802.3/DIX MAC "adapter" filtering, and USB device interface functions in the same box. Similar devices can be implemented that are attached using PCI or IEEE 1394 buses.

20.28. Integrated cable modem meets PC 99 network adapter requirements
Required

For the integrated cable modem, the following requirements must be met as defined in "Network Adapter Requirements" earlier in this chapter:

- 20.10, "Adapter automatically senses presence of functional network connection"
- 20.12, "Adapter supports quadword or smaller buffer alignment for receive and byte buffer alignment for send"
- 20.13, "Adapter communicates with driver across any bridge"
- 20.17, "PCI network adapters are bus masters"
- 20.18, "Device Bay-type network adapter meets PC 99 requirements"
- 20.19, "USB or IEEE 1394 device meets specifications for network communications devices"

For an integrated cable modem exposing an ATM interface, the following requirements must be met as defined in "Network Adapter Requirements" earlier in this chapter:

- 20.7, "Adapter uses NDIS 5.0 miniport driver" for connection-oriented media

For an integrated cable modem exposing an Ethernet interface, the following requirements must be met as defined in "Network Adapter Requirements" earlier in this chapter:

- 20.7, "Adapter uses NDIS 5.0 miniport driver"
- 20.14, "Adapter supports filtering for at least 32 multicast addresses"
- 20.15, "Adapter and driver support promiscuous mode"

20.29. Integrated cable modem exposes an ATM or Ethernet interface
Required

An integrated cable modem should expose an ATM or Ethernet interface to the operating system. For the specific requirements if an ATM/cable modem solution is implemented, see "ATA Adapter Requirements" later in this chapter.

ATM Adapter Requirements

This section summarizes requirements for ATM hardware.

The NDIS 5.0 extensions provide kernel-mode NDIS 5.0 client drivers with direct access to connection-oriented media such as ATM. The new architecture for Windows 98 and Windows NT 5.0 extends native ATM support to Windows Sockets 2.0 (WinSock), Telephony API (TAPI), and DirectShow-based applications by providing system-level components that map the applicable WinSock, TAPI, and DirectShow APIs to NDIS 5.0, extending direct ATM access to user-mode applications.

If ATM is included in a PC 99 system or is specifically designed for Windows or Windows NT, it must meet the requirements defined in this chapter. For basic requirements for Plug and Play, power management, and driver support, see "PC 99 Design for Network Communications" later in this chapter.

For more information related to these requirements, please refer to "ATM Layer Specification," in *ATM User-Network Interface Specification, Version 3.1.* This specification includes references to other relevant specifications.

20.30. ATM adapter meets PC 99 network adapter requirements

Required

The following requirements must be met as defined in "Network Adapter Requirements" earlier in this chapter:

- 20.7, "Adapter uses NDIS 5.0 miniport driver" for connection-oriented media
- 20.10, "Adapter automatically senses presence of functional network connection"
- 20.12, "Adapter supports quadword or smaller buffer alignment for receive and byte buffer alignment for send"
- 20.13, "Adapter communicates with driver across any bridge"
- 20.17, "PCI network adapters are bus masters"
- 20.18, "Device Bay-type network adapter meets PC 99 requirements" and
- 20.19, "USB or IEEE 1394 device meets specifications for network communications devices"

20.31. ATM adapter supports a minimum number of simultaneous connections

Required

The Virtual Path Identifier (VPI) and Virtual Channel Identifier (VCI) ranges supported by the adapter affect the maximum number of simultaneous connections supported on a system.

This affects the applicability of the adapter to ATM applications such as LAN emulation, where at least one dedicated VC is created between each pair of communicating ATM hosts.

System type	Simultaneous connections
Client (ATM adapter)	64 or more
Client (Integrated ATM/ADSL adapter)	32 or more

A sample driver is provided in the Windows NT 5.0 DDK to guide developers in properly supporting resources to meet this requirement.

20.32. ATM adapter supports all service types defined by the ATM Forum

Recommended

The ATM adapter should support the constant bit rate (CBR), variable bit rate (VBR), available bit rate (ABR), and unspecified bit rate (UBR) service types as defined by the ATM Forum.

20.33. ATM adapter supports UBR service type
Required

UBR is used by default for standard ATM services such as LAN Emulation and IP over ATM. In addition, PPP is a widely used model for residential network access, and UBR is used by default for PPP-over-ATM virtual circuits. Therefore, it is required for ATM adapters to support the UBR service type.

20.34. ATM adapter supports a minimum number of simultaneously active VBR or CBR connections
Required

Support is required for at least two simultaneously active VBR or CBR connections for basic ATM signaling and management.

Support for at least six VBR/CBR connections is needed for ATM adapters that support multimedia or other traffic that demands QoS.

20.35. ATM adapter supports traffic shaping
Required

The ATM adapter must support and enforce all the traffic-shaping rules specified for each service type it supports, including CBR, VBR, ABR, and UBR.

This includes enforcement of peak cell rate on UBR virtual circuits as described in the following requirement.

20.36. ATM adapter enforces PCR on UBR virtual circuits
Required

ATM adapters can be used to connect the router, remote access, and content servers to the public ATM network. High-speed residential broadband access networks such as ADSL and cable modem can enable direct connection, using an ATM virtual circuit, from home or small office computers to these servers.

When the Windows Dial-Up Networking user interface is used to connect from the home or SOHO computer to the remote router or server, a PPP link is established over an ATM virtual circuit, using the UBR service type. When creating the UBR virtual circuit, Windows will request upstream and downstream line rates, or Peak Cell Rates (PCR), equal to the upstream and downstream line rates provided for the user. Windows uses the ATM Interim Local Management Interface (ILMI) protocol to obtain information such as the user's line rates provided by the public network.

To avoid packet loss and ensure efficient network utilization, it is critical that all ATM adapters, integrated ATM/ADSL adapters, and ATM/cable modem adapters enforce requested PCR on UBR virtual circuits.

Because any ATM adapter might be installed in a server to which clients connect through the public network, this requirement applies to all ATM adapters.

20.37. ATM adapter and driver support dynamic link speed configuration

Required

When connected to a residential broadband network, ATM adapters must restrict the aggregate transmission rate across all active virtual circuits so that it does not exceed the upstream bandwidth provided by the residential broadband network.

Therefore, all integrated ATM/ADSL adapters and ATM/cable modem adapters must support aggregate shaping of upstream bandwidth, according to the provisioned upstream bandwidth, or the trained bandwith, whichever is lower. Some implementations can support rate adoption and lower-than-provisioned rates might be negotiated because of poor line conditions. In addition, because any 25 Mbps ATM adapter might be used to connect to an ADSL network by way of an external ADSL modem, it is required that all 25 Mbps ATM adapters support this as well. This support is optional for ATM adapters with line rates higher than 25 Mbps.

The Windows ATM Call Manager uses ILMI to query the public network to determine the maximum line rates provisioned for incoming and outgoing traffic. The Call Manager then uses the OID_GEN_CO_LINK_SPEED NDIS request (in SET mode) to set the line rate for both incoming and outgoing traffic, within which the adapter can shape the aggregate of all ATM traffic.

20.38. ATM adapter supports OAM

Recommended

Operation and maintenance (OAM) is needed for diagnostics.

This capability is recommended for Client systems. If implemented, it is required that received F4 and F5 loopback OAM cells must be responded to. Support for other layers, F1–F3, is optional.

20.39. ATM adapter supports buffer chaining (Tx + Rx)

Recommended

This feature is needed for large packets.

This capability is recommended for Client systems, but is required for Server systems.

ADSL Requirements

This section summarizes requirements for ADSL hardware.

Support is provided in the Windows 98 and Windows NT operating systems for ADSL adapters and external ADSL modems, such as those using USB, which provide a faster method for moving data over regular phone lines.

Recommended: Manufacturers should participate in developing standards for this technology and review the white paper jointly developed by over 30 leading ADSL vendors, *An Interoperable End-to-End Broadband Service Architecture over ADSL System, Version 3.0,* which discusses end-to-end service interoperability over ATM over ADSL. This paper is available at http://www.microsoft.com/hwdev/devdes/publicnet.htm. The core idea of this white paper (PPP over ATM over ADSL) has been adopted by the ADSL Forum.

20.40. ADSL device is implemented as an integrated ADSL modem
Recommended

An ADSL modem should be implemented. This means the integration of the ADSL modem, higher layer transmission and media access functions on a single network device. A typical implementation is an integration of ADSL modem and an ATM interface on a single PCI network adapter. Another example is a similar device that connects to the PC using the USB or IEEE 1394 buses.

An external ADSL modem, other than IEEE 1394 or USB, should have an ATM interface for the ADSL modem to PC connection. In addition, an Ethernet interface can be included.

20.41. Integrated ADSL modem meets PC 99 network adapter requirements
Required

For the integrated ADSL modem, the following requirements must be met as defined in "Network Adapter Requirements" earlier in this chapter:

- 20.10, "Adapter automatically senses presence of functional network connection"
- 20.12, "Adapter supports quadword or smaller buffer alignment for receive and byte buffer alignment for send"
- 20.13, "Adapter communicates with driver across any bridge"
- 20.17, "PCI network adapters are bus masters"
- 20.18, "Device Bay-type network adapter meets PC 99 requirements"
- 20.19, "USB or IEEE 1394 device meets specifications for network communications devices"

For the integrated ADSL modem exposing ATM interface, the following requirements must be met as defined in "Network Adapter Requirements" earlier in this chapter.

- 20.7, "Adapter uses NDIS 5.0 miniport driver" for connection-oriented media

For the integrated ADSL modem exposing Ethernet interface, the following requirements must be met as defined in "Network Adapter Requirements" earlier in this Chapter.

- 20.7, "Adapter uses NDIS 5.0 miniport driver"
- 20.14, "Adapter supports filtering for at least 32 multicast addresses"
- 20.15, "Adapter and driver support promiscuous mode"

20.42. ATM/ADSL solution is implemented for integrated ADSL modems
Recommended

An integrated ADSL modem should expose ATM to the operating system. For ATM-specific requirements when an ATM/ADSL solution is implemented, see the requirements in "ATM Adapter Requirements" earlier in this chapter. This should comply with the PPP-over-ATM architecture discussed earlier.

Note: ATM/ADSL is required for UADSL implementations In the current market, both ATM/ADSL-based and Ethernet/ADSL-based implementations provide full-rate ADSL services. The PPP/ATM/ADSL implementation referred to in this section is required to support Universal ADSL-based services that will be available to residential markets within the next few years.

20.43. ADSL modem supports DMT line encoding
Recommended

The ADSL modem should support Discrete Multi-tone (DMT) line encoding, which is recognized as the industry standard for ADSL by ANSI as the T1.413 Issue 2 specification, and also by the Universal ADSL Working Group (UAWG). For information, see http://www.uawg.org.

Note: DMT is required for UADSL implementations. The UAWG has adopted DMT specified by T1.413, with modifications being made for it to work in a splitterless environment.

20.44. ADSL modem supports rate adaptation

Recommended

On a rate-adaptive ASDL (RA-ADSL), the downstream and upstream data rates should be independently set either by an automatic adaptive algorithm or by manual selection.

RA-ADSL provides the capability to optimize the transmission speed and performance over a range of telephone-line loop distances. Adaptive channel equalization ensures more robust performance in the presence of channel impairments and narrow-band interference.

This also helps telephone companies to provide RA-ADSL access on their existing networks. RA-ADSL products can be provided on many telephone lines without costly and time-consuming network upgrades.

IrDA Requirements for Network Communications

The interface between Infrared Data Association (IrDA) hardware (framers) and the Windows IrDA stack is through NDIS 5.0 miniport drivers that adhere to the conventions defined in *Infrared Extensions to the NDIS Version 4.0 Functional Specification*. The Windows IrDA stack expects that hardware and NDIS drivers deal with framing, transparency, and error detection, as well as supporting media-sense and speed-change commands. Miniport drivers are responsible for discarding incoming frames with bad cyclic redundancy checks. These frames must never be forwarded to the protocol.

Although the IrDA protocol stack in Windows NT 5.0 is different from the one on Windows 98, the Windows NT 5.0 DDK should be used for driver development for both platforms. The Windows NT 5.0 IrDA protocol stack imposes stricter requirements on drivers than the protocol stack on Windows 98.

20.45. Infrared device meets PC 99 network adapter requirements

Required

The following requirements must be met as defined in "Network Adapter Requirements" earlier in this chapter:

- 20.7, "Adapter uses NDIS 5.0 miniport driver"
- 20.12, "Adapter supports quadword or smaller buffer alignment for receive and byte buffer alignment for send"
- 20.13, "Adapter communicates with driver across any bridge"
- 20.17, "PCI network adapters are bus masters"
- 20.18, "Device Bay-type network adapter meets PC 99 requirements"
- 20.19, "USB or IEEE 1394 device meets specifications for network communications devices"

20.46. Infrared device supports both FIR and SIR

Required

All infrared devices must comply with approved IrDA specifications, including support for SIR and FIR data devices.

20.47. IrDA hardware supports unattended driver installation

Required

FIR Plug and Play hardware must report a unique Plug and Play ID that matches the combination of the chip set, transceiver, and any other system-specific parameters, in order for the operating system to find and install the correct INF and the associated driver for the IrDA hardware.

In the best case, the IrDA hardware has only one Plug and Play ID associated INF file, and a miniport driver that can autodetect the transceiver type and other system-specific parameters. This enables the installation and configuration of the hardware and the driver without user intervention.

In other cases, for example, where the miniport driver cannot autodetect the transceiver type or any other system-specific parameters, a unique Plug and Play ID for each combination of the chip set and the transceiver type must be reported. Also, the vendor must provide for each combination an associated driver and INF file describing the configuration parameters.

Home Networking Requirements

Home networking is a significant new area with different constraints than conventional networking and few products currently on the market. Currently, important applications are sharing Internet access and peripherals, but new applications might develop.

Because this networking area is so new, it is appropriate that this guide set a standard for the quality of the user experience with as few hard technical standards as possible, allowing time for a marketplace to develop.

A Consumer PC system must include a modem or other Internet access device. However, in a home with networked PCs, some kind of gateway is desirable to enable simultaneous access to the Internet from multiple clients. Such a gateway can be implemented in PC software or embedded in a non-PC networking solution. These gateway functions can include networking services such as DHCP Proxy, NAT Router, and Firewall. All the PCs in this scenario must have a network adapter for peer-to-peer connectivity for accessing the Internet link provided by the home gateway.

Although there is no explicit speed requirement for home networking media, designers should recognize that higher bandwidth supports greater capabilities. For example, to support MPEG-2 playback, 1.5 Mbps is needed.

20.48. Home networking adapter meets PC 99 network adapter requirements

Required

The following requirements must be met as defined in "Network Adapter Requirements" earlier in this chapter:

- 20.7, "Adapter uses NDIS 5.0 miniport driver"
- 20.10, "Adapter automatically senses presence of functional network connection"
- 20.11, "Adapter automatically senses transceiver type"
- 20.12, "Adapter supports quadword or smaller buffer alignment for receive and byte buffer alignment for send"
- 20.13, "Adapter communicates with driver across any bridge"
- 20.18, "Device Bay-type network adapter meets PC 99 requirements"
- 20.19, "USB or IEEE 1394 device meets specifications for network communications devices"

Home networks will differ from traditional, homogeneous business networks because they are expected to incorporate many types of media and link layer protocols spanning a smaller number of hosts. Even though media types and link layer protocols will be optimized with respect to features such as bandwidth and isochrony, it is important that IP protocols be supported in every case in order to enable traditional PC-to-PC networking.

The following features are recommended:

- 20.14, "Adapter supports filtering for at least 32 multicast addresses"
- 20.15, "Adapter and driver support promiscuous mode," for network media that confine network traffic signals within a single home
- 20.17, "PCI network adapters are bus masters"

20.49. Home networking uses appropriate media

Recommended

For new construction or remodeling, wiring or fiber cable capable of at least 100 Mbps over a distance of at least 100 meters should be implemented. An example would be using 100BaseT on CAT5 wiring.

Networking media solutions that do not require new wiring are also needed. Alternatives for these "no new wires" technologies include new uses for wireless technologies and for existing in-home power wiring, phone wiring, and cable TV (coaxial) wiring. There are organizations working on developing standards for home networking media, including the Home Phoneline Networking Alliance and the Home Radio Frequency Working Group.

All home networking implementations should comply with Federal Communication Commission (FCC) or regional regulatory requirements for use within residential environments.

20.50. Home networking media supports IP
Required

Any home networking media must support IP, yet not preclude the use of other protocols.

PC 99 Design for Network Communications

This section summarizes requirements related to the PC 99 design initiatives defined in Part 1 of this guide.

Plug and Play and Bus Design for Network Communications

The items in this section are requirements for Plug and Play capabilities.

20.51. Each device has a unique Plug and Play device ID
Required

For a system-board device, there must be a Plug and Play device-specific ID.

Each bus-specific device must provide Plug and Play device IDs in the manner required for the bus it uses, as defined in Part 3 of this guide. For example, a PCI device also must comply with PCI 2.1 requirements and provide a Subsystem ID and Subsystem Vendor ID as defined in Chapter 9, "PCI."

20.52. Dynamic resource configuration is supported for all devices
Required

The system must be capable of automatically assigning, disabling, and relocating the resources used by a network device as necessary, using the method required for the related bus class. When an end user changes a device or adds it to the system, setting resource assignments must not require changing jumpers or switches on either the adapter or the system board. In the event of an irreconcilable conflict with other devices on the system, the system must be able to disable the device to prevent the system from stalling.

20.53. Plug and Play capabilities support multiple adapters

Required

For network communications devices, the Plug and Play IDs and resource support must be sufficient to automatically support the addition of multiple network communications devices to the system. This is true both for the same and different types of network communications devices.

20.54. All resource settings are reported in the user interface

Required

All resource settings must be viewable in Device Manager and in the adapter properties dialog boxes. All resource settings that can be changed by the user must be changed using the standard Windows user interface, not by way of INI files or other setting files.

This implies that all device resources must be set and read through the standard interfaces provided by the bus on which the device resides. For PCI devices, this interface is the PCI configuration space. Also, device parameter settings must be stored in the registry.

Power Management for Network Communications

This section summarizes the specific power management requirements for network communications devices.

20.55. Device complies with device class power management reference specification

Required

The *Network Device Class Power Management Reference Specification, Version 1.0a*, provides definitions of the OnNow device power states (D0–D3) for network adapters. The specification also covers the device functionality expected in each power state and the possible wake-up event definitions for the class.

Network communications devices that directly attach to the PC over USB, PCI, and IEEE 1394 must comply with this specification.

20.56. Device supports wake-up events

Required

This requirement applies specifically to the following network communications devices and their associated NDIS 5.0 miniport drivers:

- Ethernet and Token Ring network adapters
- Integrated DOCSIS cable modems
- Other devices that transfer IEEE 802.3/DIX Ethernet framed packets

Network Device Class Power Management Reference Specification does not yet define wake-up mechanisms for ISDN adapters or any network communications adapter that uses ATM signaling.

The system must be capable of wake-up from a lower power state based on network events that are specified by the local networking software. This capability yields the result that any standard Windows network access—such as connections to shared drives and WinSock connections, plus service and management applications—can wake a system from lower power states transparently.

As defined in *Network Device Class Power Management Reference Specification,* a network adapter and its driver must support wake-up on receipt of a network wake-up frame. Support for wake-up on detection of a change in the network link state or on receipt of a Magic Packet event is optional. Implementation details are described in the "Network Wake-up Frames" and "Network Wake-up Frame Details" sections of *Network Device Class Power Management Reference Specification, Version 1.0a* and in the Windows NT 5.0 DDK. See also the implementation notes at http://www.microsoft.com/hwdev/devdes/netpm.htm.

The packet patterns that define the wake-up frames are provided to the NDIS 5.0 miniport driver by the operating system. To enable Wake-On-LAN capability for basic networking scenarios, the network adapter must be capable of storing information describing a minimum of three wake-up packet patterns, and it must be able to recognize wake-up packets based on pattern matches anywhere in the first 128 bytes of the packet.

Network adapters should be capable of storing information describing at least five wake-up packet patterns to enable more advanced applications, such as Wake-On-LAN capability on multi-homed systems or on receipt of multicast packets, in addition to the above basic scenarios.

PCI-based network adapters must support the generation of a power management event (PME# assertion) from the D3 cold device state if the physical layer technology is generally capable of operating under the voltage and current constraints of the D3 cold device state. For example, 100baseTX adapters can meet this requirement based on the state of the art available in mid-1998. 1000baseSX or 1000baseLX (gigabit Ethernet using optical fiber media) cannot meet this requirement because of the power required to operate the optical physical layer.

Device Drivers and Installation for Network Communications

This section summarizes requirements for network communications device drivers, in addition to the requirements for using an NDIS 5.0 miniport driver as defined in "System Requirements for Network Communications" earlier in this chapter.

20.57. Device drivers and installation meet PC 99 requirements

Required

The manufacturer does not need to supply a driver if a PC 99-compliant driver provided with the operating system can be used. If the manufacturer supplies a driver, it must comply with requirement 3.16, "Device driver and installation meet PC 99 requirements." The basic requirements include driver support for unattended installation and Help file support if special driver parameters are used.

For exceptions to unattended installation requirements for ISDN adapters, see "ISDN Requirements" earlier in this chapter.

20.58. Driver works correctly with Microsoft network clients and protocols

Required

This includes the 32-bit Microsoft client and NetWare-compatible clients provided with Windows, whether connected to a Windows NT-based server, a Novell NetWare 3.*x* or 4.*x* server, or a Windows-based peer server. In all cases, this includes connections using Microsoft TCP/IP, IPX/SPX-compatible protocol, and NetBEUI in local area networks and TCP/IP in wide area networks.

20.59. NDIS miniport driver makes only NDIS library calls or WDM system calls

Required

A miniport driver must make calls only to the NDIS library or the WDM system. This results in binary compatibility of the driver between Windows 98 and Windows NT 5.0.

NDIS conformance must be validated over a single network connection and multiple connections. For Windows NT, this must be validated on a multiprocessor system as part of compliance testing.

20.60. NDIS 5.0 driver uses new INF format

Required

All network components must use the INF format defined in the Windows NT 5.0 DDK.

Note: For Windows NT 5.0, there will be no legacy INF support and no satisfactory upgrade option for OEM components created for Windows NT 4.0.

Network Communications References

The following represents some of the references, services, and tools available to help build hardware that is optimized to work with Windows operating systems.

1997 Version of National ISDN Basic Rate Interface Terminal Equipment Generic   Guidelines, Document Number SR-3888
   Phone: (800) 521-2673 (North America)
                (908) 699-5800 (Outside North America)
   http://www.bellcore.com

An Interoperable End-to-End Broadband Service Architecture over ADSL System
   http://www.microsoft.com/hwdev/publicnet/

ATM: The New Paradigm for Internet, Intranet & Residential Broadband Services   and Applications, T. Kwok
   Prentice Hall, 1998; ISBN 0-13-107244-7

ATM User-Network Interface Specification, Version 3.1
   Prentice Hall; 1995ISBN 0-13-393828-X
   http://www.atmforum.com

Device Bay Interface Specification, Version 1.0
   http://www.device-bay.org

DVB/DAVIC (Digital Video Broadcasting/Digital Audio-Visual Council)
   http://www.dvb.org
   http://www.davic.org

ETSI (European Telecommunication Standards Institute)
   http://www.etsi.fr

Home Phoneline Networking Alliance
   http://www.homepna.org

Home Radio Frequency Working Group
   http://www.homerf.org

ITU (International Telecommunication Union)
   http://www.itu.ch

IEEE 802.14 Cable TV Working Group
   http://www.walkingdog.com/

Infrared Extensions to the NDIS Version 4.0 Functional Specification
MCNS *Data-Over-Cable Service Interface Specifications*
   http://www.cablemodem.com/

Microsoft Windows 95 DDK, Windows 98 DDK, and Windows NT 5.0 DDK
   MSDN Professional membership

NDIS and Windows networking white papers
   http://www.microsoft.com/communications/
   http://www.microsoft.com/hwdev/network/

Network Device Class Power Management Reference Specification, Version 1.0a
   http://www.microsoft.com/hwdev/onnow.htm

Network PC System Design Guidelines, Version 1.0b
   http://www.microsoft.com/hwdev/netpc.htm
   http://www.intel.com/businesscomputing/netpc/netpc.htm

USB specifications
   Phone: (503) 264-0590
   Fax: (503) 693-7975
   http://www.usb.org

Checklist for Network Communications

If a recommended feature is implemented, it must meet the requirements for that feature as defined in this document.

