

Developer Note

iMac



January 2002

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About This Developer Note

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

Note: This developer note describes the flat-panel models of the iMac computer. For a complete description of the CRT models, refer to the previous iMac developer note.

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 51).

The information in this note is arranged in four chapters.

- [Chapter 1, “Introduction”](#) (page 11), introduces the iMac (Flat Panel) computer, describes its features, and mentions a few software issues of interest to developers.
- [Chapter 2, “Architecture”](#) (page 17), describes the internal organization of the computer. It includes a functional block diagram and descriptions of the main components on the logic board.
- [Chapter 3, “Devices and Ports”](#) (page 25), describes the I/O ports and the built-in I/O devices.
- [Chapter 4, “RAM Expansion”](#) (page 45), includes development guidelines for the RAM expansion modules.

P R E F A C E

About This Developer Note

Introduction

This chapter lists the features of the current models of the iMac computer, with emphasis on the new flat-panel model. It also provides information about a few software issues of interest to developers.

Note: For a complete description of the CRT model, refer to the previous developer note.

New Features

New features are listed here with links to the sections that describe them. For a comparison of new and old features, see [Table 1-1](#) (page 12).

- **Processor and speed:** The microprocessor in the iMac (Flat Panel) is a PowerPC G4 with a clock speed of 700 or 800 MHz. For more information, see [“PowerPC G4 Microprocessor”](#) (page 19).
- **Memory:** The computer comes with 128 or 256 MB of SDRAM installed. The maximum total memory is 1 GB. For more information, see [“RAM Expansion Modules”](#) (page 46).
- **Display:** The iMac (Flat Panel) has a built-in 15-inch flat-panel display (measured diagonally). For more information, see [“Flat Panel Display”](#) (page 36).
- **Graphics acceleration:** The graphics IC used in the iMac (Flat Panel) is an NVIDIA GeForce2 MX. For more information, see [“Video Display Subsystem”](#) (page 22).

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- **Video RAM:** The video hardware in the iMac (Flat Panel) includes 32 MB of DDR RAM, which supports 3D features and millions of colors in all resolutions. For more information, see “[Video Display Subsystem](#)” (page 22).
- **CD-RW drive:** One configuration of the iMac (Flat Panel) has a CD-RW drive. For more information, see “[CD-RW Drive](#)” (page 34).
- **Combo (CD-RW/DVD-ROM) drive:** One configuration of the iMac (Flat Panel) has a combination CD-RW/DVD-ROM drive. For more information, see “[Combo \(CD-RW/DVD-ROM\) Drive](#)” (page 35).
- **SuperDrive (CD-RW/DVD-R) drive:** One configuration of the iMac (Flat Panel) has a SuperDrive (CD-RW/DVD-R) drive. For more information, see “[SuperDrive \(CD-RW/DVD-R\) Drive](#)” (page 35).
- **Sound:** The iMac (Flat Panel) has a built-in microphone and speaker, a stereo headphone jack, and an Apple Speaker minijack. Some configurations come with Apple Pro Speakers. For more information, see “[Sound System](#)” (page 41).

Table 1-1 (page 12) provides a quick comparison of the features of the latest configurations of the iMac computer with those of the previous models introduced in August, 2000.

Table 1-1 Feature comparison

	July 2001 iMac	Current CRT iMac	iMac (Flat Panel)
CPU and speed	500, 600, or 700 MHz PowerPC G3	500 or 600 MHz PowerPC G3	700 or 800 MHz PowerPC G4
L2 cache speed	500, 600, or 700 MHz	500 or 600 MHz	700 or 800 MHz
System bus speed	100 MHz	100 MHz	100 MHz
Main memory	64 or 128 MB, expandable up to 1 GB	128 or 256 MB, expandable up to 1 GB	128 or 256 MB, expandable up to 1 GB
Display	Built-in 15-inch CRT	Built-in 15-inch CRT	Built-in 15-inch flat panel
Graphics IC	ATI RAGE 128 Ultra	ATI RAGE 128 Ultra	NVIDIA GeForce2 MX
Graphics memory	16 MB SDRAM	16 MB SDRAM	32 MB DDR RAM
Video Output	Mirrored VGA	Mirrored VGA	Mirrored VGA
Hard disk drive	20, 40, or 60 GB IDE	20 or 40 GB IDE	40 or 60 GB IDE

Table 1-1 Feature comparison (continued)

	July 2001 iMac	Current CRT iMac	iMac (Flat Panel)
Optical drive	Slot-load CD-RW drive	Slot-load CD-ROM or CD-RW drive	Tray-load CD-RW, Combo drive, or SuperDrive
Data ports	Four USB ports (two on keyboard); two FireWire ports	Four USB ports (two on keyboard); two FireWire ports	Five USB ports (two on keyboard); two FireWire ports
Communication features	10/100 Ethernet; 56K fax modem; optional AirPort card	10/100 Ethernet; 56K fax modem; optional AirPort card	10/100 Ethernet; 56K fax modem; optional AirPort card
Sound features	Stereo, with built-in speakers, microphone, and I/O jacks	Stereo, with built-in speakers, microphone, and I/O jacks	Built-in speaker and microphone; stereo headphone jack and Apple Speaker minijack; Apple Pro speakers included on some models

All Features

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

- **Processor and speed:** The microprocessor is a PowerPC G4 with a clock speed of 700 or 800 MHz. For more information, see “[PowerPC G4 Microprocessor](#)” (page 19).
- **Cache:** The backside L2 cache is included on the microprocessor IC and has the same clock speed as the microprocessor. For more information, see “[Level 2 Cache](#)” (page 20).

