Developer Note

iMac

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About This Developer Note

This developer note gives a technical description of the iMac computer. The note provides information about the internal design of the computer, its input-output and expansion capabilities, and issues affecting compatibility.

Note
This developer note has been updated to include information about the latest product configurations. ◆

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 57).

The information in this note is arranged in four chapters:

■ Chapter 1, "Introduction," introduces the iMac, describes its features, and lists compatibility issues of interest to developers

■ Chapter 2, "Architecture," 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," describes the I/O ports and the built-in I/O devices.

■ Chapter 4, "RAM Expansion," includes development guidelines for the RAM expansion modules.

P R E F A C E

Introduction

This chapter lists the features of the current models of the iMac computer, with emphasis on the changes from the previous models. It also provides information about compatibility issues.

New Features

The features that have changed are listed here with links to the sections that describe them. For a comparison of new and old features, see Table 1-1.

- **Processor speed:** The microprocessor clock speed is 350, 400, 450, or 500 MHz. For more information, see "G3 Microprocessor" (page 22).

- **Memory:** The RAM slots can support up to 512 MB each for a maximum total of 1 GB. For more information, see "RAM Expansion Modules" (page 52).

- **Hard disk storage:** The capacity of the built-in hard disk drive is 7, 10, 20, or 30 GB. For more information, see "Hard Disk Drive" (page 39).

- **Target Disk Mode:** The computer can act like a FireWire storage device connected to another computer. See "Target Disk Mode" (page 35).

- **Graphics acceleration:** The IC used in the video circuits is an ATI RAGE 128 PRO 4XL. For more information, see "Video Display Subsystem" (page 25).

- **Keyboard:** The computer comes with an Apple Pro Keyboard, a full-size USB keyboard. For more information, see "Keyboard" (page 43).

- **Mouse:** The computer comes with an Apple Pro Mouse, a USB mouse with optical tracking. For more information, see "Mouse" (page 46).

Table 1-1 provides a quick comparison of the features of the latest configurations of the iMac with those of the previous models introduced in October, 1999.

Table 1-1   Feature comparison

	iMac family of October, 1999	Current iMac family
CPU speed	350 or 400 MHz	350, 400, 450, or 500 MHz
L2 cache speed	140 or 160 MHz	140, 160, 180, or 200 MHz
System bus speed	100 MHz	100 MHz
Main memory	64 or 128 MB, expandable up to 512 MB	64 or 128 MB, expandable up to 1 GB
Graphics IC	ATI RAGE 128 VR	ATI RAGE 128 PRO 4XL
Graphics memory	8 MB, plus AGP expansion	8 MB, plus AGP expansion
Video Output	Mirrored VGA on DV models	Mirrored VGA on DV models
Hard disk drive	6, 10, or 13 GB IDE drive	7, 10, 20, or 30 GB IDE drive
CD drive	Slot-load 24x CD-ROM or 4x DVD-ROM drive	Slot-load 24x CD-ROM or 4x DVD-ROM drive
Data ports	Two USB ports; two FireWire ports on DV models	Two USB ports; two FireWire ports on DV models
Communication features	Ethernet; 56K modem; optional AirPort card	Ethernet; 56K modem; optional AirPort card
Sound features	Stereo with enhanced AC-3 and surround sound	Stereo with enhanced AC-3 and surround sound
Keyboard	Apple USB Keyboard	Apple Pro Keyboard (USB)
Mouse	Apple USB Mouse	Apple Pro Mouse (USB)

All Features

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

- **Processor:** The iMac has a PowerPC G3 microprocessor running at a clock speed of 350, 400, 450, or 500 MHz. For more information, see "G3 Microprocessor" (page 22).

- **Cache:** The computer has a backside L2 cache consisting of 512 KB of fast static RAM. For more information, see "Backside Cache" (page 23).

- **Memory:** The computer comes with 64 or 128 MB of SDRAM installed in one of two standard 168-pin DIMM expansion slots. The RAM slots can support up to 512 KB each for a maximum total of 1 GB. For more information, see "RAM Expansion Modules" (page 52).

- **Hard disk storage:** The built-in hard disk drive has a capacity of 7, 10, 20, or 30 GB. For more information, see "Hard Disk Drive" (page 39).

- **Target Disk Mode:** The computer can act like a FireWire storage device connected to another computer. See "Target Disk Mode" (page 35).

- **CD-ROM or DVD-ROM drive:** One model has a built-in CD-ROM drive with 24X speed. The other models have a DVD-ROM with 4x speed. Both drives provide slot loading of the media. For more information, see "CD-ROM Drive" (page 40) and "DVD-ROM Drive" (page 40).

- **Display:** The iMac has a built-in 15-inch color monitor with a 13.8-inch viewable diagonal. For more information, see "Video Display" (page 41).

- **External video monitor:** The DV models have a port for connecting an external video monitor. For more information, see "Video Monitor Port" (page 41).

- **Graphics acceleration:** The video circuits provide built-in 2D and 3D acceleration using an ATI RAGE 128 PRO 4XL IC. For more information, see "Video Display Subsystem" (page 25).

- **Video RAM:** The video IC includes 8 MB of video SDRAM, which supports 3D features and millions of colors in all resolutions. For more information, see "Video Display Subsystem" (page 25).

- **USB ports:** The iMac has two USB ports for keyboard, mouse, and other USB devices, described in "USB Ports" (page 30).

- **FireWire ports:** The DV models have two IEEE-1394 FireWire high-speed serial ports, which support transfer rates of 100, 200, and 400 Mbps. For more information, see "FireWire Ports" (page 33).

- **Modem:** The iMac has a built-in V.90 modem with a 56 Kbps data rate. For more information, see "Internal Modem" (page 37).

- **Ethernet:** The iMac has a built in Ethernet port for a 10Base-T and 100Base-TX operation. For more information, see "Ethernet Port" (page 36).

