iMac Developer Note

Hardware & Drivers > Apple Hardware

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Figures and Tables

Introduction to iMac Developer Note

This developer note gives a technical description of the 15″, 17″, and new 20″ iMac. 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, you should refer to "Supplemental Reference Documents" (page 45)".

Organization of This Document

The information in this note is arranged in the following chapters.

- Chapter 1, "Introduction", (page 11) introduces both configurations of the iMac, describes the features, and mentions a few software issues of interest to developers.

- Chapter 2, "Architecture", (page 15) 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 for the computer.

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

- Appendix A, "Supplemental Reference Documents", (page 45) tells where to find more information about specific technologies used in the iMac.

- Appendix B, "Abbreviations", (page 49) lists the standard units and abbreviations used in this developer note.

Overview of the iMac Developer Note

This chapter provides an overview of the hardware and software features of the current models of the iMac.

New Features

New features are listed here with links to the sections that describe them. For a comparison of 15", 17", and 20" iMac features, see Table 1-1 (page 13).

- **Display:** The iMac has a built-in 20-inch widescreen flat-panel, 17-inch widescreen flat-panel, or 15-inch flat-panel display (measured diagonally). The 20" display is new for this release. For more information, see "Flat Panel Display" (page 31).

- **Processor and speed:** The microprocessor in the iMac is a PowerPC G4 with a clock speed of 1 GHz in the 15" configuration and 1.25 GHz in the 17" and 20" configurations. For more information, see "PowerPC G4 Microprocessor" (page 17).

- **Graphics acceleration:** The AGP 4X graphics IC used in the iMac is an nVidia GeForce4 MX in the 15" configuration and an nVidia GeForce FX 5200 Ultra in the 17" and 20" configurations. For more information, see "Video Display Subsystem" (page 19).

- **Wireless keyboard and mouse:** The iMac supports the Apple wireless keyboard and mouse.

Feature Set

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

- **Processor and speed:** The microprocessor in the iMac is a PowerPC G4 with a clock speed of 1 GHz in the 15" configuration and 1.25 GHz in the 17" and 20" configurations. For more information, see "PowerPC G4 Microprocessor" (page 17).

- **Cache:** The backside 256 KB 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 17).

- **Memory:** The computer comes with 256 MB of DDR333 SDRAM installed in an internal 184-pin DIMM expansion slot, with a build-to-order option of 512 MB. A second user-accessible slot accepts an SO-DIMM with up to 512 MB. The maximum supported memory is 1 GB. For more information, see "System RAM" (page 18).

- **Hard disk storage:** The built-in hard disk is 7200 rpm with a capacity of 80 GB and a 160 GB build to order option. For more information, see "Hard Disk Drive" (page 29).

- **SuperDrive:** The 17" and 20" configurations of the iMac have a SuperDrive (CD-RW/DVD-R). For more information, see "SuperDrive (CD-RW/DVD-R)" (page 29).

- **Combo drive:** The 15" configuration of the iMac has a combination CD-RW/DVD-ROM drive. For more information, see "Combo (CD-RW/DVD-ROM) Drive" (page 30).

- **Display:** The iMac has a built-in 20-inch widescreen flat-panel, 17-inch widescreen flat-panel, or 15-inch flat-panel display (measured diagonally). The 20" display is new for this release. For more information, see "Flat Panel Display" (page 31).

- **USB 2.0 ports** The computer has three USB 2.0 ports; see "USB Interface" (page 21).

- **System bus:** The speed of the system bus is 167 MHz. For more information, see "Memory and I/O Device Controller" (page 17).

- **Graphics acceleration:** The AGP 4X graphics IC used in the iMac is an nVidia GeForce4 MX in the 15" configuration and an nVidia GeForce FX 5200 Ultra in the 17" and 20" configurations. For more information, see "Video Display Subsystem" (page 19).

- **Video RAM:** The video hardware in the iMac includes 32 MB (15" configuration) or 64 MB (17" and 20" configurations) of DDR SDRAM, which supports 3D features and millions of colors in all resolutions. For more information, see "Video Display Subsystem" (page 19).

- **External video port:** The external display connector supports VGA, composite and S-video formats for devices such as monitors, projectors, and television sets. The Apple VGA adapter is available to connect with a VGA display. A video adapter with composite and S-video connectors is available separately. For more information, see "Video Monitor Port" (page 32).

- **FireWire 400 ports:** The iMac has two IEEE-1394a FireWire 400 ports, which support transfer rates of 100, 200, and 400 Mbps. For more information, see "FireWire 400 Connector" (page 25).

- **Target disk mode:** The computer can be configured like a FireWire storage device connected to another computer. See "Target Disk Mode" (page 26).

- **Modem:** The iMac has a built-in V.92 modem with a 56 Kbps data rate. For more information, see "Internal Modem" (page 28).

- **Ethernet:** The iMac has a built in Ethernet port for a 10Base-T and 100Base-TX operation. For more information, see "Ethernet Port" (page 26).

- **AirPort Extreme (optional):** A 54 Mbps AirPort Extreme Card is available as a build-to-order option or as a user-installable upgrade. For more information, see "AirPort Extreme Wireless Support" (page 21).

- **Bluetooth (optional):** 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 29).

- **Sound:** The iMac includes external Apple Pro Speakers, a built-in speaker and microphone, stereo headphone jack, Apple Speaker minijack, and audio line-in. For more information, see "Sound System" (page 37).

- **Keyboard:** The iMac comes with an Apple Keyboard. The keyboard is also a USB hub with two USB 1.1 ports. For more information, see "Keyboard Features" (page 34).

- **Mouse:** The iMac comes with an Apple Mouse, a USB mouse with optical tracking. For more information, see "Mouse" (page 37).

- **Wireless keyboard and mouse:** The iMac supports the Apple wireless keyboard and mouse.