Consumer	Office	Mobile	Workstation	Entertainment
20.1. PC system includes network adapter				
Recommended	*Required*	*Recommended*	*Required*	*Recommended*
20.2. PC system includes internal or external ISDN device				
Recommended*	*Recommended*	*Recommended*	*Recommended*	*Recommended**
20.3. PC system includes cable modem				
Recommended*	*Recommended*	*Recommended*	*Recommended*	*Recommended**
20.4. PC system includes ATM adapter				
Optional	*Optional*	*Optional*	*Optional*	*Optional*
20.5. PC system includes ADSL adapter				
Recommended*	*Recommended*	*Recommended*	*Recommended*	*Recommended**
20.6. PC system includes satellite or broadcast receiver with NDIS driver				
Recommended*	*Recommended*	*Recommended*	*Recommended*	*Recommended**
20.7. Adapter uses NDIS 5.0 miniport driver				
Required				
20.8. Intermediate NDIS 5.0 miniport driver is deserialized				
Recommended				
20.9. Full-duplex adapter automatically detects and switches to full duplex mode				
Required				
20.10. Adapter automatically senses presence of functional network connection				
Required				
20.11. Adapter automatically senses transceiver type				
Required				
20.12. Adapter can transmit packets from buffers aligned on any boundary				
Required				
20.13. Adapter communicates with driver across any bridge				
Required				
20.14. Adapter supports filtering for at least 32 multicast addresses				
Required				

20.15. Adapter and driver support promiscuous mode
Required

20.16. Adapter is compatible with remote new system setup capabilities if used as a boot device
Required

20.17. PCI network adapters are bus masters
Required

20.18. Device Bay-type network adapter meets PC 99 requirements
Required

20.19. USB or IEEE 1394 device meets specifications for network communications devices
Recommended

20.20. Network adapter and driver supports priority for IEEE 802-style networks
Recommended

20.21. Internal ISDN device meets PC 99 network adapter requirements
Required

20.22. Internal ISDN device supports synchronous HDLC framing
Required

20.23. NDIS interface and driver support raw unframed synchronous B channel I/O
Required

20.24. ISDN driver supports unattended installation, with limitations
Required

20.25. ISDN device with U-interface includes built-in NT-1 capability
Recommended

20.26. ISDN device includes software-selectable terminating resistors
Required

20.27. Device is implemented as an integrated cable modem
Recommended

20.28. Integrated cable modem meets PC 99 network adapter requirements
Required

20.29. Integrated cable modem exposes an ATM or Ethernet interface
Required

20.30. ATM adapter meets PC 99 network adapter requirements
Required

20.31. ATM adapter supports a minimum number of simultaneous connections
Required

20.32. ATM adapter supports all service types defined by the ATM Forum
Recommended

20.33. ATM adapter supports UBR service type
Required

20.34. ATM adapter supports a minimum number of simultaneously active VBR or CBR connections
Required

20.35. ATM adapter supports traffic shaping
Required

20.36. ATM adapter enforces PCR on UBR virtual circuits
Required

20.37. ATM adapter and driver support dynamic link speed configuration
Required

20.38. ATM adapter supports OAM
Recommended

20.39. ATM adapter supports buffer chaining (Tx + Rx)
Recommended

20.40. ADSL device is implemented as an integrated ADSL modem
Recommended

20.41. Integrated ADSL modem meets PC 99 network adapter requirements
Required

20.42. ATM/ADSL solution is implemented for integrated ADSL modems
Recommended

20.43. ADSL modem supports DMT line encoding
Recommended

20.44. ADSL modem supports rate adaptation
Recommended

20.45. Infrared device meets PC 99 network adapter requirements
Required

20.46. Infrared device supports both FIR and SIR
Required

20.47. IrDA hardware supports unattended driver installation
Required

20.48. Home networking adapter meets PC 99 network adapter requirements
Required

20.49. Home networking uses appropriate media
Recommended

20.50. Home networking media supports IP
Required

20.51. Each device has a unique Plug and Play device ID
Required

20.52. Dynamic resource configuration is supported for all devices
Required

20.53. Plug and Play capabilities support multiple adapters
Required

20.54. All resource settings are reported in the user interface
Required

20.55. Device complies with device class power management reference specification
Required

20.56. Device supports wake-up events
Required

20.57. Device drivers and installation meet PC 99 requirements
Required

20.58. Driver works correctly with Microsoft network clients and protocols
Required

20.59. NDIS miniport driver makes only NDIS library calls or WDM system calls
Required

20.60. NDIS 5.0 driver uses new INF format
Required

Note: For items marked with an asterisk (*) symbol, it is recommended to implement an ADSL modem, ISDN device, or home networking adapter.

C H A P T E R   2 1

Printers

This chapter presents the PC 99 requirements and recommendations for printers. Printers and other devices attached to parallel ports should be capable of high-speed, bi-directional data transfers. The design criteria for parallel devices follows the design criteria for parallel ports as described in "Parallel Port Requirements" in Chapter 13, "I/O Ports and Devices."

The goal of the PC 99 requirements for printers and parallel ports is to ensure the following:

- Maximum speed for transfer of parallel data between the system and the peripheral
- A true Plug and Play experience for users

Contents

Basic Printer Features

This section summarizes the basic PC 99 hardware requirements for printers.

21.1. IEEE 1394 printer meets PC 99 requirements for IEEE 1394
Required
The IEEE 1394 bus is recommended for support of fast, high-density data transfer. For information about implementing IEEE 1394 for PC 99, see Chapter 8, "IEEE 1394."

21.2. USB printer meets PC 99 requirements for USB devices
Required
The USB bus is a requirement for PC 99 systems. USB printers must conform to the *Universal Serial Bus Device Class Definition for Printing Devices, Version 1.0* or later. For information about implementing USB for PC 99, see Chapter 7, "USB."

21.3. IEEE 1284 printer supports compatibility mode, nibble mode, and ECP, compliant with IEEE 1284-I
Required
Parallel peripherals must implement nibble mode and compatibility mode. Nibble mode provides a means of transferring the identification string from the peripheral to the system. Compatibility mode provides backward compatibility with non-Plug and Play systems that do not support more advanced modes.

A parallel device complies with IEEE 1284 if it meets the required criteria documented in the IEEE 1284 specification, *Standard Signaling Method for a Bi-directional Parallel Peripheral Interface for Personal Computers.* For a parallel device that connects to a PC 99 system, the minimum requirement is IEEE 1284 Level I compliance, which implements the compatibility and nibble modes as specified in IEEE 1284 and defines the mechanical and electrical specifications of the peripheral.

An IEEE 1284-I–compliant peripheral uses the standard IEEE 1284-B connector. In all cases, ensure that there is enough space between the connectors and the surrounding enclosure to allow for a mating connector, a connector shell, and a latch assembly.

For more information about the electrical specifications for IEEE 1284-I–compliant peripherals, refer to the IEEE 1284 specification.

For more information, see "Parallel Port Requirements" in Chapter 13, "I/O Ports and Devices," which defines the following related parallel port requirements:

- Support for compatibility, nibble mode, and extended capabilities port (ECP) protocols compliant with IEEE 1284-1994
- Port connectors compliant with IEEE 1284-I, at a minimum
- Support for ECP mode compliant with IEEE 1284

Recommended: ECP mode enabled by default.

21.4. IEEE 1284 printer meets IEEE 1284-II requirements
Recommended
Peripheral devices capable of handling a high-speed data rate should comply with the mechanical, electrical, and protocol specification of IEEE 1284-II. In particular, such devices should support the protocols of the IEEE 1284-II ECP mode and should use the IEEE 1284-C connector.

21.5. ECP printer works correctly when ECP mode is turned off
Required
This ensures that the user has correct printing support when ECP mode is not in use.

21.6. IEEE 1284 hardware supports error notification
Required
The following minimum errors must be reported individually by the hardware:

- Out of paper
- Paper jam
- Load other paper size

21.7. Daisy-chained parallel port device is Plug and Play capable
Required
The daisy-chained parallel port device must be capable of answering Plug and Play requests from the host. Because of end-of-chain issues with IEEE 1284 and IEEE 1284.3, it is also required that all pass-through devices comply with IEEE 1284.3.

21.8. Network printer supports standard port monitor
Required
Network-connected printers must support TCP/IP standards such as Line Printer Remote (LPR) and Line Printer Daemon (LPD) (RFC 1179), Port 9100 printing (raw mode printing), or both types.

PC 99 Printer Design

This section summarizes requirements related to the PC 99 design initiatives in Part 1 of this guide.

Plug and Play for Printers

The items in this section are requirements for Plug and Play capabilities. For Plug and Play requirements related to the printer port on the PC, see Chapter 13, "I/O Ports and Devices," or the related bus port requirements in Part 3 of this guide.

21.9. Plug and Play support implemented for all supported buses
Required

Complete Plug and Play support must be implemented for all buses that the device supports. Each print device must have a unique Plug and Play ID. For information about the Plug and Play requirements, see the related bus-class definitions in Part 3 of this guide.

21.10. Peripheral device meets IEEE 1284 requirements
Required

Recommended: Support CompatibleID key in the device identification string.

These requirements include a Plug and Play device ID as described in the IEEE 1284 specification. For more information, see "Parallel Port Requirements" in Chapter 13, "I/O Ports and Devices."

Device Drivers and Installation for Printers

This section summarizes device driver requirements for printers. The items in this section are requirements for all PC 99 systems.

21.11. Printer INF file and installation meet PC 99 requirements
Required

Each device requires a printer INF file for both Windows and Windows NT Workstation operating systems. The manufacturer does not need to supply a printer INF file if a standard printer INF file provided with the operating system can be used.

If the manufacturer provides an INF file, it must be complete and free of errors. This INF file must comply with the printer-specific extensions listed in the Windows 95 DDK and Windows NT 5.0 DDK.

If the manufacturer supplies an INF file or another file, it must comply with requirement 3.16, "Device driver and installation meet PC 99 requirements."

21.12. Driver correctly reports device capabilities
Required

The driver must correctly support the DEVMODE structure as defined in the
Windows 95 DDK and Windows NT 5.0 DDK.

21.13. Driver supports error notification
Required

At a minimum, the device driver must support notifying the user of errors reported
by the hardware.

21.14. Driver supports ICC color management
Required

Windows 95/98 and Windows NT operating systems support using color profiles
that comply with the International Color Consortium (ICC) Profile Format
specification. The device either must create sRGB output or must embed the ICC
profile for the newly acquired image into the image file to identify the color-space
information for that image.

For contact information on device profiles, see the references at the end of this
chapter. The Integrated Color Management (ICM) APIs and functionality for
Windows and Windows NT operating systems are described in the Microsoft
Platform SDK and the Windows NT 5.0 DDK.

Color-capable devices such as desktop monitors, printers, scanners, still-image
cameras, LCDs, color plasma displays, or other flat-panel devices are required to
install one or more ICC profiles for ICM. Providing a monitor color-calibration
utility is recommended for generating, editing, and installing ICC profiles. The
sRGB profile is distributed with Windows 98 and Windows NT 5.0. Devices that
are sRGB compliant are not required to associate a profile.

21.15. Port monitor software meets DDK guidelines
Required

Any port monitor or language monitor software provided with a print device must
accurately report errors and support bi-directional communication as defined in the
Windows 95 DDK and Windows NT 5.0 DDK.

21.16. Driver supports point-and-print network installation
Required

The user must be able to install a driver from a server by double-clicking on the
printer share.

21.17. Device is available immediately following installation

Required

The user must not have to restart the system after device installation in order to print.

21.18. Device supports accurate printable regions

Required

The printable regions that can be selected in the user interface must be accurately supported in the actual print output.

21.19. Driver supports required DDIs

Required

Printer drivers must ensure that print commands from Win32-based applications are executed correctly on the specified printer or plotter. Because Win32 APIs are not hardware-specific, it is the job of each printer driver to interpret the commands for its specific hardware.

For Windows NT drivers, the required device driver interfaces (DDIs) are defined in the Windows NT 5.0 DDK.

For Windows 98 drivers, this requirement includes correct support of all features advertised for the device, plus required support for Windows features. The required DDIs for Windows 98 drivers are listed in the "Printer Driver Overview" section of the Windows 95 DDK. This includes the following support, in addition to other support defined in the DDK:

- TrueType glyph indexes
- Big fonts (those that require more than 64K to express)
- Enhanced metafile (EMF) spooling
- Bezier curve output
- Services from the Windows device-independent bitmap (DIB) engine

21.20. Driver is based on Unidriver

Recommended

Microsoft provides a universal printer driver (Unidriver) that is capable of carrying out requests such as printing text, rendering bitmaps, or advancing a page on most printer types. To build a driver for a particular printer, a developer builds a minidriver. This minidriver accepts requests from the Graphics Device Interface (GDI) and then, in most cases, passes the request to the Unidriver along with information that describes the capabilities, commands, and resident fonts of the particular printer. For more information, see the Windows NT 5.0 DDK and Windows 95 DDK.

Printer References

The following represents some of the references, services, and tools available to help build hardware that is optimized to work with Windows operating systems.

ICC Profile Format Specification, Version 3.4,
   International Color Consortium
   http://www.color.org

Microsoft Windows 95 DDK, Windows 98 DDK, Windows NT 5.0 DDK, and
     Microsoft Platform SDK
   MSDN Professional membership

*Standard Signaling Method for a Bi-directional Parallel Peripheral Interface
     for Personal Computers (*IEEE 1284 specification)
   ASK*IEEE
   Phone: (800) 949-4333
   Fax: (212) 310-4091

   Global Engineering Documents
   Fax: (303) 397-2740
   Phone: (800) 854-7179 (US)
             (613) 237-4250 (Canada)
             (303) 792-2181 (Outside North America)

Universal Serial Bus Device Class Definition for Printing Devices, Version 1.0
   http://www.usb.org

White papers on printing under Microsoft operating systems
   http://www.microsoft.com/hwdev/print/

Checklist for Printers

If a recommended feature is implemented, it must meet the PC 99 requirements for that feature as defined in this document.

21.1. IEEE 1394 printer meets PC 99 requirements for IEEE 1394
Required

21.2. USB printer meets PC 99 requirements for USB devices
Required

21.3. IEEE 1284 printer supports compatibility mode, nibble mode, and ECP, compliant with
IEEE 1284-I
Required

21.4. IEEE 1284 printer meets IEEE 1284-II requirements
Recommended

21.5. ECP printer works correctly when ECP mode is turned off
Required

21.6. IEEE 1284 hardware supports error notification
Required

21.7. Daisy-chained parallel port device is Plug and Play capable
Required

21.8. Network printer supports standard port monitor
Required

21.9. Plug and Play support implemented for all supported buses
Required

21.10. Peripheral device meets IEEE 1284 requirements
Required

21.11. Printer INF file and installation meet PC 99 requirements
Required

21.12. Driver correctly reports device capabilities
Required

21.13. Driver supports error notification
Required

21.14. Driver supports ICC color management
Required

21.15. Port monitor software meets DDK guidelines
Required

21.16. Driver supports point-and-print network installation
Required

21.17. Device is available immediately following installation
Required

21.18. Device supports accurate printable regions
Required

21.19. Driver supports required DDIs
Required

21.20. Driver is based on Unidriver
Recommended

C H A P T E R   2 2

Digital Still Image Peripherals

This chapter presents the PC 99 requirements and recommendations for digital still image peripherals, including but not limited to digital cameras and scanning devices such as sheet-fed, flatbed, handheld, film, and fingerprint scanners.

For an overview of the design and market issues, see "Scanner and Digital Still Image Device Issues" in Chapter 2, "PC 99 Design Initiatives."

Contents

Digital Still Image Devices Basic Features

This section summarizes the basic PC 99 hardware requirements for scanners and digital cameras.

22.1. Device uses PC 99 compatible port connection with USB or IEEE 1394 connection

Required

Recommended: USB or IEEE 1394 connection for all imaging peripherals.

PC 99 requires the use of USB for digital cameras that generate uncompressed images of more that 800K pixels. Although digital cameras maintain a serial port interface for mainstream connectivity, the low bandwidth and slow throughput provided by the serial port do not match the bandwidth requirements of megapixel cameras. This creates a less than satisfactory user experience while transferring images to the PC.

Multiple device support, adequate bandwidth, and ease of connectivity make USB and IEEE 1394 excellent conduits for both digital cameras and scanners.

All scanners and digital cameras must use PC 99 compatible port connections. No proprietary solutions are acceptable for PC 99.

22.2. Icons provided for port and peripheral connectors

Required

To ensure proper connection by the user between cable and connector, an icon or text identifier must be added to any external connector, using vendor designs or the icons provided in Appendix A, "Icons." The icon can be molded into or printed on the plastic, either by stamping or by affixing as a permanent sticker.

22.3. Device supports ICC color management

Required

Windows and Windows NT Workstation operating systems support using color profiles that comply with the International Color Consortium (ICC) Profile Format specification. All color output from still-image devices must be defined. The device either must create sRGB output or must embed the ICC profile for the newly acquired image into the image file to identify the color-space information for that image.

For contact information on device profiles, see the references at the end of this chapter. The Integrated Color Management (ICM) APIs and functionality for Windows and Windows NT operating systems are described in the Microsoft Platform SDK and the Windows NT 5.0 DDK.

Color-capable devices such as desktop monitors, printers, scanners, still-image cameras, LCDs, color plasma displays, or other flat-panel devices are required to install one or more ICC profiles for ICM. Providing a monitor color-calibration utility is recommended for generating, editing, and installing ICC profiles. The sRGB profile will be distributed in Windows 98 and Windows NT 5.0.

22.4. IR device meets PC 99 IR requirements
Required
For imaging devices that include an IR interface, all IR hardware must at minimum comply with the IR requirements defined in Chapter 13, "I/O Ports and Devices."

22.5. Digital still image device with an IR interface uses Fast IR
Required
To improve the customer experience, the use of fast transfer mechanisms is advocated for digital cameras. It is required that every digital camera with an IR interface support Fast IR and include backward compatibility to Serial IR.

22.6. Digital still image device with an IR interface provides a secondary PC interface
Required
Devices with an IR interface must provide a secondary interface using a PC 99 compatible port connection, such as USB or IEEE 1394, to ensure that the widest variety of imaging devices are available for use with PC applications. A non-megapixel IR camera that ships with an IR serial interface adapter complies with this requirement.

Although IR interfaces are increasingly available in desktop systems and especially mobile PCs, many PCs do not include an IR interface.

22.7. SCSI device meets PC 99 SCSI requirements
Required
All SCSI hardware must comply with the requirements defined in Chapter 11, "SCSI." This ensures complete Plug and Play capabilities with SCSI hardware. For example, a user must be able to attach any SCSI peripheral on a system with SCSI support. The operating system should automatically recognize it, load and initialize the appropriate drivers, and then make the device available for use.

22.8. SCSI device attaches to any PC 99-compliant SCSI controller
Required

All SCSI scanners must be able to attach successfully to any SCSI controller that meets the PC 99 requirements defined in Chapter 11, "SCSI."

22.9. USB device meets PC 99 USB requirements
Required

All USB hardware must comply with the requirements defined in Chapter 8, "USB," which includes the USB specifications for specific device types. This ensures complete Plug and Play capabilities with USB hardware and meets all the core and device requirements for USB. For example, a user must be able to dynamically attach any USB peripheral to any USB connector. The operating system should automatically recognize the device, load and initialize the appropriate drivers, and then make the device available for use.

Compliance with the related USB imaging device class specification becomes a requirement for PC 99 when the revision number of that specification reaches version 1.0.

The USB Imaging Class Device Working Group is working on three specifications that, together, will comprise the category "USB Imaging Class," as referred to in *PC 98 System Design Guide.* The first of the specifications expected to reach revision 1.0, expected in Q3 of 1998, is the *USB Video Camera Device Definition*, which addresses digital moving images.

The other two USB Imaging Class specifications, which will be released after the *USB Video Camera Device Definition,* are the specifications that will contain requirements for still images. The first of these, which may be titled *USB Dual-Mode Video Camera and Digital Still Camera Device Definition,* will contain requirements for still images produced by dual-mode video cameras or digital still cameras. The second of these may be titled *USB Still Image Device Definition,* and will contain requirements for still images produced by scanners.

Manufacturers are urged to join the USB Imaging Class Working Group. For information, see http://www.usb.org. Also, manufacturers should urge their competitors and peers to join. The more companies that participate in creating the specifications, the sooner they will be released.

22.10. USB device supports string descriptors
Required

The device descriptor, as listed in Section 9.6.1 of the USB specification, must have valid iManufacturer and iProduct string descriptor indexes. All USB imaging devices must comply with requirements defined in Sections 9.4.3 and 9.6.5 of the USB specification.

The iProduct string will identitfy the device to the end user during initial hardware detection, creating a better end-user experience.

22.11. USB imaging device has a zero-bandwidth alternate interface
Recommended

Imaging devices should not pre-allocate bandwidth based on intended use. This results in limited bandwidth for other USB devices. USB bandwidth requests must be based on usage demand at the time of demand.

The USB device should have a zero-bandwidth alternate interface and other alternate incremental interfaces, for example, the imaging device driver should be capable of requesting subsequently smaller bandwidth quantities. This is to ensure that the imaging device can deliver data to the system when optimal bandwidth is not available. In the future, standards bodies might enforce a stricter bandwidth limitation to specific device classes.

22.12. USB device does not saturate the USB bus
Recommended

With an increasing number of USB peripherals in the PC environment, saturation of the USB bus is occurring on a more frequent basis. This saturation is specifically due to the integration of high-bandwidth devices such as digital still cameras, scanners, and video cameras.

It is recommended that no imaging device use more than 8 Mb/s of available bandwidth to ensure the continued operation of low bandwidth devices such as USB mice and keyboards. In the future, standards bodies might enforce a stricter bandwidth limitation to specific device classes.

22.13. USB device follows PC 99 USB performance recommendations
Required

All USB devices must comply with the performance requirements listed in Chapter 8, "USB."

22.14. Digital camera uses PC-compatible file system for removable storage
Required

For devices that include removable flash memory, a file system that is PC-compatible must be provided. The Flash Translation Layer (FTL) specification is an example of such a file system.

22.15. Digital camera stores images in common file formats such as JPEG or FlashPix
Recommended

Enhancing the user experience is essential for the widespread use of digital images. Increasing satisfaction can be accomplished by standardizing on the file format used to store the image inside the camera, providing interoperability between devices and software. JPEG, TIFF, BMP, GIF, and PNG file filters are incorporated in a great number of image and productivity software, providing comprehensive imaging support so that images can be shared.

Reducing the time required to transmit and process images will also further the use of digital images. The FlashPix (FPX) file format provides a rich experience with digital images, offering multiple resolution levels and allowing local region edits, improving the user experience. In the future, the FPX file format is expected to be universal, especially in Internet-related imaging.

22.16. IEEE 1394 device meets PC 99 requirements for IEEE P1394.a
Required
All IEEE 1394 hardware must comply with the requirements defined in Chapter 8, "IEEE 1394."

PC 99 Design for Digital Still Image Devices

This section summarizes requirements related to the PC 99 design initiatives described in Part 1 of this guide.

Plug and Play for Digital Still Image Devices

The items in this section are requirements for Plug and Play capabilities. For Plug and Play requirements related to parallel ports, see Chapter 13, "I/O Ports and Devices," or the related bus port requirements in Part 3 of this guide.

22.17. Serial device complies with Plug and Play External COM Device Specification v. 1.0
Required
To improve the installation process, imaging devices with a serial port interface must provide full Plug and Play support for the PC using serial enumeration. Serial enumeration provides a mechanism to support automatic configuration capability for peripheral devices that connect to a PC using Asynchronous Serial Data Interchange on standard serial ports, commonly known as COM ports.

For information, see the *Plug and Play External COM Device Specification, Version 1.0,* available at http://www.microsoft.com/hwdev/respec/.

22.18. Plug and Play capabilities implemented for all supported buses
Required
Complete Plug and Play capabilities must be implemented for all buses that the device supports. For information about the Plug and Play requirements, see the related bus requirements in Part 3 of this guide.

22.19. Each device has a Plug and Play device ID
Required

All devices for all buses must supply a human-readable device ID in the manner required for the bus it uses. The device ID requirements for each bus type are defined in Part 3 of this guide; however, the device ID requirements for devices that use parallel ports are defined in the IEEE 1284 specification, as summarized in Chapter 13, "I/O Ports and Devices." This requirement applies for IR devices that use the parallel port.

22.20. Daisy-chained parallel port imaging devices must be Plug and Play capable.
Required

Daisy-chained parallel port devices, such as scanners, must be Plug and Play capable as defined in Chapter 13, "I/O Ports and Devices." The daisy-chained parallel port device must be capable of answering Plug and Play requests from the host. Because of end-of-chain issues with IEEE 1284 and IEEE 1284.3, it is also required that all pass-through devices comply with IEEE 1284.3.

Digital Still Image Device Power Management

This section summarizes the specific power management requirements for scanners and digital still image devices.

22.21. Device supports power management requirements for its bus
Required

The device must support the power management requirements for the bus it uses, as defined in Part 3 of this guide.

Device Drivers and Installation for Digital Still Image Devices

This section summarizes the device driver requirements for scanners and digital still image devices.

22.22. Device drivers and installation meet PC 99 requirements
Required

The manufacturer does not need to supply a driver if a PC 99-compliant driver provided with the operating system can be used. If the manufacturer supplies a driver, the requirements for the device drivers and installation are defined in Chapter 3, "PC 99 Basic Requirements." The basic requirements include driver support for unattended installation and Help file support if special driver parameters are used.

22.23. Driver support is implemented under the Still Image architecture
Required

Still image devices must provide drivers based on the Still Image architecture (STI 1.0 or later). The services provided by STI provide hardware abstraction, installation wizards, and event polling.

Note: The IR bus interface is exempt from this requirement.

Still image devices capable of creating video streams also must provide a WDM minidriver based on WDM Stream class support.

For information about the Still Image architecture and WDM Stream Class support, see the Windows 98 DDK and the Windows NT 5.0 DDK. See also the related articles on the web site at http://www.microsoft.com/hwdev/stillimage/.

22.24. Applications provided with the device meet Win32 specifications
Required

Any Windows-based applications provided with the device must meet Microsoft requirements for software compatibility as defined in the Microsoft Platform SDK.

22.25. Device driver supports TWAIN 1.7 or later
Required

For those devices that ship a TWAIN datasource, the device must support TWAIN v. 1.7 or later, ensuring it can run without a hardware-specific user interface and download n number of images at a single time.

Note: Fingerprint scanners are excluded from this requirement.

22.26. Digital still image devices with an IR interface use the Windows Sockets interface
Required

Windows NT 5.0 does not provide support for IrComm-based devices. For imaging devices that include an IR interface, an IR driver must be provided that is based on the Windows Sockets interface. For more information, see "Wireless Component Requirements" in Chapter 13, "I/O Ports and Devices."

22.27. Asynchronous imaging device with an IEEE 1394 interface uses SBP2Port
Recommended

SBP2Port is the IEEE 1394 SPB2 protocol/transport driver and provides transport services for SCSI-like commands over IEEE 1394. It is recommended that asynchronous imaging devices use SBP2Port to communicate over IEEE 1394 if converting the device from a SCSI or SCSI-like interface.

Digital Still Image Device References

The following represents some of the references, services, and tools available to help build hardware that is optimized to work with Windows operating systems.

Device class power management reference specifications
   http://www.microsoft.com/hwdev/onnow.htm

International Color Consortium (ICC)
ICC Profile Format Specification
   http://www.color.org

Microsoft Windows 98 DDK, Windows NT 5.0 DDK, and
      Microsoft Platform SDK
   MSDN Professional membership

Plug and Play specifications
   http://www.microsoft.com/hwdev/respec/pnpspecs.htm

Universal Serial Bus Specification, Version 1.0
USB Imaging Class Specification
   http://www.usb.org

WDM device driver support and WDM Still Image architecture white papers
   http://www.microsoft.com/hwdev/wdm/
   http://www.microsoft.com/hwdev/stillvideo/

Checklist for Digital Still Image Devices

If a recommended feature is implemented, it must meet the PC 99 requirements for that feature as defined in this document.