- **AirPort Card slot:** An internal AirPort Card wireless LAN module is available as a build-to-order option or as a user-installable upgrade on the DV models. For more information, see "AirPort Card Wireless LAN Module" (page 37).

- **Sound:** The iMac has a built-in microphone and two stereo speakers, line-level stereo input and output jacks, and two stereo headphone jacks. The sound system includes playback of AC-3 surround sound from DVD video discs. For more information, see "Sound System" (page 46).

- **Keyboard:** The iMac comes with an Apple Pro Keyboard. The keyboard is also a USB hub with two USB ports. For more information, see "Keyboard" (page 43) and "Mouse" (page 46).

- **Mouse:** The computer comes with an Apple Pro Mouse, a USB mouse with optical tracking. For more information, see "Keyboard" (page 43) and "Mouse" (page 46).

- **Size and weight:** The iMac is 39.5 cm (15.8 inches) high, 38.0 cm (15.2 inches) wide, and 44.0 cm (17.6 inches) deep; it weighs 15.5 kg (34.0 pounds).

External Features

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

The top of the enclosure includes a built-in handle for carrying the computer. The handle can also be used to secure the computer using a cable and lock.

The bottom of the enclosure has a flip-out foot that can be used to change the tilt angle of the front of the computer from about 11 degrees to about 17 degrees.

The front of the enclosure is dominated by the 15-inch display. The front also includes, below the display, the following features:

- CD-ROM or DVD-ROM drive slot, in the center
- Stereo speakers, one on either side
- Two headphone jacks, next to the speaker on the left side
- Power button, green when on, pulsing amber in Sleep mode, located near the speaker on the right side

The receptacle for the power cord is located on the back. On the DV models, the connector for an external video monitor is located on the underside of the back.

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

- Sound input and output jacks
- Two FireWire ports (on DV models)
- Modem connector
- Ethernet port
- Two USB ports
- Programmer's buttons: reset and NMI

The back portion of the bottom of the enclosure has a hinged plastic door that can be opened for access to the expansion RAM and the AirPort Card slot. For more information, see "RAM Expansion Slots" (page 52).

System Software

The iMac comes with Mac OS 9 installed. For the latest information about Mac OS 9, see the references listed in "Mac OS 9" (page 58).

ROM In RAM

Since the introduction of the first iMac model, Macintosh system software has used a design based on ROM in RAM and Open Firmware. With this approach, a small ROM contains the code needed to initialize the hardware and load an operating system. The rest of the system code that formerly resided in the Mac OS ROM is loaded into RAM from disk or from the network. For more information, see the references listed in "ROM-in-RAM Architecture" (page 58) and "Open Firmware" (page 59).

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 machine should use Gestalt calls to test for the features they require.

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. For the iMac, the value of the first string in the `compatible` property is `PowerMac2,2`.

The string obtained from the `compatible` property cannot be displayed to the computer user. If it is available, you can 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.

Introduction

Architecture

This chapter describes the architecture of the iMac computer. 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 is a simplified block diagram of the main logic board. The diagram shows the main ICs and the buses that connect them together.

Architecture

Figure 2-1   Block diagram
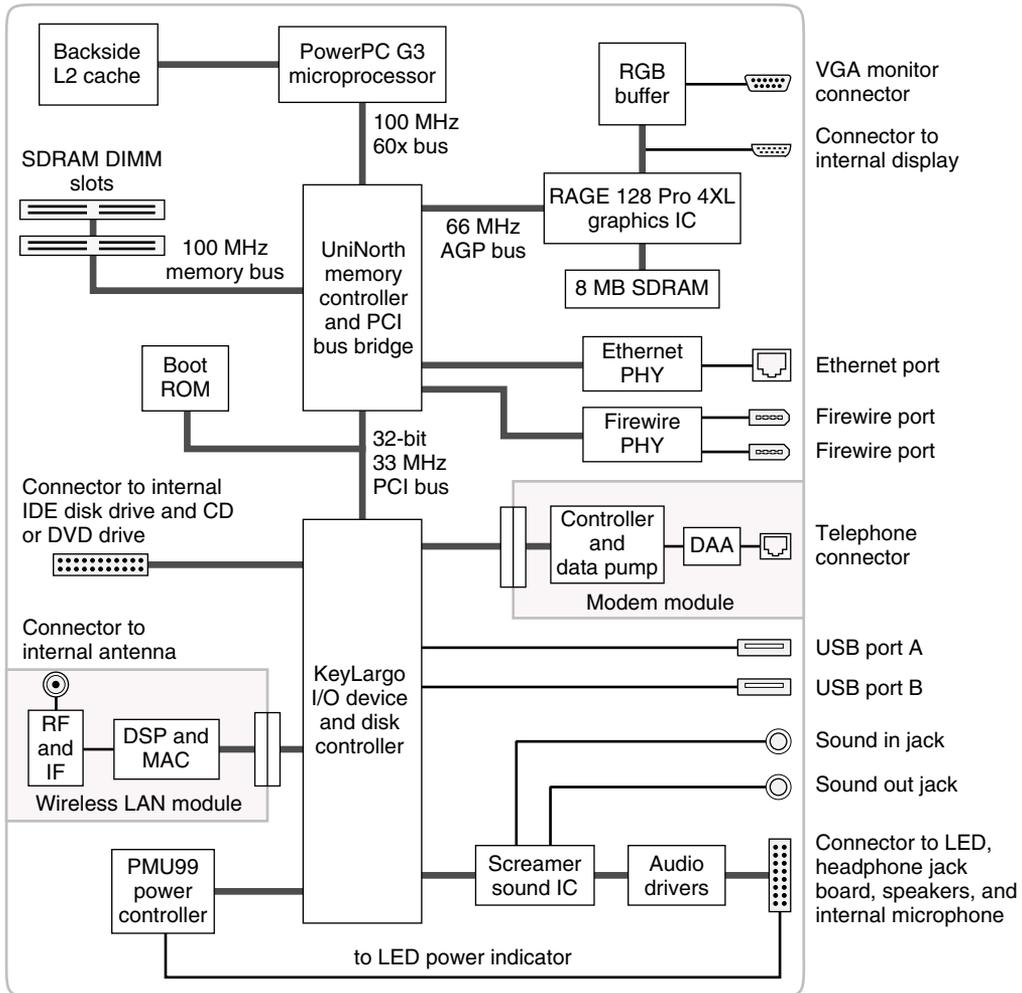
Main ICs and Buses

The architecture of the iMac is designed around the PowerPC G3 microprocessor and two new custom ICs: the Uni-N memory controller and bus bridge, and the KeyLargo I/O device controller. Those three ICs occupy the center of the block diagram.