Comparison of 15″, 17″, and 20″ iMac Features

Table 1-1 (page 13) provides a quick comparison of the features of the configurations of the iMac computer.

Table 1-1   Feature comparison

	15″ iMac	**17″ iMac**	**20″ iMac**
CPU and speed	PowerPC G4 1 GHz	PowerPC G4 1.25 GHz	PowerPC G4 1.25 GHz
System bus speed	167 MHz	167 MHz	167 MHz
Main memory	256 MB, 333 MHz DDR SDRAM, supports expansion up to 1 GB	256 MB, 333 MHz DDR SDRAM, supports expansion up to 1 GB	256 MB, 333 MHz DDR SDRAM, supports expansion up to 1 GB
Display	Built-in 15-inch flat panel	Built-in 17-inch, widescreen flat panel	Built-in 20-inch, widescreen flat panel
Graphics IC	nVidia GeForce4 MX	nVidia GeForce FX 5200 Ultra	nVidia GeForce FX 5200 Ultra
Graphics memory	32 MB DDR RAM	64 MB DDR RAM	64 MB DDR RAM
Power supply	160 W	160 W	190 W
Hard disk drive	80 GB Ultra ATA-100 7200 rpm	80 GB Ultra ATA-100 7200 rpm	80 GB Ultra ATA-100 7200 rpm
Optical drive	Tray-load Combo drive	Tray-load SuperDrive	Tray-load SuperDrive
External monitor port	VGA output port/S-video and composite video output	VGA output port/S-video and composite video output	VGA output port/S-video and composite video output
Data ports	Three external USB 2.0 ports plus two USB 1.1 ports on keyboard; two FireWire 400 ports	Three external USB 2.0 ports plus two USB 1.1 ports on keyboard; two FireWire 400 ports	Three external USB 2.0 ports plus two USB 1.1 ports on keyboard; two FireWire 400 ports
Comm features	10/100 Ethernet; 56K V.92 fax modem	10/100 Ethernet; 56K V.92 fax modem	10/100 Ethernet; 56K V.92 fax modem
Wireless features	Optional 54 Mbps AirPort Extreme Card; optional internal Bluetooth	Optional 54 Mbps AirPort Extreme Card; optional internal Bluetooth	Optional 54 Mbps AirPort Extreme Card; optional internal Bluetooth
Sound features	Built-in speaker and microphone; stereo headphone jack and Apple Pro Speaker minijack; external Apple Pro speakers, audio line-in	Built-in speaker and microphone; stereo headphone jack and Apple Pro Speaker minijack; external Apple Pro speakers, audio line-in	Built-in speaker and microphone; stereo headphone jack and Apple Pro Speaker minijack; external Apple Pro speakers, audio line-in

System Software

The 15" and 17" iMac come with Mac OS X version 10.2.7 or later installed; the 20" iMac comes with Mac OS X version 10.3 or later installed. Mac OS 9 applications can be run in Classic mode. For more information about Mac OS X, see the reference listed in "Mac OS X" (page 46).

Machine Identification

Apple Computer discourages the targeting of code to specific machine models. However, if it is necessary to identify a machine in order to determine the features of the machine, applications can use the IORegistry with Mac OS X. Or, in many cases, it is feasible to use Gestalt calls to test a machine for specific features.

Asset management software that reports the kind of machine it is run on can obtain the value of the property at `Devices:device-tree:compatible` in the Name Registry. The model string is the first program-usable string in the array of C strings in the `compatible` field. The value of the string in the `compatible` property is `PowerMac6,3`.

The string obtained from the `compatible` property cannot be displayed to the computer user. If it is available, use the result from calling `Gestalt ('mnam', &result)` where `result` is a string pointer. This call returns a Pascal style string that can be displayed to the user.

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

For more information, please see the references at "Velocity Engine" (page 46).

Architecture

This chapter describes the architecture of the iMac. 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 IC and buses on the computer's main logic board.

Block Diagram

Figure 2-1 (page 16) provides a simplified block diagram of the main logic board and the buses that connect them together.

