eMac Developer Note

Hardware & Drivers > Apple Hardware

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Figures and Tables

Introduction to eMac Developer Note

This developer note gives a technical description of the eMac. The note provides information about the computer's internal design, input-output features, and expansion capabilities.

This developer note is intended to help hardware and software developers design products that are compatible with the products described here. If you are not already familiar with Macintosh computers or if you would simply like additional technical information, refer to Appendix A, "Supplemental Reference Documents", (page 45) for details.

Organization of This Document

The information in this note is arranged in four chapters and two appendixes.

- Chapter 1, "Overview to the eMac", (page 11) introduces the eMac, describes its features, and mentions a few software issues of interest to developers.

- Chapter 2, "Architecture", (page 17) describes the internal organization of the computer. It includes a functional block diagram and descriptions of the main components on the logic board.

- Chapter 3, "Devices and Ports", (page 23) describes the I/O ports and the built-in I/O devices.

- Chapter 4, "RAM Expansion", (page 41) includes development guidelines for the RAM expansion modules.

- Appendix A, "Supplemental Reference Documents", (page 45) provides sources of additional information about the technologies used in the eMac.

- Appendix B, "Abbreviations", (page 51) lists standard units of measure and other abbreviations used in this developer note.

Overview to the eMac

This chapter lists the features of the eMac and provides information about a few software issues of interest to developers.

New Features

The features that have changed from the previous eMac are listed here with links to the sections that describe them.

- **Microprocessor:** The eMac has a PowerPC G4 microprocessor running at a clock speed of 1.25 GHz or 1.42 GHz. For more information, see "PowerPC G4 Microprocessor" (page 19).

- **Memory:** The computer comes with 256 MB or 512 MB of DDR333 (PC2700) SDRAM installed in an internal 184-pin DIMM expansion slot; 512 MB and 1 GB memory is available as a build-to-order option. The second user-accessible slot accepts a DIMM up to 512 MB. The maximum supported memory is 1 GB. For more information, see "RAM Expansion Modules" (page 41).

- **Graphics acceleration:** The video circuits provide built-in 2D and 3D acceleration using an ATI Radeon 9200 with 32 MB DDR memory or an ATI Radeon 9600 with 64 MB DDR memory. For more information, see "Video Display Subsystem" (page 20).

- **SuperDrive (DVD+R DL/DVD±RW/CD-RW):** One configuration has an 8x SuperDrive, which supports DVR+R Double Layer (DL) format. For more information, see "SuperDrive" (page 31).

- **Bluetooth** Fully-integrated Bluetooth is available as a build-to-order option to enable short-range wireless connections between desktop and laptop computers and a host of other peripheral devices. For more information, see "Bluetooth Technology" (page 21).

All Features

Here is a complete list of the features of the eMac. Each feature is described in more detail in a later section.

- **Microprocessor:** The eMac has a PowerPC G4 microprocessor running at a clock speed of 1.25 GHz or 1.42 GHz. For more information, see "PowerPC G4 Microprocessor" (page 19).

- **Main memory bus:** The speed of the memory bus is 167 MHz. For more information, see "Main ICs and Buses" (page 18).

- **Cache:** The 512 KB backside L2 cache is included on the microprocessor IC and has the same clock speed as the microprocessor. For more information, see "Level 2 Cache" (page 19).

- **Memory:** The computer comes with 256 MB or 512 MB of DDR333 (PC2700) SDRAM installed in an internal 184-pin DIMM expansion slot; 512 MB and 1 GB memory is available as a build-to-order option. The second user-accessible slot accepts a DIMM with up to 512 MB. The maximum supported memory is 1 GB. For more information, see "RAM Expansion Modules" (page 41).

- **Hard disk storage:** The built-in hard disk drive has a capacity of 5400 rpm 40 GB or 7200 rpm 80 GB. Some configurations have 7200 rpm 80 GB and 160 GB build-to-order options. For more information, see "Hard Disk Drive" (page 30).

- **CD-ROM drive:** One configuration has a CD-ROM drive. For more information, see "CD-ROM Drive" (page 31).

- **Combo drive**: One configuration has a combination DVD-ROM/CD-RW drive. For more information, see "Combo Drive" (page 31).

- **SuperDrive (DVD+R DL/DVD±RW/CD-RW):** One configuration has an 8x SuperDrive, which supports DVR+R Double Layer (DL) format. For more information, see "SuperDrive" (page 31).

- **External video monitor:** The mini-VGA display connector supports VGA, composite, and S-video formats for devices such as monitors, projectors, and television sets. A video adapter with composite and S-video connectors is available separately. For more information, see "External Display Port" (page 33).

- **Graphics acceleration:** The video circuits provide built-in 2D and 3D acceleration using an ATI Radeon 9200 with 32 MB DDR memory or an ATI Radeon 9600 with 64 MB DDR memory. For more information, see "Video Display Subsystem" (page 20).

- **Video RAM:** The video hardware supports 3D features and millions of colors in all resolutions. For more information, see "Video Display Subsystem" (page 20) and "Video Display" (page 32).

- **USB ports:** The eMac has three USB 2.0 ports on the main chassis. For more information, see "USB Ports" (page 23).

- **FireWire 400 ports:** The eMac has two IEEE-1394a FireWire 400 ports, which support transfer rates of 100, 200, and 400 Mbps. For more information, see "FireWire 400 Ports" (page 24).

- **Target Disk Mode:** The computer can act like a FireWire storage device connected to another computer. See "Target Disk Mode" (page 27).

- **Modem:** Some models have a built-in fax modem with a 56 Kbps data rate. For more information, see "Internal Modem" (page 28).

- **Ethernet:** The eMac has a built-in Ethernet port for a 10Base-T and 100Base-T operation. For more information, see "Ethernet Port" (page 27).

- **AirPort Extreme Card:** An internal AirPort Extreme Card wireless LAN module is available as a build-to-order option or as a user-installable upgrade. For more information, see "AirPort Extreme Card" (page 28).

- **Bluetooth:** Fully-integrated Bluetooth is available as a build-to-order option to enable short-range wireless connections between desktop and laptop computers and a host of other peripheral devices. For more information, see "Bluetooth Technology" (page 21).

- **Audio:** The eMac has a built-in microphone, stereo speakers with amp, a line-level stereo input jack, and a stereo headphone jack. For more information, see "Audio System" (page 36).

- **Keyboard:** The eMac comes with an Apple Keyboard. The keyboard is also a USB hub with two USB ports. For more information, see "Keyboard" (page 35).

- **Mouse:** The computer comes with an Apple Mouse, a USB mouse with optical tracking. For more information, see "Mouse" (page 36).

- **Size and weight:** The eMac is 40.6 cm (15.8 inches) high, 40.6 cm (15.8 inches) wide, and 43.3 cm (17.1 inches) deep; it weighs 22.7 kg (50.0 pounds).

- **Display:** The eMac has a built-in 17-inch flat color CRT monitor with a 16-inch viewable diagonal. For more information, see "Video Display" (page 32).

External Features

The eMac is housed in a polycarbonate plastic enclosure that includes the display. The separate keyboard and mouse are also designed in polycarbonate plastic.

The front of the enclosure is dominated by the 17 inch flat display. The front also includes the following features:

- Center-positioned, tray-loading CD-ROM, Combo drive, or SuperDrive (and no-optical drive configuration)
- Access to AirPort Extreme Card slot
- Stereo speakers, one on either side
- Power-on light, located near the speaker on the right side; the light has a steady white glow when on; it pulses in sleep mode
- Built-in microphone

The right side of the enclosure, as viewed from the front, contains the I/O panel. The I/O panel contains the following features:

- Two FireWire 400 ports
- Modem connector (on the models that have an internal modem)
- Ethernet port
- Three USB 2.0 ports
- Video monitor connector (mini-VGA)
- Headphone jack
- Audio line-in port

The receptacle for the power cord is located on the right rear panel. The right rear panel also includes the following features:

- Power button
- Kensington security slot

The back portion of the bottom of the enclosure has a door that can be opened for access to the expansion RAM. For more information, see "RAM Expansion Slots" (page 41).

System Software

The eMac comes with Mac OS X version 10.4 installed as the default system. Mac OS 9 applications can be run in Classic mode. Install the Classic environment from the optical media shipped with your computer. For more information about Mac OS X, see the reference listed in "Mac OS X" (page 46).