The PowerPC G3 microprocessor is connected to the Uni-N memory controller and bus bridge IC by a 60x bus with 64 data lines and a bus clock speed of 100 MHz. The Uni-N IC has other buses that connect with the KeyLargo IC, the main system RAM, and the graphics IC. The buses implemented by the Uni-N IC are summarized in Table 2-1, which is in the section "Memory Controller and Bus Bridge".

The Uni-N IC is connected to the KeyLargo I/O controller IC by a 32-bit PCI bus with a bus clock speed of 33 MHz. That bus also connects to the Boot ROM. The KeyLargo IC has other buses that connect with the hard disk drive and the CD-ROM or DVD-ROM drive, the power controller IC, the sound IC, the internal modem module, and the optional wireless LAN module.

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

Microprocessor and Cache

The microprocessor communicates with the rest of the system by way of a 100-MHz, 64-bit 60x bus to the Uni-N IC. The microprocessor has a separate backside bus to its second-level cache.

G3 Microprocessor

The processor in the iMac is a PowerPC G3 microprocessor. The G3 microprocessor has several features that contribute to superior performance, including:

■ large on-chip (L1) caches, 32 KB each for instruction cache and data cache

■ a built-in cache controller and cache tag RAM for the second level (L2) cache

■ a separate backside bus for the L2 cache, providing faster clock speed and overlapped bus transactions

■ a microprocessor core optimized for Mac OS applications

The G3 microprocessor in the iMac runs at a clock speed of 350, 400, 450, or 500 MHz.

Backside Cache

The data storage for the backside L2 cache consists of 512 KB of fast static RAM on the main logic board. The controller and tag storage for the backside cache are built into the microprocessor. The cache controller includes bus management and control hardware that allows the cache to run at a sub-multiple of the processor's clock speed, rather than at the clock speed of the main system bus. The ratio of the clock speeds of the microprocessor and the backside cache is 5:2.

Memory Controller and Bus Bridge

The Uni-N memory controller and bus bridge IC provides cost and performance benefits by combining several functions into a single IC. It contains the memory controller, the PCI bus bridge, the Ethernet and FireWire interfaces, and the AGP port.

In addition to the four buses listed in Table 2-1, the Uni-N IC also has separate interfaces to the physical layer (PHY) ICs for Ethernet and FireWire and an I^2C interface that is used for configuring the memory subsystem.

Table 2-1   Buses supported by the Uni-N IC

Name of bus	Destinations	Width of data path	Bus clock speed
60x bus	Microprocessor	64 bits	100 MHz
Memory bus	System RAM	64 bits	100 MHz
PCI bus	KeyLargo IC and Boot ROM	32 bits	33 MHz
AGP port	Graphics IC	32 bits	66 MHz

The microprocessor and the I/O controller IC are described in their own sections. The following sections describe the other subsystems that are connected to the Uni-N IC.

System RAM

The memory subsystem in the iMac supports two slots for 168-pin DIMMs (dual inline memory modules). The data bus to the RAM and DIMM is 64 bits wide, and the memory interface is synchronized to the 60x bus interface at 100 MHz. See "RAM Expansion" (page 51).

Boot ROM

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

FireWire Controller

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

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 ports by way of external connectors in the I/O bay.

IMPORTANT

The FireWire PHY on the iMac does not accept external 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 Uni-N IC includes an ethernet media access controller (MAC) that implements the Link layer. As a separate channel connected directly to the

Uni-N IC, it can operate at its full capacity without degrading the performance of other peripheral devices. The Uni-N IC provides DB-DMA support for the Ethernet interface.

The controller is connected 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 36).

Video Display Subsystem

The display subsystem consists of a graphics controller ASIC and 8 MB of SDRAM on the main logic board. The graphics controller IC is an ATI RAGE 128 Pro 4XL. 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 an AGP (accelerated graphics port) bus on the Uni-N 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 41).

I/O Device Controller

The I/O controller IC in the iMac is a custom IC called KeyLargo. It is an integrated I/O controller and DMA engine for use in Power Macintosh computers with a PCI bus.

The KeyLargo IC provides the interface and control signals for the following devices:

■ the internal hard drive

- the CD-ROM or DVD-ROM drive

- the USB ports

- the built-in modem

- the sound codec IC

- the power manager IC

- the optional wireless LAN module

DMA Support

The KeyLargo IC provides DB-DMA (descriptor-based direct memory access) support for the following I/O channels:

- Ultra DMA IDE interface to the internal hard drive and the CD-ROM drive or DVD-ROM drive

- modem slot interface to the built-in modem

- DAV channel to the sound IC

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.

Interrupt Support

The KeyLargo IC has an interrupt controller (MPIC) that handles interrupts generated within the IC as well as external interrupts, such as those from the Ethernet and FireWire controllers.

USB Interface

The KeyLargo IC implements two independent USB controllers (root hubs), each of which is connected to one of the ports on the back panel of the computer. The use of two independent controllers allows both USB ports to support high data rate devices at the same time with no degradation of their performance. If a user connects a high-speed (12 Mbps) device to one port and another high-speed device to the other, both devices can operate at their full data rates.

The two external USB connectors support USB devices with data transfer rates of 1.5 Mbps or 12 Mbps. For more information about the connectors, see "USB Ports" (page 30).