Figure 2-1 Block diagram
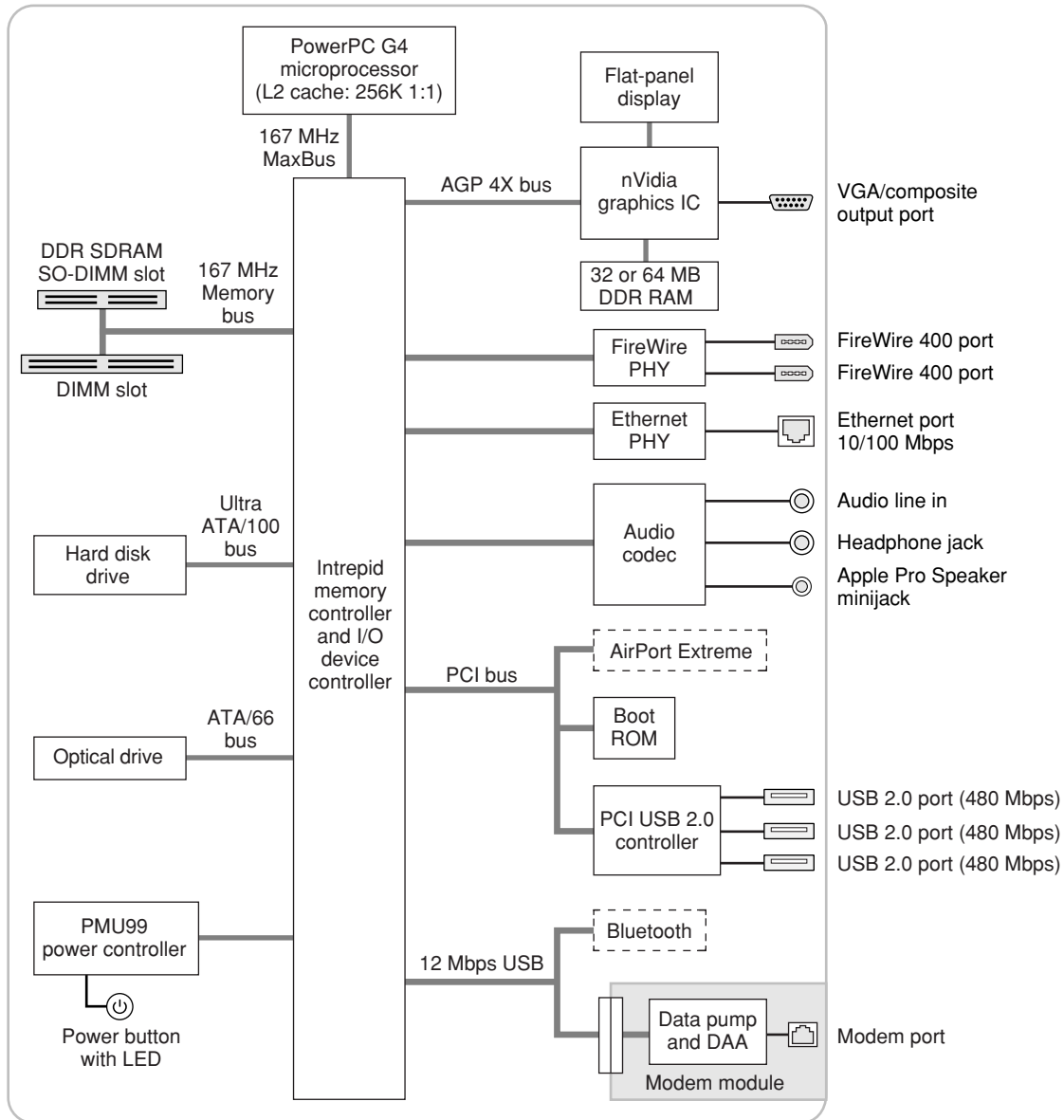
Main IC and Buses

The architecture of iMac 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 PowerPC G4 microprocessor is a 1 GHz in the 15" configuration or a 1.25 GHz in the 17"and 20" configurations and includes a built-in 256 KB level 2 (L2) cache.

PowerPC G4 Microprocessor

The PowerPC G4 microprocessor used in the iMac 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 one)
- 256 KB on-chip L2 cache with a 1:1 ratio of L2 clock speed to processor clock speed

To find more information, see the reference at "PowerPC G4 Microprocessor" (page 17).

Level 2 Cache

The data storage for the L2 cache consists of 256 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 cache.

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 17), 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)

Name of bus	Destinations	Width of data path	Bus clock speed/ data rate
AGP 4x bus	Graphics IC	32 bits	66 MHz (4x)
Ultra ATA -100 bus	Hard drive	16 bits	100 MBps
ATA	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 iMac consists of 256 MB or 512 MB of DDR333 (PC2700) SDRAM in the internal slot. The data bus to the RAM is 64 bits wide, and the memory interface is synchronized to the MaxBus interface at 167 MHz. The expansion slot capacity is an additional 512 MB, supporting a maximum of 1 GB.

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

> **Note:** Only the SO-DIMM slot is accessible by the user. See "RAM Expansion Slots" (page 41)

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.

FireWire 400 Controller

The iMac includes an IEEE 1394a FireWire 400 controller with a data rate of 400 Mbits (50 MBytes) per second and provides DMA (direct memory access) support for the FireWire 400 interface.

The controller IC implements the FireWire 400 link layer. A physical layer IC, called a PHY, implements the electrical signalling protocol of the FireWire 400 interface. The PHY supports two FireWire 400 ports by way of external connectors on the back of the enclosure.

Important: The FireWire PHY on the iMac does not operate with external bus power. As long as the computer is plugged into an active AC power outlet, the FireWire PHY is active and the FireWire bus remains connected. If AC power is interrupted, the PHY will not operate.

Ethernet Controller

The iMac 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-BaseTX mode. The actual speed of the link is automatically negotiated by the PHY and the bridge or router to which it is connected. For more information, see "Ethernet Port" (page 26).

Video Display Subsystem

The display subsystem for the iMac consists of an nVidia graphics controller ASIC on the main logic board. In the 15" iMac, the graphics controller is an nVidia GeForce4 MX with 32 MB DDR RAM. In the 17" and 20" iMac, the graphics controller is an nVidia GeForce FX 5200 Ultra with 64 MB DDR RAM. Both graphics controllers contain 2D and 3D acceleration engines, front-end and back-end scalers, a display controller, and an AGP 4x bus interface with bus master capability.

The nVidia GeForce4 MX supports a display size of 1024x768 pixels, with lesser resolutions scaled accordingly. The nVidia GeForce FX 5200 Ultra supports a display size of 1440x900 pixels for the 17" model and 1680x1050 pixels for the 20" model, with lesser resolutions scaled accordingly.

The display generated for the flat panel display is simultaneously available for an external monitor in mirror mode; see "Video Monitor Port" (page 32). Composite video and S-video signals can be displayed on either an NTSC display or a PAL display; see "Video Display Adapter" (page 33).

The interface between the graphics IC and the rest of the system is an AGP (accelerated graphics port) 4x bus on the Intrepid ASIC. 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 running in 4x mode.

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 DDR RAM and the main memory.

For information about the display and supported resolutions, see "Flat Panel Display" (page 31) and "Video Monitor Port" (page 32).

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 29).

ATA/66 Interface

The ATA/66 Interface complies with and supports a subset of industry standard ATA/ATAPI-5 and transfer protocols up to DMA mode 2. The Combo drive and SuperDrive are device-selected as Cable Select in an ATA device configuration. For more information, see "SuperDrive (CD-RW/DVD-R)" (page 29) and "Combo (CD-RW/DVD-ROM) Drive" (page 30).