Computer Identification

Rather than reading the box flag or the model string and then making assumptions about the computer's features, applications that need to find out the features of the computer should use IORegistry calls to test for the features they require. IORegistry calls are part of the I/O Kit API. For more information, see the references listed at "I/O Kit" (page 46).

Asset management software that reports the kind of computer it is run on can obtain the value of the model property from the IOService plane of the IORegistry. For the eMac, the value of the string in the `compatible` property is `PowerMac6,4`.

NMI without Programmer's Switch

Current Macintosh computers do not have a programmer's switch, which allowed users to generate a non-maskable interrupt (NMI). The paragraphs below describe how to generate an NMI from a remote session for systems that do not have a physical programmer's switch.

Starting with Mac OS X 10.1.2, the OS will promote and recognize the `DB_NMI` bit in the debug parameter of the "boot-args" property from Open Firmware. When the `DB_NMI` bit is set, the user can generate a non-maskable interrupt (NMI) by pressing the system's power button. This replaces the power button's sleep or wake response. The system reads the state of the bit at boot time from the `boot-args` configuration variable. For more information about the debug flags, please see *Inside Mac OS X: Kernel Programming*.

To set the `DB_NMI` bit, enter the following command at the Terminal to display the current debug flag settings.

```
% nvram boot-args
```

Add the parameter `debug=0x4`, as follows.

```
% sudo nvram boot-args="<current settings> debug=0x4"
```

After the `DB_NMI` bit in the debug parameter is set, reboot the machine. After reboot, pressing the power button for approximately 1 second will generate an NMI.

> **Note:** If the power button is pressed for more than five seconds, the system will immediately power off.

The power button will retain this functionality until Mac OS X is restarted without the `DB_NMI` bit set. To clear this bit, issue the `nvram` command omitting `debug=0x4` parameter, as follows, then restart the machine.

```
% sudo nvram boot-args=""
```

> **Note:** The debug flags bit will be cleared if you use System Preferences to change the startup disk. It may also be cleared if you perform an installation that requires a restart.

Velocity Engine Acceleration

The Velocity Engine (an implementation of AltiVec) is the vector processing unit in the PowerPC G4 microprocessor. Some system software has been modified to take advantage of the accelerated processing that the Velocity Engine makes possible. System software has also been modified to support low-level operations using the Velocity Engine.

For complete information on the Velocity Engine, refer to the following Apple website:

http://developer.apple.com/hardwaredrivers/ve/index.html

Architecture

This chapter describes the architecture of the eMac. It includes information about the major components on the main logic board: the microprocessor, the other main ICs, and the buses that connect them to each other and to the I/O interfaces.

Block Diagram and Buses

This section is an overview of the major ICs and buses on the computer's main logic board.

Block Diagram

Figure 2-1 (page 18) is a simplified block diagram of the main logic board. The diagram shows the main ICs and the buses that connect them together.

Figure 2-1   Block diagram
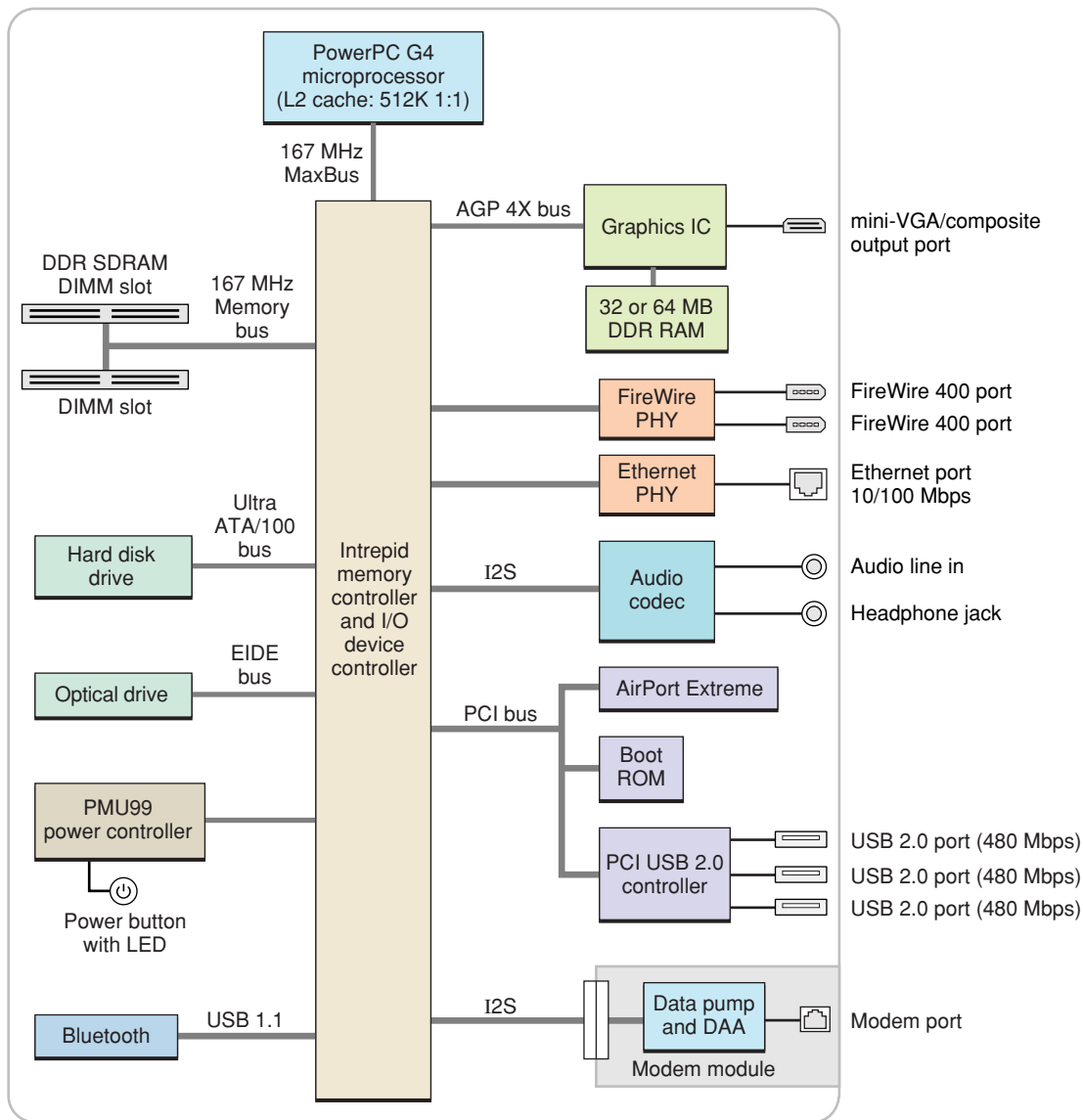
Main ICs and Buses

The architecture of eMac is designed around the PowerPC G4 microprocessor and the Intrepid memory and I/O device controller. The Intrepid occupies the center of the block diagram.

The MaxBus connects the PowerPC G4 microprocessor to the Intrepid ASIC. The MaxBus has 64 data lines, 32 address lines, and a bus clock speed of 167 MHz. The Intrepid ASIC has other buses that connect with the boot ROM, the hard disk drive, and the optical drive, the power controller IC, the sound IC, the internal modem module, and the optional wireless LAN module.

The Intrepid I/O controller has a 32-bit PCI bus with a bus clock speed of 33 MHz.

Each of the components listed here is described in one of the following sections.

Microprocessor and Cache

The microprocessor is a 1.25 GHz or 1.42 GHz PowerPC G4 with a built-in level 2 (L2) cache.

PowerPC G4 Microprocessor

The PowerPC G4 microprocessor used in the eMac has many powerful features, including.

- 32-bit PowerPC implementation

- superscalar PowerPC core

- Velocity Engine (AltiVec technology): 128-bit wide vector execution unit

- pipelined, high bandwidth system bus, called MaxBus

- dual 32 KB instruction and data caches (level 1)

- built-in 512 KB backside L2 cache

To find more information, see the reference at "PowerPC G4 Microprocessor" (page 45).