22.1. Device uses PC 99 compatible port connection with USB or IEEE 1394 connection
Required

22.2. Icons provided for port and peripheral connectors
Required

22.3. Device supports ICC color management
Required

22.4. IR device meets PC 99 IR requirements
Required

22.5. Digital still image device with an IR interface uses Fast IR
Required

22.6. Digital still image device with an IR interface provides a secondary PC interface
Required

22.7. SCSI device meets PC 99 SCSI requirements
Required

22.8. SCSI device attaches to any PC 99-compliant SCSI controller
Required

22.9. USB device meets PC 99 USB requirements
Required

22.10. USB device supports string descriptors
Required

22.11. USB imaging device has a zero-bandwidth alternate interface
Recommended

22.12. USB device does not saturate the USB bus
Recommended

22.13. USB device follows PC 99 USB performance recommendations
Required

22.14. Digital camera uses PC-compatible file system for removable storage
Required

22.15. Digital camera stores images in common file formats such as JPEG or FlashPix
Recommended

22.16. IEEE 1394 device meets PC 99 requirements for IEEE P1394.a
Required

22.17. Serial device complies with Plug and Play External COM Device Specification v. 1.0
Required

22.18. Plug and Play capabilities implemented for all supported buses
Required

22.19. Each device has a Plug and Play device ID
Required

22.20. Daisy-chained parallel port imaging devices must be Plug and Play capable.
Required

22.21. Device supports power management requirements for its bus
Required

22.22. Device drivers and installation meet PC 99 requirements
Required

22.23. Driver support is implemented under the Still Image architecture
Required

22.24. Applications provided with the device meet Win32 specifications
Required

22.25. Device driver supports TWAIN 1.7 or later
Required

22.26. Digital still image devices with an IR interface use the Windows Sockets interface
Required

22.27. Asynchronous imaging device with an IEEE 1394 interface uses SBP2Port
Recommended

A P P E N D I X   A

Icons

This appendix presents a recommended set of standard icons that can be used for connectors on a personal computer. A set of icons must be added to any external connector on a PC 99 system. And the same icons also should be added to any cable connectors that plug into the PC. (Icons are not required for peripherals or the peripheral end of the cable.)

Although no specific types of icons are required, you can base your icons either on existing vendor designs or on the designs shown in this appendix. Files that contain art for these icons, plus alternative designs from Hewlett-Packard, are available at http://www.microsoft.com/hwdev/desguid/icons.htm.

For PC cases and cable-plug housings, the icon can be molded into the plastic. Icons printed on permanent labels are also acceptable.

PC 99 does not specifically require or recommend color coding of connectors and other cable markings, but the PC designer is encouraged to implement color coding in order to enhance user accessibility.

Connector Icons

Suggested icons	Description
	Expansion Bus/Docking Station
	Gameport/Joystick
	Headphone
	Keyboard

Continued

Connector Icons *(continued)*

Suggested icons	Description
	Microphone
	Monaural/Stereo In
	Monaural/Stereo Out
	Monitor
	Mouse
	Network/Thicknet+Twisted
	Parallel/Printer
	SCSI
	Serial Port
	Serial Port 1
	Serial Port 2
	Telephone Line
	Telephone Set
	USB

Note: A standard icon for IEEE 1394 is not yet available.

A P P E N D I X   B

Device Identifiers

This appendix lists Compatible IDs for Plug and Play vendor IDs and device IDs.

Note: For non-BIOS enumerated Industry Standard Architecture (ISA) devices, new vendor IDs must be registered by sending e-mail to pnpid@microsoft.com.

Contents

Plug and Play Vendor and Device IDs

All non-BIOS enumerated devices must not use "PNP" in their vendor and device codes. Instead, the vendor must register a three-character vendor code by sending mail to pnpid@microsoft.com. The PNP vendor code is reserved for Microsoft and can be used only when defining a device's Compatible ID after indicating the device's Hardware ID in the Plug and Play header.

Use of Compatible IDs is strongly recommended for devices that use inbox device drivers, such as a "Standard PC COM Port" (PNP0500) or "Sound Blaster 16 Sound Device" (PNPB003).

The following example output of a Plug and Play header from Isolate.exe is provided as a reference for the Microsoft Windows operating system.

```
Vendor ID:      XXXFFFF
Serial Number: 00000001
Checksum (reported): 0x5E
PNP Version:   1.0
Vendor Ver.:   10
Device Description: IDE Port
Device ID:  XXX0001
Doesn't Support I/O Range Checking
Vendor Defined Logical Device Control Registers:
None
Compatible Device ID: PNP0600
Device Description: IDE

Dependent Function 0
:
Dependent Function 1
:
End of Dependent Functions
```

When the user is installing devices that use this method, a dialog box appears at beginning of the enumeration sequence to suggest use of the Windows 95 default driver. Windows 95 also provides the option of using a manufacturer-supplied disk in case the user wants to choose a manufacturer-supplied driver.

For multifunction adapters, you should supply an INF file that chooses the appropriate drivers, including default drivers, for all the adapter's devices. This prevents additional dialog boxes from repeatedly requesting the default driver or a manufacturer's disk for the remaining devices on the adapter.

When an INF file is used in this manner for default driver selection, it must link the Hardware ID (XXX0000) to the appropriate compatible device driver from the Windows 95 distribution CD or installation discs. If this is not done, Windows 95 will continue to query the user for either the default driver or a new driver, thus defeating the purpose of using the INF file in this way.

Generic Windows Device IDs

Many devices, such as the interrupt controller or the keyboard controller, have no standard EISA ID. Also, a set of compatible devices, such as video graphics array (VGA) and Super VGA (SVGA), are not actually devices, but define a compatibility hardware subset. Yet another set of IDs needs to be used to identify buses.

Microsoft has reserved an EISA prefix (PNP) to identify various devices that do not have existing EISA IDs. Microsoft also uses PNP to define compatibility devices. The IDs are defined in the following tables.

Device ID Ranges

ID range	Category
PNP0xxx	System devices
PNP8xxx	Network adapters
PNPAxxx	Small computer system interface (SCSI), proprietary CD adapters
PNPBxxx	Sound, video capture, multimedia
PNPCxxx–Dxxx	Modems

The following obsolete device ID is provided only for compatibility with earlier device ID lists.

Device ID	Description
PNP0802	Microsoft Windows Sound System-compatible device (obsolete; use PNPB0xx instead)

Interrupt Controllers

Device ID	Description
PNP0000	AT interrupt controller
PNP0001	EISA interrupt controller
PNP0002	MCA interrupt controller
PNP0003	Advanced Protocol Interrupt Controller (APIC)
PNP0004	Cyrix SLiC MP interrupt controller

Timers

Device ID	Description
PNP0100	AT timer
PNP0101	EISA timer
PNP0102	MCA timer

DMA

Device ID	Description
PNP0200	AT direct memory access (DMA) controller
PNP0201	EISA DMA controller
PNP0202	MCA DMA controller

Keyboards

Device ID	Description
PNP0300	IBM PC/XT keyboard controller (83-key)
PNP0301	IBM PC/AT keyboard controller (86-key)
PNP0302	IBM PC/XT keyboard controller (84-key)
PNP0303	IBM Enhanced (101/102-key, PS/2 mouse support)
PNP0304	Olivetti keyboard (83-key)
PNP0305	Olivetti keyboard (102-key)
PNP0306	Olivetti keyboard (86-key)
PNP0307	Microsoft Windows keyboard
PNP0308	General Input Device Emulation Interface (GIDEI) legacy

Continued

Keyboards *(continued)*

Device ID	Description
PNP0309	Olivetti keyboard (A101/102-key)
PNP030A	AT&T 302 keyboard
PNP030B	Reserved by Microsoft
PNP0320	Japanese keyboard A01 (106-key)
PNP0321	Japanese keyboard (101-key)
PNP0322	Japanese AX keyboard
PNP0323	Japanese keyboard 002/003 (106-key)
PNP0324	Japanese keyboard 001 (106-key)
PNP0325	Japanese Toshiba desktop keyboard
PNP0326	Japanese Toshiba laptop keyboard
PNP0327	Japanese Toshiba notebook keyboard
PNP0340	Korean keyboard (84-key)
PNP0341	Korean keyboard (86-key)
PNP0342	Korean enhanced keyboard
PNP0343	Korean enhanced keyboard 101b
PNP0343	Korean enhanced keyboard 101c
PNP0344	Korean enhanced keyboard 103

Parallel Devices

Device ID	Description
PNP0400	Standard LPT port
PNP0401	Extended capabilities port (ECP) printer port

Serial Devices

Device ID	Description
PNP0500	Standard PC COM port
PNP0501	16550A-compatible COM port
PNP0502	Multiport serial device (non-intelligent 16550)
PNP0510	Generic IrDA-compatible device
PNP0511	Generic IrDA-compatible device

Disk Controllers

Device ID	Description
PNP0600	Generic ESDI/IDE/ATA-compatible hard disk controller
PNP0601	Plus Hardcard II
PNP0602	Plus Hardcard IIXL/EZ
PNP0603	Generic Integrated Device Electronics (IDE) supporting Device Bay specifications
PNP0700	PC standard floppy disk controller (FDC)
PNP0701	Standard FDC supporting Device Bay specification

Display Adapters

Device ID	Description
PNP0900	VGA compatible
PNP0901	Video Seven VRAM/VRAM II/1024i
PNP0902	8514/A compatible
PNP0903	Trident VGA
PNP0904	Cirrus Logic laptop VGA
PNP0905	Cirrus Logic VGA
PNP0906	Tseng ET4000
PNP0907	Western Digital VGA
PNP0908	Western Digital laptop VGA
PNP0909	S3 Inc. 911/924
PNP090A	ATI Ultra Pro/Plus (Mach 32)
PNP090B	ATI Ultra (Mach 8)
PNP090C	XGA compatible
PNP090D	ATI VGA Wonder
PNP090E	Weitek P9000 graphics adapter
PNP090F	Oak Technology VGA
PNP0910	Compaq QVision
PNP0911	XGA/2
PNP0912	Tseng Labs W32/W32i/W32p
PNP0913	S3 Inc. 801/928/964
PNP0914	Cirrus Logic 5429/5434 (memory-mapped)

Continued

Display Adapters *(continued)*

Device ID	Description
PNP0915	Compaq Advanced VGA (AVGA)
PNP0916	ATI Ultra Pro Turbo (Mach 64)
PNP0917	Reserved by Microsoft
PNP0918	Matrox MGA
PNP0919	Compaq QVision 2000
PNP091A	Tseng W128
PNP0930	Chips & Technologies SVGA
PNP0931	Chips & Technologies Accelerator
PNP0940	NCR 77c22e SVGA
PNP0941	NCR 77c32blt
PNP09FF	Plug and Play monitors (VESA display data channel [DDC])

Peripheral Buses

Device ID	Description
PNP0A00	ISA bus
PNP0A01	EISA bus
PNP0A02	MCA bus
PNP0A03	Peripheral Component Interconnect (PCI) bus
PNP0A04	VESA/VL-bus
PNP0A05	Generic Advanced Configuration and Power Interface (ACPI) bus
PNP0A06	Generic ACPI Extended I/O (EIO) bus

Real-Time Clock, BIOS, and System Board Devices

Device ID	Description
PNP0800	AT-style speaker sound
PNP0B00	AT real-time clock
PNP0C00	Plug and Play BIOS (only created by the ROOT enumerator)
PNP0C01	System board
PNP0C02	General ID for reserving resources required by Plug and Play system board registers (not specific to a particular device)
PNP0C03	Plug and Play BIOS event notification interrupt

Continued

Real-Time Clock, BIOS, and System Board Devices *(continued)*

Device ID	Description
PNP0C04	Math co-processor
PNP0C05	Advanced Power Management (APM) BIOS (version-independent)
PNP0C06	Reserved for identification of early Plug and Play BIOS implementation
PNP0C07	Reserved for identification of early Plug and Play BIOS implementation
PNP0C08	ACPI system board hardware
PNP0C09	ACPI embedded controller
PNP0C0A	ACPI control method battery
PNP0C0B	ACPI fan
PNP0C0C	ACPI power-button device
PNP0C0D	ACPI lid device
PNP0C0E	ACPI sleep-button device
PNP0C0F	PCI interrupt link device
PNP0C10	ACPI system indicator device
PNP0C11	ACPI thermal zone
PNP0C12	Device Bay Controller (DBC)
PNP0C13	Plug and Play BIOS (used when ACPI mode cannot be used)

PCMCIA Controller Chip Sets

Device ID	Description
PNP0E00	Intel 82365-compatible PCMCIA controller
PNP0E01	Cirrus Logic CL-PD6720 PCMCIA controller
PNP0E02	VLSI VL82C146 PCMCIA controller
PNP0E03	Intel 82365-compatible CardBus controller

Mouse

Device ID	Description
PNP0F00	Microsoft bus mouse
PNP0F01	Microsoft serial mouse
PNP0F02	Microsoft InPort mouse
PNP0F03	Microsoft PS/2-style mouse
PNP0F04	Mouse Systems mouse

Continued

Mouse *(continued)*

Device ID	Description
PNP0F05	Mouse Systems 3-button mouse (COM2)
PNP0F06	Genius mouse (COM1)
PNP0F07	Genius mouse (COM2)
PNP0F08	Logitech serial mouse
PNP0F09	Microsoft BallPoint serial mouse
PNP0F0A	Microsoft Plug and Play mouse
PNP0F0B	Microsoft Plug and Play BallPoint mouse
PNP0F0C	Microsoft-compatible serial mouse
PNP0F0D	Microsoft InPort-compatible mouse
PNP0F0E	Microsoft-compatible PS/2-style mouse
PNP0F0F	Microsoft Serial BallPoint-compatible mouse
PNP0F10	Texas Instruments QuickPort mouse
PNP0F11	Microsoft-compatible bus mouse
PNP0F12	Logitech PS/2-style mouse
PNP0F13 [1]	PS/2 port for PS/2-style mouse
PNP0F14	Microsoft Kids mouse
PNP0F15	Logitech bus mouse
PNP0F16	Logitech SWIFT device
PNP0F17	Logitech-compatible serial mouse
PNP0F18	Logitech-compatible bus mouse
PNP0F19	Logitech-compatible PS/2-style mouse
PNP0F1A	Logitech-compatible SWIFT device
PNP0F1B	HP Omnibook mouse
PNP0F1C	Compaq LTE Trackball PS/2-style mouse
PNP0F1D	Compaq LTE Trackball serial mouse
PNP0F1E	Microsoft Kids Trackball mouse
PNP0F1F	Reserved by Microsoft Input Device Group
PNP0F20	Reserved by Microsoft Input Device Group
PNP0F21	Reserved by Microsoft Input Device Group
PNP0F22	Reserved by Microsoft Input Device Group
PNP0F23	Reserved by Microsoft Input Device Group
PNP0FFF	Reserved by Microsoft Systems

[1] The system BIOS should report the PS/2 port, not which type of mouse is connected to that port.

Network Adapters

Device ID	Description
PNP8001	Novell/Anthem NE3200
PNP8004	Compaq NE3200
PNP8006	Intel EtherExpress/32
PNP8008	HP Ethertwist EISA LAN Adapter/32 (HP27248A)
PNP8065	Ungermann-Bass NIUps or NIUps/EOTP
PNP8072	DEC (DE211) Etherworks MC/TP
PNP8073	DEC (DE212) Etherworks MC/TP_BNC
PNP8078	DCA 10-MB MCA
PNP8074	HP MC LAN Adapter/16 TP (PC27246)
PNP80C9	IBM Token Ring
PNP80CA	IBM Token Ring II
PNP80CB	IBM Token Ring II/Short
PNP80CC	IBM Token Ring 4/16-MB
PNP80D3	Novell/Anthem NE1000
PNP80D4	Novell/Anthem NE2000
PNP80D5	NE1000 compatible
PNP80D6	NE2000 compatible
PNP80D7	Novell/Anthem NE1500T
PNP80D8	Novell/Anthem NE2100
PNP80DD	SMC ARCNETPC
PNP80DE	SMC ARCNET PC100, PC200
PNP80DF	SMC ARCNET PC110, PC210, PC250
PNP80E0	SMC ARCNET PC130/E
PNP80E1	SMC ARCNET PC120, PC220, PC260
PNP80E2	SMC ARCNET PC270/E
PNP80E5	SMC ARCNET PC600W, PC650W
PNP80E7	DEC DEPCA
PNP80E8	DEC (DE100) EtherWorks LC
PNP80E9	DEC (DE200) EtherWorks Turbo

Continued

Network Adapters *(continued)*

Device ID	Description
PNP80EA	DEC (DE101) EtherWorks LC/TP
PNP80EB	DEC (DE201) EtherWorks Turbo/TP
PNP80EC	DEC (DE202) EtherWorks Turbo/TP_BNC
PNP80ED	DEC (DE102) EtherWorks LC/TP_BNC
PNP80EE	DEC EE101 (built-in)
PNP80EF	DECpc 433 WS (built-in)
PNP80F1	3Com EtherLink Plus
PNP80F3	3Com EtherLink II or IITP (8-bit or 16-bit)
PNP80F4	3Com TokenLink
PNP80F6	3Com EtherLink 16
PNP80F7	3Com EtherLink III
PNP80F8	3Com generic EtherLink Plug and Play device
PNP80FB	Thomas-Conrad TC6045
PNP80FC	Thomas-Conrad TC6042
PNP80FD	Thomas-Conrad TC6142
PNP80FE	Thomas-Conrad TC6145
PNP80FF	Thomas-Conrad TC6242
PNP8100	Thomas-Conrad TC6245
PNP8105	DCA 10-MB
PNP8106	DCA 10-MB Fiber Optic
PNP8107	DCA 10-MB Twisted Pair
PNP8113	Racal NI6510
PNP811C	Ungermann-Bass NIUpc
PNP8120	Ungermann-Bass NIUpc/EOTP
PNP8123	SMC StarCard PLUS (WD/8003S)
PNP8124	SMC StarCard PLUS with on-board hub (WD/8003SH)
PNP8125	SMC EtherCard PLUS (WD/8003E)
PNP8126	SMC EtherCard PLUS with boot ROM socket (WD/8003EBT)
PNP8127	SMC EtherCard PLUS with boot ROM socket (WD/8003EB)

Continued

Network Adapters *(continued)*

Device ID	Description
PNP8128	SMC EtherCard PLUS TP (WD/8003WT)
PNP812A	SMC EtherCard PLUS 16 with boot ROM socket (WD/8013EBT)
PNP812D	Intel EtherExpress 16 or 16TP
PNP812F	Intel TokenExpress 16/4
PNP8130	Intel TokenExpress MCA 16/4
PNP8132	Intel EtherExpress 16 (MCA)
PNP8137	Artisoft AE-1
PNP8138	Artisoft AE-2 or AE-3
PNP8141	Amplicard AC 210/XT
PNP8142	Amplicard AC 210/AT
PNP814B	Everex SpeedLink /PC16 (EV2027)
PNP8155	HP PC LAN Adapter/8 TP (HP27245)
PNP8156	HP PC LAN Adapter/16 TP (HP27247A)
PNP8157	HP PC LAN Adapter/8 TL (HP27250)
PNP8158	HP PC LAN Adapter/16 TP Plus (HP27247B)
PNP8159	HP PC LAN Adapter/16 TL Plus (HP27252)
PNP815F	National Semiconductor Ethernode *16AT
PNP8160	National Semiconductor AT/LANTIC Ethernode 16-AT3
PNP816A	NCR Token-Ring 4-MB ISA
PNP816D	NCR Token-Ring 16/4-MB ISA
PNP8191	Olicom 16/4 Token Ring Adapter
PNP81C3	SMC EtherCard PLUS Elite (WD/8003EP)
PNP81C4	SMC EtherCard PLUS 10T (WD/8003W)
PNP81C5	SMC EtherCard PLUS Elite 16 (WD/8013EP)
PNP81C6	SMC EtherCard PLUS Elite 16T (WD/8013W)
PNP81C7	SMC EtherCard PLUS Elite 16 Combo (WD/8013EW or 8013EWC)
PNP81C8	SMC EtherElite Ultra 16
PNP81E4	Pure Data PDI9025-32 (Token Ring)
PNP81E6	Pure Data PDI508+ (ArcNet)
PNP81E7	Pure Data PDI516+ (ArcNet)
PNP81EB	Proteon Token Ring (P1390)
PNP81EC	Proteon Token Ring (P1392)

Continued

Network Adapters *(continued)*

Device ID	Description
PNP81ED	Proteon ISA Token Ring (1340)
PNP81EE	Proteon ISA Token Ring (1342)
PNP81EF	Proteon ISA Token Ring (1346)
PNP81F0	Proteon ISA Token Ring (1347)
PNP81FF	Cabletron E2000 Series DNI
PNP8200	Cabletron E2100 Series DNI
PNP8209	Zenith Data Systems Z-Note
PNP820A	Zenith Data Systems NE2000-compatible
PNP8213	Xircom Pocket Ethernet II
PNP8214	Xircom Pocket Ethernet I
PNP821D	RadiSys EXM-10
PNP8227	SMC 3000 Series
PNP8228	SMC 91C2 controller
PNP8231	Advanced Micro Devices AM2100/AM1500T
PNP8263	Tulip NCC-16
PNP8277	Exos 105
PNP828A	Intel 595-based Ethernet
PNP828B	TI2000-style Token Ring
PNP828C	AMD PCNet Family cards
PNP828D	AMD PCNet32 (VL-bus version)
PNP8294	IrDA Infrared NDIS driver (Microsoft-supplied)
PNP82BD	IBM PCMCIA-NIC
PNP82C2	Xircom CE10
PNP82C3	Xircom CEM2
PNP8321	DEC Ethernet (all types)
PNP8323	SMC EtherCard (all types except 8013/A)
PNP8324	ARCNET-compatible
PNP8326	Thomas Conrad (all ARCNET types)
PNP8327	IBM Token Ring (all types)
PNP8385	Remote network access (RNA) driver
PNP8387	RNA point-to-point protocol (PPP) driver
PNP8388	Reserved for Microsoft networking components
PNP8389	Peer IrLAN IR driver (Microsoft-supplied)
PNP8390	Generic network adapter

SCSI and Proprietary CD-ROM Adapters

Device ID	Description
PNPA002	Future Domain 16-700–compatible controller
PNPA003	Panasonic proprietary CD-ROM adapter (SBPro/SB16)
PNPA01B	Trantor 128 SCSI controller
PNPA01D	Trantor T160 SCSI controller
PNPA01E	Trantor T338 Parallel SCSI controller
PNPA01F	Trantor T348 Parallel SCSI controller
PNPA020	Trantor Media Vision SCSI controller
PNPA022	Always IN-2000 SCSI controller
PNPA02B	Sony proprietary CD-ROM controller
PNPA02D	Trantor T13b 8-bit SCSI controller
PNPA02F	Trantor T358 Parallel SCSI controller
PNPA030	Mitsumi LU-005 Single Speed CD-ROM controller + drive
PNPA031	Mitsumi FX-001 Single Speed CD-ROM controller + drive
PNPA032	Mitsumi FX-001 Double Speed CD-ROM controller + drive

Sound, Video Capture, and Multimedia

Device ID	Description
PNPB000	Sound Blaster 1.5 sound device
PNPB001	Sound Blaster 2.0 sound device
PNPB002	Sound Blaster Pro sound device
PNPB003	Sound Blaster 16 sound device
PNPB004	Thunderboard-compatible sound device
PNPB005	Adlib-compatible frequency modulation (FM) synthesizer device
PNPB006	MPU401 compatible
PNPB007	Microsoft Windows Sound System-compatible sound device
PNPB008	Compaq Business Audio
PNPB009	Plug and Play Microsoft Windows Sound System device
PNPB00A	MediaVision Pro Audio Spectrum (Trantor SCSI-enabled, Thunder Chip-disabled)
PNPB00B	MediaVision Pro Audio 3-D

Continued

Sound, Video Capture, and Multimedia *(continued)*

Device ID	Description
PNPB00C	MusicQuest MQX-32M
PNPB00D	MediaVision Pro Audio Spectrum Basic (no Trantor SCSI, Thunder Chip-enabled)
PNPB00E	MediaVision Pro Audio Spectrum (Trantor SCSI-enabled, Thunder Chip-enabled)
PNPB00F	MediaVision Jazz-16 chip set (OEM versions)
PNPB010	Auravision VxP500 chip set–Orchid Videola
PNPB018	MediaVision Pro Audio Spectrum 8-bit
PNPB019	MediaVision Pro Audio Spectrum Basic (no Trantor SCSI, Thunder chip-disabled)
PNPB020	Yamaha OPL3-compatible FM synthesizer device
PNPB02F	Joystick/gameport

Modems

Device ID	Description
PNPC000	Compaq 14400 modem (TBD)
PNPC001	Compaq 2400/9600 modem (TBD)

A P P E N D I X   C

Accessibility

This appendix presents recommendations for computer and component design related to lowering access barriers to computer use for persons with special physical needs.

These guidelines were developed in consultation with the Trace Research and Development Center at the University of Wisconsin-Madison and were based on research funded by the National Institute for Disability and Rehabilitation Research (NIDRR). For more information, see the references at the end of this appendix.

For information about software accessibility guidelines, see the web site at http://www.microsoft.com/enable/.

Contents

Introduction

Personal computers are powerful tools that enable people to work, create, and communicate in ways that might otherwise be difficult or impossible. The goal of making computers easier for everyone to use, however, can be realized only when people with disabilities have equal access.

Computer accessibility has become an increasingly important issue in the home and workplace. An estimated eight out of ten major corporations employ people with disabilities who might need to use computers as part of their jobs. In the United States alone, more than 30 million people have disabilities that affect PC accessibility. In addition, as the post-war generation ages and more people experience functional limitations, computer accessibility will become a more important issue. Addressing disabilities in design will benefit all users by simplifying tasks.

In the United States, legislation such as the Americans with Disabilities Act and Section 508 of the Rehabilitation Act has brought accessibility to national attention in both the public and private sectors. Accessibility is also being incorporated into official and international standards for usability, such as ANSI 200. Such recommendations affect the following:

- Visual displays and indicators
- Sound
- Manipulation and physical design
- Input devices and software controls
- Labeling
- Documentation

What Are Disabilities?