USB devices connected to the iMac are required to support USB-suspend mode as defined in the USB specification. Information about the operation of USB-suspend mode on Macintosh computers is included in the *Mac OS USB DDK API Reference*. That document is part of Apple's USB DDK and is available on the World Wide Web, at:

http://developer.apple.com/techpubs/hardware/DeviceManagers/usb/usb.html

The USB ports on the iMac comply with the Universal Serial Bus Specification 1.1 Final Draft Revision. The USB controllers comply with the Open Host Controller Interface (OHCI) specification.

Ultra DMA Interface

In the iMac, the KeyLargo IC provides an Ultra DMA IDE (integrated drive electronics) channel that is connected to the internal hard disk drive and the CD-ROM or DVD-ROM drive. The KeyLargo IC provides DB-DMA (descriptor-based direct memory access) support for the Ultra DMA interface.

The Ultra DMA IDE interface, also called Ultra-DMA/33 and ATA-4, is an improved version of the EIDE interface.

The internal hard disk drive is connected as device 0 (master) in an ATA Device 0/1 configuration; the CD-ROM drive or DVD-ROM drive is an ATAPI drive and is connected as device 1 (slave).

Modem Support

The KeyLargo IC has a Macintosh serial port that is the interface to the modem connector. The KeyLargo IC provides DB-DMA support for the modem interface. The modem provides analog call progress signals to the Screamer sound IC.

The internal hardware modem is a separate module that contains the modem ICs (controller and datapump) and the interface to the telephone line (DAA). For more information about the modem, see "Internal Modem" (page 37).

Sound IC Support

The KeyLargo IC has a traditional DAV port that connects to the Screamer sound IC. The KeyLargo IC provides DB-DMA support for the DAV port.

The Screamer sound IC is an audio codec that provides analog input conditioning, A/D (analog to digital) conversion, D/A (digital to analog) conversion, and analog output conditioning. The A/D and D/A conversions use 16-bit data.

For a description of the features of the sound system, see "Sound System" (page 46).

Power Controller

The power management controller in the iMac is a custom IC called the PMU99. It supports several power-saving modes of operation, including idle, doze, and sleep.

Wireless LAN Module

The interface between the wireless LAN module and the KeyLargo IC is a subset of the PCMCIA interface.

The module contains a media access controller (MAC), a digital signal processor (DSP), and a radio-frequency (RF) section. The module has a connector for the cable to the antennas, which are built into the computer's enclosure.

The wireless LAN module is based on the IEEE 802.11 standard. The wireless LAN module transmits and receives data at up to 11 Mbps and is compatible with older systems that operate at 1 or 2 Mbps. For information about its operation, see "AirPort Card Wireless LAN Module" (page 37).

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 iMac has two 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 low-speed storage devices. The USB ports are connected to separate USB root hubs, allowing both USB ports to support 12 Mbps devices at the same time with no degradation of their performance. See "USB Interface" (page 26).

For more information about USB on Macintosh computers, please refer to Apple Computer's *Mac OS USB DDK API Reference* and the other sources listed in "USB Interface" (page 60).

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 is an illustration of a Type A port; Table 3-1 shows the signals and pin assignments.

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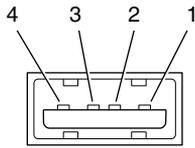
Table 3-1   Signals on the USB port

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 ports. The maximum current available is 500 mA on each port (1 A total).

The USB ports support both low-speed and high-speed data transfers, at up to 1.5 Mbits per second and 12 Mbits per second, respectively. High-speed operation requires the use of shielded cables.

The iMac comes with version 1.4.3 of the Macintosh USB system software, which supports all four data transfer types defined in the USB specification.

USB Features

Features of the USB ports include power saving modes and the ability to boot the computer using a USB mass-storage device.

"Power Off During Sleep"

"Connect and Resume"

"USB Storage Devices"

"USB Controller"

Power Off During Sleep

In the iMac, the USB port can be completely powered down during Sleep mode. USB devices must be able to start up again when the computer wakes up from Sleep mode. This functionality is part of the USB-suspend mode defined in the USB specification. Information about the operation of USB-suspend mode on Macintosh computers is included in the *Mac OS USB DDK API Reference*, available on the World Wide Web at

http://developer.apple.com/techpubs/hardware/DeviceManagers/usb/usb.html

In addition to restarting themselves out of Sleep mode, USB devices can also 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 KeyLargo IC 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 Storage Devices

The iMac can boot from a USB storage device that follows the USB Mass Storage Class specification.

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 includes USB Mass Storage Support 2.0, a class driver that supports devices that meet the USB Mass Storage Class 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.

FireWire Ports

The DV models have two external FireWire IEEE 1394 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 (no power when the computer is off or in Sleep mode)

- Support up to 62 devices

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

Developers of FireWire peripherals are required to provide device drivers. A driver for DV (digital video) is included in QuickTime 4, which comes installed on the iMac.

It is possible to connect two computers to each other using a FireWire cable, but no software is provided to make use of such a connection.

FireWire Connector

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

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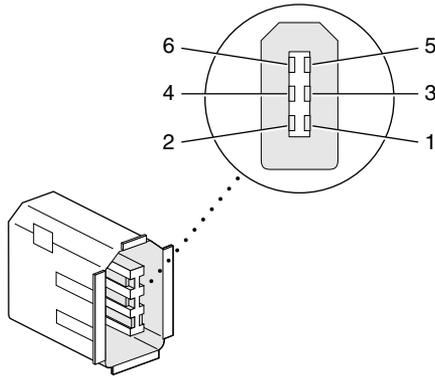
Table 3-2 Signals on the FireWire connector

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.

IMPORTANT

The FireWire PHY on the iMac does not accept external
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 cannot
be repeated. ▲

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 61).

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). This mode is similar to SCSI Disk
mode on a PowerBook computer equipped with a SCSI port, except it uses a
FireWire connection instead of a special SCSI cable.