Level 2 Cache

The data storage for the L2 cache consists of 512 KB of fast static RAM that is built into the microprocessor chip along with the cache controller. The built-in L2 cache runs at the same clock speed as the microprocessor.

Memory and I/O Device Controller

The Intrepid ASIC combines several functions into a single IC. The IC contains the memory controller, the PCI bus bridge, the Ethernet and FireWire 400 interfaces, the USB 1.1 interface, and the AGP interface.

In addition to the buses listed in Table 2-1 (page 19), the Intrepid ASIC also has separate interfaces to the physical layer (PHY) ICs for Ethernet and FireWire 400 and an I2C interface that is used for configuring the memory subsystem.

Table 2-1   Bus speeds

Name of bus	Destinations	Width of data path	Bus clock speed/ data rate
MaxBus	Microprocessor	64 bits	167 MHz
Memory bus (DDR)	System RAM	64 bits	167 MHz (2x)
AGP 4x bus	Graphics IC	32 bits	66 MHz (4x)
Ultra ATA -100 bus	Hard drive	16 bits	100 MBps
EIDE	Optical drive	16 bits	16.6 MBps

The Intrepid ASIC provides DB-DMA (descriptor-based direct memory access) support for the I/O channels. The DBDMA system provides a scatter-gather process based on memory resident data structures that describe the data transfers. The DMA engine is enhanced to allow bursting of data files for improved performance.

The following sections describe the subsystems that are connected to the Intrepid ASIC.

System RAM

The memory subsystem in the eMac consists of 256 MB or 512 MB of DDR333 (PC2700) SDRAM in one of the two DIMM slots. The data bus to the RAM is 64 bits wide, and the memory interface is synchronized to the MaxBus interface at 167 MHz. The system supports a maximum of 1 GB.

For more information on system RAM, see "RAM Expansion" (page 41).

Video Display Subsystem

The display subsystem consists of a graphics controller IC and 32 MB or 64 MB of DDR on the main logic board. The graphics controller IC is either an ATI Radeon 9200 with 32 MB 190 MHz DDR memory or an ATI Radeon 9600 with 64 MB 200 MHz DDR memory. It contains 2D and 3D acceleration engines, front-end and back-end scalers, a CRT controller, and an AGP bus interface with bus master capability.

The interface between the graphics IC and the rest of the system is a 4x AGP (accelerated graphics port) bus on the Intrepid IC. To give the graphics IC fast access to system memory, the AGP bus has separate address and data lines and supports deeply pipelined read and write operations. The AGP bus has 32 data lines and a clock speed of 66 MHz.

The graphics IC uses a graphics address remapping table (GART) to translate AGP logical addresses into physical addresses. The graphics driver software can allocate memory in both the dedicated SDRAM and the main memory.

For information about the display and supported resolutions, see "Video Display" (page 32).

Boot ROM

The boot ROM is a 1 M by 8 bit device and is connected to the Intrepid ASIC by way of the high byte of the PCI bus plus three additional control signals: chip select, write enable, and output enable.

Ethernet Controller

The eMac includes an ethernet media access controller (MAC) that implements the Link layer. The Intrepid ASIC provides DB-DMA support for the Ethernet interface.

The controller is connected by a PCI bus to a PHY interface IC that is capable of operating in either 10-BaseT or 100-BaseT mode. The actual speed of the link is automatically negotiated by the PHY and the bridge or router to which it is connected. For information about the port, see "Ethernet Port" (page 27).

FireWire 400 Controller

The eMac includes an IEEE 1394a FireWire 400 controller with a maximum data rate of 400 Mbps (50MBps). The Intrepid IC provides DMA (direct memory access) support for the FireWire interface. The FireWire 400 controller complies with the Open Host Controller Interface (OHCI) specification.

The controller IC implements the FireWire link layer. A physical layer IC, called a PHY, implements the electrical signalling protocol of the FireWire interface. The PHY supports two FireWire 400 ports by way of external connectors in the I/O bay.

The PHY is powered as long as the computer is connected to AC power. While the PHY is operating, it acts as a repeater from one port to another so that the FireWire bus remains connected. For more information, see "FireWire 400 Ports" (page 24).

Ultra ATA/100 Interface

The Ultra ATA/100 interface complies with and supports a subset of industry standard ATA/ATAPI-6 and transfer protocols up to ultra DMA mode 5. The internal hard disk drive is configured as cable select. For more information, see "Hard Disk Drive" (page 30).

EIDE Interface

The EIDE interface complies with and supports a subset of industry standard ATA/ATAPI-5 and transfer protocols up to Multiword DMA Mode 2. The Combo drive and SuperDrive are device-selected as cable select in an ATA device configuration. For more information, see "CD-ROM Drive" (page 31), "Combo Drive" (page 31), and "SuperDrive" (page 31).

Modem Support

The internal modem is connected to an internal I2S interface. The modem provides digital call progress signals to the sound circuitry. The analog side of the connection gets power from the phone line; the digital side gets power from the eMac.

The modem is a separate module that contains the datapump and the interface to the telephone line (DAA). For more information about the modem, see "Internal Modem" (page 28).

Bluetooth Technology

Bluetooth is available as an internal build-to-order option in the eMac. Bluetooth is an open specification that enables short-range wireless connections between desktop and laptop computers and a host of other peripheral devices. For more information on Bluetooth technology, refer to "Bluetooth Technology" (page 30).

Power Controller

The power management controller in the eMac is a custom IC called the PMU99. In addition to turning the machine on and off, the power controller supports several power-saving modes of operation.

Sound Circuitry

The sound circuitry is connected to the Intrepid IC by standard IIC and IIS buses. The IIC bus provides configuration access to the audio circuitry ICs and the IIS bus is used for data transfers. The Intrepid IC provides DB-DMA (descriptor-based direct memory access) support for the IIS port.

The audio circuitry performs digital audio processing and codec functions. The audio processing functions include output equalization and volume control. The codec functions include A-to-D and D-to-A conversion.

Stereo signals from the audio line-in jack drive the audio circuitry's A-to-D converter. Audio data from the Intrepid IC drives the audio circuitry's D-to-A converter. Analog output from the D-to-A converter is routed to the headphone jack and the audio power amplifier.

The power amplifier drives the internal speaker. When headphones are connected to the headphone jack, the internal speaker is muted.

For a description of the features of the sound system, see "Audio System" (page 36).

Wireless LAN Support

Apple's internal wireless LAN module, the 54 Mbps AirPort Extreme Card, is available as a build-to-order option or as a user-installable upgrade. The proprietary connector for the AirPort Extreme Card uses the PCI bus. A second connector attaches to the AirPort antenna. The AirPort antenna is built into the system. For information about operation, see and "AirPort Extreme Card" (page 28).

The build-to-order Bluetooth connectivity is connected to the Intrepid IC via a USB 1.1 interface. See "Bluetooth Technology" (page 30) for more information.

USB Interface

The Intrepid ASIC has three USB 1.1 controllers, numbered 0, 1, and 2. Port 2 is used by Bluetooth and ports 0 and 1 are not available for use. The two ports on the keyboard support USB 1.1 devices.

The eMac uses a PCI USB 2.0 controller to support three external ports on the side of the computer. These ports support USB 2.0 and 1.1 devices with data transfer rates of 480 Mbps, 12 Mbps, or 1.5 Mbps.

USB devices connected to the eMac are required to support USB-suspend mode as defined in the USB specification.

The USB ports on the eMac comply with the Universal Serial Bus Specification 2.0. The USB 2.0 controllers comply with the Enhanced Host Controller Interface (EHCI) specification.

For more information about USB, see "USB Ports" (page 23). For USB reference information, see "USB Interface" (page 47).

Devices and Ports

This chapter describes both the built-in I/O devices and the ports for connecting external I/O devices. Each of the following sections describes an I/O port or device.

USB Ports

The eMac has five Universal Serial Bus (USB) ports that are used for connecting the keyboard and mouse as well as additional I/O devices such as printers, scanners, and storage devices. Three USB 2.0 ports are on the side of the eMac and two USB 1.1 ports are on the keyboard. The three USB 2.0 ports are connected to a discrete USB 2.0 controller chip. The optional Bluetooth module is connected to the Intrepid ASIC via a USB 1.1 connection. See "USB Interface" (page 47) for reference information.