Individuals are not disabled; rather, some people have difficulties performing certain tasks, such as using a mouse or reading small print. When these limitations are serious enough to impact the person's performance, they are referred to as "disabilities." Anyone can experience the same difficulties because of illness, accident, environment (such as loud background noise) or hardware error (such as a missing mouse).

Disabilities can be classified into the following general categories:

- **Visual impairment.** This ranges from slightly reduced visual acuity to total blindness. Those with reduced visual acuity might only need images to be reasonably sized or specially enlarged, or they might need high contrast between foreground and background. Users with more severe impairments might require that output be translated into audible cues, spoken text, or Braille.

- **Hearing impairment.** Some individuals do not hear beeps, distinguish different sounds, or recognize spoken words. These users might need the computer to prompt them in a different manner, such as a screen flash, an indicator lamp, or an on-screen message.

- **Movement impairment.** Some users are unable to perform certain manual tasks, such as using a mouse or typing two keys at the same time. Others might have a tendency to hit multiple keys, might "bounce" fingers off keys, or might be unable to hold a printed book. Many users need keyboards and mouse functions adapted to their requirements, or they may rely exclusively on a single input device.

- **Cognitive impairment.** Cognitive impairments take many forms, including memory loss, perceptual differences, and conditions such as Downs syndrome. Language impairments such as dyslexia or illiteracy are also very common. Those who speak English as a second language can be considered to have a form of language impairment. Proper design can increase accessibility for these computer users.

- **Seizure disorders.** People with some forms of epilepsy might experience minor or severe seizures when a monitor flashes at certain rates or they hear certain types of random or repetitive sounds.

- **Speech impairment.** Although speech difficulties do not normally affect a person's ability to use a computer, it can be a problem in using telecommunications and voice menus. And in the future, speech difficulties might affect normal computer usage if voice recognition becomes a common form of input.

What Is Accessibility?

Accessibility means making computers accessible to a wider range of users than would otherwise be the case. Special needs can be addressed in several ways:

- New features built into hardware and operating systems help make computers accessible to users with and without specialized needs. These solutions, often referred to as "electronic curb cuts," are preferred because the features are available on all workstations and can be used with all applications.

- Usability features can be built into mainstream products, making them easier to use for people with disabilities. Examples include customizable colors and keyboard accelerators. In many cases, these features also benefit people without disabilities.

- Utilities that upgrade a system make the PC more usable by people with disabilities. Examples of utilities include Braille-output systems for people who are blind or software that modifies the behavior of the keyboard and mouse.

- Specialized applications, such as a word processor designed to integrate voice and text, help individuals with limited reading and writing skills.

A variety of hardware and software products have been designed to help people with disabilities make use of PCs. The following are some of the different products available for upgrading the accessibility of the Windows and Windows NT Workstation operating systems:

- Programs that enlarge or alter the color of information on the screen

- Programs that describe on-screen information in Braille or synthesized speech

- Hardware and software utilities that modify the behavior of the mouse and the keyboard

- Programs that enable users to "type" using a mouse or their voice

- Word or phrase prediction software that allows quicker typing with fewer keystrokes

- Alternative input devices, such as single-switch or puff-and-sip devices

Visual Displays and Indicators

Visual display is the predominant form of display on today's computers. This includes the standard display screen, light-emitting diode (LED) or liquid crystal display (LCD) icon displays on or near the keyboard, and special visual indicators on peripheral devices.

For people with low vision or blindness, these displays are a barrier to computer use. Special screen-magnification software can increase the image size for people with low vision. Similarly, software "screen readers" can access information and read it aloud to users who are blind. Information provided by indicator lights or LCD mini-displays, however, must also be made available and readable.

Hardware design strategies for providing greater access to visual information include the following:

1   Minimize glare.

    Glare caused by reflections or mismatched color combinations, overly bright indicators, and so on might present problems for users with low vision. Minimizing glare allows these users greater access to displays.

2   Avoid 5-Hz to 50-Hz refresh rate or flicker rate.

    This allows users with photosensitive epilepsy, who might have a seizure if exposed to strong stimuli in the 50-Hz range, to more safely use the system.

3   Make LCD and LED indicators, warning lights, and alert lights software-readable.

    This allows users who are blind to use their screen-reading software to access important indicators, warnings, and notices.

The following standard design practices also facilitate accessibility:

4   Provide contrast and brightness controls.

    This is important for users with low vision and color blindness, making it possible for them to adjust the display to accommodate their needs and preferences.

5   Provide a display connector for an external or additional monitor.

    Users with low vision often need to augment the system with a larger monitor to take full advantage of screen-magnification software. This is especially true for mobile PC users.

6   Provide adjustable monitors.

    Users with physical disabilities adjust the angle and position of the monitor to suit their seating position and approach to the system. Other users with low vision often adjust the monitor to reduce glare.

Sound

Sound is increasingly being used to convey information important to the computer operator. This includes alerts in addition to speech and other complex audio feedback. This can pose problems for any user on an airplane or in other noisy environments, and it especially can cause problems for those who are deaf or hard of hearing.

Hardware design strategies for providing greater access to aural information include the following:

1   Provide a headphone jack.

    Headphone jacks allow users with reduced hearing to block out background noise and make the output louder (by using headphones or by connecting directly to their hearing aids).

2   Maximize the range of volume adjustment.

    Volume controls allow users with reduced hearing to adjust the volume level to suit their needs.

3   Direct speakers toward the user.

    This maximizes the signal-to-noise ratio (SNR) for all users. This is especially important for users with hearing loss.

4   Provide a visually distinct indicator for all alerts or warning sounds created by hardware.

    Visual indicators make recognizing alerts easier for users working in loud environments or for users with deafness or reduced hearing. (Software-generated alerts should be handled by software.)

5   Provide a visual indication of important sounds generated in normal computer operation.

    Some natural sounds, such as those generated by a disk drive or printer, can be important to system operation. Where this is true, some visual indication of the sound should be provided so users in loud environments or those with reduced hearing or deafness can effectively use the systems.

6   Send hardware-generated beeps to the operating system.

    This allows visual display of beeps for users in loud environments, users located in another room, or users with reduced hearing or deafness. Examples include beeps related to the keyboard and printer.

7   Place the microphone in the orientation recommended by the microphone manufacturer.

Along with speech-recognition software, properly locating the microphone makes the computer more accessible to users who are blind, have low vision, are physically disabled (including those with repetitive strain injury [RSI] and carpal tunnel syndrome), or have difficulty writing.

8   Include a speech-capable sound system.

Such a sound system provides speech capabilities for nonspeaking persons. It also provides the necessary hardware support for a speech-based access system used by people with low vision, blindness, or reading difficulties.

9   Reduce noise level of operating internal components.

This increases the ability of users with neural hearing loss or hearing aids to converse or use computer sound-based features.

Manipulation and Physical Design

Often, accessibility efforts focus on the input or display components of a computer. However, many of the physical design characteristics of the computer are equally important. For example, if the person is unable to operate the latches to open a portable computer, other aspects of the computer's design are of little importance.

Some users have conditions that result in weakness or poor motor control. Some have use of just one hand or reduced range of motion or reach. Hardware design strategies for providing greater access include the following:

1   Eject media a sufficient distance for grasping.

Ejecting 0.5 to 0.75 inch or more is helpful for those with reduced hand functions.

2   Sculpt or bevel device entry slots.

This assists in guiding the disk into the slot for those with reduced motor control. This also gives a tactile indicator, which helps those with low vision locate the slot. CDs should seat themselves properly when dropped into trays (that is, no fine positioning is required from the user). The CD should also be easy to remove from the tray (that is, slots at the sides of the tray allow for placing a finger under the disc to lift it out).

3 Make latches operable with one hand.

This allows those who do not have use of limbs or who use assistive pointing devices to operate latches.

4 Minimize the force required for inserting and retrieving media.

This assists those with reduced strength and grasp capabilities. A maximum force of 2 Newtons is advised, but it is preferable for the mechanism to "suck" the disk in for insertion and to not require a force of more than 2 Newtons for pulling it out of the slot.

5 Ensure that media stands up to rough handling, and use caddies for media that do not.

This allows individuals with poor motor control to safely handle all media without inflicting irreversible damage.

6 Provide error flags for misinserted media, especially CDs.

When it is not possible to block misinserted media (see item 8 in this section), the hardware could contain a disk-present detector to warn the user that a disk has been inserted but is unreadable because it is upside-down (and not just in an unreadable format). This would be an asset for users with visual impairments and for novice users.

7 Ensure that devices do not generate electromagnetic or radio frequency (RF) fields that would affect users with hearing aids.

Electromagnetic fields can couple with induction pick-ups in hearing aids, causing loud or disturbing noises. RF can affect all hearing aids. There are currently no industry standards for these levels; reasonable care should be taken and testing is recommended.

The following design practices are fairly standard and also facilitate access and use by users with disabilities:

8 Use media misinsertion blocking.

Blocking assists all users as a memory aid, but it especially helps those with low vision or cognitive impairments who might forget or misinterpret how to insert media.

9 Offer components that allow for use of alternative input devices.

This assists those who use alternative input or output devices because of the nature of their reduced ability.

10 Provide adjustable height, swivel, and so on where appropriate.

Adjustable components assist those who do not have a full range of movement; displays and input devices can be oriented toward the user.

11 Minimize operation noise levels.

In general, quieter components (fans, disk drives, and so on) are easier to use for users with neural hearing loss or hearing aids.

12 Eliminate hard edges or sharp corners that could cause injury or inhibit correct device placement.

Softening component edges assists those with reduced motor control, minimizing the potential for injury.

13 Manufacture outer surfaces using only hypoallergenic materials.

Chromium and nickel are known to cause allergic reactions in some users and should therefore be avoided in any part that could come into contact with users' skin during normal use.

Input and Controls

The ability to operate a computer directly depends on the ability to use its input devices and controls. For many people with physical or visual disabilities, using a computer depends either on the design of the input and control devices or on the computer's ability to substitute other control mechanisms (such as use alternative input devices or software controls). Users who are blind cannot use input mechanisms that require hand-eye coordination, such as a mouse or a control with no tactile or auditory reference.

Easier-to-operate controls are appreciated by all users, as is the ability to connect and use alternative preferred input devices.

Hardware design strategies for providing greater access to input and control functions include the following:

1 Allow connection, substitution, or addition of alternative input devices.

A second serial port is helpful for those using SerialKeys software in Windows 95 to provide alternative access, as well as for blind users who typically use speech synthesizers with serial connections. For users who cannot use standard input devices (even with software extensions such as StickyKeys), the availability of an external keyboard and mouse connection on portable systems allows the user to substitute specially designed keyboards or pointing devices.

2 Design all controls to operate from the keyboard.

This allows users with restricted reach or motor skills to operate controls on the CPU, monitor, and so on that they would otherwise be unable to use. It also allows these users to operate the controls from any other keyboard they might use.

3   Mount all controls on the front of the device.

By placing all controls facing the user, disabled users have better access.

4   Limit button design primarily to push-button controls.

Push-button controls assist those with reduced motor control and those using head or mouth sticks or other alternative pointing devices.

5   Use concave buttons, especially where sustained force is required.

Concave buttons help keep fingers or pointers from slipping, assisting those with reduced finger or motor control (such as tremor) and those who must use headsticks or other pointing devices.

6   Avoid twisting motions.

Users with some disabilities, such as cerebral palsy or arthritis, find twisting motions difficult or impossible. Instead, use push-button or edge controls.

7   Minimize force required for operation.

A maximum force of 2 Newtons for any operation is advised. For controls, use a light touch or substitute manual mechanisms with power-driven mechanisms to achieve sustained or heavy touch.

8   Make all controls operable with one hand.

This allows individuals who have only one hand or who use assistive pointing devices to operate the controls.

9   Avoid capacitance-based controls.

Capacitance-based controls require contact with human skin. Avoiding these types of controls allows users with assistive pointing devices or artificial limbs to use the system.

10   Use functional grouping and layout of controls.

Functional grouping assists those with low vision or cognitive impairments to quickly find the right keys. Examples of functional sets are direction keys and control keys. The keys can be grouped by color (making sure to take color blindness into account) or by other design characteristics, such as shape or feel.

11   Make controls tactually discernible.

This includes locator ridges or nibs on the home keys. Flat-membrane keypads with no tactile features should be avoided because they provide no feedback on the location of the buttons.

12   Make the state of non-momentary controls tactually discernible.

This allows those who have low vision or who are blind to discern the state of a control.

13   Provide tactile and audible actuation feedback for controls.

People who have low vision or who are blind require non-visual signals to determine when a key has been pressed.

14   Avoid keys that cannot be read or simulated by software.

Many users rely on software programs that either detect or simulate keystrokes. For example, the StickyKeys, SlowKeys, and SerialKeys features in Windows 95 rely on this ability when compensating for a user's difficulty with the keyboard. Blind users can also query the state of toggle keys using software. Any nonstandard keys should produce scan codes that trigger their functionality.

15   Maximize size of controls within the space available.

This makes operation easier for those with low vision and those with limited dexterity who might have difficulty manipulating small controls.

16   Space the controls a sufficient distance to allow for tactile and visual discrimination.

This facilitates access by users with visual impairments as well as assisting those with reduced motor control. For example, on keyboards, key-top spacing should be approximately one-half of the key width. For small controls, spacing can be tighter, but functional grouping should be maintained to minimize pressing several controls at once.

17   Design stable controls.

Unintended activation should not change the adjustment state of the control. Some users with reduced motor control or blindness might inadvertently change the setting of one control while activating another. Controls or input devices should be designed to prevent this.

18   Manufacture input guards or provide mounting for guards.

Keyguards go over the keyboard and allow users to press one key at a time while resting their hands on the keyguard surface. They allow those with reduced strength or reduced motor control to have more control over their input. Guards can also be made for other input devices, where applicable. The FilterKeys features in Windows 95 allows direct access for many users, but others benefit further from hardware guards. Manufacturers should also ensure grooves or holes are made in the edge of the device to allow for mounting of a guard.

19   Provide stable keyboards.

Features such as non-slip feet assist those with reduced motor control who might otherwise inadvertently move the keyboard when trying to use it.

20   Remove left-right bias.

Designing equipment with no left-right bias assists those who have use of only one hand or who are left-handed. Where this is not possible (for example, built-in numeric keypads) alternatives should be provided (for example, support for external numeric keypads).

Labeling

The ability to read labels is important to ensure that users are able to detect and recognize controls, connectors, and media interfaces. Users with low vision or blindness often have difficulty if these labels are printed in small or low-contrast type. All users have difficulty with small labels on the back of or in hard-to-view areas of the product.

Hardware design strategies for providing greater access to labels include the following:

1   Use large, high-contrast, bold stroke, sans serif lettering, and avoid using artwork behind text.

This allows users with low vision or reduced vision to more easily read the lettering.

2   Use tactually distinct icons for controls, connectors, and legends.

Raised icons (raised at least 1/32 inch) allow users who are blind to more easily discern an item's label by touch. They also allow any user to identify a component located out of view (such as on the back of the unit).

3   Provide optional Braille and tactile labels.

This allows users who are blind the option of customizing labels on the unit.

Documentation

Modern multimedia computers and peripherals require more documentation than ever. For users with low vision or blindness, standard print manuals might be unusable. Users with physical disabilities might be unable to hold perfect-bound manuals open. All users would welcome manuals that are easier to understand.

Documentation design strategies for providing greater access and usability include the following:

1   Provide electronic documentation (ASCII).

This enables generation of Braille, speech, and variable-sized text outputs for users with blindness, low vision, and cognitive or physical disabilities.

2   Provide text descriptions of graphical information.

Written descriptions of illustrations, graphs, and so on allow users with blindness or low vision to access the information in the graphic.

3   Use clear, simple language.

Clear and concise writing benefits everyone, but it is especially helpful to those for whom English is a second language (including sign language) or for users with cognitive disabilities.

4   Bind manuals in a way that allows the manual to lie open.

A manual that lies flat is easier to manipulate by the user who has one hand or uses a mouthstick.

5   Provide manuals in alternative formats such as large print or Braille.

This allows users with blindness or low vision access to the information. Recommended large print is 18-point sans serif.

6   Use high-contrast layouts.

Users with color blindness or low vision require high contrast to access printed information.

7   Use colors that reproduce well on copy machines.

Avoid colors that copy all gray or low contrast. Users with low vision often enlarge the information in manuals using a copy machine.

8   Provide online help.

Online help allows users to access information without having to refer to manuals.

9   Avoid conveying information by color alone.

Users with low vision or color blindness may have difficulty perceiving certain colors. Users who are blind scan the documentation to convert it to ASCII text.

Accessibility Recommendations for PC Design

This section presents summary lists of recommendations for design issues related to access for persons with disabilities. Item numbers are based on lists in related sections of this appendix.

1. Accessibility recommendations for physical design (casing)

Recommended

Manipulation and Physical Design:

2	Sculpt or bevel device entry slots.
3	Make latches operable with one hand.
7	Ensure devices do not generate electromagnetic or RF fields that would affect users with hearing aids.
9	Offer separate components that allow for use of alternative devices.
10	Provide adjustable height, swivel, and so on where appropriate.
11	Minimize operation noise levels.
12	Eliminate hard edges or sharp corners that could cause injury or inhibit correct device placement.

Input and Controls:

4	Limit button design primarily to push-button controls.
5	Use concave buttons, especially where sustained force is required.
6	Avoid twisting motions.
7	Minimize force required for operation.
8	Make all controls operable with one hand.
11	Make controls tactually discernible.
13	Provide tactile and audible actuation feedback for controls.
15	Maximize size of controls within the space available
16	Space the controls a sufficient distance to allow for tactile and visual discrimination.

Labeling:

1   Use large, high-contrast, bold stroke, sans-serif lettering, and avoid using artwork behind text.

2   Use tactually distinct icons for controls, connectors, and legends.

3   Provide optional Braille and tactile labels.

Documentation:

All points in the Documentation section of this appendix.

Accessibility for PC Card

This section presents summary lists of recommendations for design issues related to access for persons with disabilities. Item numbers are based on lists in related sections of this appendix.

2. Accessibility recommendations for PC Cards

Recommended

Labeling:

1   Use large, high-contrast, bold stroke, sans-serif lettering, and avoid using artwork behind text.

2   Use tactually distinct icons for controls, connectors, and legends.

3   Provide optional Braille and tactile labels.

Documentation:

All points in the Documentation section of this appendix.

Accessibility Guidelines for Input Components

This section presents summary lists of recommendations for design issues related to access for persons with disabilities. Item numbers are based on lists in related sections of this appendix.

3. Accessibility recommendations for pointing devices

Recommended

Manipulation and Physical Design:

9   Offer separate components that allow for use of alternative input devices.

12   Eliminate hard edges or sharp corners that could cause injury or inhibit correct device placement.

13   Manufacture outer surfaces using only hypoallergenic materials.

Input and Controls:

1   Allow connection, substitution, or addition of alternative input devices.

2   Design all controls to operate from the keyboard.

4   Limit button design primarily to push-button controls.

5   Use concave buttons, especially where sustained force is required.

6   Avoid twisting motions.

7   Minimize force required for operation.

8   Make all controls operable with one hand.

9   Avoid capacitance-based controls.

10 Use functional grouping and layout of controls.

11 Make controls tactually discernible.

13 Provide tactile and audible actuation feedback for controls.

16 Space the controls a sufficient distance to allow for tactile and visual discrimination.

17 Design stable controls.

18 Manufacture input guards or provide mounting for guards.

20 Remove left-right bias.

4. Accessibility recommendations for keyboards

Recommended

Visual Displays and Indicators:

3   Make LCD and LED indicators, warning, and alert lights software-readable.

Manipulation and Physical Design:

9   Offer separate components that allow for use of alternative input devices.

10 Provide adjustable height, swivel, and so on where appropriate.

12 Eliminate hard edges or sharp corners that could cause injury or inhibit correct device placement.

13 Manufacture outer surfaces using only hypoallergenic materials.

Input and Controls:

1   Allow connection, substitution, or addition of alternative input devices.

2   Design all controls to operate from the keyboard.

3   Mount all controls on the front of the device.

4   Limit button design primarily to push-button controls.

5   Use concave buttons, especially where sustained force is required.

6   Avoid twisting motions.

7   Minimize the force required for operation.

8   Make all controls operable with one hand.

9   Avoid capacitance-based controls.

10   Use functional grouping and layout of controls.

11   Make controls tactually discernible.

12   Make the state of non-momentary controls tactually discernible.

13   Provide tactile and audible actuation feedback for controls.

14   Avoid keys that cannot be read or simulated by software.

15   Maximize size of controls within the space available.

16   Space the controls a sufficient distance to allow for tactile and visual discrimination.

18   Manufacture input guards or provide mounting for guards.

19   Provide stable keyboards.

Labeling:

1   Use large, high-contrast, bold stroke, sans serif lettering, and avoid using artwork behind text.

2   Use tactually distinct icons for controls, connectors, and legends.

3   Provide optional Braille and tactile labels.

Documentation:

All points in the Documentation section of this appendix.

Accessibility Guidelines for Display Monitors

This section presents summary lists of recommendations for design issues related to access for persons with disabilities. Item numbers are based on lists in related sections of this appendix.

5. Accessibility guidelines for display monitors

Recommended

Visual Displays and Indicators:

1   Minimize glare.

2   Avoid 5-Hz to 50-Hz refresh rate or flicker rate.

3   Make LCD and LED indicators, warning, and alert lights software-readable.

4   Provide contrast and brightness controls.

5   Provide a display connector for an external or additional monitor.

6   Provide adjustable monitors.

Manipulation and Physical Design:

3   Make latches operable with one hand.

7   Ensure that devices do not generate electromagnetic or RF fields that would affect users with hearing aids.

9   Offer separate components that allow for use of alternate input devices.

10   Provide adjustable height, swivel, and so on, where appropriate.

11   Minimize operation noise levels.

12   Eliminate hard edges or sharp corners that could cause injury or inhibit correct device placement.

13   Manufacture outer surfaces using only hypoallergenic materials.

Input and Controls:

2   Design all controls to operate from the keyboard.

3   Mount all controls on the front of the device.

4   Limit button design primarily to push-button controls.

5   Use concave buttons, especially where sustained force is required.

6   Avoid twisting motions.

7   Minimize the force required for operation.

8   Make all controls operable with one hand.

9   Avoid capacitance-based controls.

10   Use functional grouping and layout of controls.

11   Make controls tactually discernible.

12   Make the state of non-momentary controls tactually discernible.

13   Provide tactile and audible actuation feedback for controls.

15   Maximize size of controls within the space available.

16   Space the controls a sufficient distance to allow for tactile and visual discrimination.

17   Design stable controls.

Labeling:

1   Use large, high-contrast, bold stroke, sans serif lettering, and avoid using artwork behind text.

2   Use tactually distinct icons for controls, connectors, and legends.

3   Provide optional Braille and tactile labels.

Documentation:

All points in the Documentation section of this appendix.

Accessibility Guidelines for Audio Components

This section presents summary lists of recommendations for design issues related to access for persons with disabilities. Item numbers are based on lists in related sections of this appendix.

6. Accessibility features for headphones
Recommended
Sound:
1 Provide a headphone jack.
2 Maximize the range of volume adjustment.
5 Provide a visual indication of important sounds generated in normal computer operation.
6 Send hardware-generated beeps to the operating system.

7. Accessibility features for microphones
Recommended
Sound:
7 Place the microphone in an orientation recommended by the microphone manufacturer.

Labeling:
1 Use large, high-contrast, bold stroke, sans serif lettering, and avoid using artwork behind text.
2 Use tactually distinct icons for controls, connectors, and legends.
3 Provide optional Braille and tactile labels.

8. Accessibility features for speakers
Recommended
Sound:
2 Maximize the range of volume adjustment.
3 Direct speakers toward the user.
8 Include a speech-capable sound system.
9 Reduce noise level of operating internal components.

Accessibility Guidelines for Storage Devices

This section presents summary lists of recommendations for design issues related to access for persons with disabilities. Item numbers are based on lists in related sections of this appendix.

9. Recommendations for 3.5-inch floppy disk drives

Recommended

Visual Displays and Indicators:

   3   Make LCD and LED indicators, warning, and alert lights software-readable.

Sound:

   4   Provide a visually distinct indicator for all alerts or warning sounds created by hardware.

   5   Provide visual indication of important sounds generated in normal computer operation.

Manipulation and Physical Design:

   1   Eject media a sufficient distance for grasping.

   2   Sculpt or bevel device entry slots.

   3   Make latches operable with one hand.

   4   Minimize the force required for inserting and retrieving media.

   5   Ensure that media takes rough handling, and use caddies for media that do not.

   6   Provide error flags for misinserted media, especially CDs.

   7   Ensure that devices do not generate electromagnetic or RF fields that would affect users with hearing aids.

   8   Use media misinsertion blocking.

  11   Minimize operation noise levels.

Input and Controls:

   1   Allow connection, substitution, or addition of alternative input devices.

   2   Design controls to operate from the keyboard.

   3   Mount all controls on the front of the device.

   4   Limit button design primarily to push-button controls.

   5   Use concave buttons, especially where sustained force is required.

6   Avoid twisting motions.

7   Minimize the force required for operation.

8   Make all controls operable with one hand.

11   Make controls tactually discernible.

Labeling:

2   Use tactually distinct icons for controls, connectors, and legends.

3   Provide optional Braille and tactile labels.

Documentation:

All points in the Documentation section of this appendix.

10. Accessibility recommendations for CD-ROM drives

Recommended

Visual Displays and Indicators:

3   Make LCD and LED indicators, warning, and alert lights software-readable.

Sound:

4   Provide a visually distinct indicator for all alerts or warning sounds created by hardware.

5   Provide visual indication of important sounds generated in normal computer operation.

Manipulation and Physical Design:

1   Eject media a sufficient distance for grasping.

2   Sculpt or bevel device entry slots.

3   Make latches operable with one hand.

4   Minimize the force required for inserting and retrieving media.

5   Ensure that media takes rough handling, and use caddies for media that do not.

6   Provide error flags for misinserted media, especially CDs.

7   Ensure that devices do not generate electromagnetic or RF fields that would affect users with hearing aids.

8   Use media misinsertion blocking.

11   Minimize operation noise levels.

12   Eliminate hard edges or sharp corners that could cause injury or inhibit correct device placement.

Input and Controls:

   2   Design all controls to operate from the keyboard.

   3   Mount all controls on the front of the device.

   4   Limit button design primarily to push-button controls.

   5   Use concave buttons, especially where sustained force is required.

   6   Avoid twisting motions.

   7   Minimize the force required for operation.

   8   Make all controls operable with one hand.

   11   Make controls tactually discernible.

   13   Provide tactile and audible actuation feedback for controls.

   15   Maximize size of controls within the space available.

Labeling:

   2   Use tactually distinct icons for controls, connectors, and legends.

   3   Provide optional Braille and tactile labels.

Documentation:

All points in the Documentation section of this appendix.