Modem Support

The internal modem is connected to an internal USB 1.1 port. The Intrepid ASIC provides DB-DMA support for the modem interface as a USB device. The modem provides digital call progress signals to the sound circuitry.

The internal hardware 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 iMac. 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 29).

Sound Circuitry

The audio codec circuitry exchanges audio data with the main IC over a standard I2S bus and receives commands from the main IC over an I2C bus. The main IC provides DB-DMA (descriptor-based direct memory access) support for the I2S bus.

The sound circuitry includes a signal processing IC for equalization and volume control functions and a codec IC for A/D and D/A conversion.

The sound circuitry performs analog-to-digital conversion for the internal microphone and digital-to-analog conversion for the audio signals it sends to the internal speaker and the headphone jack. A switch-mode power amplifier drives the internal speaker and the Apple Pro Speaker minijack.

For a description of the features of the sound system, see "Sound System" (page 37).

Power Controller

The power management controller in the iMac 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.

AirPort Extreme Wireless 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 separate connector is used for the cable to the antennas, which are built into the computer's enclosure. For information about operation, see and "AirPort Extreme Card" (page 27).

USB Interface

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

The iMac uses a PCI USB 2.0 controller to support three external ports on the back 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 iMac are required to support USB-suspend mode as defined in the USB specification.

The USB ports on the iMac 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 on the iMac. Each of the following sections describes an I/O port or device.

USB Ports

The iMac 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 back of the iMac 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 internal modem and Bluetooth module are 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
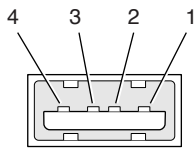
Table 3-1   Signals on the USB port

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

The iMac provides 5-volt power to the USB 2.0 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 USB system software supports all four data transfer types defined in the USB specification.

USB Features

Features of the USB ports are listed in the following paragraphs.

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 iMac supports USB Mass Storage specification.

USB Controller

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

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

- Share 8 watts per port of power when the computer system is on

- Support up to 62 devices

The FireWire 400 hardware and software provided with the iMac are capable of all asynchronous and isochronous transfers defined by IEEE standard 1394a.

FireWire 400 Connector

The FireWire400 connector has six contacts, as shown in Figure 3-2 (page 25). The connector signals and pin assignments are shown in Table 3-2 (page 25).

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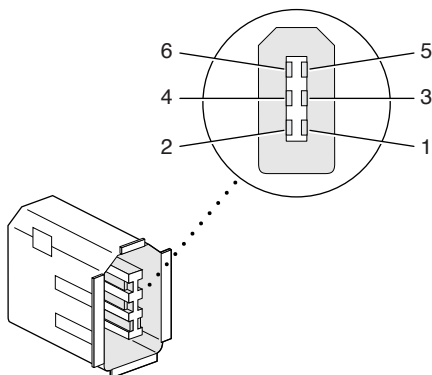
Table 3-2   Signals on the FireWire 400 connector

Pin	Signal name	Description
1	Power	regulated, 12 VDC for 15" and 17" models and 24 VDC for the 20" model
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 pins provide a regulated power and 8 W per port total. Zero voltage is present at the power pins when the computer is off. Power is provided during sleep mode.

Important: The FireWire PHY on the iMac does not operate from external bus power. As long as the computer is plugged into an active AC power outlet, the FireWire PHY is active and the FireWire bus remains connected. If AC power is interrupted, the PHY will stop operating and data on the bus cannot be repeated.

Pin 2 of the 6-pin FireWire 400 connector is ground for both power and inner cable shield. If a 4-pin connector is used on the other end of the FireWire 400 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 400 interface and the Apple APIs for FireWire 400 device control, developers should refer to the resources listed in "FireWire 400 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 iMac is in Target Disk Mode and connected to another Macintosh computer by a FireWire 400 cable, the iMac 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 iMac can operate in Target Disk Mode as long as the other computer has a FireWire 400 port and either Mac OS X (any version) or Mac OS 9 with FireWire 400 software version 2.3.3 or later.

To put the iMac into Target Disk mode, you restart the iMac and hold down the T key until the FireWire icon appears on the display. You then connect a FireWire 400 cable from the iMac to the other computer. When the other computer completes the FireWire 400 connection, a hard disk icon appears on its desktop.

If you disconnect the FireWire 400 cable or turn off the iMac while in Target Disk Mode, an alert appears on the other computer.

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

Ethernet Port

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

Both CAT 5 unshielded twisted pair (UTP) and shielded twisted pair (STP) cables work with the Ethernet port. An STP cable is recommended for noisy environments or run of greater than 100 meters.

> **Note:** When connecting a iMac computer directly to another computer without using an Ethernet hub, a crossover cable is not required; circuits in the PHY detect the type of connection and switch the signal configuration as required.

The connector for the Ethernet port is a an RJ-45 connector located on the I/O panel. Table 3-3 (page 26) 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)

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

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

AirPort Extreme Card

The iMac supports the AirPort Extreme Card, an internal wireless LAN module. 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, a DSL or cable modem, and a standard telephone line using the optional 56K modem that is built-in on some models.

AirPort Extreme transmits and receives data at speeds up to 54 Mbps. 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.

AirPort Extreme Data Security

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

■ The system uses direct-sequence spread-spectrum (DSSS) technology that uses a multibit 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.

■ AirPort Extreme supports over-the-air encryption standards, including 40-bit and 128-bit WEP and WPA.

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

■ The AirPort Extreme Base Station can authenticate users by their unique Ethernet IDs, preventing unauthorized computers from logging into a 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 based on the IEEE 802.11g 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 802.11b standard at speeds of 11 Mbps, 5.5 Mbps, 2 Mbps, and 1 Mbps. Using OFDM, AirPort Extreme is compatible with all 802.11g standard speeds.