For more information about USB on Macintosh computers, please refer to sources listed in "USB Interface" (page 47).

USB Connectors

The USB ports use USB Type A connectors, which have four pins each. Two of the pins are used for power and two for data. Figure 3-1 (page 23) is an illustration of a Type A port; Table 3-1 (page 23) shows the signals and pin assignments.

Figure 3-1   USB Type A port and pins
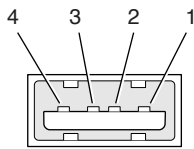
Table 3-1   Signals on the USB port

Pin	Signal name	Description
1	VCC	+5 VDC
2	D–	Data –
3	D+	Data +
4	GND	Ground

The eMac provides 5 volt power to the USB ports. The maximum current available is 500 mA on each port.

The external USB 2.0 ports support low-speed (1.5 Mbps), full-speed (12 Mbps), and high-speed (480 Mbps) data transfers. High-speed operation requires the use of shielded cables.

The Macintosh system software supports all four data transfer types defined in the USB specification.

USB Features

Features of the USB ports include the following sections.

Note: When powered-off or in sleep mode, the USB port does not receive power.

Wake Up From Sleep

USB devices can provide a remote wakeup function for the computer. The USB root hub in the computer is set to support remote wakeup whenever a device is attached to or disconnected from the bus. The keyboard that comes with the computer uses this method to wake the computer on a key press.

Connect and Resume

The Intrepid ASIC contains special circuitry that allows the computer to wake from sleep mode on connect, disconnect, and resume events. Compatible USB devices should support the USB-suspend mode defined in the USB specification.

USB Device Drivers

Class drivers are software components that are able to communicate with many USB devices of a particular kind. If the appropriate class driver is present, any number of compliant devices can be plugged in and start working immediately without the need to install additional software. The Mac OS for the eMac supports USB Mass Storage specification.

USB Controller

The eMac uses Open Host Controller Interface (OHCI) controller for USB communication. Some early USB devices (most notably keyboards) can't interoperate with an OHCI controller. Those devices are not supported by the Macintosh USB system software. The USB 2.0 controllers comply with the Enhanced Host Controller Interface (EHCI) specification.

FireWire 400 Ports

The eMac has two external FireWire 400 IEEE 1394a ports. The features of the FireWire ports are:

■ Support serial I/O at 100, 200, and 400 Mbps (megabits per second)

■ Share up to 8 watts of power when the computer system is on

■ Support up to 62 devices

■ When powered-off or in sleep mode, the FireWire port does not receive power.

> **Note:** When in sleep mode, the FireWire port is not receiving power. Therefore if a device such as an iPod is connected to the FireWire port, it is running off its own power.

The FireWire hardware and software provided with the eMac are capable of all asynchronous and isochronous transfers defined by the IEEE 1394a standard.

FireWire Device Programming

Mac OS X includes general support for the FireWire bus and specific support for various kinds of FireWire devices and protocols. Developers can use the built-in support or provide additional applications and drivers for use with their products.

The general FireWire services will configure the FireWire bus, scan the bus for new devices, and allow multiple drivers and devices to share a single FireWire interface cooperatively. The general services also publish information about the bus and the devices in the IO Registry, so that IO Kit can match protocols and drivers to each connected FireWire device.

The specific device and protocol support in Mac OS X as provided with the eMac includes the following:

■ General services for Serial Bus Protocol 2 (SBP-2) and support for most mass storage devices using SBP-2, such as hard disk drives, optical drives, flash card readers, Target Disk Mode (see "Target Disk Mode" (page 27)), and the iPod. Mac OS X can boot from most of these devices.

■ General services for the Audio Video Control (AV/C) protocol and support for most digital video (DV) cameras and decks using this protocol, including video capture through standard QuickTime APIs.

■ A QuickTime device driver for IIDC/DCAM type cameras such as the iSight.

■ A network device driver supporting IP (Internet Protocol) over FireWire according to IEEE RFC 2734.

■ Additional services for user-space and kernel access to all FireWire resources.

For information on writing FireWire drivers or applications, download the latest FireWire SDK from http://developer.apple.com/sdk/

For additional references, refer to "FireWire Interface" (page 48).

FireWire 400 Connector

The FireWire 400 connector has six contacts, as shown in Figure 3-2 (page 26). The connector signals and pin assignments are shown in Table 3-2 (page 26).

Figure 3-2   FireWire 400 connector
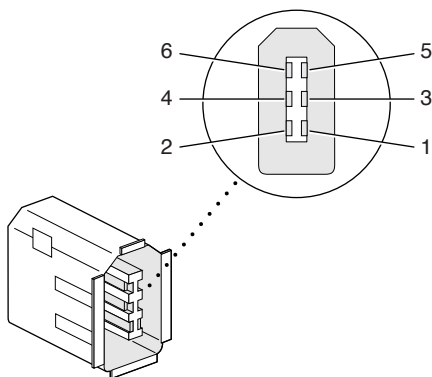
Table 3-2   Signals on the FireWire 400 connector

Pin	Signal name	Description
1	Power	unregulated DC; 17-24 V no load
2	Ground	Ground return for power and inner cable shield
3	TPB–	Twisted-pair B, differential signals
4	TPB+	Twisted-pair B, differential signals
5	TPA–	Twisted-pair A, differential signals
6	TPA+	Twisted-pair A, differential signals
Shell	—	Outer cable shield

When the computer is on, the power pin provides a maximum voltage of 24 V (no load) and up to 8 W total power (shared by both connectors). Zero voltage is present at the power pin when the computer is in sleep mode or when it is off.

The FireWire PHY is powered as long as the computer is connected to AC power. While the PHY is operating, it acts as a repeater from one port to another so that the FireWire bus remains connected.

Pin 2 of the 6-pin FireWire connector is ground for both power and inner cable shield. If a 4-pin connector is used on the other end of the FireWire cable, its shell should be connected to the wire from pin 2.

The signal pairs are crossed in the cable itself so that pins 5 and 6 at one end of the cable connect with pins 3 and 4 at the other end. When transmitting, pins 3 and 4 carry data and pins 5 and 6 carry clock; when receiving, the reverse is true.

For additional information about the FireWire interface and the Apple APIs for FireWire device control, developers should refer to the resources listed in "FireWire Interface" (page 48).

Target Disk Mode

The user has the option at boot time to put the computer into a mode of operation called Target Disk Mode (TDM).

When the eMac is in Target Disk Mode and connected to another Macintosh computer by a FireWire cable, the eMac operates like a FireWire mass storage device with the SBP-2 (Serial Bus Protocol) standard. Target Disk Mode has two primary uses:

■ high-speed data transfer between computers

■ diagnosis and repair of a corrupted internal hard drive

The eMac can operate in Target Disk Mode as long as the other computer has a FireWire port and either Mac OS X (any version) or Mac OS 9 with FireWire software version 2.3.3 or later.

To put the eMac into Target Disk Mode, restart the eMac and hold down the T key until the FireWire icon appears on the display. Then connect a FireWire cable from the eMac to the other computer. When the other computer completes the FireWire connection, a hard disk icon appears on its desktop.

If the FireWire cable is disconnected or the eMac is turned off while in Target Disk Mode, an alert appears on the other computer.

To take the eMac out of Target Disk Mode, drag the hard-disk icon on the other computer to the trash, then press the power button on the eMac.

Ethernet Port

The eMac has a built-in 10/100 Mbps Ethernet port. The user can connect it to either a 10Base-T or a 100Base-T hub; the port will automatically sense which type of hub is connected.

The connector for the Ethernet port is a an RJ-45 connector located on the I/O panel. Table 3-3 (page 27) shows the signals and pin assignments on the connector.

Table 3-3   Signals on the Ethernet connector

Pin	Signal name	Signal definition
1	TXP	Transmit (positive lead)
2	TXN	Transmit (negative lead)
3	RXP	Receive (positive lead)
4	–	Not used
5	–	Not used
6	RXN	Receive (negative lead)
7	–	Not used

Pin	Signal name	Signal definition
8	–	Not used

The Ethernet interface in the eMac conforms to the ISO/IEC 802.3 specification, where applicable.