Accessibility Guidelines for Printers

This section presents summary lists of recommendations for design issues related to access for persons with disabilities. Item numbers are based on lists in related sections of this appendix.

11. Accessibility for printers

Recommended

Visual Displays and Indicators:

   3   Make LCD and LED indicators, warning, and alert lights software-readable.

Sound:

   4   Provide a visually distinct indicator for all alerts or warning sounds created by hardware.

   5   Provide visual indication of important sounds generated in normal computer operation.

   6   Send hardware-generated beeps to the operating system.

   9   Reduce noise level of operating internal components.

Manipulation and Physical Design:

1   Eject media a sufficient distance for grasping.

3   Make latches operable with one hand.

4   Minimize force required for inserting and retrieving media.

6   Provide error flags for misinserted media, especially CDs.

7   Ensure that devices do not generate electromagnetic or RF fields that would affect users with hearing aids.

11   Minimize operation noise levels.

12   Eliminate hard edges or sharp corners that could cause injury or inhibit correct device placement.

13   Manufacture outer surfaces using only hypoallergenic materials.

Input and Controls:

1   Allow connection, substitution, or addition of alternative input devices.

2   Design all controls to operate from the keyboard.

3   Mount all controls on the front of the device.

4   Limit button design primarily to push-button controls.

5   Use concave buttons, especially where sustained force is required.

6   Avoid twisting motions.

7   Minimize the force required for operation.

8   Make all controls operable with one hand.

9   Avoid capacitance-based controls.

10   Use functional grouping and layout of controls.

11   Make controls tactually discernible.

12   Make the state of non-momentary controls tactually discernible.

13   Provide tactile and audible actuation feedback for controls.

15   Maximize size of controls within the space available.

16   Space the controls a sufficient distance to allow for tactile and visual discrimination.

20   Remove left-right bias.

Labeling:

1   Use large, high-contrast, bold stroke, sans serif lettering, and avoid using artwork behind text.

2   Use tactually distinct icons for controls, connectors, and legends.

3   Provide optional Braille and tactile labels.

Documentation:

All points in the Documentation section of this appendix.

Accessibility References and Resources

The following represents some of the references, services, and tools available to help build hardware and software that addresses accessibility needs.

Accessibility Publications

The following publications provide supplementary information.

Berliss, J. R. *Checklists for implementing accessibility in computer laboratories at colleges and universities.* University of Wisconsin-Madison, Trace Research and Development Center, 1990.

Fontaine, P. *Writing Accessible HTML Documents.* General Services Administration, 1995.

Lowney, G. C. *The Microsoft Windows Guidelines for Accessible Software Design.* Microsoft Corporation, 1995.

Novak, M. (Ed.) *General Input Device Emulating Interface: Version 1.* University of Wisconsin-Madison, Trace Research and Development Center, 1991.

Thoren, Clas (Ed.) *Nordic guidelines for computer accessibility.* Gotab, Sthlm, 1993.

Vanderheiden, G. C. *Consideration in the design of computers and operating systems to increase their accessibility to persons with disabilities.* University of Wisconsin-Madison, Trace Research and Development Center, 1988.

———. *Making software more accessible to people with disabilities.* University of Wisconsin-Madison, Trace Research and Development Center, 1991.

——— and Vanderheiden, K. R. *Accessibility Design Guide I: Guidelines for the Design of Consumer Products to Increase Their Accessibility to Persons with Disabilities or Who Are Aging.* University of Wisconsin-Madison, Trace Research and Development Center, 1991.

Resources for Accessibility Design

This section lists some documents and services related to accessibility design.

Microsoft Windows Guidelines for Accessible Software Design

These guidelines describe techniques for developing software applications that are usable by people with disabilities. This document is included on the Microsoft Developer Network (MSDN) CD-ROM. For a list of organizations that can assist in converting documentation into large print or Braille, contact the Microsoft Sales Information Center.

To obtain additional copies or for information about other Microsoft products and services for people with disabilities, contact:

Microsoft Sales Information Center
One Microsoft Way
Redmond, WA 98052-6393
Voice: (800) 426-9400
Text Telephone: (800) 892-5234
Fax: (206) 635-6100

Research and Product Information

For information on research and development concerning technology, communication, and disabilities, or for catalogs of accessibility products and service providers, contact:

Trace Research and Development Center
Waisman Center and Department of Industrial Engineering
University of Wisconsin
Madison, WI 53705
E-mail: info@Trace.Wisc.Edu
Fax: (608) 262-8848
FTP, Gopher, and WWW servers: trace.wisc.edu

For a list of listserve discussions, send "LISTS" to listproc@trace.wisc.edu.

Documentation in Accessible Formats

Recording for the Blind and Dyslexic, Inc., is an organization that can assist in preparing documentation in accessible formats, including electronic text and audio tape. Contact:

Recording for the Blind and Dyslexic, Inc.
20 Roszel Road
Princeton, NJ 08540
Voice telephone: (800) 221-4792
Fax: (609) 987-8116

Assistive Technology Programs

For general information or recommendations for how computers can help specific users, consult a trained evaluator. An assistive technology program will provide referrals to programs and services that are available to you. To locate the assistive technology program nearest you, contact:

National Information System
Center for Developmental Disabilities
Midland Center
Education Building
8301 Sarrow Road
Columbia, SC 29203
Voice or text telephone: (803) 777-4435
Fax: (803) 935-5250

Closed Captioning and Video Description

The following service providers can assist in adding closed captions or video description to video tape and film:

The Caption Center
125 Western Avenue
Boston, MA 02134
Voice/text telephone: (617) 492-9225
Fax: (617) 562-0590

National Captioning Institute
5203 Leesburg Pike, Suite 1500
Falls Church, VA 22041

A P P E N D I X D

Legacy Support

This appendix summarizes assignments for interrupt request (IRQ), direct memory access (DMA), and I/O port addresses used by built-in devices on legacy system boards. This appendix also includes requirements for any Industry Standard Architecture (ISA) legacy implementations.

Contents

Fixed ISA Interrupts

The following IRQs are used by ISA devices and are considered to be fixed assignments.

Fixed ISA Interrupts

Hardware IRQ	Default assignment
IRQ 0	System timer
IRQ 1	Keyboard
IRQ 2	Second programmable interrupt controller (PIC) cascade
IRQ 3	COM 2
IRQ 4	COM 1
IRQ 5	Sometimes LPT 2—not considered fixed
IRQ 6	Standard floppy disk controller (FDC)
IRQ 7	LPT 1
IRQ 8	Real-time clock/CMOS
IRQ 9	—
IRQ 10	Sometimes COM 4—not considered fixed
IRQ 11	Sometimes COM 3—not considered fixed
IRQ 12	PS/2-style mouse
IRQ 13	Coprocessor
IRQ 14	Primary Integrated Device Electronics (IDE) controller
IRQ 15	Secondary IDE controller

Legacy ISA DMA Assignments

The following table lists DMA channel assignments that are used by legacy ISA devices and are therefore considered fixed.

Legacy ISA DMA Considered Fixed

Hardware DMA	System function (default)
DMA 0	ISA expansion
DMA 1	—
DMA 2	FDC
DMA 3	Extended capabilities port (ECP) parallel port on LPT 1
DMA 4	DMA controller cascading
DMA 5	—
DMA 6	—
DMA 7	—

Legacy ISA I/O Address Assignments

The following table lists I/O addresses that are used by legacy ISA devices and are therefore considered fixed.

Legacy ISA System I/O

I/O Address	Default system function
0000–000F	Slave DMA
0010–0018	System
0001F	System
0020–0021	Master 8259
0040–0043, 0048–004B	Programmable interrupt timer (PIT) #1, PIT #2
0050–0052	System
0060	Keyboard/mouse controller
0061	System control port B
0064	Keyboard/mouse status
0070–0071	Nonmaskable Interrupt (NMI) enable/real-time clock
0081–008B	DMA page registers
0090–0091	System
0092	System control port A
0093–009F	System

Continued

Legacy ISA System I/O *(continued)*

I/O Address	Default system function
00A0–00A1	Slave interrupt controller
00C0–00DE	Master DMA controller
00F0–00F1	Coprocessor busy clear/reset
0170–0177	Secondary IDE controller
01F0–01F7	Primary IDE controller
0201	Joystick interface
0220–022F	Sound Blaster
0278–027A	LPT 2 (XT parallel port 3)
02E8–02EF	Alternate COM (4)
02F8–02FF	COM 2
0330–0331	MPU-401
0376	IDE Controller
0378–037A	LPT 1 (XT parallel port 2)
0388–038B	Frequency modulation (FM) synthesis
03B0–03BB	MDA, EGA/video graphics array (VGA)
03BC–03BE	LPT 3 (XT parallel port 1)
03C0–03DF	EGA/VGA
03E0–03E7	PCIC PCMCIA controllers
03E8–03EF	Alternate COM (3)
03F0–03F7	FDC — excluding 03F6
03F8–03FF	COM 1
0534–0537	Windows Sound System-compatible
0CF8–0CFB	Peripheral Component Interconnect (PCI) ports

Plug and Play ISA System Requirements

Although in general ISA devices are excluded from PC 99, many PC 99 systems will include ISA support, allowing users to insert ISA add-on devices. This section summarizes the basic requirements for a system that includes the ISA bus.

In addition to ISA expansion cards, the following are also ISA devices:

- 8042 and similar controllers, ports, keyboards, and mice
- DMA controllers and slaves
- FDCs
- Interrupt controllers
- Legacy parallel and serial ports
- Math coprocessors
- PITs
- VGA controllers

Any such devices located at I/O addresses below 100h can use fixed resources and are exempt from Plug and Play requirements for unique IDs, flexible resource configuration, and dynamic disable capabilities.

1. System supports Plug and Play ISA specification and Plug and Play BIOS
Required
If ISA support is included in a PC 99 system, the manufacturer must implement the standards described in the following Plug and Play specifications:

- *Plug and Play ISA Specification, Version 1.0a*
- *Plug and Play BIOS Specification, Version 1.0a*
- *Clarifications to the Plug and Play BIOS Specification, Version 1.0a.*

The Plug and Play specifications are available from the web site at http://www.microsoft.com/hwdev/specs/pnpspecs.htm. Additional ISA clarifications and white papers related to ISA Plug and Play under the Microsoft Windows operating system are available from the web site at http://www.microsoft.com/hwdev/legacy/.

Note: Standard system devices are excluded from this requirement. The system can reserve static resources for devices such as interrupt controllers 1 and 2, 8254-2 timer, 8042 keyboard controller, real-time clock, DMA page registers, DMA controllers 1 and 2, and math coprocessor (if present). For a system based on Intel Architecture, these fixed resources are located at I/O addresses below 100h and can also include an NMI mask.

Plug and Play ISA Device Requirements

This section includes additional requirements for ISA cards, including requirements for design implementations that appear only as recommendations in the ISA specification, to ensure that such cards will perform correctly under Windows.

The information in this section is provided for manufacturers of ISA devices who want to ensure that their devices are completely compatible with Plug and Play operating systems.

For more details, see the Plug and Play ISA specification.

2. ISA device complies with Plug and Play ISA standards
Required
Any card or bus that implements Plug and Play ISA must fully implement the standards defined in the *Plug and Play ISA Specification, Version 1.0a.* This specification also defines the requirements for a unique ID for each ISA device. The unique ID is used to identify the device for Plug and Play configuration.

3. Option ROMs are used only on cards with boot devices
Required
This requirement applies only for Intel Architecture systems. Option ROMs must be used only on cards that contain boot devices.

Cards with option ROMs must not hook the primary boot interrupts (Int 9h, Int 10h, Int 13h, Int 18h, and Int 19h) until the system calls the boot connection vector in the selected option ROM expansion header.

For cards with option ROMs, the default configuration must be able to be disabled after the card has been isolated.

4. Implement full 16-bit I/O address decode logic

Required

This circuit can be simple enough to limit I/O addresses to the 0h to 3FFh range, or it can be flexible enough to use the upper address regions. For more information, see Chapter 3, "PC 99 Basic Requirements."

5. ISA device and driver support IRQ sharing if resource requirements cannot be met

Required

This requirement does not apply for Windows NT Workstation drivers. This is a requirement only if the device cannot meet the PC 99 resource requirements (as defined for the particular device class in the related chapter in Part 4 of *PC 99 Hardware Design Guide*). This requirement applies only for devices of the same class, not across device classes.

To share IRQs, the following requirements must be met:

- The IRQ line must be pulled high by the system board.

- The IRQ line must never be driven high by the devices.

- To signal an interrupt, devices must pull the IRQ line low for a minimum of 100 nanoseconds and then release it. The interrupt is signaled by the rising edge that occurs as a result of the pull-up on the IRQ line.

- The drivers for all devices connected to the IRQ line must correctly support the interrupt-sharing services of the virtual programmable interrupt controller device (VpicD). This means that after dispatching an interrupt from VpicD, the drivers must respond to VpicD and correctly indicate whether they actually processed an interrupt for their devices. VpicD will ensure that all devices with pending interrupts have been serviced before returning from the interrupt.

- IRQ sharing support implemented in the device driver for servicing interrupts.

6. Unimplemented registers return a deterministic value when read

Required

Any unimplemented registers in the range 00h–2Fh must return a deterministic value when they are read. Unimplemented configuration registers must return the "disabled" or "unused" value (not necessarily 0) when they are read.

7. Each ISA card provides complete and correct identifiers

Required

In the Plug and Play ISA specification, it is required that a Plug and Play card have both an industry-unique Vendor ID (acquired by sending e-mail to pnpid@microsoft.com) and a company-unique Product ID (assigned by the manufacturer). The specification requires that this Product ID be unique among all Plug and Play ISA cards manufactured by that company. This means each product (for example, fax card, display adapter, sound adapter, and so on) and every model (for example, 14.4 fax, 28.8 fax, and so on) from the same manufacturer must have different product identifiers.

This is a requirement because it allows the operating system to isolate and identify these different cards. The user must never have a Plug and Play card that cannot be identified because it cannot be distinguished from other models of cards from the same manufacturer. The use of a unique Product ID does not solve the problems that occur when a user installs two of the same cards in a PC system.

In those cases, the user might install a Plug and Play card but will not receive an indication that it was installed and the card will not work. For this purpose, the Plug and Play ISA specification defines a unique serial-number field that can be added to the Vendor and Product IDs to make the card completely unique. A board-unique number in the serial-number field is required for ISA devices included on a system.

8. ISA system board devices are reported through the BIOS or use unique Serial ID

Required

A peripheral ISA device implemented on the system board can use a fixed Serial ID (which is not unique) if the device is reported through the BIOS.

If the system board device participates in the Plug and Play ISA isolation scheme (rather than being reported through the BIOS), then it must meet the same requirements for a unique Serial ID as for an add-on card.

Notice that it is possible that an add-on card containing an ISA chip might be added to a PC system that contains the same chip on the system board. In such a case, the add-on device will be found only if it has a different Serial ID.

9. IDs using PNP suffix are allowed only in the Compatible Device ID field

Required

Device IDs that use the three-character PNP suffix are allowed only in the Compatible Device ID field and cannot be used as Device ID or Logical Device ID fields. The exception would be the device to which the PNP-based ID was originally assigned.

Resource data describe what resources must be available for each logical device on the card (for example, number of available IRQ numbers, address ranges of memory, and so on). Resource data can be stored in the same nonvolatile storage device (such as a serial ROM) that contains the serial identifier. The resource data in the nonvolatile storage device must be sequentially loaded into the resource data register (04h).

The content of the nonvolatile storage device must be programmed with the information the system needs to interpret which resources the card requires. The structure of the data contained in the storage device is variable, depending on what resources are needed.

The resource data for a Plug and Play ISA card can be read while the card is in the Config state. This card can enter the Config state either after it has been isolated during the isolation sequence or whenever it receives a Wake (Card Select Number [CSN]) software command in which the CSN matches the CSN assigned to the card. Only one card at a time can be in the Config state.

10. Option ROMs correctly support boot devices
Required

Plug and Play ISA expansion cards that contain boot devices require some special considerations to properly boot the system. The system must implement support for Plug and Play ISA boot devices and option ROMs as described in the Plug and Play BIOS specification.

The types of devices required for the boot process include the primary input device (usually a keyboard), the primary output device (usually a display adapter and monitor), and any Initial Program Load (IPL) devices.

Any Plug and Play ISA expansion card that provides a boot function must be active when the system powers up. This gives non-Plug and Play systems the means for using Plug and Play ISA devices during a legacy boot process. In this case, a non-Plug and Play system BIOS will not perform the isolation sequence, but will instead perform a ROM scan to detect the presence of a boot device. After the ROM scan detects the presence of an option ROM on the boot device, the system ROM will jump to the option ROM to initialize the device. The Plug and Play option ROM on the card will detect that the system BIOS is not Plug and Play-compatible and will respond accordingly. Although an initial set of static resources must be provided during this legacy boot, the Plug and Play ISA card must be capable of changing these resources using the standard Plug and Play ISA isolation and configuration process.

As required in the Plug and Play ISA specification, resource usage of a card is always reflected in the card's configuration registers. This information allows Windows 95 to easily determine the default settings of a Plug and Play boot device. The default settings can then be overridden by the operating system with full cooperation of the device driver.

A P P E N D I X   E

PC 99 Master Checklist

If a recommended feature is implemented, it must meet the PC 99 requirements for that feature as defined in this document.

Checklist for PC 99 Basic Requirements

Consumer	Office	Mobile	Workstation	Entertainment
3.1. System performance meets PC 99 minimum requirements				
300 MHz,	*300 MHz,*	*233 MHz,*	*400 MHz,*	*300 MHz*
32 MB	*64 MB*	*32 MB*	*128 MB*	*64 MB*

3.2. System design meets ACPI 1.0 specification and PC 99 requirements
Required for all system types, with exceptions for mobile PCs

3.3. Hardware design supports OnNow and Instantly Available PC initiatives
Required for all system types, with exceptions for mobile PCs

3.4. BIOS meets PC 99 requirements for OnNow support
Required for all system types

3.5. BIOS meets PC 99 requirements for boot support
Required for all systems, with exceptions for mobile PCs

3.6. All expansion slots in the system are accessible for users to insert cards
Required for all system types, with extra guidelines for mobile

3.7. Audible noise meets PC 99 requirements
Required for all system types

3.8. System and component design practices follow accessibility guidelines
Recommended for all system types

3.9. Internal system modification capabilities are not accessible to end users
Recommended for all system types

3.10. System design provides physical security
Recommended for all system types

3.11. Each device and driver meets PC 99 device requirements
Required for all system types

3.12. Each bus and device meets Plug and Play specifications
Required for all system types

3.13. Unique Plug and Play device ID provided for each system device and add-on device
Required for all system types

3.14. Option ROMs meet Plug and Play requirements
Required for all system types

3.15. "PNP" vendor code used only to define a legacy device's Compatible ID
Required for all system types

3.16. Device driver and installation meet PC 99 requirements
Required for all system types

3.17. Minimal user interaction needed to install and configure devices
Required for all system types

3.18. Connections use icons, plus keyed or shrouded connectors, with color coding
Required for all system types, with exceptions for mobile PCs

3.19. Hot-plugging capabilities for buses and devices meet PC 99 requirements
Required for all system types

3.20. System includes Device Bay 1.0-compatible bay
Recommended for all system types

3.21. Multifunction add-on devices meet PC 99 device requirements for each device
Required for all system types

3.22. All devices support correct 16-bit decoding for I/O port addresses
Required for all system types

3.23. All PC 99 input devices support Microsoft DirectInput and work simultaneously
Required for all system types

3.24. Each bus meets written specifications and PC 99 requirements
Required for all system types

3.25. System includes USB with two USB ports, minimum
Required for all system types, with exceptions for mobile PCs

3.26. System includes support for IEEE 1394
Recommended for all system types, with 3 ports recommended for Entertainment PCs

3.27. If present, PCI bus meets PCI 2.1 or later, plus PC 99 requirements
Required for all system types

3.28. System does not include ISA expansion devices or slots
Required for all system types

3.29. System includes keyboard connection and keyboard
Required for all system types

3.30. System includes pointing-device connection and pointing device
Required for all system types

3.31. System includes connection for external parallel devices
Required for all system types

3.32. System includes connection for external serial devices
Required for all system types

3.33. System includes IR devices compliant with IrDA specifications
Recommended for all system types

3.34. System includes PC 99-compatible CD or DVD drive and controller

Required	*Recommended*	*Recommended*	*Required*	*DVD required*

3.35. System includes audio support that meets PC 99 requirements

Recommended	*Recommended*	*Recommended*	*Recommended*	*Required*

3.36. System includes a modem or other public network communications support

Required	Recommended	Required	Required	Required

3.37. System includes a network adapter

Recommended	Required	Recommended	Required	Recommended

3.38. System includes smart card support
Recommended for all system types

3.39. Graphics adapter meets PC 99 minimum requirements
Required for all system types, with specific guidelines for each system type

3.40. Color monitor is DDC-compliant with unique EDID identifier
Required for all system types, with exceptions for mobile PCs

3.41. System meets PC 99 DVD-Video and MPEG-2 playback requirements, if system supports DVD-Video
Required for all system types, with exceptions for mobile PCs

3.42. Adapter supports television output if system does not include a large-screen monitor
Recommended for all system types

3.43. System supports PC 99 analog video input and capture capabilities
Recommended for all system types

3.44. System includes analog television tuner
Recommended for all system types

3.45. System BIOS and option ROMs support Int 13h Extensions
Required for all system types

3.46. Host controller for storage device meets PC 99 requirements
Required for all system types

3.47. Host controllers and hard disk devices support bus mastering
Required for all system types

3.48. Hard drive meets PC 99 requirements
Required for all system types

3.49. Operating system recognizes the boot drive in a multiple-drive system
Required for all system types

3.50. Floppy disk capabilities, if implemented, do not use legacy FDC
Recommended for all system types

3.51. System supports WHIIG

Not applicable	Required	Required with Windows NT	Required	Not applicable

3.52. System includes driver support for WMI

Not applicable	Required	Required with Windows NT	Required	Not applicable

3.53. Management information service provider enabled by default

Not applicable	Required	Required with Windows NT	Required	Not applicable

3.54. Expansion devices can be remotely managed

Not applicable	Required	Recommended	Required	Not applicable

3.55. SMBIOS 2.2 static table support is provided

Not applicable	Required	Recommended	Required	Not applicable

Checklist for Workstation PC 99

4.1. Workstation meets all requirements for Office PC 99
Required

4.2. Workstation performance meets Workstation PC 99 minimum requirements
Required

4.3. Workstation supports multiple processors
Recommended

4.4. Workstation RAM can be expanded
Recommended

4.5. Workstation system memory includes ECC memory protection
Required

4.6. Workstation includes APIC support
Required

4.7. Workstation includes high-performance components
Recommended

4.8. Workstation supports 64-bit I/O bus architecture
Required for 64-bit platforms

4.9. Workstation does not include ISA expansion slots
Required

4.10. Graphics subsystem supports workstation performance demands
Required, with special conditions depending on PC 99 market category

4.11. Storage components rely on SCSI controller
Recommended

4.12. Workstation includes multiple hard drives
Recommended

Checklist for Entertainment PC 99

5.1. System performance meets Entertainment PC 99 minimum requirements
Required

5.2. Entertainment PC includes three IEEE 1394 ports, with at least one easily accessible connector
Recommended

5.3. All Entertainment PC input devices meet USB HID specifications
Recommended

5.4. Entertainment PC includes a remote-control pointing device
Recommended

5.5. Entertainment PC audio subsystem meets PC 99 audio requirements
Required

5.6. Graphics subsystem meets Entertainment PC 99 requirements for 3-D acceleration
Required

5.7. Entertainment PC includes support for television output if the system doesn't have a large-screen monitor
Recommended

5.8. Entertainment PC includes large-screen DDC2B color entertainment monitor
Recommended

5.9. Entertainment PC DVD and TV playback meet PC 99 requirements
Required

5.10. Entertainment PC includes analog video input and capture capabilities
Recommended

5.11. Entertainment PC includes analog television tuner
Recommended

5.12. Entertainment PC includes digital broadcast satellite subsystem
Recommended

5.13. Entertainment PC includes DTV support
Recommended

Checklist for Mobile PC 99

6.1. Mobile PC performance meets Mobile PC 99 minimum requirements
Required

6.2. Mobile PC supports Smart Battery or ACPI Control Method battery
Required

6.3. Expansion capabilities of mobile PC are accessible to users
Required

6.4. Mobile PC connections use icons plus keyed or shrouded connectors
Required

6.5. Mobile PC includes one USB port
Required

6.6. USB-connected device does not maintain fully on power state
Required

6.7. Mobile PC includes an IEEE 1394 port
Recommended

6.8. Mobile PC includes CardBus
Required

6.9. Mobile PC keyboard and pointing device meet PC 99 requirements
Required

6.10. Mobile PC includes IR devices compliant with IrDA specifications
Recommended

6.11. Mobile PC includes support for installing the operating system
Required

6.12. Mobile PC includes audio that meets Mobile PC 99 audio requirements
Recommended

6.13. Mobile PC includes communications device
Recommended

6.14. Mobile system supports hot-pluggable devices and alternative network connections
Recommended

6.15. Mobile system meets Mobile Power Guidelines '99
Recommended

6.16. Mobile system includes CD or DVD drive
Recommended

6.17. Mobile system meets Manageability Baseline requirements
Required if Windows NT is preinstalled

6.18. Built-in display adapter meets Mobile PC 99 minimum capability
Required

6.19. Built-in display adapter with 3-D hardware acceleration capabilities meets Mobile PC 99 minimum capability
Required