Two AirPort Extreme antennas are built into the computer's enclosure. One antenna is always used for transmitting. Either of the two antennas may be used for receiving. Using a diversity technique, the AirPort Extreme Card selects the antenna that gives the best reception. AirPort Extreme shares the antennas with Bluetooth.

The AirPort Extreme wireless LAN is on the PCI bus.

AirPort Extreme Software

Software that is provided with the AirPort Extreme Card includes

■ AirPort Extreme Setup Assistant, an easy-to-use program that guides the user through the steps necessary to set up the AirPort Extreme Card 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- Menu-Extra pulldown in System Preferences.

■ 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.

Internal Modem

The iMac comes with a built-in modem. The telephone connector for the modem is an RJ-11 connector on the I/O panel.

The modem has the following features:

■ modem bit rates up to 56 Kbps (supports V.92 and K56flex modem standards)

■ Group 3 fax modem bit rates up to 14.4 Kbps

The modem appears to the system as a USB device that responds to the typical AT commands. The modem provides an analog sound output for monitoring the progress of the modem connection.

Bluetooth Technology

Bluetooth is an internal build-to-order option in the iMac. 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 v1.1. It operates on a globally available 2.4 GHz frequency band (ISM band) for worldwide compatibility and has a maximum throughput of 1Mbps.

The Bluetooth technology supports the following profiles:

- synchronization —enables synchronization of devices over Bluetooth
- serial —provides a wireless serial connection to other Bluetooth devices
- dial-up networking (DUN) — enables a mobile phone to act as a modem
- object push —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

In the iMac, 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 dongle.

For more information on Bluetooth technology, refer to "Bluetooth" (page 48).

Hard Disk Drive

The internal hard disk drive has a storage capacity of 80 GB, uses the Ultra ATA-100 interface, and spins at 7200 rpm. The internal hard disk drive conforms to a subset of ATA/ATAPI-6 and -5 protocols and is connected as Cable Select (CS) in an ATA Device 0/1 configuration.

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 Interface" (page 47).

SuperDrive (CD-RW/DVD-R)

The 17" and 20" iMac have a tray-loading, combination DVD-R and CD-RW SuperDrive.

The drive can read and write DVD media and CD media, as shown in Table 3-4 (page 30). The host provides DVD-Video playback with DVD MPEG2 decode.

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

Media type	Reading speed	Writing speed
DVD-R	2x	4x, 2x, 1x depending on media
DVD-ROM	8x max (single layer), 2x (dual layer)	–
DVD-RW	2x	2x, 1x depending on media
CD-R	32x max	16x
CD-RW	32x max	8x, 4x depending on media
CD-ROM	32x max	–

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

The SuperDrive is configured as device 0 (master) by cable select jumper and complies with ATA/ATAPI-5 industry standard.

Combo (CD-RW/DVD-ROM) Drive

The 15" iMac has a combination CD-RW and DVD-ROM drive. The combination drive has a tray for loading the disc.

The drive can read DVD media and read and write CD media, as shown in Table 3-5 (page 30). The Combo drive also provides DVD-Video playback with DVD MPEG2 decode.

Table 3-5   Types of media used in the Combo (CD-RW/DVD-ROM) drive

Media type	Reading speed	Writing speed
DVD-ROM	8x (CAV)	–
DVD-R	4.8x max (CAV)	_
CD-R	32x (CAV)	32x max
CD-RW	20x (CAV)	10x (CLV)
CD or CD-ROM	32x (CAV)	–

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

The Combo drive is configured as device 0 (master) by cable select jumper and complies with ATA/ATAPI-5 industry standard.

Flat Panel Display

Measured diagonally, the flat-panel iMac has a built-in 20-inch widescreen,17-inch widescreen, or 15-inch color display. The display is backlit by a cold cathode fluorescent lamp (CCFL). The display uses TFT (thin-film transistor) technology for high contrast and fast response.

The 17-inch display contains 1440x900 pixels and the 20-inch display contains 1680x1050 pixels. Both graphics subsystems use an nVidia GeForce FX 5200 Ultra with 64 MB of DDR RAM and can show up to millions of colors.

The 15-inch display contains 1024x768 pixels and can show up to millions of colors. The graphics subsystem uses an nVidia GeForce4 MX with 32 MB of DDR RAM.

All three displays support 3D acceleration and display depths up to 24 bits per pixel at all screen resolutions. For more information, see "Video Display Subsystem " (page 19).

Both graphics ICs include a scaling function that expands smaller-sized images to fill the screen. By means of the scaling function, the iMac can show full-screen images at the resolutions listed in Table 3-6 (page 31) for the 20" model, Table 3-7 (page 32) for the 17" model, and Table 3-8 (page 32) for the 15" model.

Table 3-6   Resolutions on the 20" widescreen flat-panel display

Resolution	Aspect ratio	Notes
640 by 480	4:3	*
640 by 480	4:3	*stretched to fit full screen
800 by 500	16:10	*
800 by 600	4:3	
800 by 600	4:3	stretched to fit full screen
840 by 524	4:3	
1024 by 640	16:10	
1024 by 768	4:3	
1024 by 768	4:3	stretched to fit full screen
1280 by 800	16:10	
1344 by 840	16:10	
1680 by 1050	16:10	
* not recommended		

Table 3-7   Resolutions on the 17" widescreen flat-panel display

Resolution	Aspect ratio	Notes
640 by 480	4:3	
640 by 480	4:3	stretched to fit full screen
800 by 500	16:10	
800 by 600	4:3	
800 by 600	4:3	stretched to fit full screen
1024 by 640	16:10	
1024 by 768	4:3	
1024 by 768	4:3	stretched to fit full screen
1152 by 720	16:10	
1440 by 900	16:10	

Table 3-8   Resolutions on the 15" flat-panel display

Resolution	Aspect ratio
640 by 480	4:3
800 by 600	4:3
1024 by 768	4:3

Video Monitor Port

The iMac has a port for an external video monitor and supports video mirroring mode. Video mirroring mode displays the same information on both monitors, enabling the control of a presentation on one display, while allowing an audience to watch the presentation on a second display or projector.