Internal Modem

Except for the education configuration, the eMac has an internal, fax modem. The telephone connector for the modem is an RJ-11 connector on the I/O panel. A telephone cable is included with the computer.

The internal modem has the following features:

- modem bit rates up to 56 Kbps (supports V.92 and K56 flex modem standards)
- Group 3 fax modem bit rates up to 14.4 Kbps

The internal modem is an I2S device that responds to typical AT commands. The modem delivers audio to the host where it is converted to analog for call progress monitoring. The modem also supports the "Wake up on Ring" feature.

AirPort Extreme Card

The eMac supports the AirPort Extreme Card, an internal wireless LAN module connected to the PCI bus. The AirPort Extreme Card is available as a build-to-order option or as a user-installable upgrade.

By communicating wirelessly with a base station, the AirPort Extreme Card can be used for Internet access, email access, and file exchange. A base station provides the connection to the Internet or the bridge between the wireless signals and a wired LAN or both. The AirPort Extreme Base Station has connectors for a wired LAN or WAN, a DSL or cable modem, and a standard telephone line using the built-in 56 Kbps modem that is available on some base station configurations.

AirPort Extreme transmits and receives data at speeds up to 54 Mbps, comparable to wired networking speeds. AirPort Extreme is compatible with earlier AirPort systems as well as other devices that adhere to the IEEE 802.11b and 802.11g standards. For more information about Wi-Fi and compatibility, see the reference at "Wireless Networks" (page 48).

> **Note:** As is the case with the existing IEEE 802.11b standard, actual data throughput speeds will be lower than the indicated maximum connection speeds. Inherent in wireless LAN systems, bandwidth overhead is required for wireless routing, scrambling, security error correction, and other processes.

Data Security

AirPort Extreme has several features designed to maintain the security of the user's data:

■ In 802.11 b mode, the system uses direct-sequence spread-spectrum (DSSS) technology that uses a multi-bit spreading code that effectively scrambles the data for any receiver that lacks the corresponding code.

■ The system can use an Access Control List of authentic network client ID values (wireless and MAC addresses) to verify each client's identity before granting access to the network.

■ When communicating with a base station, AirPort Extreme uses 64-bit and 128-bit WEP encryption and WPA personal and enterprise modes to encode data while it is in transit. Additional security features may be available via firmware upgrades as 802.11 enhancements are ratified by IEEE.

■ The AirPort Extreme Base Station can be configured to use NAT (Network Address Translation), protecting data from Internet hackers.

■ The AirPort Extreme Base Station can authenticate users by their unique Ethernet IDs, preventing unauthorized computers from logging into your network. Network administrators can take advantage of RADIUS compatibility, used for authenticating users over a remote server. Smaller networks can offer the same security using a local look-up table located within the base station.

As an additional data security measure, VPN can be used in conjunction with the AirPort Extreme data security.

AirPort Extreme Hardware

The AirPort Extreme Card is a wireless LAN module ompliant with the IEEE specification of the 802.11 g standard using both OFDM (orthogonal frequency-division multiplexing) and DSSS technologies. Using DSSS, AirPort Extreme is interoperable with PC-compatible wireless LANs that conform to the 802.11 b standard at speeds of 11 Mbps, 5.5 Mbps, 2 Mbps, and 1 Mbps. Using OFDM, AirPort Extreme is compatible with all 802.11 g standard speeds.

An AirPort Extreme antenna is built into the computer's enclosure.

AirPort Extreme Software

Software that is provided with the AirPort Extreme Card includes:

■ AirPort Extreme Setup Assistant, an easy-to-use program that guides users through the steps necessary to set up AirPort Extreme or set up an AirPort Extreme Base Station.

■ Users can switch between wireless networks and can create and join peer-to-peer networks. These functions are accessed via the AirPort Extreme status menu.

■ AirPort Extreme Admin Utility, a utility for advanced users and system administrators. With it the user can edit the administrative and advanced settings needed for some advanced configurations.

Bluetooth Technology

Available as a fully-integrated, build-to-order option, Bluetooth is an open specification that enables short-range wireless connections between desktop and laptop computers and a host of other peripheral devices. Bluetooth support is built into Mac OS X and compliant with Bluetooth specification 1.1. It operates on a globally available 2.4 GHz frequency band (ISM band) for worldwide compatibility and has a maximum throughput of 1 Mbps.

The Bluetooth technology supports the following profiles:

- serial port (SPP) —provides a wireless serial connection to other Bluetooth devices
- dial-up networking (DUN) — enables a mobile phone to act as a modem
- object push (OPP) —enables the transfer of files between Bluetooth devices
- human interface device (HID) — enables the use of Bluetooth input devices (keyboards and mice)
- Bluetooth file transfer profile (FTP) — enables browsing of the file system of other Bluetooth devices which support Bluetooth FTP
- hardcopy cable replacement profiler (HCRP) — describes how to send rendered data over a Bluetooth link to a device, such as a printer. Although other profiles can be used for printing, the HCRP is specially designed to support hardcopy applications.
- headset profile (HSP) — enables the use of Bluetooth-enabled wireless headsets for applications such as iChat. This profile does not enable use of Apple Speech Recognition due to the fact that it is a low-precision audio channel.

Bluetooth is available as a build-to-order option, which is installed by Apple at the time of purchase as a fully integrated module. Accessing the Bluetooth capabilities without purchasing the integrated module will require a third-party USB device.

When the Bluetooth option is included in the factory order, the Bluetooth antenna is built into the computer's enclosure.

For more information on Bluetooth technology, refer to "Bluetooth" (page 49).

Hard Disk Drive

The eMac has an internal hard disk drive storage capacity of 5400 rpm 40 GB or 7200 rpm 80 GB; 80 GB and 160 GB 7200 rpm build-to-order options are available. The internal hard disk drive operates at ATA-100 and conforms to the ATA/ATAPI-6 standard. It is set as Cable Select (CS) and operates as a device 0 on the host's ATA port.

The software that supports the internal hard disk is similar to that in previous Macintosh models and includes DMA support. To obtain information about that software and about the ANSI standard for the Ultra DMA ATA interface, see "ATA Devices" (page 47).

CD-ROM Drive

One configuration of the eMac has an internal CD-ROM drive. The drive has a tray for loading the disc. The drive is capable of reading at 32x speed.

Digital audio signals from the CD-ROM drive can be played through the sound outputs under the control of System Preferences.

The CD-ROM drive is cable-select jumpered. The device configuration (master/slave) is determined by the ATA interface capable of multi-word DMA mode 2, 16 megabytes per second. This interface is compatible with ANSI-NCITS industry standard ATA/ATAPI-5.

Combo Drive

One configuration of the eMac has a tray-loading combination DVD-ROM and CD-RW drive. The Combo drive can read DVD media and read and write CD media, as shown in Table 3-4 (page 31). The Combo drive also provides DVD-Video playback.

Table 3-4   Types of media read and written by the Combo drive

Media type	Reading speed	Writing speed
DVD-ROM	12x DVD5 (CAV max) 8x DVD9 (CAV max)	–
DVD±R	6x max (CAV)	_
DVD+R DL	4x max (CAV)	_
DVD±RW	6x (CAV max)	-
CD-R	32x (CAV max)	32x (ZCLV)
CD-RW	32x (CAV max)	10x (CLV, for high speed media)
CD-ROM	32x (CAV max)	–

Digital audio signals from the Combo drive can be played through the sound outputs under the control of System Preferences.

The Combo drive is cable-select jumpered. The device is capable of Ultra-DMA Mode 2, which is a maximum of 33 megabytes per second. This interface is compatible with ANSI-NCITS industry standard ATA/ATAPI-5.

SuperDrive

One configuration of the eMac has a tray-loading SuperDrive. The drive can read and write DVD media and CD media, as shown in Table 3-5 (page 32). The SuperDrive also provides DVD-Video playback.

Table 3-5 Types of media read and written by the SuperDrive

Media type	Reading speed	Writing speed
DVD-R	8x (CAV max)	8x, 4x, 1x (CLV) depending on media
DVD+R	8x (CAV max)	8x, 4x, 2x (CLV) single layer depending on media
DVD+R DL	6x (CAV max)	2.4x double layer
DVD-ROM	12x DVD5 (CAV max) 8x DVD9 (CAV max)	–
DVD-RW	8x (CAV max)	4x, 2x, 1x (CLV) depending on media
DVD+RW	8x (CAV max)	4x, 2x (CLV) depending on media
CD-R	32x (CAV max)	24x (PCLV)
CD-RW	32x (CAV max)	16x ultra high speed (CD-RW)
CD-ROM	32x (CAV max)	–

Digital audio signals from the SuperDrive can be played through the sound outputs under the control of System Preferences.