6.20. Mobile system meets Mobile PC 99 requirements for supporting multiple adapters and multiple monitors
Required

6.21. External graphics adapter interface supports DDC monitor detection
Required

6.22. Mobile system with MPEG-2 or DVD playback features meets Mobile PC 99 requirements for video playback
Required

6.23. Mobile system with AGP supports meets Mobile PC 99 requirements
Required

6.24. System meets Mobile PC 99 requirements if television output is implemented
Required

6.25. Built-in mobile display supports ICC color management
Required

6.26. System supports PCI docking through a bridge connector
Recommended

6.27. Docked mobile PC supports state change notification using ACPI
Required

6.28. Docked mobile PC has the ability to identify the specific model of the dock
Required

6.29. Docked mobile PC has the ability to uniquely identify the dock
Required

6.30. Mobile PC/docking station combination meets PC 99 requirements
Required

6.31. Docking station meets all PC 99 system requirements
Required

6.32. Mobile/docking station interface is supported using ACPI-defined mechanisms
Required

6.33. Mobile PC/docking station combination supports automatic resource assignment and dynamic disable capabilities
Required

6.34. Docking station supports warm docking
Required

6.35. Docking system supports fail-safe docking
Required

6.36. Docking station includes an IEEE 1394 port
Recommended

6.37. Docking station/mobile pair meets PC 99 audio requirements
Recommended

6.38. Mini-dock supports automatic resource assignment and dynamic disable capabilities for replacement devices
Required

6.39. Mini-dock supports warm docking
Required

6.40. Mini-dock supports fail-safe docking
Required

6.41. Mini-dock includes an IEEE 1394 port
Recommended

6.42. Mini-notebook performance meets PC 99 minimum requirements
Required

Checklist for USB

7.1. System includes USB with two USB ports, minimum
Required for all system types, with exceptions for mobile PCs

7.2. Systems include BIOS support for USB keyboards and hubs
Required

7.3. All USB hardware complies with USB 1.0 specification
Required

7.4. Connections use USB icon
Required

7.5. Devices and drivers support maximum flexibility of hardware interface options
Required

7.6. USB host controller meets either OpenHCI or UHCI specification
Required

7.7. USB host controller can wake the system
Required

7.8. USB hubs comply with USB 1.1 specification
Recommended

7.9. Bus-powered USB hubs provide ports that can be individually power switched
Recommended

7.10. Systems and devices comply with USB power management requirements
Required

7.11. USB devices meet requirements in related USB device class specification
Required

Checklist for IEEE 1394

8.1. Controllers and devices support mandatory features in IEEE P1394.a with backward compatibility with IEEE 1394-1995
Required

8.2. Controllers comply with OpenHCI for IEEE 1394
Required

8.3. OpenHCI controllers and devices support advances defined in IEEE P1394.a
Required

8.4. Host supports peak data rate of 400 Mb/s, minimum
Required

8.5. Design avoids excessive currents resulting from ground-fault potential among devices
Recommended

8.6. Device command protocols conform to standard device class interfaces
Required

8.7. Devices support peak data rate of 400 Mb/s, minimum
Required

8.8. Devices requiring support for high-bandwidth data transfer use IEEE 1394
Recommended

8.9. Plug and Play devices demonstrate interoperability with other devices
Required

8.10. Topology faults do not cause the bus to fail
Required

8.11. Removable media devices support media status notification
Required

8.12. Devices that can initiate peer-to-peer communications also support remote programming
Required

8.13. Device provides a configuration ROM for unique device identification
Required

8.14. Device configuration ROM implements general ROM format
Required

8.15. Bus information block implemented at a base address offset of 0404h
Required

8.16. Configuration ROM provides globally unique device ID
Required

8.17. Root directory is located at a fixed address following the bus information block
Required

8.18. Configuration ROM includes a unit directory for each independent device function
Required

8.19. Each unit directory provides a valid Unit_Spec_Id and Unit_Sw_Version
Required

8.20. Each unit directory provides a pointer to a unit-dependent directory
Required

8.21. Vendor and model leaves support textual descriptor leaf format
Required

8.22. Unit-dependent directory provides a pointer to the unit's CSRs
Required

8.23. Device provides more than one connector port
Recommended

8.24. Device uses the approved IEEE 1394 connectors
Required

8.25. Self-powered devices propagate the power bus through each connector
Required

8.26. Only single-port leaf-node devices use 4-pin connectors
Required

8.27. Device connectors exhibit common speed and power characteristics
Required

8.28. Standard S400-rated IEEE 1394 cable is provided with devices
Required

8.29. Devices provide sufficient power to their PHY at appropriate times
Required

8.30. Devices report power source and cable power consumption in Self_id packet
Required

8.31. Devices implement link power control
Required

8.32. Device requiring power increments in excess of Link_on implements unit-power CSRs
Required

8.33. Devices that source cable power report this capability
Required

8.34. IEEE 1394-enabled PC sources cable power
Required

8.35. Power source supplies appropriate cable power
Recommended

8.36. Devices notify the power manager of power change requests
Required

8.37. Devices and controllers comply with Cable Power Distribution specification
Required

8.38. Devices and controllers comply with IEEE 1394 power specification
Required

Checklist for PCI

9.1. All components comply with PCI 2.1
Required

9.2. System does not contain ghost devices
Required

9.3. System uses standard method to close BAR windows on nonsubtractive decode PCI bridges
Required

9.4. System provides 3.3 V to all PCI connectors
Required

9.5. PCI add-on devices support both 5 V and 3.3 V signaling
Recommended

9.6. System-board bus complies with PCI 2.1
Required

9.7. Bus master privileges are supported for all connectors
Required

9.8. Functions in a multifunction PCI device do not share writable PCI Configuration Space bits
Required

9.9. All PCI devices complete memory write transaction (as a target) within specified times
Required

9.10. Devices use PCI 2.1 Configuration Space for Plug and Play device ID
Required

9.11. Device IDs include Subsystem IDs
Required

9.12. Configuration Space is correctly populated
Required

9.13. Interrupt routing is supported using ACPI
Required

9.14. BIOS does not configure I/O systems to share PCI interrupts
Recommended

9.15. BIOS configures boot device IRQ and writes to the interrupt line register
Required

9.16. Systems that support hot plugging for any PCI device use ACPI-based methods
Required

9.17. All PCI components comply with PCI Bus Power Management Interface specification
Required

9.18. System provide support for 3.3Vaux if a system supports S3 or S4 states
Required

9.19. Bus power states are correctly implemented
Required

9.20. PCI-based modem and network adapters support wake-up
Required

Checklist for ATA and ATAPI

10.1. Controller and peripherals comply with ATA-2, ATA-3, or ATA/ATAPI-4 standards
Required

10.2. Bootable ATA controller supports El Torito No Emulation mode
Required

10.3. Option ROMs support Int 13h Extensions
Required

10.4. Dual ATA adapters use single FIFO with asynchronous access or dual FIFOs and channels
Required

10.5. System BIOS and devices support LBA
Required

10.6. System BIOS supports ARMD
Recommended

10.7. Controller and peripherals support Ultra DMA
Required

10.8. Controller and peripheral connections include Pin 1 cable designation with keyed and shrouded connectors
Required

10.9. Peripherals comply with ATA/ATAPI-4 or SFF 8020i v.2.5
Required

10.10. Removable media devices support media status notification
Required

10.11. BIOS enumeration of all ATAPI devices complies with ATA/ATAPI-4 or SFF 8020i v.2.5
Required

10.12. ATAPI devices support DEVICE RESET command
Required

10.13. Each device has a Plug and Play device ID
Required

10.14. Dynamic resource configuration is supported for all devices
Required

10.15. Resource configuration meets bus requirements
Required

10.16. ISA address ranges 3F7h and 377h are not claimed by ATA controllers
Required

10.17. Bus and device meet PC 99 power management requirements
Required

10.18. ATA device supports ATA STANDBY command
Required

Checklist for SCSI

11.1. SCSI host controller supports bus mastering
Required

11.2. Bootable SCSI controller supports El Torito No Emulation mode
Required

11.3. Option ROM supports Int 13h Extensions
Required

11.4. Option ROM supports virtual DMA services
Required

11.5. Bus type is clearly indicated on connectors for all adapters, peripherals, cables, and terminators
Required

11.6. Differential devices support DIFFSENS as defined in SPI standard
Required

11.7. Automatic termination circuit and SCSI terminators meet SCSI-3 standard
Required

11.8. Terminator power is supplied to the SCSI bus with overcurrent protection
Required

11.9. External connector meets SCSI-2 or later standard
Required

11.10. Controller and peripherals implement SCSI bus data protection signal
Required

11.11. SCSI connections use keyed and shrouded connectors
Required

11.12. External devices use automatic termination or an accessible on-board termination switch
Required

11.13. Shielded device connector meets SCSI-2 or later standard
Required

11.14. Removable media devices support media status notification
Required

11.15. Each device has a Plug and Play device ID
Required

11.16. Dynamic resource configuration is supported for all devices
Required

11.17. Resource configuration meets bus requirements
Required

11.18. SCAM support is disabled by default
Required

11.19. SCSI devices that support hot-plugging meet PC 99 requirements
Required

11.20. SCSI controllers provide multi-initiator support
Recommended

11.21. Bus and device meet PC 99 power management requirements
Required

11.22. Hardware supports the STOP/START UNIT command as defined in the SPI standard
Required

11.23. STOP/START UNIT command is used to decrease power consumption
Required

Checklist for PC Card

12.1. All devices comply with the PC Card standards
Required

12.2. System and ZV-compatible 16-bit PC Cards comply with ZV standard definitions
Required

12.3. Controller supports industry-standard ExCA register set
Required

12.4. System maintains mapping of IRQ Routing Register bits to system interrupt vectors
Required

12.5. IRQ connections can be determined by using the 0805 register
Required

12.6. CardBus controllers support both ISA and PCI interrupts
Required

12.7. System supports industry-standard definition for CardBus bridges
Required

12.8. BIOS initializes CardBus controller in 82365-compatible mode and supports backward compatibility
Recommended

12.9. CardBus controllers do not share writable PCI Configuration Space bits
Required

12.10. Each 16-bit PC Card memory window in CardBus controller has it own page register
Required

12.11. Card supports required I/O card tuples
Required

12.12. Configuration table entry tuples listed in priority order
Required

12.13. Card specifies maximum configuration options
Required

12.14. Configuration Space meets Common Silicon Guidelines
Required

12.15. RESERVED fields comply with PCI 2.1
Required

12.16. CardBus card implements required and recommended tuples
Required

12.17. Socket controller complies with device class power management reference specification
Required

12.18. 16-bit PC Card cards implement power-related events using ReqAttn bit and #STSCHG mechanism
Required

12.19. CardBus controllers and cards implement PCI power management specifications
Required

12.20. No user intervention required for correctly installing devices
Required

12.21. Device is immediately functional without restarting the system
Required

12.22. ZV-compatible PC Card driver uses DirectDraw LVE
Required

12.23. 16-bit PC Card card driver supports sharing of level-mode interrupts
Required

Checklist for I/O Ports and Devices

Consumer	**Office**	**Mobile**	**Workstation**	**Entertainment**

13.1. System includes connection for external serial devices
Required for all system types

13.2. System includes connection for external parallel devices
Required for all system types

13.3. System includes external connection for keyboard
Required for all system types

13.4. System includes pointing-device connection and pointing device
Required for all system types

13.5. System includes USB game pad or joystick
Required for all system types; wireless recommended for Entertainment PC

13.6. System includes built-in wireless capabilities
Recommended for all system types

13.7. Devices use USB or external bus connections rather than legacy serial or parallel ports
Required   Recommended   Recommended   Required   Required

13.8. All devices meet PC 99 general device requirements
Required

13.9. Serial port meets device class specifications for its bus
Required

13.10. Legacy serial port is implemented as 16550A UART or equivalent and supports 115.2K baud
Required

13.11. Legacy serial port supports dynamic resource configuration
Required

13.12. Conflict resolution for legacy serial port ensures availability of at least one serial port
Required

13.13. Parallel port meets device class specifications for its bus
Required

13.14. Flexible resource configuration supported for each parallel port
Required

13.15. EPP support does not use restricted I/O addresses
Required

13.16. Compatibility, nibble mode, and ECP protocols meet IEEE 1284-1994 specifications
Required

13.17. Port connectors meet IEEE 1284-I specifications, minimum
Required

13.18. IEEE 1284 peripherals have Plug and Play device IDs
Required

13.19. Device identification string provides a Compatible ID key
Recommended

13.20. Daisy-chained parallel port device is Plug and Play capable
Required

13.21. Pointing-device connection meets requirements for its bus class
Required

13.22. Remote control pointing device provides PC 99 minimum support
Recommended

13.23. Keyboard connection meets requirements for its bus class
Required

13.24. No interference occurs between multiple keyboards
Required

13.25. Keyboard includes Windows and Application logo keys
Recommended

13.26. Device meets USB HID class specification requirements
Required

13.27. IR device uses NDIS 5.0 miniport driver
Required

13.28. IR device meets IrDA specifications
Required

13.29. IR device meets PC 99 bus and port specifications
Required

13.30. IR device supports dynamic resource configuration
Required

13.31. IR device meets USB guidelines for interfacing with IrDA Data and IrDA Control devices
Required

13.32. System supports standard input speeds of 4 Mb/s
Required

13.33. System provides a separate, physically-isolated transceiver for each IR protocol supported
Required

13.34. System supports RF capabilities
Optional

13.35. RF implementation uses a low-power RF alternative
Recommended

13.36. RF implementation provides a method to defeat noise and conflict with other RF devices
Recommended

13.37. System and RF device have separate local certification
Recommended

13.38. Smart card reader complies with ISO 7816
Required

13.39. Smart card reader supports ISO 7816 T=0 and T=1 protocols
Required

13.40. Smart card reader supports inverse-convention smart cards
Required

13.41. Smart card reader supports 258 byte packets in T=0 and 259 byte packets in T=1
Required

13.42. Smart card reader supports a smart card insertion/removal monitor
Required

13.43. Smart card reader supports PTS
Required

13.44. Smart card reader supports 3.5795 MHz minimum clock frequency
Required

13.45. Smart card reader supports 9600 bps minimum data rate
Required

13.46. Smart card reader supports the Power Down command
Required

13.47. Smart card reader does not use an additional power supply
Recommended

13.48. Each device has a unique Plug and Play device ID
Required

13.49. Dynamic resource configuration is supported for all devices
Required

13.50. Each device complies with its device class power management reference specification
Required

13.51. Device supports wake-up events
Required for wireless input; optional for other devices

13.52. Device drivers and installation meet PC 99 requirements
Required

13.53. All PC 99 input devices support Microsoft DirectInput and work simultaneously
Required

Checklist for Graphics Adapters

Consumer	Office	Mobile	Workstation	Entertainment
14.1. Graphics adapter uses PCI, AGP, or another high-speed bus *Required for all system types*				
14.2. System provides hardware-accelerated 3-D graphics				
Required	*Recommended*	*Recommended*	*Required*	*Required*
14.3. System uses WC with higher-performance processors *Required for all system types*				
14.4. Primary graphics adapter works normally with default VGA mode driver *Required for all system types*				
14.5. Adapter and driver support multiple adapters and multiple monitors				
Required	*Required*	*Recommended*	*Required*	*Required*
14.6. Adapter supports television output if system does not include large-screen monitor *Recommended for all system types*				
14.7. Adapter meets PC 99 general device requirements *Required for all system types*				
14.8. Screen resolution and local memory capacity meet PC 99 minimum requirements *Required for all system types, with exceptions for mobile PCs*				
14.9. Adapter meets VESA specifications for ergonomic timing rates *Required for all system types, with exceptions for mobile PCs and flat panel desktop displays*				
14.10. All supported color depths are enumerated *Required for all system types*				
14.11. Graphics operations use relocatable registers only *Required for all system types*				
14.12. Adapter supports downloadable RAMDAC entries for integrated color management *Required for all system types*				
14.13. Adapter supports DDC monitor detection *Required for all system types, with exceptions for mobile PCs*				
14.14. Hardware supports video overlay surface with scaling *Required for systems that support TV or DVD video playback, with exceptions for mobile PCs*				
14.15. Hardware supports VGA destination color keying for video rectangle *Required for systems that support TV or DVD video playback*				
14.16. Hardware supports alpha blending of graphics and video *Required for systems that support TV or DVD video playback, with exceptions for mobile PCs and Office PCs*				

14.17. Video port meets PC 99 specifications if present on graphics adapter
Required

14.18. Hardware supports MPEG-2 motion compensation acceleration
Recommended

14.19. Hardware supports scanning at the same frequency as the incoming video
Recommended   Recommended   Recommended   Recommended   Required

14.20. Extended resources can be dynamically relocated after system boot
Required

14.21. VGA resources can be disabled by software
Required

14.22. Frame buffer can be accessed directly by applications
Required for all system types

14.23. Adapter and driver support linear-mapped, low-resolution modes
Required for all system types

14.24. Hardware supports transparent blter
Required for all system types

14.25. Hardware provides support to prevent tearing
Required for all system types

14.26. Hardware supports programmable blter stride
Required for all system types

14.27. Hardware supports PC 99-required RGB rasterization
Required for all system types, with exceptions for mobile PCs

14.28. Hardware supports recommended RGB rasterization features
Recommended for all system types, with exceptions for mobile PCs

14.29. Hardware supports multi-texturing
Recommended   Recommended   Recommended   Required   Required

14.30. Hardware supports texture formats
Required for all system types, with exceptions for mobile PCs

14.31. Hardware complies with texture size limitations
Required   Recommended   Recommended   Required   Required

14.32. Hardware supports destination RGB alpha blending
Recommended for all system types

14.33. Hardware supports Z comparison modes and Direct3D-compatible formats
Recommended   Recommended   Recommended   Required   Required

14.34. Hardware meets PC 99 3-D accelerator performance requirements
Recommended   Recommended   Recommended   Required   Required

14.35. Adapter supports both NTSC and PAL output
Recommended for all system types

14.36. Default boot mode supports appropriate locale
Required for all system types

14.37. Adapter supports underscan scaling
Required Recommended Recommended Recommended Required

14.38. Adapter supports flicker filter
Required for all system types, with exceptions for mobile PCs

14.39. Adapter provides proper termination
Required

14.40. Adapter supports composite video and S-Video connectors
Recommended   Recommended   Recommended   Recommended   Required

14.41. Adapter with television output supports both VGA and television output
Required for all system types

14.42. Software supports positioning
Required   Recommended   Recommended   Recommended   Required

14.43. Software supports detection of television connection
Required   Recommended   Recommended   Recommended   Required

14.44. Analog video outputs, such as NTSC, have copy protection on DVD-enabled platforms
Required for all system types

14.45. Each device has a Plug and Play device ID
Required

14.46. System supports conflict resolution, VGA compatibility, and extended registers
Required

14.47. Chips support linear packed-pixel frame buffer, relocatable above 16 MB
Required

14.48. Option ROM supports DDC2B
Required, with exceptions for Mobile PCs

14.49. BIOS setup utility provides option to force use of system-board graphics
Recommended

14.50. BIOS supports large frame buffers for graphics adapters
Required

14.51. AGP meets PC 99 implementation guidelines
Required

14.52. PCI graphics device supports IRQ and correctly populates PCI BARs
Required   Recommended   Recommended   Required   Required

14.53. PCI system-board graphics device is not hidden from Plug and Play enumeration
Required for all system types

14.54. Graphics adapter complies with device class power management reference specification
Required

14.55. Graphics adapter complies with VBE/Core 2.0 extensions for power management
Required

14.56. Device drivers and installation meet PC 99 requirements
Required

14.57. Driver does not bypass any Microsoft-provided system components
Required

14.58. Applications provided with device meet requirements for Win32-based applications
Required

14.59. Driver supports dynamic color bit-depth change
Required

Checklist for Video and Broadcast Components

Consumer	Office	Mobile	Workstation	Entertainment

15.1. System meets PC 99 requirements for playback of MPEG-2 video from DVD-Video
Required for all systems that support TV or DVD video playback

15.2. System meets PC 99 requirements for playback of MPEG-2 video from digital TV broadcasts

Consumer	Office	Mobile	Workstation	Entertainment
Recommended	*Recommended*	*Recommended*	*Recommended*	*Required*

15.3. System supports PC 99 analog video input and capture capabilities
Recommended for all system types

15.4. System includes analog TV tuner
Recommended for all system types

15.5. System includes digital satellite receiver module
Recommended for all system types

15.6. System includes digital cable receiver module
Recommended for all system types

15.7. System includes ATSC DTV support
Recommended for all system types

15.8. System includes DVB cable, satellite, or terrestrial receiver module
Recommended for all system types

15.9. System includes support for multiple digital TV delivery methods
Recommended for all system types

15.10. System supports DV decoding and encoding
Recommended for all system types

15.11. MPEG sources such as DVD or a receiver module support bus mastering
Required for all system types, with exceptions for mobile PCs

15.12. Separate MPEG-2 hardware decoder for high-definition video does not cause PCI bus contention
Required

15.13. PCI-based sources of uncompressed standard-definition digital video support bus mastering with scatter/gather DMA
Required

15.14. All MPEG-2 decoders can accept an MPEG-2 elementary stream
Required

15.15. All MPEG transport stream information is available to the central host processor
Required

15.16. Background tasks do not interfere with MPEG-2 playback

Consumer	Office	Mobile	Workstation	Entertainment
Required	*Recommended*	*Recommended*	*Required*	*Required*

15.17. Video input, capture, and broadcast device support is based on DirectX foundation class and WDM Stream class
Required

15.18. All components meet PC 99 general device requirements
Required

15.19. MPEG-2 MP@ML playback meets PC 99 requirements
Required for all systems that support TV or DVD video playback, with exceptions for mobile PCs

15.20. MPEG-2 playback for ATSC, DVB, or other digital TV systems meets PC 99 requirements
Recommended   Recommended   Recommended   Recommended   Required

15.21. MPEG-2 video decode implementations meet PC 99 quality requirements
Required for all systems that support TV or DVD video playback, with exceptions for mobile PCs

15.22. De-interlacing of standard-definition video meets PC 99 requirements
Required for all systems that support TV or DVD video playback

15.23. MPEG-2 decoder supports the pull-down algorithm
Recommended

15.24. DVD decoder driver correctly handles media types, time discontinuity, and decode-rate adjustment
Required

15.25. DVD decoder supports subpicture compositing and closed captioning
Required for all system types, with exceptions for mobile PCs

15.26. Subpicture decoder correctly handles subpicture properties and other functions
Required for all system types, with exceptions for mobile PCs

15.27. System supports seamless DVD-Video 1.0 navigation
Required

15.28. All DVD video decoders must support Line21 closed-caption data
Required

15.29. System provides a licensed CSS copyright protection scheme
Required

15.30. Analog video decoder such as NTSC/PAL/SECAM meets PC 99 quality requirements
Required

15.31. Analog video capture device outputs video data at 3.7 MB/sec, minimum
Required

15.32. Video input or capture device provides raw sampled VBI data
Required

15.33. Digital video camera uses external bus support
Required

15.34. Video input image orientation identification meets PC 99 requirements
Required

15.35. Analog TV tuner/decoder supports PC 99 audio and video performance
Required

15.36. Analog TV tuner/decoder includes stereo audio decoder and supports SAP
Recommended for all system types

15.37. VBI capture oversamples VBI data at least four times
Required

15.38. VBI capture makes VBI data available to the CPU for processing
Required

15.39. Digital broadcast module can receive all streams contained in the particular transport stream
Required

15.40. Digital broadcast module can receive full bandwidth from each frequency
Required

15.41. Digital broadcast module can receive a minimum of 16 simultaneous elementary streams
Required

15.42. System can simultaneously receive two or more broadcast frequencies
Recommended

15.43. Digital broadcast module provides support for conditional access
Recommended

15.44. Digital broadcast module provides signal quality and other diagnostic information
Required

15.45. Digital broadcast receiver module supports general-purpose data cryptography
Recommended

15.46. Digital broadcast receiver module supports stream filtering
Recommended

15.47. ATSC DTV tuner/demodulator is fully implemented
Required

15.48. Stream splitting is supported using DirectShow filters
Recommended

15.49. Each hardware device has a Plug and Play device ID
Required

15.50. Dynamic resource configuration is supported for all devices
Required

15.51. Dependent video device is not independently enumerated
Required

15.52. Device drivers and installation meet PC 99 requirements
Required

15.53. Software drivers are installed during hardware driver installation
Required

15.54. Applications provided with device meet Win32 requirements
Required

15.55. NDIS 5.0 miniport driver provided for digital broadcast receiver
Required

Checklist for Monitors

16.1. Color monitor is DDC2B-compliant with unique EDID identifier
Required

16.2. Monitor supports Integrated Color Management
Required

16.3. Monitor meets all PC 99 general device and driver requirements
Required

16.4. CRT-based monitor supports a mechanism for control from host software
Recommended

16.5. Monitor meets minimum graphics resolution, based on monitor size
Required

16.6. CRT-based monitor supports ergonomic timing standards
Required

16.7. CRT-based monitor synchronizes to a new format in a timely fashion
Recommended

16.8. Large-screen monitor is 20 inches (viewable diagonal) or larger if included with an Entertainment PC system
Required

16.9. Entertainment CRT-based monitor supports 800 × 600 at 60 Hz refresh rate
Required

16.10. Entertainment monitor operates at the lower scan rates used by the operating system
Required

16.11. Entertainment monitor's host control has digitally controlled geometry
Recommended

16.12. External monitor meets DDC2B and EDID standards
Required

16.13. Monitor complies with device class power management reference specification
Required

Checklist for Audio Components

Consumer	Office	Mobile	Workstation	Entertainment
17.1. PC system includes PC 99 audio capabilities				
Recommended	*Recommended*	*Recommended*	*Recommended*	*Required*
17.2. Audio device does not connect to ISA bus				
Required for all system types				
17.3. Audio device does not use legacy hardware interfaces for MS-DOS–based applications				
Required for all system types				
17.4. Audio performance meets PC 99 requirements				
Required, with exceptions for mobile PCs				
17.5. Audio subsystem supports basic data formats in full duplex				
Required				
17.6. Audio subsystem supports full-duplex operation at independent sampling rates				
Required				
17.7. Analog microphone input meets PC 99 jack and circuit specifications				
Required				
17.8. Audio driver reports sample position for stream synchronization				
Required				
17.9. Audio connectors use icons with color coding				
Required				
17.10. Audio subsystem provides sufficient externally accessible inputs and outputs				
Recommended				
17.11. Microphone meets performance recommendations for PC 99 speech-recognition microphones				
Recommended				
17.12. Audio subsystem provides hardware or software support for DLS				
Recommended				
17.13. Audio subsystem supports AEC reference inputs				
Recommended				