Due to display mirroring, the external monitor could have black borders during mirroring, depending on the supported timings between the two displays and on the monitor's selection algorithm. Both displays show full-sized images only when the display resolution for the second monitor is set to the first display's native resolution: 1680x1050 on the 20-inch display, 1440x900 on the 17-inch display, and 1024x768 on the 15-inch display.

The external monitor supports user-selectable display sizes up to 2048x1536 at 75 Hz.

Monitor Connector

The video display connector is a 14-pin rectangular connector, Hosiden TCX3143, or compatible. The connector accepts either a VGA adapter or a composite adapter. The system requires a composite adapter to use composite output over this connector. The connector pins are identified in Table 3-3 (page 26).

Figure 3-3   Video display connector
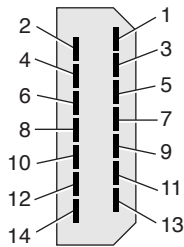
The pins and signals are listed in Table 3-9. An adapter is available for use with monitors with VGA 15-pin miniature D-type connectors.

Table 3-9   Video signals for a VGA R-G-B 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

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

The video display connector is compliant with the VESA specification.

Video Display Adapter

The iMac 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 when the composite adapter is attached are shown in Table 3-10 (page 34).

Table 3-10   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

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 composite adapter, the computer detects this configuration and enables the composite and S-video outputs. The settings for the resolutions and standards (NTSC or PAL) are then selectable in System Preferences.

Keyboard

The iMac comes with an Apple Keyboard. It is a full-size keyboard with function keys and separate numeric keypad and editing sections.

The keyboard has an attached 1-meter cable and comes with a 1-meter extender cable for installations where the computer is located away from the immediate desktop area. The iMac supports the Apple wireless keyboard.

Keyboard Features

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

- sloped design
- 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, standard layouts (including: ANSI, JIS, ISO)
- LED indicator on the Num Lock key
- USB hub functionality with two USB 1.1 sockets

> **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).

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 (page 35) shows the keyboard layout for the ANSI keyboard.

Figure 3-4   ANSI keyboard layout
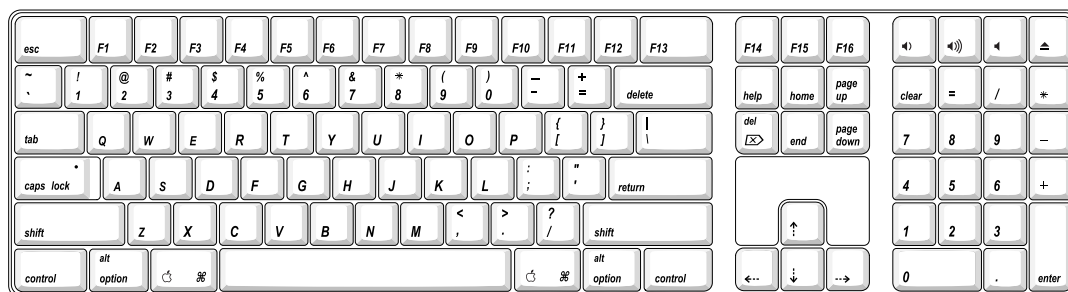
MultiMedia Control Keys

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 computer 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 as defined in the USB specification does not provide enough power to support a second bus-powered hub. A second bus-powered hub must be connected to a USB port on the computer or other self-powered hub, not to a port on the keyboard.

Apple provides a HID class driver for the Apple 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).

Programmer's Switches

Key combinations for programmer's switches that used the Power button on earlier models now use the Eject key. Here are the key combinations for the PowerMac G4 computer.

■ Control-Command-Eject: restart immediately (reset)

■ Control-Command-Option-Eject: shut down immediately

■ Control-Eject: display the dialog for shutdown, restart, and sleep

The key combinations are decoded in software and may not be available under some crashed conditions.