The SuperDrive is cable-select jumpered. The device is capable of Ultra-DMA Mode 2, which is a maximum of 33 megabytes per second. This interface is compatible with ANSI-NCITS industry standard ATA/ATAPI-5.

Video Display

The built-in video display uses a 17-inch CRT (16-inch viewable diagonal). The CRT uses shadow-mask technology and has a dot pitch of 0.25 mm. Table 3-6 (page 32) lists the resolutions and the vertical and horizontal scan rates supported.

The display supports pixel depths up to 24 bits (millions of colors) at all resolutions.

Table 3-6 Display resolutions and pixel depths

Resolution	Vertical rate
640 by 480	138 Hz
800 by 600	112 Hz
1024 by 768	89 Hz
1152 by 870	80 Hz
1280 by 960	72 Hz

External Display Port

The eMac has a video output port for connecting an external video monitor or projector. The port supports both RGB and composite/S-video signals (for VGA and TV) by means of adapters. The port detects the type of adapter connected to it and programs the graphics IC to provide the appropriate type of video signals, as shown in the table below.

Table 3-7   Display adapters

Adapter type	Video signals	Connector type(s)
Apple VGA adapter	RGB	VGA 15-pin miniature D-type
Apple Video adapter	Composite and S-video TV signals	RCA and S-video

Resolutions supported are up to 2048 x 1536 pixels at 75 Hz, 24 bit per pixel (based on the EDID and attached monitor). When either type of display adapter is connected, the settings for the resolutions with multiple vertical refresh rates are selectable in System Preferences.

Composite video and S-video signals can be displayed on either an NTSC display or a PAL display. When a display is connected by way of the video adapter, the computer detects the type of adapter and enables the composite and S-video outputs. The settings for the resolutions and standards (NTSC or PAL) are then selectable in the monitor control panel or control strip.

The video output mirrors the internal display: internal and external video share the same buffer, and the hardware sends the image to both displays.

Note: A VGA display adapter is required to convert to VGA display.

Mini Video Display Connector

The mini video display connector is a 14-pin rectangular connector (Hosiden TCX3143 or compatible). The connector pins are identified in Figure 3-3 (page 33).

Figure 3-3   Mini Video display connector
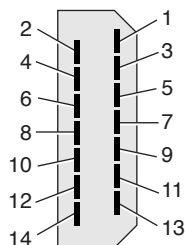
The eMac detects the type of display adapter that is plugged in and programs the graphics IC to route the appropriate video signals to the connector. The signal assignments on the video connector are shown in Table 3-8 (page 34). The signal assignments for the video adapter are shown in Table 3-9 (page 34).

Table 3-8   Video signals for a VGA display

Pin	Signal name	Pin	Signal name
1	Ground	8	+5 volts
2	VSync	9	Blue video
3	Hsync	10	DDC data
4	Red return	11	DDC clock
5	Red video	12	Ground
6	Green return	13	/Cable detect
7	Green video	14	Blue return

Table 3-9   Video signals for a TV display

Pin	Signal name	Pin	Signal name
1	Ground	8	+5 volts
2	n.c.	9	Composite video
3	n.c.	10	DDC data
4	Ground	11	DDC clock
5	S-video C	12	Ground
6	Ground	13	Ground (for /Cable Detect)
7	S-video Y	14	Ground

The cable detect function on pin 13 is implemented by connecting pin 13 to ground in the display cable. The computer detects the video adapter by reading its EDID (Extended Display Identification Data) via DDC.

The video display connector is compliant with the VESA specification (DDC version 3).

Older Monitors Not Supported

The computer supports current video monitors. The detection scheme on some older monitors are not supported and will use default configurations, including the following Apple monitors:

- Multiple Scan 17
- Multiple Scan 20
- AudioVision 14
- Apple Hi-Res RGB

- Apple 16" Color
- Apple Hi-Res Monochrome
- Macintosh 12" RGB

Keyboard

The eMac comes with an Apple Keyboard. It is a USB compatible full-size keyboard with 16 function keys and separate groups of numeric keypad and editing keys.

The keyboard also provides two additional USB ports; see "Keyboard and USB" (page 36).

Keyboard Features

Here is a list of the features of the Apple Keyboard.

- Fixed slope keyboard
- 109 keys (on the ANSI versions)
- 16 function keys
- 6 editing keys (Page Up, Page Down, Home, End, Forward Delete, and Help)
- USB HID Consumer Page Usage multimedia control keys
- Full travel, standard pitch keys on alphanumeric, editing, and keypad sections, including function keys and cursor position keys
- Localized worldwide: 33 versions, 3 standard layouts (ANSI, JIS, ISO)
- LED indicator on the Num Lock and Cap Lock keys
- USB hub functionality with two Type A USB bus-powered ports

> **Note:** There is no power key on this keyboard.

Keyboard Layout

There are localized versions of the Apple Keyboard for use in different parts of the world. The three standards used are ANSI (US and North America), JIS (Japan), and ISO (Europe). Figure 3-4 (page 36) shows the keyboard layout for the ANSI keyboard.

Applications can determine which keyboard is connected by calling the Gestalt Manager and checking for the corresponding value of the `gestaltKeyboardType` selector.

Figure 3-4   ANSI keyboard layout
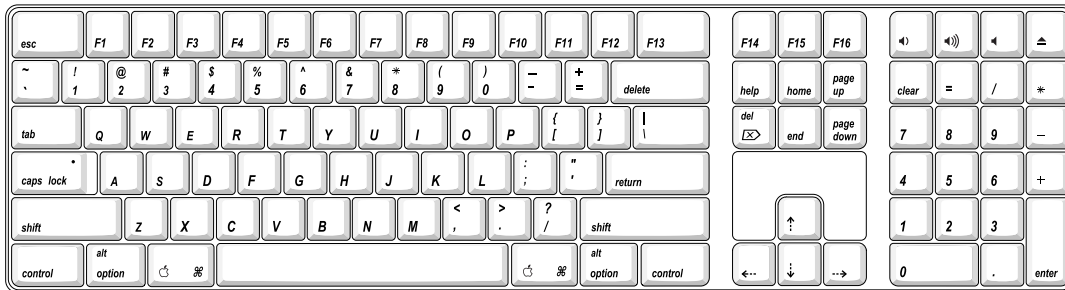
MultiMedia Control Keys

The keyboard has six multimedia keys: Volume Up, Volume Down, Mute, Brightness Up (F15), Brightness Down (F14), and Eject. Theses keys provide direct control of the features on the computer by way of the USB.

Keyboard and USB

The Apple Keyboard is designed to work with the eMac by way of the USB ports. The keyboard has a captive cable with a USB Type A connector. The keyboard is a bus-powered USB hub with two USB Type A ports.

> ⚠️ **Warning:** A bus-powered hub does not provide enough power to support a second bus-powered hub. To use a second bus-powered hub with an eMac, connect it to the second USB port on the computer, not to a port on the Apple USB keyboard.

Apple provides a HID class driver for the Apple USB keyboard, which supports the USB boot protocol. Other keyboards intended for use on the Macintosh platform must support the HID boot protocol, as defined in the USB Device Class Definition for Human Interface Devices (HIDs). For information about the USB HID definition, see the HID reference in "USB Interface" (page 47).

Mouse

The eMac comes with an Apple Mouse. The mouse case is made of polycarbonate plastic like the computer.

The Apple Mouse uses optical tracking in place of the traditional rolling ball. It works on almost any surface, though non-reflective, opaque surfaces without repetitive patterns work best.

Audio System

The audio system provides high-quality stereo sound input and output through the built-in microphone and speakers. The user can also connect external input and output devices by way of the sound input and output jacks.

> **Note:** The eMac also supports speakers and microphones that connect to the USB port.

To maintain the highest fidelity when digital audio program material from CDs is played, the audio data is kept in digital form until just before being sent to the internal speakers or the headphone jack.