17.14. Audio subsystem provides hardware filtering of 3-D localization filters
Optional

17.15. CD, DVD, and broadcast audio playback meet PC 99 requirements
Required with systems that support video playback

17.16. Audio subsystem provides consistent volume levels for different devices
Optional

17.17. Audio subsystem does not provide a DB-15 analog joystick/MIDI port
Recommended

17.18. Each hardware device has a unique Plug and Play device ID
Required

17.19. Dynamic resource configuration is supported for all devices
Required

17.20. PCI device conforms to PCI 2.1 and additional PC 99 requirements
Required

17.21. PCI device supports initiator, target, and block transfer
Required

17.22. PCI device supports non-DWORD-aligned audio buffers
Required

17.23. PCI device does not use ISA-based resources
Required

17.24. PCI device is digital ready
Required

17.25. Audio meets USB specification and USB audio device class specification
Required

17.26. USB audio device uses MMHID for control of basic functions
Required

17.27. Audio meets PC 99 requirements for IEEE 1394
Required

17.28. System and device comply with PCI bus power management specification
Required

17.29. Audio device complies with device class power management reference specification
Required

17.30. Device drivers and installation meet PC 99 requirements
Required

17.31. Audio meets PC 99 requirements for WDM driver support
Required

17.32. Applications provided with device meet Win32 requirements
Required

Checklist for Storage and Related Peripherals

18.1. Storage controller and hard disk devices support bus master capabilities
Required

18.2. Removable media devices support media status notification
Required

18.3. Device meets PC 99 general device requirements
Required

18.4. Device meets PC 99 requirements for ports or buses
Required

18.5. Device Bay storage device meets PC 99 requirements
Required

18.6. ATA controllers and devices support Ultra DMA
Required

18.7. USB-based mass storage device meets PC 99 requirements for USB
Required

18.8. System BIOS or option ROM supports El Torito No Emulation mode
Required

18.9. System BIOS or option ROM supports bootable ARMD
Recommended

18.10. Host controller for secondary storage uses IEEE 1394
Recommended

18.11. Floppy disk capabilities, if implemented, do not use legacy FDC
Recommended for all system types

18.12. Legacy FDC device meets resource configuration requirements, if present
Required

18.13. System supports dynamic configuration of legacy FDC
Required

18.14. Operating system recognizes the boot drive in a multiple-drive system
Required

18.15. Hard drive is SMART-compliant and uses SMART IOCTL API
Optional

18.16. CD device provides 8x minimum transfer rate or better performance
Required

18.17. CD drive is CD-Enhanced compatible
Required

18.18. CD drive supports specified logical and physical CD formats
Required

18.19. ATA/ATAPI CD drive complies with SFF 8020i v. 2.6
Required

18.20. CD drive supports multisession and compatibility forms of the READ_TOC command
Required

18.21. ATA/ATAPI CD changer complies with the MMC-2 standard
Required

18.22. CD device supports digital audio detection
Required

18.23. CD device uses push-to-close design
Recommended

18.24. Block rewritable optical ATAPI device complies with SFF 8070i
Required

18.25. DVD device provides 2x minimum transfer rate or better performance anywhere on the disc
Required

18.26. DVD drive and controller support bus master DMA transfers
Required

18.27. DVD drive meets minimum compatibility requirements
Required

18.28. DVD device complies with the MMC-2 standard
Required

18.29. DVD device uses push-to-close design
Recommended

18.30. DVD device supports defect management
Required

18.31. DVD device supports copyright protection
Required

18.32. Each device has a Plug and Play device ID
Required

18.33. Dynamic resource configuration is supported for all devices
Required

18.34. 3F7h and 377h are unclaimed by devices
Required

18.35. Physical security is provided for storage devices
Recommended

18.36. Option ROMs support Int 13h Extensions
Required

18.37. Device and controller comply with device class power management reference specification
Required

18.38. Device supports wake-up events
Optional

18.39. Device drivers and installation meet PC 99 requirements
Required

18.40. Device driver runs in protected mode following installation
Required

18.41. Applications provided with the device meet Win32 requirements
Required

18.42. Device driver for partitioned media supports all Windows and Windows NT partition types
Required

18.43. Device driver for block-mode device supports extended BPBs
Required

Checklist for Modems

Consumer	Office	Mobile	Workstation	Entertainment
19.1. Modem device is provided with PC system				
Required	*Recommended*	*Required*	*Required*	*Required*
19.2. Modem controller meets PC 99 requirements				
Required				

19.3. Modem supports V.250 AT command set
Required

19.4. Data modem supports V.90 (1998) analog modem modulation
Required

19.5. Data modem supports Annex A/V.34 (1998) SRC
Recommended

19.6. Data modem supports V.42 LAPM, V.42 bis, and V. 80 Synchronous Access data protocols
Required

19.7. Modem supports call control signaling, controlled using V.251 modem commands
Required

19.8. Fax modem supports 14.4 Kbps (V.17) with Class 1 (TIA-578-A) command set
Required

19.9. Modem supports delayed and blacklisted number clearing
Recommended

19.10. Modem supports TDD, meeting V.18-1996 with V.250 AT commands
Recommended

19.11. Voice modem supports ITU V.253 (AT+V)
Required in modems supporting voice

19.12. Voice modem support includes PC 99 recommendations
Recommended

19.13. Voice modem supports Caller ID Detection and Reporting
Recommended

19.14. Voice modem supports speakerphone
Required in modems supporting voice

19.15. Wireless support is implemented for modems
Recommended

19.16. Digital cellular phone support is implemented for modems
Recommended

19.17. ISDN driver supports unattended installation, with limitations
Required

19.18. ISDN modem supports required command set
Required

19.19. ISDN modem exposes both B channels
Recommended

19.20. ISDN modem supports asynchronous-to-synchronous conversion
Required

19.21. ISDN modem defaults to HDLC PPP after INF installation
Recommended

19.22. ISDN modem uses high-speed port
Recommended

19.23. Modem pair passes basic V.34 file transfer test
Required

19.24. Modem pair passes basic call connect reliability test
Required

19.25. Modem pair passes concurrency test
Required

19.26. Driver-based modem uses a WDM-based driver solution
Required

19.27. Driver-based modem processor usage is not excessive
Recommended

19.28. Driver does not disable interrupts for excessive periods of time
Recommended

19.29. Driver handles thread priorities appropriately
Recommended

19.30. Driver tolerates reasonable operating system and bus latencies.
Recommended

19.31. Driver does not make excessive use of locked memory
Recommended

19.32. Each hardware device has a unique Plug and Play device ID
Required

19.33. Each device has a Plug and Play compatible ID
Required

19.34. Dynamic resource configuration is supported for all devices
Required

19.35. PCI modem meets PC 99 requirements
Required

19.36. USB modem meets PC 99 specifications
Required

19.37. Device Bay modem meets PC 99 requirements
Required

19.38. Device complies with device class power management reference specification
Required

19.39. Device supports wake-up events
Required

19.40. Device drivers and installation meet PC 99 requirements
Required

19.41. Driver supports Unimodem
Required

19.42. Applications provided with device meet Win32 requirements
Required

Checklist for Network Communications

Consumer	Office	Mobile	Workstation	Entertainment
20.1. PC system includes network adapter				
Recommended	*Required*	*Recommended*	*Required*	*Recommended*
20.2. PC system includes internal or external ISDN device				
Recommended*	*Recommended*	*Recommended*	*Recommended*	*Recommended**
20.3. PC system includes cable modem				
Recommended*	*Recommended*	*Recommended*	*Recommended*	*Recommended**

20.4. PC system includes ATM adapter

Optional	Optional	Optional	Optional	Optional

20.5. PC system includes ADSL adapter

Recommended*	Recommended	Recommended	Recommended	Recommended*

20.6. PC system includes satellite or broadcast receiver with NDIS driver

Recommended*	Recommended	Recommended	Recommended	Recommended*

20.7. Adapter uses NDIS 5.0 miniport driver
Required

20.8. Intermediate NDIS 5.0 miniport driver is deserialized
Recommended

20.9. Full-duplex adapter automatically detects and switches to full duplex mode
Required

20.10. Adapter automatically senses presence of functional network connection
Required

20.11. Adapter automatically senses transceiver type
Required

20.12. Adapter can transmit packets from buffers aligned on any boundary
Required

20.13. Adapter communicates with driver across any bridge
Required

20.14. Adapter supports filtering for at least 32 multicast addresses
Required

20.15. Adapter and driver support promiscuous mode
Required

20.16. Adapter is compatible with remote new system setup capabilities if used as a boot device
Required

20.17. PCI network adapters are bus masters
Required

20.18. Device Bay-type network adapter meets PC 99 requirements
Required

20.19. USB or IEEE 1394 device meets specifications for network communications devices
Recommended

20.20. Network adapter and driver supports priority for IEEE 802-style networks
Recommended

20.21. Internal ISDN device meets PC 99 network adapter requirements
Required

20.22. Internal ISDN device supports synchronous HDLC framing
Required

20.23. NDIS interface and driver support raw unframed synchronous B channel I/O
Required

20.24. ISDN driver supports unattended installation, with limitations
Required

20.25. ISDN device with U-interface includes built-in NT-1 capability
Recommended

20.26. ISDN device includes software-selectable terminating resistors
Required

20.27. Device is implemented as an integrated cable modem
Recommended

20.28. Integrated cable modem meets PC 99 network adapter requirements
Required

20.29. Integrated cable modem exposes an ATM or Ethernet interface
Required

20.30. ATM adapter meets PC 99 network adapter requirements
Required

20.31. ATM adapter supports a minimum number of simultaneous connections
Required

20.32. ATM adapter supports all service types defined by the ATM Forum
Recommended

20.33. ATM adapter supports UBR service type
Required

20.34. ATM adapter supports a minimum number of simultaneously active VBR or CBR connections
Required

20.35. ATM adapter supports traffic shaping
Required

20.36. ATM adapter enforces PCR on UBR virtual circuits
Required

20.37. ATM adapter and driver support dynamic link speed configuration
Required

20.38. ATM adapter supports OAM
Recommended

20.39. ATM adapter supports buffer chaining (Tx + Rx)
Recommended

20.40. ADSL device is implemented as an integrated ADSL modem
Recommended

20.41. Integrated ADSL modem meets PC 99 network adapter requirements
Required

20.42. ATM/ADSL solution is implemented for integrated ADSL modems
Recommended

20.43. ADSL modem supports DMT line encoding
Recommended

20.44. ADSL modem supports rate adaptation
Recommended

20.45. Infrared device meets PC 99 network adapter requirements
Required

20.46. Infrared device supports both FIR and SIR
Required

20.47. IrDA hardware supports unattended driver installation
Required

20.48. Home networking adapter meets PC 99 network adapter requirements
Required

20.49. Home networking uses appropriate media
Recommended

20.50. Home networking media supports IP
Required

20.51. Each device has a unique Plug and Play device ID
Required

20.52. Dynamic resource configuration is supported for all devices
Required

20.53. Plug and Play capabilities support multiple adapters
Required

20.54. All resource settings are reported in the user interface
Required

20.55. Device complies with device class power management reference specification
Required

20.56. Device supports wake-up events
Required

20.57. Device drivers and installation meet PC 99 requirements
Required

20.58. Driver works correctly with Microsoft network clients and protocols
Required

20.59. NDIS miniport driver makes only NDIS library calls or WDM system calls
Required

20.60. NDIS 5.0 driver uses new INF format
Required

Note: For items marked with an asterisk (*) symbol, it is recommended to implement an ADSL modem, ISDN device, or home networking adapter.

Checklist for Printers

21.1. IEEE 1394 printer meets PC 99 requirements for IEEE 1394
Required

21.2. USB printer meets PC 99 requirements for USB devices
Required

21.3. IEEE 1284 printer supports compatibility mode, nibble mode, and ECP, compliant with IEEE 1284-I
Required

21.4. IEEE 1284 printer meets IEEE 1284-II requirements
Recommended

21.5. ECP printer works correctly when ECP mode is turned off
Required

21.6. IEEE 1284 hardware supports error notification
Required

21.7. Daisy-chained parallel port device is Plug and Play capable
Required

21.8. Network printer supports standard port monitor
Required

21.9. Plug and Play support implemented for all supported buses
Required

21.10. Peripheral device meets IEEE 1284 requirements
Required

21.11. Printer INF file and installation meet PC 99 requirements
Required

21.12. Driver correctly reports device capabilities
Required

21.13. Driver supports error notification
Required

21.14. Driver supports ICC color management
Required

21.15. Port monitor software meets DDK guidelines
Required

21.16. Driver supports point-and-print network installation
Required

21.17. Device is available immediately following installation
Required

21.18. Device supports accurate printable regions
Required

21.19. Driver supports required DDIs
Required

21.20. Driver is based on Unidriver
Recommended

Checklist for Digital Still Image Devices

22.1. Device uses PC 99 compatible port connection with USB or IEEE 1394 connection
Required

22.2. Icons provided for port and peripheral connectors
Required

22.3. Device supports ICC color management
Required

22.4. IR device meets PC 99 IR requirements
Required

22.5. Digital still image device with an IR interface uses Fast IR
Required

22.6. Digital still image device with an IR interface provides a secondary PC interface
Required

22.7. SCSI device meets PC 99 SCSI requirements
Required

22.8. SCSI device attaches to any PC 99-compliant SCSI controller
Required

22.9. USB device meets PC 99 USB requirements
Required

22.10. USB device supports string descriptors
Required

22.11. USB imaging device has a zero-bandwidth alternate interface
Recommended

22.12. USB device does not saturate the USB bus
Recommended

22.13. USB device follows PC 99 USB performance recommendations
Required

22.14. Digital camera uses PC-compatible file system for removable storage
Required

22.15. Digital camera stores images in common file formats such as JPEG or FlashPix
Recommended

22.16. IEEE 1394 device meets PC 99 requirements for IEEE P1394.a
Required

22.17. Serial device complies with Plug and Play External COM Device Specification v. 1.0
Required

22.18. Plug and Play capabilities implemented for all supported buses
Required

22.19. Each device has a Plug and Play device ID
Required

22.20. Daisy-chained parallel port imaging devices must be Plug and Play capable.
Required

22.21. Device supports power management requirements for its bus
Required

22.22. Device drivers and installation meet PC 99 requirements
Required

22.23. Driver support is implemented under the Still Image architecture
Required

22.24. Applications provided with the device meet Win32 specifications
Required

22.25. Device driver supports TWAIN 1.7 or later
Required

22.26. Digital still image devices with an IR interface use the Windows Sockets interface
Required

22.27. Asynchronous imaging device with an IEEE 1394 interface uses SBP2Port
Recommended

Glossary

Acronyms and Abbreviations

ABR available bit rate

AC alternating current

ACPI Advanced Configuration and Power Interface

A/D analog to digital

ADA Americans with Disabilities Act

ADC analog-to-digital converter

ADSL Asymmetric Digital Subscriber Line

AEC acoustic echo cancellation

AGP Accelerated Graphics Port

ANSI American National Standards Institute

API application programming interface

APIC Advanced Programmable
Interrupt Controller

APM Advanced Power Management

APS analog protection system

ARC Advanced RISC Computing

ASCII American Standard Code for
Information Interchange

ATA AT Attachment

ATAPI ATA Packet Interface

ATM Asynchronous Transfer Mode

ATSC Advanced Television Systems Committee

AT#UD Unimodem diagnostics command

AUI Attachment Unit Interface

A/V audio/video

AVGA Advanced VGA

BAR base address register

BDA BIOS Data Area

BIOS basic I/O system

BNC Bayonet Nut Connector. (*Also* British Naval
Connector *or* Bayonet Neil Consulman)

BPB BIOS Parameter Blocks

bpp bits per pixel

bps bits per second

CAD computer-aided design

CBR constant bit rate

CDMA code division multiplexed access

CDPD cellular digital packet data

CHAP Challenge Handshake
Authentication Protocol

CID CompatibleID

CIS card information structure

CMOS complementary metal-oxide semiconductor

COM (1) Component Object Model;
(2) legacy serial port

CPTWG Copyright Protection Technical Working Group

CPU central processing unit

CRC cyclic redundancy check

CSEL Cable Select

CSN Card Select Number

CSR control and status register

CSS copy scramble system

CT Computer Telephony

D/A digital to analog

DAC digital-to-analog converter

dB decibel

DBC Device Bay Controller

DC direct current

DCE Data Communications Equipment

DDC display data channel

DDC2B *DDC Standard, Version 2.0*, Level B

DDI device driver interface

DDK Device Driver Kit

DES data encryption standard

DHCP Dynamic Host Configuration Protocol

DIB device-independent bitmap

DIP dual in-line package

DLL dynamic link library

DLS Downloadable Sounds

DMA direct memory access

DMI Desktop Management Interface

DMTF Desktop Management Task Force

DRAM Direct Random Access Memory

DSP digital signal processor

DSS directory synchronization server

DSVD digital simultaneous voice/data

DTMF dual tone multifrequency

DTV digital television

DVB Digital Video Broadcast

DVC Digital Video Compression

DVD Optical disk storage that encompasses audio, video, and computer data

ECC error correction code

ECP extended capabilities port

ECR Engineering Change Request

EDID Extended Display Identification Data

EDT European Deaf Telephone

EGA enhanced graphics adapter

EIA Electronics Industries Association

8-VSB ATSC 8-Vestigial Side Band

EIO Extended I/O

EISA Extended Industry Standard Architecture

EMF enhanced metafile

EMI electromagnetic interference

EPG electronic program guide

EPP enhanced parallel port

ESCD Extended System Configuration Data

ETSI European Telecommunications Standards Institute

ExCA Exchangeable Card Architecture

FAT file allocation table

FAQ frequently asked questions

FCC Federal Communications Commission

FDC floppy disk controller

FDDI Fiber Distributed Data Interface

FEC forward error correction

FIFO first in/first out

FM frequency modulation

FP floating point

fps frames per second

FS A *See Glossary.*

FSIP full-scale input

FSK Frequency Shift Keyed

FSOP full-scale output

FTP file transfer protocol

GART Graphics Address Re-mapping Table

GDI Graphics Device Interface

GIDEI General Input Device Emulation Interface

GSM global system for mobile communications

HCL Hardware Compatibility List

HCT Hardware Compatibility Tests

HDLC high-level data link control

HDTV high-definition television

HEL hardware emulation layer

HFC hybrid fiber-coax

HID Human Interface Device

HRTF Head Related Transfer Function

HSCDS high-speed cable data services

Hz Hertz

IAL Intel Architecture Labs

ICC International Color Consortium

ICM Integrated Color Management

ID identifier

IDE Integrated Device Electronics

IEC International Electrotechnical Commission

IEEE Institute for Electrical and Electronics Engineers

IETF Internet Engineering Task Force

IF Implementers Forum

IHV independent hardware vendor

I/O input/output

IOCTL I/O control

IP Internet Protocol

IPL Initial Program Load

IPX Internetwork Packet Exchange

IR infrared

IrDA Infrared Data Association

IRP I/O request packet

IRQ interrupt request

ISA Industry Standard Architecture

ISDN Integrated Service Digital Network

ISO International Standards Organization

ISO/OSI International Standards Organization Open Systems Interconnection

ISP Internet service provider

ISV independent software vendor

I2O intelligent I/O

ITU International Telecommunication Union

IVR interactive voice response

K kilobyte

Kbps kilobytes per second

Kss kilo-samples per second

L2 Level 2

LAN local area network

LBA logical block addressing

LCD liquid crystal display

LED light-emitting diode

LPCM location PCM

LPT line printer

LSB least significant bit

LUN logical unit number

LVE Live Video Extensions

m meter

MAC Media Access Control

MB megabyte

Mb/s megabits per second

MDK Modem Developers Kit

MEI Matsushita Electronics Incorporated

MESN Media Status Event Notification

MIDI Musical Instrument Digital Interface

MIP Multimission Interactive Picture

MP@ML Main Profile at Main Level

MPEG Moving Picture Expert Group

ms millisecond

MSB most significant bit

MSCDEX Microsoft CD-ROM Extensions

MSDN Microsoft Developer Network

MUX multiplex

NABTS North American Basic Teletext

NDIS Network Driver Interface Specification

NetBEUI NetBIOS Extended User Interface

Net PC Network PC

NICAM Near-Instantaneously Companded Audio Multiplex

NIDRR National Institute for Disability and Rehabilitation Research

NIUF National ISDN User's Forum

NMI Nonmaskable Interrupt

nrt non-real time

NTFS Windows NT file system

NT-1 network terminator

NTSC National Television System Committee

OAM operation and maintenance

OEM original equipment manufacturer

OFDM Orthogonal Frequency Division Multiplexing

OpenHCI Open Host Controller Interface

OR *See Glossary.*

OSR OEM service release

PAL Phase Alternation Line

PC personal computer

PCI Peripheral Component Interconnect

PCIC PC Card I/O cards

PCI PM *PCI Bus Power Management Specification, Revision 1.0* or higher

PCI 2.1 *PCI Local Bus Specification, Revision 2.1*

PCM pulse coded modulation

PCMCIA Personal Computer Memory Card International Association

PCR peak cell rate

PDA Personal Digital Assistant

PIC programmable interrupt controller

PID program ID

PIO programmed I/O

PIT programmable interrupt timer

PME power management event

POST power-on self-test

POTS plain old (analog) telephone service/system

PPP point-to-point protocol

PRI primary rate interface

PS/2 Personal System/2

PSTN Public Switched Telephone Network

PTT Post, Telephone, and Telegraph

QOS quality of service

RADSL rate adaptive digital subscriber line

RAID redundant array of inexpensive disks

RAM random-access memory

RAMDAC RAM digital-to-analog converter

RF radio frequency

RFC request for comments

RFP request for proposals

RISC reduced instruction set computing

RM resource management

RNA remote network access

ROM read-only memory

RP recommended practice

RSA public-key cipher for encryption/decryption

RSX Intel Realistic Sound eXperience

rt real time

SAP (1) Service Access Protocol; (2) secondary audio programming

SAR segmentation and re-assembly

SCAM SCSI Configured Automatically

SCART Solent Club for Amateur Radio and Television; *also called* Peritel

SCID service channel ID

SCL system clock line

SCSI small computer system interface

SDK Software Developers Kit

SFF Small Form Factor

SIG Special Interest Group

SIR Serial IR

SIT Special Information Tone

SMART Self-Monitoring, Analysis, and Reporting Technology

SMBus System Management Bus

SMPTE Society of Motion Picture and Television Engineers

SNMP Simple Network Management Protocol

SNR signal-to-noise ratio

SOHO small office/home office

SPI Service Provider Interface

SPID service profile ID

SPX Sequenced Packet Exchange

SRC sample rate converter

STI Still Image architecture

STS/EN Status and Enable

SVGA Super VGA

TAM telephone answering machine

TAPI Telephony Application Program Interface

TCO total cost of ownership

TCP/IP Transmission Control Protocol/
Internet Protocol

TDD Telephone Device for the Deaf

TDMA time division multiplexed access

telset local telephone instrument

TFTP Trivial File Transfer Protocol

THD+N total harmonic distortion

3-D three-dimensional

TIA Telecommunications Industry Association

TP twisted pair

2-D two dimensional

UART Universal Asynchronous
Receiver/Transmitter

UBR unspecified bit rate

UDF Universal Disk Format

UHCI Universal Host Controller Interface

UHF ultra-high frequency

unidriver universal printer driver

Unimodem universal modem driver

USB Universal Serial Bus

V volts

VBE VESA BIOS Extension

VBI vertical blanking interval

VBR variable bit rate

VCI virtual channel ID

VDD Virtual display driver

VDIF Video Display Information Format

VDS virtual DMA services

VESA Video Electronics Standards Association

VfW Video for Windows

VGA video graphics array

VHF very high frequency

VLB VESA local bus

VPE Video Port Extensions

VPI virtual path ID

VpicD virtual PIC device

Vpp voltage point-to-point

VRML virtual reality modeling language

VRMS volts root-mean-square

VSD vendor specific driver

Vsync vertical synchronization

VxD virtual device driver

WAN wide area network

WBEM Web-Based Enterprise Management

WC write combining

WDL Windows Driver Library

WDM Windows Driver Model

WfM Wired for Management

WHIIG *Windows Hardware Instrumentation
Implementation Guidelines*, *Version 1.0*

WHQL Windows Hardware Quality Labs

WinSock Windows Sockets 2.0

WMI Windows Management Instrumentation

WSS Windows Sound System

YUV *See Glossary.*

ZV Zoomed Video

Glossary

A

AC-3 An audio standard developed by Dolby Laboratories for delivering 5.1 audio. This system compresses six channels of digital audio into 384 Kbps versus 4 Mb/s uncompressed.

ACPI Advanced Configuration and Power Interface. A specification that defines a new interface to the system board. This interface enables the operating system to implement operating system–directed power management and system configuration. ACPI allows system manufacturers to build systems consistent with the OnNow design initiative for instantly available PCs.

ACPI hardware Computer hardware with the features necessary to support operating system power management and with the interfaces to those features described using the Description Tables as specified in the ACPI specification.

adapter *See* device.

add-on devices Devices that are traditionally added to the base PC system to increase functionality, such as audio, networking, graphics, SCSI controller, and so on. Add-on devices fall into two categories: devices built onto the system board, and devices on expansion cards added to the system through a system-board connector such as PCI.

ADSL Asymmetric Digital Subscriber Line. A method for moving data over regular phone lines. An ADSL circuit is much faster than a regular phone connection, even though the wires coming into the subscriber's premises are the same (copper) as used for regular phone service.

analog A method of signal representation by an infinitely smooth universe of numeric values. Measurements that are characterized as analog include readings of voltage and current. *Compare with* digital.

analog video A video signal that represents an infinite number of smooth gradations between given video levels. *Compare with* digital video.

API Application programming interface. A set of routines that an applications program uses to request and carry out lower-level services performed by a computer operating system.