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 "boot-args" property of the "chosen" node 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 is set, reboot by pressing the power button for approximately 3 seconds to 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.

```
% 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.

Mouse

The iMac comes with the Apple Mouse, which uses optical tracking in place of the traditional rolling ball. It works on almost any surface, though non-reflective, opaque surface without repetitive patterns work best. The iMac supports the Apple wireless mouse.

Sound System

The sound system provides sound input and output through the built-in microphone and speaker. The user can also connect external input and output devices by way of the headphone jack, the Apple Pro Speaker minijack, the USB ports, and audio line-in.

To maintain the highest fidelity when digital audio program material from CDs or DVDs is played, the audio data is kept in digital form until just before being sent to the sound output jack or the headphone jack. A switch mode power amplifier provides the power for the external speaker.

The sound system supports sample sizes up to 24 bits and sample rates of up to 48 kHz.

Sound Inputs

The sound system accepts inputs from the following sources:

- the built-in microphone
- digital audio from the internal optical drive
- call progress audio from the internal modem
- USB audio devices connected to the USB ports
- audio line-in
- sound input from FireWire audio devices

Built-in Microphone

The iMac has a built-in microphone located at the bottom of the display. The analog signal from the microphone is converted to a digital signal by the audio circuitry.

The nominal SNR of the internal microphone is 65 dB.

Audio Line-in

The iMac has a stereo audio line-in jack on the base. Low level consumer products operating below -10 dBu require a pre-amp.

The audio inputs are designed to accept high-level audio signals: 2 Vrms or +8 dBu, which is the standard output level from CD and DVD players. The output level of some consumer audio devices is lower, often 0.1 Vrms or –10 dBu. Sound recordings made on the iMac with such low-level devices have more noise than those made with high-level devices. The user may obtain better results by connecting an amplifier between the low-level device and the computer's audio input jack.

The audio input jack is a 3.5 mm miniature phone jack with the signals connected as follows:

Tip	Left-channel audio
Ring	Right-channel audio
Sleeve	Audio ground

The sound input jack has the following electrical characteristics:

■ maximum input signal amplitude 2 Vrms (5.65 Vpp), +8 dBu peak

■ input impedance at least 47 kilohms

■ channel separation greater than 60 dB

■ recommended source impedance 2 kilohms or less

■ ground noise rejection greater than 40 dB

■ frequency response 5 Hz to 20 kHz, +0.0, –0.5 dB

■ distortion below –80 dB

■ signal to noise ratio (SNR) greater than -85 dB (unweighted)

Sound Outputs

The sound system sends computer-generated sounds to the following destinations:

■ internal speaker

■ Apple Pro Speaker minijack

■ stereo headphone jack

■ USB audio devices connected to the USB ports

■ FireWire audio devices connected to FireWire ports

Internal Speaker

The iMac has a single internal speaker that operates when no external speakers are connected. The internal speaker uses a monaural mix of the left and right channels.

Apple Pro Speaker Minijack

The Apple Pro Speaker minijack is a 2.5-mm stereo minijack. It has a smaller diameter than the headphone jack so that the user cannot inadvertently plug typical headphones into it.

⚠️ **Warning:** Many cell phones, along with some types of headphones and other audio devices, have a 2.5-mm plug. The user must not plug such devices into the Apple Pro Speaker minijack. Doing so could cause damage to the devices.

Headphone Jack

The iMac has a 3.5 mm minijack for stereo sound output. The headphone jack is suitable for connecting a pair of headphones or amplified external speakers. When a plug is inserted into the headphone jack, the internal speaker and the Apple Pro Speaker minijack are disconnected.

The sound output through the headphone jack has the following electrical characteristics:

■ output level 4.0 V peak-to-peak (1.4 V RMS), open circuit

■ source impedance 44 ohms

■ signal-to-noise (SNR) 90 dB unweighted (typical)

■ total harmonic distortion (THD) 0.03% or less

Sound 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 3-11.

Table 3-11   Distortion specifications

Connector and level	THD+N
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 3-12. The values shown are unweighted.

Table 3-12   SNR specifications

Connector	Signal-to-noise ratio
Microphone	65 dB
Headphone jack	90 dB

Connector	Signal-to-noise ratio
Internal CD or DVD	90 dB
Line-in jack	>= 85 dB SNR

RAM Expansion

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

RAM Expansion Slots

The iMac has two RAM expansion slots: one for an SO-DIMM (referred to as DIMM0 in the System Profiler) and one for a DIMM, which is preloaded by the factory (referred to as DIMM1 in the System Profiler). The iMac has 184-pin, 8-byte, DDR333 (PC2700) SO-DIMM (small outline, dual inline memory module) that uses DDR SDRAM devices The expansion slot capacity is an additional 512 MB, supporting a maximum of 1 GB.

For instructions on installing RAM, refer to the iMac 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.

> ⚠ **Warning:**   The computer must be turned off and unplugged before RAM modules are removed or inserted. To remind the user, a red LED is visible in the access door. If the red LED is on, power is on, and must be turned off before changing RAM modules.

The RAM Expansion Modules

The RAM expansion slot accommodates a standard DDR333 PC2700 compliant SO-DIMM (small outline, dual inline memory module) that uses DDR SDRAM devices.

> **Important:**   A RAM expansion SO-DIMM for the iMac must use proper speed DDR SDRAM devices.

Mechanical Design of RAM SO-DIMM

The mechanical characteristics of the RAM expansion module are given in the JEDEC specification JESD95 for the 184-pin, 8-byte DRAM SO-DIMM. To find out how to obtain the specification, see "RAM Expansion Modules" (page 47).

The specification defines SO-DIMMs with nominal heights of 1.0, 1.25, 1.5, or 2.0 inches. The iMac can accommodate standard SO-DIMMs with a height of 1.0 or 1.25 inches.

The JEDEC specification defines the maximum depth or thickness of an SO-DIMM as 4 mm. That specification is also a maximum: modules that exceed the specified thickness can cause reliability problems.

Electrical Design of DDR RAM SO-DIMM

The electrical characteristics of the RAM SO-DIMM are given in section 4.5.6 of the JEDEC Standard 21-C, release 7 (JESD-21C). To find out how to obtain the specification, see "RAM Expansion Modules" (page 47).

The specification defines several attributes of the DIMM, including storage capacity and configuration, connector pin assignments, and electrical loading. The specification supports SO-DIMMs with either one or two banks of memory.