The audio system is based on a set of ICs that perform digital audio processing functions such as output equalization, dynamic range compression, and volume control.

The audio system supports sample sizes up to 16 bits at a sample rate of 44.1 kHz.

Audio Inputs

The audio system accepts inputs from five possible sources:

- built-in microphone
- external audio line-in jack
- sound from internal optical drive
- call progress audio from the internal modem
- sound from USB audio devices
- sound input from FireWire audio devices

Built-in Microphone

The audio signal from the built-in microphone is amplified by a preamp and sent to the codec circuits in the audio IC.

External Audio Line-in Jack

The audio line-in jack is a 3.5 mm miniature phone jack located on the I/O panel on the right side of the computer. The line-in jack accepts line-level stereo signals. It also accepts a stereo miniplug-to-RCA cable adapter for connecting stereo equipment to the computer.

The line-in jack signal connections are:

- tip: audio left channel
- ring: audio right channel
- sleeve: audio ground

The line-in jack has the following electrical characteristics:

- input impedance: nominal 40 kilohms
- maximum level: nominal 2 V rms (5.6 V peak-to-peak)

Audio Outputs

The audio system sends computer-generated sounds to two destinations:

■ built-in stereo speakers

■ headphone jack

Internal Speakers

The computer has two internal speakers. The computer turns off the sound signals to the internal speakers under the following conditions:

■ when headphones are plugged into the headphone jack

■ when external USB speakers are connected and selected in Sound Preferences Output pane

■ during sleep mode

Headphone Jack

The headphone jack is located on the I/O panel on the right side of the computer. The jack provides enough current to drive a pair of low-impedance headphones.

The headphone jack has the following electrical characteristics:

■ output impedance: 5.0 ohms (nominal)

■ maximum level: 1.5 Vrms (4.2 V peak-to-peak)

Headphones should have an impedance not lower than the recommended minimum impedance of 32 ohms. Headphones with lower impedance can be used, but with some degradation in performance.

Audio Specifications

The frequency response of the sound circuits, not including the microphone and speakers, is within plus 1 dB or minus 3 dB from 20 Hz to 20 kHz.

Total harmonic distortion plus noise (THD+N) as a percentage of full scale are shown in Table 3-10 (page 38).

Table 3-10   Distortion specifications

Connector	THD+N
Line input	0.03%
Headphone jack, open circuit	0.03%
Headphone jack, 32 ohm headphones	0.5%

The signal-to-noise ratios (SNR) for various inputs and outputs are shown in Table 3-11 (page 39). The values shown are unweighted.

Table 3-11   SNR specifications

Connector	Signal-to-noise ratio
Microphone	65 dB
Headphone jack	90 dB
Line input	85 dB
Internal CD or DVD	90 dB

RAM Expansion

This chapter tells how to gain access to the expansion slots in the eMac and describes the RAM expansion modules.

RAM Expansion Slots

The eMac has two RAM expansion slots. The slots accept standard DDR333 (PC2700), 184-pin DIMMs (dual inline memory modules) that use SDRAM devices. The eMac supports DIMM sizes 256 MB or 512 MB of memory for a total system maximum of 1 GB.

Note: DDR400 (PC3200) DIMMs are supported in the slots; however they will run at a speed of 333 MHz.

A door on the bottom of the computer provides access to the RAM expansion slots. Before opening the bottom door, the user should place the computer face down on a soft cloth.

When the door is open, the portion of the main logic board that contains the two RAM expansion slots is visible. The top slot is normally occupied by the factory-installed RAM DIMM. Either RAM expansion slot can accept a user-installed DIMM.

For instructions on installing RAM, refer to the *eMac User Guide* that shipped with your computer or see the following Apple website:

http://www.info.apple.com/usen/cip

Important: The user should be reminded to observe the usual precautions to avoid damage to the electronic components due to static electricity.

RAM Expansion Modules

The RAM expansion modules for the eMac are 184-pin SDRAM DIMMs that are 2.5 volt, unbuffered/unregistered, 8-byte, non-parity, and PC2700 compliant. The speed of the SDRAM devices must be rated at 167 MHz or faster.

Important: RAM expansion DIMMs for the eMac must use DDR SDRAM devices. If the user installs a DIMM that uses EDO or SGRAM devices, the computer will beep several times when the user attempts to restart the computer.

Mechanical Design of RAM DIMMs

The mechanical characteristics of the RAM expansion DIMM are given in the JEDEC specification for the 184-pin 8-byte DRAM DIMM. The specification number is JEDEC MO-161-D. To obtain a copy, see the reference information at "RAM Expansion Modules" (page 47).

The maximum height of DIMMs for use in the eMac is 1.50 inches.

Electrical Design of RAM DIMMs

The electrical characteristics of the RAM DIMM are given in section 4.5.6 of the JEDEC Standard 21-C. The specification is available from the Electronics Industry Association's website. The specification defines several attributes of the DIMM, including storage capacity and configuration, connector pin assignments, and electrical loading. To obtain a copy, see the reference information at "RAM Expansion Modules" (page 47).

The presence detect serial EEPROM specified in the JEDEC standard is required and must be set to properly define the DIMM configuration. Details about the required values to be stored in the presence detect EEPROM can be found in sections 4.5.4 and 4.1.2.5 of the JEDEC standard 21-C specification.

The RAM DIMMs are required to be PC2700 compliant. To obtain information about the PC2700 specification, see the reference information at "RAM Expansion Modules" (page 47).

The SDRAM devices used in the RAM expansion modules must be self-refresh type devices for operation from a 2.5 V power supply.

DIMM Configurations

The largest DIMM supported is a two-bank DIMM of 512 MB using 256 Mbit SDRAM devices. The largest bank size supported by the memory controller is 256 MB. The maximum number of devices per DIMM is 16. CAS latency is 2.5.

Table 4-1 (page 42) shows information about the different sizes of SDRAM devices used in the memory modules.

Table 4-1   Sizes of DDR SDRAM expansion DIMMS and devices

Size of DIMM	SDRAM device size	Device configuration	Devices per bank	Size of each bank
128 MB	128 Mbits	4 M x 8 x 4	8	64 MB
128 MB	256 Mbits	2 M x 16 x 4	4	64 MB
256 MB	128 Mbits	4 M x 8 x 4	8	128 MB
256 MB	256 Mbits	4 M x 16 x 4	4	128 MB

Size of DIMM	SDRAM device size	Device configuration	Devices per bank	Size of each bank
512 MB	256 Mbits	8 M x 8 x 4	8	256 MB

The eMac accepts either one or two DIMMs. Any of the supported DIMM sizes can be installed in either slot. The memory controller configures the combined memory of the DIMMs into a contiguous array of memory addresses.

Note: The eMac does not use memory interleaving, so installing two DIMMs of the same size does not result in any performance gain.

RAM Addressing

Signals A[0] – A[12] and BA[0] – BA[1] on each RAM DIMM make up a 15-bit multiplexed address bus that can support several different types of SDRAM devices. Table 4-2 (page 43) lists the types of devices that can be used in the eMac by size, configuration, and sizes of row and column addresses.

Important: The eMac supports only the types of SDRAM devices listed in Table 4-2 (page 43). Other types of DRAM devices should not be used with this computer.

Table 4-2   Address multiplexing modes for SDRAM devices

Device size	Device configuration	Size of row address	Size of column address
128 Mbits	4 M x 8 x 4	12	10
128 Mbits	2 M x 16 x 4	12	9
256 Mbits	8 M x 8 x 4	13	10
256 Mbits	4 M x 16 x 4	13	9
512 Mbits	16 M x 8 x 4	13	11
512 Mbits	8 M x 16x 4	13	10

Supplemental Reference Documents

For more information about the technologies mentioned in this developer note, consult the following references.

For information about older models of Macintosh computers, refer to the developer notes archive at

http://developer.apple.com/documentation/Hardware/hardware2.html

Apple Technical Notes

Apple Technical Notes answer many specific questions about the operation of Macintosh computers and the Mac OS. The Technical Notes are available on the Technical Note website at

http://developer.apple.com/technotes/

3D Graphics

Developers of 3D graphics for games should know about OpenGL for Macintosh¬®, a version of SGI's application programming interface (API) and software library for 3D graphics.

