CHAPTER 17

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.

PC 99A clarification: Windows 98 and Windows 2000 provide software mixing and sample rate conversion (SRC), which eliminate the need for hardware to support all possible rates. Therefore, the hardware is required to support only two key rates: 44.1 and 48kHz:

- 44.1kHz is required for efficiency reasons. Most game content uses a sampling rate that is an integer multiple of 44.1 kHz. In addition, CD audio is 44.1kHz. When the highest input stream is 44.1kHz and below, the optimal way to operate the audio output is to convert everything to 44.1kHz and run the audio device at this rate. This provides the best quality and least CPU overhead.
- 48kHz is required because it is the highest frequency that consumer content uses. DVD audio is a good example. When 48kHz content is present, the operating system will switch the audio output to 48kHz.

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)	20 Hz to 20.0 kHz[4]
	Dynamic range (SNR)	≥80 dB FS A[4]
	THD+N (-3 dB FS)	≤–65 dB FS[4]
	Microphone input to line output	
	Frequency response (-3 dB)	100 Hz to 12.0 kHz
	Dynamic range (SNR)	≥70 dB FS A[4]
	THD+N (-3 dB FS)	≤–60 dB FS[4]
	Line input to speaker output with 8-ohm load[2]	
	Frequency response (-3 dB)	20 Hz to 20.0 kHz[4]
	Dynamic range (SNR)	≥70 dB FS A[4]
	THD+N (-3 dB FS)	≤–55 dB FS[4]
Digital playback (PC-D-A) for line output	Frequency response (-3 dB)	
	44.1 kHz source material	20 Hz to 17.6 kHz[4]
	48.0 kHz source material	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	20 Hz to 17.6 kHz[4]
	48.0 kHz destination	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.

PC 99A clarification: For all cases in this requirement (and similar audio requirements), the reference should be to "audio hardware," and *not* to "audio codec hardware."

- **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.

    PC 99A clarification: The built-in or external audio hardware must support 16-bit stereo at 44.1 and 48 kHz at minimum. Output performance must meet or exceed minimum requirements stated in requirement 17.4.
  - 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 2000 Professional.

- **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.

    PC 99A clarification: The built-in or external audio hardware must support 16-bit stereo at 44.1 and 48 kHz at minimum. Input performance must meet or exceed minimum requirements stated in requirement 17.4.
  - 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 2000.

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.

  PC 99A correction: Three-conductor 1/8 inch (3.5 mm) tip/ring/sleeve microphone jack where the mic signal is on the tip, bias is on the ring, and the sleeve is grounded. This design is optimized for electret microphones with three-conductor plugs, but will also support dynamic microphones with two-conductor (ring and sleeve shorted together) plugs.

- Minimum AC input impedance between tip and ground: 10 kOhm.

  PC 99A correction: Minimum AC input impedance between tip and ground: minimum, 4 kOhm; recommended, 10 kOhm.

- Input voltages of 10–100 mV deliver full-scale digital input, using software-programmable ≥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 ≥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 ≥8.8 kHz bandwidth input signal with ≥70 dB FS A weighted dynamic range (SNR) and ≤-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 2000 DDK. See also the related articles available on the web at http://www.microsoft.com/hwdev/desinit/csa1.htm.

PC 99A clarification: For information about WDM device driver support for streaming capabilities, see the "Kernel Streaming Drivers Design Guide" in the Windows 2000 DDK (online at http://www.microsoft.com/ddk/ddkdocs/Win2kRC1/ks-overview_4svn.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
  14 dB at 500 Hz
  9 dB at 1000 Hz
  4 dB at 2000 Hz
  0 dB at 3500 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

Recommended

PC 99A clarification: This item is recommended, not 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.

PC 99A clarification: The following items are added to the recommendations for item 17.22, and might become requirements in future Design Guide guidelines.

- The audio device should not consume more than two percent of the CPU transferring audio data. This is two percent for all streams, not per stream.
- The audio device should be able to fully function when the system can only provide single pages of contiguous memory. In other words, the audio device can require many pages of memory, but should not require the largest block of contiguous memory to exceed one page. This ensures audio support in docking and dynamic loading scenarios where memory may be completely fragmented page-wise.
- The audio device should not introduce more than 1ms latency. In this context, latency is defined as the time between when the driver receives the audio data and when the audio data leaves the device.

The intent here is to provide performance guidelines for developers, rather than to specify implementation requirements.

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 98 and Windows 2000. For information, see the Windows 2000 DDK.

PC 99A clarification: For information about WDM device driver support for audio, see “WDM Audio Driver Design Guide” in the “Kernel Streaming Design Guide” in the Windows 2000 DDK (online at http://www.microsoft.com/ddk/ddkdocs/Win2kRC1/aud-design_5rn7.htm).

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/tech.htm

Audio '98 Roadmap
Audio Codec '97 Component Specification
Audio Codec '97 Design Guide papers
http://developer.intel.com/solutions/tech/audio.htm

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 2000 DDK (with DirectX DDK), and Microsoft Platform SDK
MSDN Professional subscription

PCI Local Bus Specification, Revision 2.2 (PCI 2.2)
PCI Bus Power Management Specification, Revision 1.0 (PCI PM)
http://www.pcisig.com/specs.html

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/developers/index.html

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
Recommended

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