The JEDEC specification for the SO-DIMM defines a Serial Presence Detect (SPD) feature that contains the attributes of the module. SO-DIMMs for use in the iMac are required to have the SPD feature. Information about the required values to be stored in the presence detect EEPROM is in section 4.1.2.5 and Figure 4.5.6–C (184-pin DDR SDRAM SO–DIMM, PD INFORMATION) of the JEDEC standard 21-C specification, release 7.

Configuration of DDR SDRAM Devices

The DDR SDRAM devices used in the RAM expansion modules must be self-refresh type devices for operation from a 2.5 V power supply. The speed of the DDR SDRAM devices must be 167 MHz or greater. The preloaded DIMM is 184-pin DDR333 (PC2700).

The devices are programmed to operate with a CAS latency of 2.5; the access time from the clock transition must be 7.5 ns or less. The burst length must be at least 4 and the minimum clock delay for back-to-back random column access cycles must be a latency of 1 clock cycle.

Table 4-1 (page 42) shows information about the different sizes of DIMMs used in the iMac computer. The first three columns show the memory size, configuration, and number of banks in the DIMMs. The other three columns show the number, density, and configuration of the DDR SDRAM devices making up the memory modules.

Table 4-1   Sizes of RAM expansion DIMMs and devices

Size of DIMM	Configuration of DIMM	Number of banks	Number of devices	Device density	Device configuration
128 MB	16 M x 64	1	4	256 Mbit	16 M x 16
256 MB	32 M x 64	2	8	256 Mbit	32 M x 8
512 MB	64 M x 64	2	16	256 Mbit	32 M x 8

Configuration of RAM SO-DIMMs

Table 4-2 (page 43) shows information about the different sizes of SO-DIMMs used in the iMac computer. The first three columns show the memory size, configuration, and number of banks in the SO-DIMMs. The other three columns show the number, density, and configuration of the DDR SDRAM devices making up the memory modules.

Table 4-2   Sizes of RAM expansion SO-DIMMs and devices

Size of SO-DIMM	Configuration of SO-DIMM	Number of banks	Number of devices	Device density	Device configuration
128 MB	16 M x 64	1	8	128 Mbit	16 M x 8
128 MB	16 M x 64	2	8	128 Mbit	8 M x 16
256 MB	32 M x 64	2	16	128 Mbit	16 M x 8
256 MB	32 M x 64	2	8	256 Mbit	16 M x 16
256 MB	32 M x 64	1	8	256 Mbit	32 M x 8
256 MB	32 M x 64	2	8	256 Mbit	16 M x 16
512 MB	64 M x 64	2	16	256 Mbit	32 M x 8

Address Multiplexing

Signals A[0] – A[12] and BA[0] – BA[1] on each RAM SO-DIMM make up a 15-bit multiplexed address bus that can support several different types of DDR SDRAM devices. (page 41)Table 4-3 lists the types of devices that can be used in the iMac by size, configuration, and sizes of row, column, and bank addresses.

Important: The iMac supports only the types of DDR SDRAM devices specified in Table 4-3. Other types of DRAM devices should not be used with this computer.

Table 4-3   Types of DDR SDRAM devices

Device size	Device configuration (bytes x bits x banks)	Row address bits	Column address bits
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 8x 4	13	10

Supplemental Reference Documents

For more information about the technologies mentioned in this developer note, you may wish to consult some of 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 new version of SGI's application programming interface (API) and software library for 3D graphics.

Information is available on the World Wide Web at

http://www.apple.com/opengl

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://e-www.motorola.com/webapp/sps/site/prod_summary.jsp?code=MPC7457&nodeId=018rH3bTdG8653

Velocity Engine

Velocity Engine is Apple's name for the AltiVec vector processor in the PowerPC G4 microprocessor. Apple provides support for developers who are starting to use the Velocity Engine in their applications. Documentation, development tools, and sample code are now 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. You can obtain a copy of the AltiVec PEM through the Motorola AltiVec site on the World Wide Web, at

http://www.freescale.com/webapp/sps/site/overview.jsp?nodeId=02VS0l81285Nf2

Mac OS X

The 15" and 17" iMac ship with Mac OS X version 10.2.7 or later installed; the 20" iMac ships with Mac OS X version 10.3 or later installed. For access to Apple's developer documentation for Mac OS X, see the Apple Developer Connection (ADC) website at

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

Open Firmware

The software architecture 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 and the SO-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 Interface

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, 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 on these classes available at

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

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

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

FireWire 400 Interface

For additional information about the FireWire 400 IEEE 1394a interface and the Apple APIs for FireWire 400 software, refer to the resources available on the Apple FireWire web site 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/

You may also find useful information at the 1394 Trade Association's web site:

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 Wireless Ethernet Compatibility Alliance, at

http://www.wi-fi.org

Bluetooth

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

Bluetooth specification:

http://www.bluetooth.com/

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
dB	decibels		Mbps	megabits per second
GB	gigabytes		Mbit	megabits
GHz	gigahertz		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-TX	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
BIOS	basic input/output system
CAS	column address strobe
CD	compact disc
CD-R	compact disc-recordable

CD-ROM	compact disc read-only memory
CD-RW	compact disc-rewrittable
CPU	central processing unit
CRM	Communications Resource Manager
D/A	digital to analog
DAA	data access adapter
DBDMA	descriptor-based direct memory access
DIMM	Dual Inline Memory Module
DMA	direct memory access
DDR	double data rate, a type of SDRAM
DSSS	direct-sequence spread-spectrum
DV	digital video
DVD	digital video disc
DVD-R	digital video disc-recordable
DVD-ROM	digital video disc read-only memory
DVD-RW	digital video disc-rewrittable
EEPROM	electrically eraseable programmable ROM
G4	Generation 4, the fourth generation of PowerPC microprocessors
GART	graphics address remapping table
GND	ground
HFS	hierarchical file system
HID	human interface device, a class of USB devices
IC	integrated circuit
IEC	International Electrotechnical Commission
I/O	input and output
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
MPEG	Motion Picture Experts Group
modem	modulator-demodulator
NMI	nonmaskable interrupt
NV-RAM	nonvolatile random-access memory
OHCI	Open Host Controller Interface
OS	operating system
PCI	Peripheral Component Interconnect
PLL	phase-locked loop
POST	power-on self test
RADIUS	Remote Authentication Dial-In User Service
RAM	random-access memory
RCA	Radio Corporation of America
rms	root mean square
ROM	read-only memory
RTAS	run-time abstraction services
SCC	Serial Communications Controller
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

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VCC	positive supply voltage (voltage for collectors)
VIA	versatile interface adapter
Wi-Fi	Logo used by the Wireless Ethernet Compatibility Alliance for certification of interoperability of 802.11 products