Developer support and documentation is available at

http://developer.apple.com/opengl/

PowerPC G4 Microprocessor

Information about the PowerPC G4 microprocessor is available on the World Wide Web at

http://www.freescale.com/webapp/sps/site/prod_summary.jsp?code=MPC7457&nodeId=018rH3bTdG8653

Velocity Engine (AltiVec)

Velocity Engine is Apple's name for the AltiVec vector processor in the PowerPC G4 microprocessor. Apple provides support for developers who use the Velocity Engine in their applications. Documentation, development tools, and sample code are available on the World Wide Web, at

http://developer.apple.com/hardwaredrivers/ve/index.html

AltiVec Technology Programming Environments Manual (AltiVec PEM) is a reference guide for programmers. It contains a description for each instruction and information to help in understanding how the instruction works. Obtain a copy of the AltiVec PEM from the following Freescale site on the World Wide Web by logging in and searching for ALTIVECPEM/D.

http://www.freescale.com/

Mac OS X

For information about Mac OS X, see Apple's developer website at

http://developer.apple.com/documentation/MacOSX/index.html

O'Reilly & Associates publishes a series of books about Mac OS X development. The books in this series have been technically reviewed by Apple engineers and are recommended by the Apple Developer Connection.

I/O Kit

The I/O Kit is part of Darwin, the operating system foundation for Mac OS X. The documentation for I/O Kit is available on Apple's Darwin website at

http://developer.apple.com/documentation/Darwin/Darwin.html

Open Firmware

The software firmware implemented on current Macintosh computers follows the standard defined by the Open Firmware IEEE 1274-1994 specification. Three Technical Notes provide an introduction to Open Firmware on the Macintosh platform. They are:

TN1061: Open Firmware, Part I, available at

http://developer.apple.com/technotes/tn/tn1061.html

TN1062: Open Firmware, Part II, available at

http://developer.apple.com/technotes/tn/tn1062.html

TN1044: Open Firmware, Part III, available at

http://developer.apple.com/technotes/tn/tn1044.html

Other Technical Notes provide additional information about Open Firmware on the Macintosh.

TN2000: PCI Expansion ROMs and You, at

http://developer.apple.com/technotes/tn/tn2000.html

TN2001: Running Files from a Hard Drive in Open Firmware, at

http://developer.apple.com/technotes/tn/tn2001.html

TN2004: Debugging Open Firmware Using Telnet, available at

http://developer.apple.com/technotes/tn/tn2004.html

RAM Expansion Modules

The mechanical characteristics of the DIMM are given in the JEDEC specification numberr JESD-95. The specification can be found by using the search string JESD-95 on the Electronics Industry Association's website at

http://www.jedec.org/DOWNLOAD/default.cfm

The electrical characteristics of the DIMM are given in JEDEC Standard 21-C, release 7 (JESD-21C). The specification can be found by using the search string JESD21-C on the Electronics Industry Association's website at

http://www.jedec.org/DOWNLOAD/default.cfm

ATA Devices

ATA (AT Attachment), also referred to as integrated drive electronics (IDE), is a standard interface used with storage devices such as hard disk drives. For more information on ATA, refer to the following Apple website at

http://developer.apple.com/documentation/Hardware/DeviceManagers/ata/ata.html

ATA Manager 4.0 supports driver software for internal IDE drives and includes DMA support. For the latest information about ATA Manager 4.0, see Technical Note TN1098, ATA Device Software Guide Additions and Corrections, available on the world wide web at

http://developer.apple.com/technotes/tn/tn1098.html

The web page for Technical Note TN1098 includes a link to a downloadable copy of *ATA Device Software Guide*.

Information about the ATA standards is available at the Technical Committee T13 AT Attachment website, at

http://www.t13.org/

USB Interface

For more information about USB on Macintosh computers, developers should refer to Apple Computer's *Accessing Hardware from Applications*. Information is also available on the World Wide Web, at

http://developer.apple.com/hardwaredrivers/usb/index.html

Mac OS X includes support for a wide variety of USB classes. Detailed specifications of these classes are available at

http://www.usb.org/developers/devclass/

For full specifications of the Universal Serial Bus, developers should refer to the USB Implementers Forum on the World Wide Web, at

http://www.usb.org/developers/docs

Ethernet

For information on Ethernet specifications and design guides, go to the World Wide Web at

http://standards.ieee.org/

FireWire Interface

For additional information about the FireWire IEEE 1394 interface and the Apple APIs for FireWire software, refer to the resources available on the Apple FireWire website at

http://developer.apple.com/firewire/index.html

The IEEE 1394 standard is available from the IEEE. Ordering information can be found on the World Wide Web at

http://shop.ieee.org/store

Additional useful information also available at the 1394 Trade Association's website:

http://www.1394ta.org/

Wireless Networks

More information about Wi-Fi and wireless networks using the IEEE 802.11 standard is available on the website of the WiFi Alliance, at

http://www.wirelessethernet.org/OpenSection/

Bluetooth

For more information regarding Bluetooth technology, refer to the following locations on the World Wide Web.

Bluetooth specification:

http://www.bluetooth.org/spec/

Bluetooth SIG:

http://www.bluetooth.org

Bluetooth developer tools on the Apple web site at:

http://developer.apple.com/hardwaredrivers/bluetooth

Abbreviations

Standard units of measure used in this developer note include:

A	amperes	MB	megabytes
cm	centimeters	Mbps	megabits per second
dB	decibels	Mbit	megabits
GB	gigabytes	MHz	megahertz
Hz	hertz	mm	millimeters
KB	kilobytes	ns	nanoseconds
kg	kilograms	V	volts
kHz	kilohertz	VDC	volts direct current
mA	milliamperes		

Other abbreviations used in this note include:

$n	hexadecimal value n
10Base-T	an Ethernet standard for data transmission at 10 Mbits per second
100Base-T	an Ethernet standard for data transmission at 100 Mbits per second
A/D	analog to digital
AGP	accelerated graphics port
ANSI	American National Standards Institute
API	application programming interface
ATA	Advanced Technology Attachment
ATAPI	ATA Packet Interface
CAS	column address strobe
CAV	constant angular velocity
CD	compact disc

CD-ROM	compact disc read-only memory
CLV	constant linear velocity
CPU	central processing unit
D/A	digital to analog
DAA	data access adapter
DB-DMA	descriptor-based direct memory access
DDR	double data rate, a type of SDRAM
DIMM	Dual Inline Memory Module
DMA	direct memory access
DRAM	dynamic random-access memory
EDO	extended data out
EEPROM	electrically eraseable programmable ROM
EIDE	enhanced integrated device electronics
G4	Generation 4, the fourth generation of PowerPC microprocessors, incorporating Altivec technology
GART	graphics address remapping table
GND	ground
HCRP	hardcopy cable replacement profiler
HFS	hierarchical file system
HID	human interface device, a class of USB devices
IC	integrated circuit
IEC	International Electrotechnical Commission
IIC (I2C)	inter IC control bus
IIS (I2S)	inter IC sound bus
I/O	input and output
Intrepid	memory controller and I/O device and disk controller
ISM	industrial, scientific, and medicine
IR	infrared
ISO	International Organization for Standardization

JEDEC	Joint Electron Device Engineering Council
L1	level 1 or first level
L2	level 2 or second level
LAN	local area network
LED	light emitting diode
MAC	media access controller
Mac OS	Macintosh Operating System
modem	modulator-demodulator
NMI	nonmaskable interrupt
OHCI	Open Host Controller Interface
OS	operating system
PCI	Peripheral Component Interconnect
PLL	phase-locked loop
RADIUS	Remote Authentication Dial-In User Service
RAM	random-access memory
RCA	Radio Corporation of America
rms	root mean square
ROM	read-only memory
SCSI	Small Computer System Interface
SDRAM	synchronous dynamic RAM
SGRAM	synchronous graphics RAM
SNR	signal to noise ratio
SPD	Serial Presence Detect
THD	total harmonic distortion
THD+N	total harmonic distortion plus noise
USB	Universal Serial Bus
VCC	positive supply voltage (voltage for collectors)
VPN	virtual private network

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Wi-Fi	wireless fidelity
ZCLV	zone constant linear velocity