When the iMac is in Target Disk Mode and connected to another Macintosh
computer by a FireWire 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 port and the FireWire 2.3.3 or newer driver.

IMPORTANT

For Target Disk Mode operation, only the iMac and the host
Macintosh computer can be connected to the FireWire bus.
Any other FireWire devices must be disconnected. ▲

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

If you disconnect the FireWire cable or turn off the iMac while in Target Disk Mode, an alert appears on the other computer asking you to reconnect the TDM volume.

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

For more information about Target Disk Mode, see the section "Target Mode" in Technote 1189, *The Monster Disk Driver Technote*.

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.

The connector for the Ethernet port is a an RJ-45 connector located on the I/O panel. Table 3-3 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
8	–	Not used

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

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.90 and K56flex modem standards)

■ Group 3 fax modem bit rates up to 14.4 Kbps

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

AirPort Card Wireless LAN Module

The iMac DV models support the AirPort Card, Apple's internal wireless LAN module. The AirPort Card is available as a build-to-order option or as a user-installable upgrade.

The AirPort Card can be used for local printer sharing, file exchange, Internet access, and email access.

The AirPort Card transmits and receives data at up to 11 Mbps. It is also interoperable with some older wireless LANs, as specified in "Hardware Components".

Wireless connection to the internet or a wired LAN requires a base station as the connection to the internet or a bridge between the wireless signals and a wired LAN. Software included with the AirPort Card enables a Macintosh computer that has an AirPort Card installed to act as a base station. The user also has the option of purchasing an AirPort Base Station that can be connected to the wired LAN or to a 56k hardware modem.

Data Security

Three features of the AirPort Card help to maintain the security of data transmissions.

- The AirPort Card 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 AirPort Card software can use a table of authentic network client ID values to verify each client's identity before granting access to the network.

- When communicating with a base station, the AirPort Card software encrypts the data using Wired Equivalent Privacy (WEP) with a 40-bit security key.

Hardware Components

The AirPort Card is a wireless LAN module based on the IEEE 802.11 standard and using direct-sequence spread-spectrum (DSSS) technology. It is interoperable with PC-compatible wireless LANs that conform to the 802.11 standard and use DSSS.

The card contains a media access controller (MAC), a digital signal processor (DSP), and a radio-frequency (RF) section. The antennas are built into the computer's case.

The MAC provides the data communication protocols and the controls for the physical layer.

The DSP provides the core physical layer functionality and controls the RF section. The DSP communicates with the MAC for data exchange, physical layer control, and parameter settings.

The RF section provides modulation and transmission of outgoing signals and reception and demodulation of incoming signals. Its power output when transmitting is nominally 31 mW.

When transmitting data, the DSP converts the outgoing data stream into a direct-sequence spread-spectrum (DSSS) signal and sends it to the RF section. When receiving data, the DSP accepts incoming DSSS data from the RF section and converts it to a normal data stream.

Two antennas are connected to the AirPort Card. One antenna is always used for transmitting. Either of the two antennas may be used for receiving. Using a diversity technique, the DSP selects the antenna that gives the best reception.

Software Components

Software that is provided with the AirPort Card includes

- AirPort Setup Assistant, a standalone assistant that takes users through the steps necessary to set up the AirPort Card, set up an AirPort Base Station, or set up a software base station.

- AirPort Application, an application that allows users to switch between wireless networks and to create and join peer-to-peer networks.

- AirPort Control Strip Module, which provides a signal strength indication and most of the functions of the AirPort Application.

- AirPort Utility, a utility for the advanced user. With it the user can edit the administrative and advanced settings for a hardware or software base station. It can also be used to determine the location for the base station that gives the best reception.

Hard Disk Drive

The internal hard disk drive has a storage capacity of 7, 10, 20, or 30 GB. The drive uses the Ultra DMA IDE interface, which is also referred to as the ATA-4 interface. The internal hard disk drive is connected as device 0 (master) in an ATA Device 0/1 configuration.

The software that supports the internal hard disk is similar to that in previous Macintosh models with internal IDE drives and includes DMA support. To obtain information about that software and about the ANSI standard for the Ultra DMA IDE interface, see "ATA Devices" (page 60).

CD-ROM Drive

One model of the iMac has a 24X-speed internal CD-ROM drive. The CD-ROM drive supports the worldwide standards and specifications for CD-ROM and CD-digital audio discs described in the Sony/Philips Yellow Book and Red Book. The drive can read CD-ROM, CD-ROM XA, CD-I, and PhotoCD discs as well as play standard audio discs.

The CD-ROM drive uses slot loading of the disc. The drive features a mechanism that supports 4X, 8X, 12X, and 24X data transfer rates and a data buffer that further enhances performance.

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

The CD-ROM drive is an ATAPI drive and is connected as device 1 (slave) in an ATA Device 0/1 configuration.

DVD-ROM Drive

The iMac DV models have a 4x-speed internal DVD-ROM drive. The drive is fully compatible with existing CD-ROM media; it supports CD-ROM at 24X speed maximum and DVD at 4x constant linear velocity (CLV). The DVD-ROM drive supports the following disc formats:

■ DVD-ROM (one- or two-layer, one- or two-sided)

■ DVD-RAM (read only)

■ CD-ROM (Modes 1 and 2) and CD-ROM XA (Mode 2, Forms 1 and 2)

■ CD-Audio, Photo CD, CD-RW (read only), CD-R (read only), and CD-Extra

■ CD-I (Mode 2, Forms 1 and 2), CD-I Ready, and CD-I Bridge

■ Video CD

Digital audio signals from the DVD-ROM can be played through the sound outputs under the control of the Sound Manager.

The DVD-ROM drive is an ATAPI drive and is connected as device 1 (slave) in an ATA Device 0/1 configuration.