APM Advanced Power Management. A software interface (defined by Microsoft and Intel) between hardware-specific power management software (such as that located in a system BIOS) and an operating system power management driver.

architecture A general term referring to the structure of all or part of a computer system. Also refers to the design of system software, such as the operating system, as well as to the combination of hardware and basic software that links machines on a computer network.

ASCII American Standard Code for Information Interchange. The most popular coding method used by small computers for converting letters, numbers, punctuation, and control codes into digital format.

ATA AT Attachment. A compatible register set, and a 40-pin connector and its associated signals. More commonly known as IDE.

ATAPI ATA Packet Interface. A hardware and software specification that documents the interface between a host computer and the CD-ROM drives using the ATA bus.

ATM Asynchronous transfer mode. A transmission protocol that segments user traffic into small, fixed-size units called cells that are transmitted to their destination, where they are reassembled into the original traffic. During transmission, cells from different users may be intermixed asynchronously to maximize utilization of network resources.

AUI Attachment Unit Interface. The portion of the Ethernet standard that specifies how a cable is to be connected to an Ethernet card. AUI specifies a cable connected to a transceiver that plugs into a 15-pin socket on the network adapter.

B

BIOS Basic I/O system. A set of routines that works closely with the hardware to support the transfer of information between elements of the system, such as memory, disks, and the monitor. Although critical to performance, the BIOS is usually invisible to the end user; however, programmers can access it.

BNC Bayonet Nut Connector. *Also* British Naval Connector *or* Bayonet Neil Consulman. A type of connector used with coaxial cables such as the RG-58 A/U cable used with the 10Base-2 Ethernet system.

C

CD-ROM Compact disc read-only memory. A 4.75-inch laser-encoded optical memory storage medium (developed by NV Philips and Sony Corporation) with the same constant linear velocity (CLV) spiral format as compact audio discs and some video discs. CD-ROMs can hold about 550 MB of data.

class For hardware, the manner in which devices and buses are grouped for purposes of installing and managing device drivers and allocating resources. The hardware tree is organized by device class.

class driver A driver that provides system-required, hardware-independent support for a given class of physical devices. Such a driver communicates with a corresponding hardware-dependent port driver, using a set of system-defined device control requests, possibly with additional driver-defined device control requests. Under WDM, the class driver creates a device object to represent each adapter registered by minidrivers. The class driver is responsible for multiprocessor and interrupt synchronization.

codec Coder-decoder. A filter that manipulates data in some form, usually by compressing or decompressing the data stream.

COM (1) Component Object Model; the core of OLE (object linking and embedding). Defines how OLE objects and their clients interact within processes or across process boundaries. (2) Legacy serial port.

concatenate To join sequentially.

configuration manager The Windows Plug and Play system component that drives the process of locating devices, setting up their nodes in the hardware tree, and running the resource allocation process. Each of the three phases of configuration management—boot time, real mode, and protected mode—have their own configuration managers.

controllerless modem *Also* host-based controller. A modem that consists of a DSP without the usual microcontroller. The host CPU provides the AT command interpreter, modem-control functions, and v.42bis implementation. *Compare with* software modem.

control method A definition of how an ACPI-compatible operating system can perform a simple hardware task. For example, the operating system invokes control methods to read the temperature of a thermal zone. Control methods are written in an encoded language called AML (ACPI Machine Language).

CPU Central processing unit. A computational and control unit of a computer; the device that interprets and executes instructions. By definition, the CPU functions as the "brain" of the computer.

CSN Card Select Number. The handle created by the system BIOS or the operating system through the isolation process and assigned as a unique ID to each Plug and Play card on the ISA bus.

D

DDC Display data channel. The Plug and Play baseline for monitors. The communications channel between a monitor and the display adapter to which it is connected. This channel provides a method for the monitor to convey its identity to the display adapter.

device Any circuit that performs a specific function, such as a parallel port.

Device Bay An industry specification that defines a mechanism for both peripheral devices and system bays. Allows adding and upgrading PC peripheral devices without opening the chassis.

device ID A unique ASCII string for a device created by enumerators to identify a hardware device and used to cross-reference data about the device stored in the registry. Distinguishes each logical device and bus from all others on the system.

device node *Also* devnode. The basic data structure for a given device, built by the configuration manager. Device nodes are built into memory at system start-up for each device and enumerator. Each device node contains information about the device, such as currently assigned resources.

device object A kernel-mode–only object type used to represent a physical, logical, or virtual device whose driver has been loaded into the system.

devnode *See* device node.

digital A method of signal representation by a set of discrete numerical values, as opposed to a continuously fluctuating current or voltage. *Compare with* analog.

digital video A video signal represented by computer-readable binary numbers that describe a finite set of colors and luminance levels. *Compare with* analog video.

disk I/O controller *Also* hard disk controller. A special-purpose chip and circuitry that directs and controls reading from and writing to a computer's disk drive.

DLL Dynamic link library. API routines that user-mode applications access through ordinary procedure calls. The code for the API routine is not included in the user's executable image. Instead, the operating system automatically points the executable image to the DLL procedures at run time.

DMA Direct memory access. A method of transferring data between peripheral and host memory without processor intervention. The system board uses a DMA controller to handle a fixed number of channels, each of which can be used by only one device at a time.

DMI Desktop Management Interface. A framework created by the DMTF. DMTF specifications define industry-standard interfaces for instrumentation providers and management applications.

docking station The base computer unit into which a user can insert a portable computer, expanding it to a desktop equivalent. A typical docking station provides drive bays, expansion slots, all the ports on an equivalent desktop computer, and AC power.

driver Kernel-mode code used either to control or emulate a hardware device.

DSP Digital signal processor. An integrated circuit designed for high-speed data manipulations. Used in audio, communications, image manipulation, and other data-acquisition and data-control applications.

DTV Digital television. DTV standards allow standard resolution mode—with about twice the horizontal resolution of conventional analog broadcasts—as well as HDTV mode. Video uses MPEG-2 digital compression, and audio uses AC-3 (Digital Dolby) compression.

DVD Optical disk storage that encompasses audio, video, and computer data.

E

ECP Extended capabilities port. An asynchronous, 8-bit–wide parallel channel defined by IEEE 1284-1944 that provides PC-to-peripheral and peripheral-to-PC data transfers.

EISA Extended Industry Standard Architecture. A 32-bit PC expansion bus designed as a superset of the ISA bus. Designed to expand the speed and data width of the legacy expansion bus while still supporting older ISA cards.

embedded controller The general class of microcontrollers used to support OEM-specific implementations, mainly in mobile environments. The embedded controller performs complex low-level functions through a simple interface to the host microprocessor.

embedded controller interface ACPI defines a standard hardware and software communications interface between an operating system driver and an embedded controller—for example, Smart Battery and AML code. This allows any operating system to provide a standard driver that can directly communicate with an embedded controller in the system, thus allowing other drivers to communicate with and use the resources of system embedded controllers.

EPG Electronic program guide. The on-screen user interface that allows users to select, manage, and search television programs and other content-viewing options.

expansion bus A group of control lines that provide a buffered interface to devices located either on the system board or on cards that are plugged into expansion connectors. Common expansion buses included on the system board are USB, PC Card, and PCI.

expansion card A card that connects to an expansion bus and contains one or more devices.

expansion ROM *See* option ROM.

F

FDC Floppy disk controller. A special-purpose chip and associated circuitry that directs and controls reading from and writing to a computer's disk drive.

FIFO First in/first out. A method for processing a queue in which items are removed in the same order in which they were added.

FS A Decibels relative to full scale, measured using "A weighting" filters.

G

GUID Globally unique ID. A 16-byte value generated from the unique ID on a adapter, the current date and time, and a sequence number. This is used to allow any party to create IDs that will be guaranteed not to overlap with other similarly created IDs.

H

hardware branch The hardware archive root key in the registry that is a superset of the memory-resident hardware tree. Although the hardware tree contains information only about those devices currently detected and running in the system, the registry contains a complete list of all hardware ever installed on the particular computer. The hardware root key is \\Hkey_Local_Machine\Hardware.

hardware tree A record in RAM of the current system configuration, based on the information for all devices in the hardware branch of the registry. The hardware tree is created each time the system is started or whenever a dynamic change occurs in the system configuration.

HCI Host controller interface. For example, a system-level interface supporting USB.

HCL Hardware Compatibility List. A registry of products that have been tested by WHQL and that have passed Windows compatibility testing.

HCT Hardware Compatibility Tests. A suite of tests from WHQL that verifies hardware and device driver operations under a specific operating environment. These tests exercise the combination of a device, a software driver, and an operating system under controlled conditions to verify that all components operate properly.

HDTV High-definition television. A proposed standard that recommends doubling the current 525 lines per picture to 1050 lines, and increasing the screen aspect ratio (that is, width to height) from the current 12:9 to 16:9, which would create a television screen shaped more like a movie screen.

HID specification The device class definition developed by the USB standards group for Human Interface Devices. Serves as the basis for WDM input device support, and unifies input devices by providing flexible data reporting, typeless data, and arrayed and variable input and output.

I

ID Identifier. Generally, any text string used as a label, such as the name of a procedure or a variable in a program, or the name attached to a hard drive or floppy disk.

IDE Integrated Device Electronics. A type of disk drive interface where the controller electronics reside on the drive itself, eliminating the need for a separate adapter card.

IEEE Institute of Electrical and Electronics Engineers, pronounced "I-triple-E." Founded in 1963, IEEE is an organization composed of engineers, scientists, and students. IEEE is best known for developing standards for the computer and electronics industry.

INF file Information file. A file created for a particular adapter that provides the operating system with information required to set up a device, such as a list of valid logical configurations for the device, the names of driver files associated with the device, and so on. The device manufacturer typically provides an INF file on a disk with an adapter.

INI file Initialization file. Commonly used under Windows 3.*x* and earlier, INI files have been used by both the operating system and individual applications to store persistent settings related to an application, driver, or piece of hardware. In Windows and Windows NT, INI files are supported for backward compatibility, but the registry is the preferred location for storing such settings.

I/O Input/output. Two of the three activities that characterize a computer (input, processing, and output). Refers to the complementary tasks of gathering data for the microprocessor to work with and making the results available to the user through a device such as the display, disk drive, or printer.

IOCTL I/O control. A custom class of IRPs available to user mode. Each WDM class driver has a set of IOCTLs that it uses to communicate with applications. The IOCTLs give the class driver information about intended usage by applications. The class driver performs all IOCTL parameter validation.

IPL Initial program load. A device used by the system during the boot process to load the operating system into memory.

IRP I/O request packet. Data structures that drivers use to communicate with each other. The basic method of communication between kernel-mode devices. An IRP is a key data structure for WDM, which features multiple layered drivers.

IRQ Interrupt request. A method by which a device can request to be serviced by the device's software driver. The system board uses a PIC to monitor the priority of the requests from all devices. When a request occurs, a microprocessor suspends the current operation and gives control to the device driver associated with the interrupt.

ISA Industry Standard Architecture. An 8-bit (and later, a 16-bit) legacy expansion bus that provides a buffered interface from devices on expansion cards to the PC internal bus.

ISDN Integrated Service Digital Network. A set of communications standards that enables a single phone line or optical cable to carry voice, digital network services, and video.

ISR Interrupt service routine. A routine whose function is to service a device when it generates an interrupt.

L

LAN Local area network. A group of computers and other devices dispersed over a relatively limited area and connected by a communications link that enables any device to interact with any other device on the network. *Compare with* WAN.

LBA Logical block address. A unit of data supplied or requested by a host computer.

legacy Any feature in the system based on older technology for which compatibility continues to be maintained in other system components.

M

Microsoft DirectShow *Formerly* ActiveMovie. A cross-platform API for developers of multimedia applications that provides a user-mode connection and Stream architecture to support high-quality digital video, high-fidelity audio, and special effects.

Microsoft DirectX A low-level API that provides user-mode media interfaces for games and other high-performance multimedia applications. DirectX is a thin layer, providing direct access to hardware services. DirectX takes advantage of available hardware accelerators and emulates accelerator services when accelerators are not present.

MIDI Musical Instrument Digital Interface. An industry-standard connection for computer control of musical instruments and devices. A hardware and data standard for communicating between hardware. Most references involve only the data standard, which is a byte stream used for controlling musical instruments and storing the output of such instruments.

minidriver A hardware-specific DLL that uses a Microsoft-provided class driver to accomplish most actions through functions call and provides only device-specific controls. Under WDM, the minidriver uses the class driver's device object to make system calls.

miniport driver A device-specific kernel-mode driver linked to a Windows NT or WDM port driver, usually implemented as a DLL that provides an interface between the port driver and the system.

motherboard *See* system board.

MPEG Moving Picture Expert Group. Refers to one of several standard video-compression schemes. A codec for squeezing full-screen, VHS-quality digital video into a small data stream so that it can be played from a CD-ROM drive.

multifunction device A piece of hardware that supports multiple, discrete functions, such as audio, mixer, and music, on a single adapter.

multimedia Refers to the delivery of information that combines different content formats, such as motion video, audio, still image, graphics, animation, text, and so forth.

N

NDIS Network Driver Interface Specification. The interface for network drivers used in Windows and Windows NT operating systems. NDIS provides a common mechanism by which any given NDIS-compatible transport driver can communicate with any NDIS-compatible network adapter driver. Moreover, it provides for multiple transports to work over multiple network adapters by supporting multiplexing between transports and drivers.

Net PC Network PC. A PC designed to meet the industry specification for Network PC systems, which optimizes PC design for flexibility and manageability in order to reduce the total cost of ownership (TCO).

NMI Nonmaskable Interrupt. An interrupt that cannot be overruled by another service request. A hardware interrupt is called nonmaskable if it cannot be masked by the processor interrupt flag.

NTSC National Television System Committee of the Electronics Industries Association (EIA). The standards-setting body for television and video in the United States. Sponsor of the NTSC standard for encoding color, a coding system compatible with black-and-white signals and the first system used for color broadcasting in the United States. The broadcast standard for the United States and Japan. *See also* PAL format *and* SECAM.

NTSC format A color-television format having 525 scan lines, a field frequency of 60 Hz, a broadcast bandwidth of 4 MHz, line frequency of 15.75 KHz, frame frequency of 1/30 of a second, and a color subcarrier frequency of 3.58 MHz. *See also* PAL format *and* SECAM.

O

OEM Original equipment manufacturer. Used primarily to refer to PC systems manufacturers.

OnNow A design initiative that seeks to create all the components required for a comprehensive, system-wide approach to system and device power control. OnNow is a term for a PC that is always on but appears off and that responds immediately to user or other requests.

OpenGL An operating system independent, industry-standard API for 3-D color graphics programming. Typically used for engineering, visualization, simulation, and other graphics-intensive applications.

option ROM *Also* expansion ROM. Optional read-only memory found on an expansion card. Option ROMs usually contain additional firmware required to properly boot the peripheral connected to the expansion card, for example, a hard drive.

OR A logical operation for combining two bits or two Boolean values. If one or both values are true, it returns the values of true. *Compare with* XOR.

P

PAL format Phase Alternation Line format. The European video standard, except for France. *See also* NTSC *and* SECAM.

PC 97 The 1997–98 requirements for PC system and peripheral design for the "Designed for Microsoft Windows" logo, as defined in *PC 97 Hardware Design Guide.*

PC 98 The 1998–99 requirements for PC system and peripheral design for the "Designed for Microsoft Windows" logo, as defined in *PC 98 System Design Guide,* which is an addendum to *PC 97 Hardware Design Guide.*

PC Card A trademark of PCMCIA. A removable device that is designed to be plugged into a PCMCIA slot and used as a memory-related peripheral.

PCI Peripheral Component Interconnect. A high-performance, 32-bit or 64-bit bus designed to be used with devices that have high bandwidth requirements, such as a display subsystem.

PCM Pulse coded modulation. A method of encoding information in a signal by varying the amplitude of pulses. The most common method of encoding an analog signal into a digital bit stream, usually 16 bits per sample.

PCMCIA Personal Computer Memory Card International Association. Sometimes used to refer to a controller for a type of expansion card documented in the PCMCIA standards.

Plug and Play A design philosophy and set of specifications that describe hardware and software changes to the PC and its peripherals that auto-matically identify and arbitrate resource require-ments among all devices and buses on the system. Plug and Play specifies a set of API elements that are used in addition to, but not in place of, existing driver architectures.

Plug and Play BIOS A BIOS with responsibility for configuring Plug and Play cards and system-board devices during system power up. Provides run-time configuration services for system-board devices after start-up. *See also* ACPI.

power management Mechanisms in software and hardware to minimize system power consumption, to manage system thermal limits, and to maximize system battery life. Power management involves trade-offs among system speed, noise, battery life, processing speed, and power consumption.

push technology In client/server applications, to send data to a client without the client requesting it—for example, sending e-mail. In contrast, the World Wide Web is based on a pull technology, where the client browser must request a web page before it is sent. Broadcast media are push technologies because they send information out regardless of whether anyone is tuned in.

R

RAM Random access memory. Semiconductor-based memory that can be read and written by the microprocessor or other hardware devices.

RAMDAC RAM digital-to-analog converter. A chip built into some VGA and SVGA display adapters that translates the digital representation of a pixel into the analog information needed by the monitor to display it.

rasterization The conversion of vector graphics (images described mathematically as points connected by straight lines) to equivalent images composed of pixel patterns that can be stored and manipulated as sets of bits.

Red Book audio The data format standard for conventional audio CDs used in home stereo systems.

registry In Windows and Windows NT, the tree-structured hierarchical database where general system hardware and software settings are stored. The registry supersedes the use of separate INI files for all system components and applications that know how to store values in the registry.

resource (1) Any sort of set from which a subset can be allocated for use by a client, such as memory or bus bandwidth. This is not the same as resources that are allocated by Plug and Play. (2) A general term that refers to IRQ signals, DMA channels, I/O port addresses, and memory addresses for Plug and Play.

resource conflict In Plug and Play device configuration, the result of more than one device sharing a nonshareable resource. Conflicts can cause the device to be partially functional or nonfunctional, or can cause the PC to malfunction completely.

RISC Reduced instruction set computing. A type of microprocessor design that focuses on rapid and efficient processing of a relatively small set of instructions. RISC architecture limits the number of instructions that are built into the microprocessor, but optimizes each so it can be carried out very rapidly—usually within a single clock cycle.

RISC-based Refers to computers based on Windows NT-compatible implementations of RISC processors.

S

SCI System control interrupt. A system interrupt used by hardware to notify the operating system of ACPI events. The SCI is an active low, shareable, level interrupt.

SCSI Small computer system interface, pronounced "scuzzy." An I/O bus designed as a method for connecting several classes of peripherals to a host system without requiring modifications to generic hardware and software.

sealed case A PC system design that does not provide end-user–accessible internal expansion slots. This is the equivalent of "no user-serviceable parts inside" for consumer appliances. A sealed case can provide external expansion capabilities.

SECAM Sequential Couleur a Memoire (Sequential Color with Memory). The television standard for France, Russia, and most of Eastern Europe. As with PAL, SECAM is based on a 50-Hz power system, but it uses a different encoding process and displays 819 horizontal lines per frame at a scan rate of 25 frames per second (50 fields per second). *See also* NTSC *and* PAL format.

SIPC Simply Interactive PC. A vision guiding investments that Microsoft is making in software and hardware advances to make the PC as simple, convenient, and approachable as an appliance.

SMBus System Management Bus. A two-wire interface based on the I²C protocol. The SMBus is a low-speed bus that provides positive addressing for devices, as well as bus arbitration.

software device A filter in kernel streaming and DirectShow (formerly ActiveMovie) that has no underlying hardware associated with it.

software modem *Also* host-based signal processing or pumpless modem. Performs signal processing on the host CPU, and implements the controller using V.42bis. The modem hardware consists of a telephone-line interface and digital-to-analog and analog-to-digital conversion circuitry. The hardware does not contain a DSP or a microcontroller. *Compare with* controllerless modem.

Sound Blaster Hardware produced by Creative Labs, Inc., that represents for MS-DOS–based games one of the major hardware interfaces for both audio and music (specifically MIDI) data.

SPI Service Provider Interface. Component in Microsoft networking, TAPI, and other communications technologies.

spin down A power-management capability in which a hard drive shuts down its spindle motor.

Still Image architecture *Also* STI. A WDM architecture for still-image devices. A still-image minidriver provides support for still-image devices such as scanners and cameras under the WDM Still Image architecture.

SVGA Super VGA. A video standard established by VESA to provide high-resolution color display on IBM-compatible computers. The most common SVGA standard is 1024 × 768 pixels resolution.

S-Video *Also* Y/C video. A video signal that separates the luminance and color (Y and C) components of the signal for improved quality over composite video. The type of video signal used in the Hi8 and S-VHS videotape formats. Transmits luminance and color portions separately, using multiple wires, thus avoiding the NTSC encoding process and its inevitable loss of picture quality.

system board *Also* motherboard *or* planar. The primary circuit board in a PC that contains most of the basic components of the system.

system devices Devices on the system board, such as interrupt controllers, keyboard controller, real-time clock, DMA page registers, DMA controllers, memory controllers, FDC, IDE ports, serial and parallel ports, PCI bridges, and so on. These devices are typically integrated into the supporting chip set.

T

TAPI Telephony API. A set of Win32-based calls that applications use to control modems and telephones by routing application function calls to the appropriate service-provider DLL for a modem.

telephony Telephone technology.

tuple A data structure defined by PCMCIA to describe a single, specific characteristic of a PC Card device. Tuples are chained together to form the CIS, which describes to system software the PC Card's resource requirements and other characteristics. Tuples consist of a tuple code, an offset to the next tuple, and a number of bytes specific to the tuple.

TWAIN API for image acquisition developed by an association of industry leaders. The *TWAIN Specification, Version 1.6* or higher, is available from http://www.twain.org.

U

UART Universal Asynchronous Receiver/Transmitter. A module composed of a circuit that contains both the receiving and transmitting circuits required for asynchronous serial communication.

Unimodem Universal modem driver. A driver-level component that uses modem description files to control its interaction with the communications driver.

UPS Uninterruptible power supply. A device connected between a computer and a power source that ensures that electrical flow to the computer is not interrupted because of a blackout and, in most cases, protects the computer against potentially damaging events such as power surges.

USB Universal Serial Bus. A bi-directional, isochronous, dynamically attachable serial interface for adding peripheral devices such as game controllers, serial and parallel ports, and input devices on a single bus.

user mode The nonprivileged processor mode in which application code executes, including protected subsystem code in Windows NT.

V

VAR Value added reseller or retailer. A company that resells hardware and software packages made by another company (such as an OEM) with extra components added (such as specialist software) to developers and/or end users.

VBI Vertical blanking interval. The time interval between television fields needed for the scanning gun to move from the bottom of the screen to the top for the start of the next field.

VCACHE In Windows, a 32-bit protected-mode cache driver.

VCOMM In Windows, a 32-bit protected-mode communications driver.

VCR Video cassette recorder. An analog magnetic recording and playback machine. Typically used for

recording and viewing full-motion video. Also useful as a data backup device.

VGA Video graphics array. A video adapter that supports 640×480-pixel color resolution. A video display standard for boot devices under Windows operating systems.

VM Virtual machine. Software that mimics the performance of a hardware device.

VPE Video Port Extensions. Extensions to the DirectDraw API to control the video stream from the video port within the context of VGA memory.

VxD Virtual device driver. A device driver that runs at the privileged ring 0 protected mode of the microprocessor. Can extend the services of the Windows kernel, supervise hardware operations, or perform both functions. Such driver files are usually named according to the scheme VxD, where *x* refers to the device or service supported.

W

WAN Wide area network. A communications network that connects geographically separated areas. *Compare with* LAN.

warm docking A method of removing or installing a mobile system in a docking station by which the computer can be docked or undocked while in a reduced power state, such as suspend.

WBEM Web-based Enterprise Management. Technology based on standards being developed by DMTF and IETF. WBEM will provide a mechanism to specify information exchange between management applications and managed components.

WDL Windows Driver Library. *See* WHQL.

WDM Windows Driver Model. A driver model based on the Windows NT driver model that is designed to provide a common architecture of I/O services for both Windows and Windows NT for specific classes of drivers. These driver classes include USB and IEEE 1394 buses, audio, still-image capture, video capture, and HID-compliant devices such as USB mice, keyboards, and joysticks. Provides a model for writing kernel-mode drivers and minidrivers, and provides extensions for Plug and Play and power management.

WHQL Windows Hardware Quality Labs. Provides compatibility testing services to test hardware and drivers for Windows NT and Windows. Administers testing for the "Designed for Microsoft Windows" logo programs. Author of WDL and HCL. For more information, see the web site at http://www.microsoft.com/hwtest/.

Win32 API A 32-bit application programming interface for both Windows and Windows NT that includes operating system capabilities, security, and API routines for Windows-based applications.

Windows Refers to the Microsoft Windows 98 operating system, including any add-on capabilities and any later versions of the operating system.

Windows NT Refers to the Microsoft Windows NT version 5.0 operating system, including any add-on capabilities and any later versions of the operating system, unless specific design issues are defined that relate to version 5.0.

Windows NT DDK Documents the Windows NT driver model (upon which WDM is based) and is an essential component for building WDM drivers. Provided through MSDN Professional membership.

Windows NT driver model The layered device driver model used under the Windows NT operating system. For information, see *Inside Windows NT*, by Helen Custer (Microsoft Press, 1993; ISBN 1 -55615-481-X).

WMI Windows Management Instrumentation. Extensions to WDM developed for Windows NT 5.0 and Windows 98 to provide an operating system interface through which instrumented components can provide information and notifications.

workstation In general, a powerful computer with considerable calculating and graphics capabilities.

X

XOR Exclusive OR. A Boolean operation that yields "true" if and only if one of its operands is true and the other is false. *Compare with* OR.

Y

YcrCb *See* YUV.

YUV The method of color encoding for transmitting color video images while maintaining compatibility with black-and-white video. Uses less bandwidth than the three separate video signals in an RGB video transmission. Consists of two major components: luminance (Y), which corresponds to the brightness of an image pixel, and chrominance (UV or CrCb), which corresponds to the color of an image pixel.

Z

Zero Administration initiative for Windows *Also* Zero Administration initiative. An initiative that focuses on improving Windows and Windows NT for maximum automation of administrative tasks with centralized control and maximum flexibility.