Video Display

The built-in video display uses a 15-inch CRT (13.8-inch viewable diagonal). The CRT uses shadow-mask technology and has a dot pitch of 0.28 mm. The display has a fixed horizontal scan rate (60.015 kHz) and supports three resolutions. Table 3-4 lists the resolutions and the vertical scan rates supported.

The display has a mode called Theater Mode that increases the display contrast and brightness when playing full-screen video material. Theater Mode is an option in the Monitors control panel and is active only when an application requests it.

The display supports pixel depths up to 32 bits (millions of colors) at all resolutions.

Table 3-4　　　Display resolutions and pixel depths

Resolution	Vertical rate	Pixel depth
640 by 480	117.233 Hz	32 bits
800 by 600	94.97 Hz	32 bits
1024 by 768	75.03 Hz	32 bits

Video Monitor Port

The DV models have a port for an external video monitor. The external monitor shows the same information as the built-in display, a mode sometimes called hardware video mirroring. The external monitor supports only the display sizes that are available on the internal monitor.

Monitor Connector

The connector for the analog video monitor is a three-row DB15 connector (DB9/15, also called mini sub D15) for use with a VGA, SVGA, or XGA monitor. Figure 3-3 shows the pin configuration and Table 3-5 lists the signals and pin assignments.

Figure 3-3   Video connector
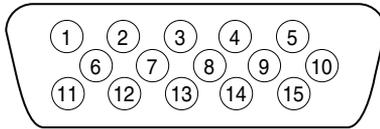
Table 3-5   Signals on the video connector

Pin	Signal name	Description
1	RED	Red video signal
2	GREEN	Green video signal
3	BLUE	Blue video signal
4	n.c.	No connect
5	GND	Ground
6	RED_RTN	Red video signal return
7	GREEN_RTN	Green video signal return
8	BLUE_RTN	Blue video signal return
9	n.c.	No connect
10	GND	Ground
11	n.c.	No connect
12	SDA	I^2C data

Table 3-5   Signals on the video connector   (continued)

Pin	Signal name	Description
13	HSYNC	Horizontal synchronization signal
14	VSYNC	Vertical synchronization signal
15	SCL	I^2C clock

The connector on the monitor cable must fit into an opening in the computer's enclosure. The maximum dimensions of the connector's overmold are 34.81 mm (1.370 inches) wide and 15.40 mm (0.606 inches) high; no additional tolerance is allowed. The dimensions are symmetrical about the mounting screws; in other words, the horizontal and vertical center lines of the overmolding coincide with the center lines of the mounting screws.

Keyboard

The iMac comes with an Apple Pro Keyboard. It is a USB compatible full-size keyboard with 15 function keys and separate groups of numeric keypad and editing keys.

Keyboard Features

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

■ Slope settable to either 0 or 6 degrees by a flip-out foot

■ 108 keys (on the ANSI versions)

■ 15 function keys, programmable by the user

■ 6 editing keys (Page Up, Page Down, Home, End, Forward Delete, and Help)

■ USB multi-media control keys (Volume Up, Volume Down, Mute, and Eject)

■ 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 indicators in the Caps Lock and Num 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 Pro 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 shows the keyboard layout for the ANSI keyboard. Applications can determine which type of keyboard is connected by calling the Gestalt Manager and checking for the corresponding value of the `gestaltKeyboardType` selector:

■ `gestaltUSBAndyANSIKbd` (value = 204)

■ `gestaltUSBAndyISOKbd` (value = 205)

■ `gestaltUSBAndyJISKbd` (value = 206)

Figure 3-4   ANSI keyboard layout

Programming the Function Keys

The function keys (F1–F15) can be programmed by the user through the Keyboard Control Panel. Operations that can be assigned include

- opening an application

- opening a document

- evoking an AppleScript

- logging on to a file server by way of an alias

Multi-Media Control Keys

The leyboard has four multi-media keys: Volume Up, Volume Down, Mute, and Eject. The provide direct control of the those features on the computer by way of the USB.

Keyboard and USB

The Apple Pro Keyboard is designed to work with the iMac 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.

▲ **W A R N I N G**

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 iMac, connect it to the second USB port on the computer, not to a port on the Apple USB keyboard. ▲

The NMI and reset key combinations now use the Eject key. The keys are decoded in software and may not be available under some crashed conditions. Therefore, NMI and reset switches are also available in the computer's I/O panel.

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 60).

Mouse

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

The Apple Pro Mouse is a new design that 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.

Sound System

The sound 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 iMac also supports speakers and microphones that connect to the USB port.

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 internal speakers, the sound output jack, or the headphone jacks.

The sound system is based on the Screamer codec IC and an output amplifier. The sound system supports sample sizes up to 16 bits at a sample rate of 44.1 kHz.

Sound Inputs

The sound system accepts inputs from five possible sources:

■ built-in microphone

■ external stereo sound input jack

■ sound from internal CD or DVD player

■ call progress audio from the internal modem

■ sound from USB audio devices

Built-in Microphone

The sound signal from the built-in microphone is sent directly to the codec circuits in the Screamer IC.

The nominal SNR of the internal microphone is 65 dB.

External Sound Input Jack

The external sound input jack is a 3.5-mm mini phone jack located on the I/O panel on the right side of the computer. The sound input jack accepts line-level stereo signals or an Apple PlainTalk microphone. It also accepts a stereo miniplug-to-RCA cable adapter for connecting stereo equipment to the computer.

The sound input jack has the following electrical characteristics:

■ input impedance: nominal 2000 ohms

■ maximum level: nominal 1 V rms (2.8 V peak-to-peak)

Sound Outputs

The sound system sends computer-generated sounds to three destinations:

■ built-in stereo speakers

■ sound output jack

■ two stereo headphone jacks.

The sound system provides user-selectable enhanced sound. The enhancements include

■ enhancement of stereo sound sources for wider stereo

■ using sound sprockets for simulation of immersive, interactive sonic environments, including sound objects that move in real time

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 either headphone jack

■ when a plug is inserted into the sound output jack

■ when external USB speakers are connected

■ during Sleep mode

External Sound Output

The external sound output jack is a 3.5-mm mini phone jack located on the I/O panel on the right side of the computer. It accepts a stereo miniplug-to-RCA cable adapter for connecting stereo equipment to the computer.

The sound output jack has the following electrical characteristics:

■ output impedance: 65 ohms

■ maximum level: nominal 1.4 V rms (4.0 V peak-to-peak)

Headphone Jacks

Two headphone jacks are located on the front of the computer next to the left speaker. Each sound output jack provides enough current to drive a pair of low-impedance headphones.

The headphone jacks have the following electrical characteristics:

■ output impedance: 65 ohms

■ maximum level: 1.0 V rms (2.8 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.

Sound Specifications

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

Total harmonic distortion plus noise (THD+N) as a percentage of full scale are shown in Table 3-6.

Table 3-6   Distortion specifications

Connector and level	THD+N
Line input	0.03%
Line output, open circuit	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 3-7. The values shown are unweighted; values with A weighting would be about 8 dB higher.

Table 3-7   SNR specifications

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

Devices and Ports

RAM Expansion

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

RAM Expansion Slots

The iMac has two RAM expansion slots. The slots accept standard PC-100 168-pin DIMMs (dual inline memory modules) using SDRAM devices. A DIMM for a iMac can contain either 64, 128, 256, or 512 MB of memory.

IMPORTANT

The 168-pin DIMMs used in the iMac are not the same as the 144-pin SO-DIMMs used in the 233, 266, and 333 MHz iMac models. ▲

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. One slot is normally occupied by the factory-installed RAM DIMM. The other RAM expansion slot is available for a user-installed DIMM.

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 iMac are 168-pin SDRAM DIMMs that are 3.3 volt, unbuffered, 8-byte, non-parity, and PC-100 compliant. The speed of the SDRAM devices must be rated at 125 MHz (8 ns) or faster.

IMPORTANT

RAM expansion DIMMs for the iMac must be PC-100 compliant and use 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 168-pin 8-byte DRAM DIMM. The specification number is JEDEC MO-161-D; the specification is available from the Electronics Industry Association's web site, at

http://www.jedec.org/download/freestd/pub95/mo-161d.pdf

The maximum height of DIMMs for use in the iMac 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 web site, at

http://www.jedec.org/download/freestd/pub21/

The specification defines several attributes of the DIMM, including storage capacity and configuration, connector pin assignments, and electrical loading.

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 the PC-100 compliant. The PC-100 specification is available from Intel's web site, at

http://developer.intel.com/design/chipsets/memory/sdram.htm#S1

The SDRAM devices used in the RAM expansion modules must be self-refresh type devices for operation from a 3.3-V power supply. The speed of the SDRAM devices must be 125 MHz or greater, corresponding to a cycle time of 8 ns or less, as required by the PC-100 specification.

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.

Table 4-1 shows information about the different sizes of SDRAM devices used in the memory modules. The memory controller supports SDRAM devices of 64, 128, 256 Mbit sizes. The device configurations include three specifications: address range, word size, and number of banks. For example, a 1 M by 16 by 4 device addresses 1 M, stores 16 bits at a time, and has 4 banks.

The third column in Table 4-1 specifies the number of devices needed to make up the 8-byte width of the data bus. The fourth column in the table shows the size of each bank of devices, which is based on the number of internal banks in each device and the number of devices per bank. The last column shows the memory size of the largest DIMM with that device size that the computer can accommodate.

Table 4-1   Sizes of RAM expansion devices and DIMMs

SDRAM device size	Device configuration	Devices per bank	Size of each bank	Size of DIMM
64 Mbits	4 M x 8 x 2	8	64 MB	128 MB
64 Mbits	2 M x 8 x 4	8	64 MB	128 MB
64 Mbits	2 M x 16 x 2	4	32 MB	128 MB
64 Mbits	1 M x 16 x 4	4	32 MB	128 MB
64 Mbits	1 M x 32 x 2	2	16 MB	128 MB
64 Mbits	512 K x 32 x 4	2	16 MB	128 MB
128 Mbits	8 M x 8 x 2	8	128 MB	256 MB
128 Mbits	4 M x 8 x 4	8	128 MB	256 MB
128 Mbits	4 M x 16 x 2	4	64 MB	256 MB
128 Mbits	2 M x 16 x 4	4	64 MB	256 MB
128 Mbits	2 M x 32 x 2	2	32 MB	256 MB
128 Mbits	1 M x 32 x 4	2	32 MB	256 MB

Table 4-1   Sizes of RAM expansion devices and DIMMs (continued)

256 Mbits	8 M x 8 x 4	8	256 MB	512 MB
256 Mbits	4 M x 16 x 4	4	128 MB	256 MB
256 Mbits	2 M x 32 x 4	2	64 MB	128 MB

The iMac 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 iMac does not support 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 lists the types of devices that can be used in the iMac by size, configuration, and sizes of row and column addresses.

IMPORTANT
The iMac supports only the types of SDRAM devices listed in Table 4-2. 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
64 Mbits	4 M x 8 x 2	13	9
64 Mbits	2 M x 8 x 4	12	9
64 Mbits	2 M x 16 x 2	13	8
64 Mbits	2 M x 16 x 2	11	10

Table 4-2   Address multiplexing modes for SDRAM devices (continued)

Device size	Device configuration	Size of row address	Size of column address
64 Mbits	1 M x 16 x 4	12	8
64 Mbits	1 M x 32 x 2	11	9
64 Mbits	512 K x 32 x 4	11	8
128 Mbits	8 M x 8 x 2	13	10
128 Mbits	4 M x 8 x 4	12	10
128 Mbits	4 M x 16 x 2	13	9
128 Mbits	2 M x 16 x 4	12	9
128 Mbits	2 M x 32 x 2	13	8
128 Mbits	1 M x 32 x 4	12	8
256 Mbits	8 M x 8 x 4	13	10
256 Mbits	4 M x 16 x 4	13	9
256 Mbits	2 M x 32 x 4	13	8

Supplemental Reference Documents

For more information about the technologies mentioned in this developer note, you may wish to consult some of the following references.

Apple publishes a series of tech notes--short documents addressing specific topics. The technotes are available on the Technote web site at

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

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

http://developer.apple.com/techpubs/hardware/hardware2.html.

You should also have copies of the relevant books describing the system software for Macintosh computers available in technical bookstores and on the World Wide Web at

http://developer.apple.com/techpubs/mac/mac.html

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

www.apple.com/opengl

Developer support and documentation is available at

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

PowerPC G3 Microprocessor

For more information about the PowerPC 750™ microprocessor used in the iMac, developers may wish to refer to the standard reference, *PowerPC Arthur Microprocessor Implementation Definition Book IV.* Information about the PowerPC 750 and other G3 microprocessors is also available on the World Wide Web at

http://www.mot.com/SPS/PowerPC/index.html

http://www.chips.ibm.com/products/powerpc/

Mac OS 9

For a description of the version of the Mac OS that comes with the new models, developers should refer to the technote for Mac OS 9. Other technotes contain information about the New World software architecture and the API changes for Power Manager 2.0. The technotes are available on the Technote web site at

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

Developers should also have copies of the relevant books describing the system software for Macintosh computers available in technical bookstores and on the World Wide Web at

http://developer.apple.com/techpubs/mac/mac.html

ROM-in-RAM Architecture

The system software in all current Macintosh computers uses a ROM-in-RAM approach, also called the New World architecture. For more information about this architecture, see Technote 1167, *NewWorld Architecture,* available on Apple's technote website at

http://developer.apple.com/technotes/tn/tn1167.html

Open Firmware

Three Technotes provide an introduction to Open Firmware on the Macintosh platform. They are:

TN 1061: Open Firmware, Part I, available on the Technote web site at

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

TN 1062: Open Firmware, Part II, available on the Technote web site at

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

TN 1044: Open Firmware, Part III, available on the Technote web site at

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

The New World software architecture follows some of the standards defined by the Open Firmware IEEE 1274-1995 specification and the CHRP binding.

The basis for the bootinfo file format and use is the document *PowerPC*^{TM} *Microprocessor Common Hardware Reference Platform (CHRP*^{TM}*) System binding to: IEEE Std 1275-1994 Standard for Boot (Initialization, Configuration) Firmware*. A bootinfo file contains Open Firmware script, a description, information for individual operating systems, icons, along with other information.

Other Open Firmware references of possible interest include:

IEEE 1275-1994 Standard for Boot (Initialization, Configuration) Firmware: Core Requirements and Practices

IEEE Std 1275-1994 Standard for Boot (Initialization, Configuration) Firmware (Version 1.7)

Open Firmware Recommended Practice: Device Support Extensions (Version 1.0)

Open Firmware Recommended Practice: Interrupt Mapping (Version 0.9)

RAM Expansion Modules

The iMac uses PC-100 compliant 168-pin SDRAM DIMMs. The mechanical characteristics of the DIMM are given in the JEDEC specification for the 168-pin

8-byte DRAM DIMM. The specification number is JEDEC MO-161; the specification is available from the Electronics Industry Association's web site, at

http://www.jedec.org/download/freestd/pub95/mo161C.pdf

The electrical characteristics of the DIMM are given in section 4.5.6 of the JEDEC Standard 21-C, release 7. The specification is available from the Electronics Industry Association's web site, at

http://www.jedec.org/download/freestd/pub21/

The RAM DIMMs are required to be the PC-100 compliant. The PC-100 specification is available from Intel's web site, at

http://developer.intel.com/design/chipsets/memory/sdram.htm#S1

ATA Devices

For the latest information about the system software for ATA devices such as the hard drive, see *ATA Device Software for Macintosh Computers.* That book is available on the reference library issue of the developer CD (June, 1999) and on the world wide web at

http://developer.apple.com/techpubs/hardware/DeviceManagers/ata/ata_ref/frameset.html

The specification for Ultra DMA IDE interface used in the iMac is ANSI T13/1153D and is available from the Technical Committee T13 web site at

http://www.t13.org/

USB Interface

For more information about USB on Macintosh computers, developers should refer to Apple Computer's *Mac OS USB DDK API Reference*. Information is also available on the World Wide Web, at:

http://developer.apple.com/techpubs/hardware/DeviceManagers/usb/usb.html

USB game controllers are supported by the InputSprocket component of the
Apple Games Sprockets software architecture. InputSprocket software and
information about the InputSprocket APIs can be found at

http://developer.apple.com/games/

Information about the standards for multi-media keys can be found in the USB
HID consumer information on the World Wide Web, at:

www.usb.org/developers/data/devclass/hut_1.pdf

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/index.html

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 web site at:

http://www.apple.com/firewire/

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

http://www.ieee.org

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

http://www.1394ta.org/

Supplemental Reference Documents

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
Hz	hertz	MHz	megahertz
KB	kilobytes	mm	millimeters
kg	kilograms	ns	nanoseconds
kHz	kilohertz	V	volts
mA	milliamperes	VDC	volts direct current

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
ADB	Apple Desktop Bus
AGP	accelerated graphics port
AIM	ATA Interface Module
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

Abbreviations

CD-ROM	compact disc read-only memory
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
DV	digital video
EDO	extended data out
EEPROM	electrically eraseable programmable ROM
G3	Generation 3, the third generation of PowerPC microprocessors, including the PPC 740 and PPC 750
GART	graphics address remapping table
GND	ground
HFS	hierarchical file system
HID	human interface device, a class of USB devices
IC	integrated circuit
IDE	integrated device electronics
IEC	International Electrotechnical Commission
I/O	input and output
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

Abbreviations

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
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
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)
VIA	versatile interface adapter

Abbreviations

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