Introduction

- **Memory:** The computer comes with 128 or 256 MB of SDRAM installed in an internal standard 168-pin DIMM expansion slot. A second user-accessible slot accepts an SO-DIMM with up to 512 MB. The maximum total memory is 1 GB. For more information, see [“RAM Expansion Modules”](#) (page 46).
- **Hard disk storage:** The built-in hard disk drive has a capacity of 40 or 60 GB. For more information, see [“Hard Disk Drive”](#) (page 33).
- **CD-RW drive:** One configuration of the iMac (Flat Panel) has a CD-RW drive. For more information, see [“CD-RW Drive”](#) (page 34).
- **Combo (CD-RW/DVD-ROM)** One configuration of the iMac (Flat Panel) has a combination CD-RW/DVD-ROM drive. For more information, see [“Combo \(CD-RW/DVD-ROM\) Drive”](#) (page 35).
- **SuperDrive (CD-RW/DVD-R) drive:** One configuration of the iMac (Flat Panel) has a SuperDrive (CD-RW/DVD-R) drive. For more information, see [“SuperDrive \(CD-RW/DVD-R\) Drive”](#) (page 35).
- **Display:** The iMac (Flat Panel) has a built-in 15-inch flat-panel display (measured diagonally). For more information, see [“Flat Panel Display”](#) (page 36).
- **External video monitor:** The iMac (Flat Panel) computer has a mini-VGA port for connecting an external video monitor. For more information, see [“Video Monitor Port”](#) (page 37).
- **Graphics acceleration:** The video circuits in the iMac (Flat Panel) use an NVIDIA GeForce2 MX graphics IC. For more information, see [“Video Display Subsystem”](#) (page 22).
- **Video RAM:** The video hardware in the iMac (Flat Panel) includes 32 MB of DDR RAM, which supports 3D features and millions of colors in all resolutions. For more information, see [“Video Display Subsystem”](#) (page 22) and [“Flat Panel Display”](#) (page 36).
- **USB ports:** The iMac (Flat Panel) has five USB ports (two on the keyboard), described in [“USB Ports”](#) (page 25).
- **FireWire ports:** The iMac (Flat Panel) computer has 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 27).
- **Target Disk Mode:** The computer can act like a FireWire storage device connected to another computer. See [“Target Disk Mode”](#) (page 30).

Introduction

- **Modem:** The iMac has a built-in V.90 modem with a 56 Kbps data rate. For more information, see “[Internal Modem](#)” (page 33).
- **Ethernet:** The iMac has a built in Ethernet port for a 10Base-T and 100Base-TX operation. For more information, see “[Ethernet Port](#)” (page 30).
- **AirPort Card:** An internal AirPort Card wireless LAN module is available as a build-to-order option or as a user-installable upgrade. For more information, see “[AirPort Card](#)” (page 31).
- **Sound:** The iMac (Flat Panel) has a built-in microphone and speaker, a stereo headphone jack, and an Apple Speaker minijack. Some configurations come with Apple Pro Speakers. For more information, see “[Sound System](#)” (page 41).
- **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 38).
- **Mouse:** The iMac comes with an Apple Pro Mouse, a USB mouse with optical tracking. For more information, see “[Mouse](#)” (page 41).

System Software

The iMac computer comes with both Mac OS X and Mac OS 9.2 installed. Mac OS X is the default system.

For more information about Mac OS X, see the reference listed in “[Mac OS X](#)” (page 53). For the latest information about Mac OS 9.2, see the references listed in “[Mac OS 9.2](#)” (page 53).

Machine 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. Applications can also use the Name Registry with Mac OS 9 or the IORegistry with Mac OS X.

Introduction

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 (Flat Panel), the value of the string in the `compatible` property is `PowerMac4,2`.

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.

Velocity Engine Acceleration

The Velocity Engine (also known as AltiVec) is the vector processing unit in the 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.

The software areas that have been modified to take advantage of Velocity Engine acceleration are

- QuickTime: key codecs, including DV and photo JPEG

The software areas that have been added or modified for low-level Velocity Engine support are

- Nanokernel: the floating-point vector denormal handler
- Process Manager: context switching
- Block Move routines

The following vector libraries are included: `vBasicOps`, `vectorOps`, `vBigNum`, and `vMathLib`.

For more information, please see the references at “[Velocity Engine \(AltiVec\)](#)” (page 52).

Architecture

This chapter describes the architecture of the iMac (Flat Panel) 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.

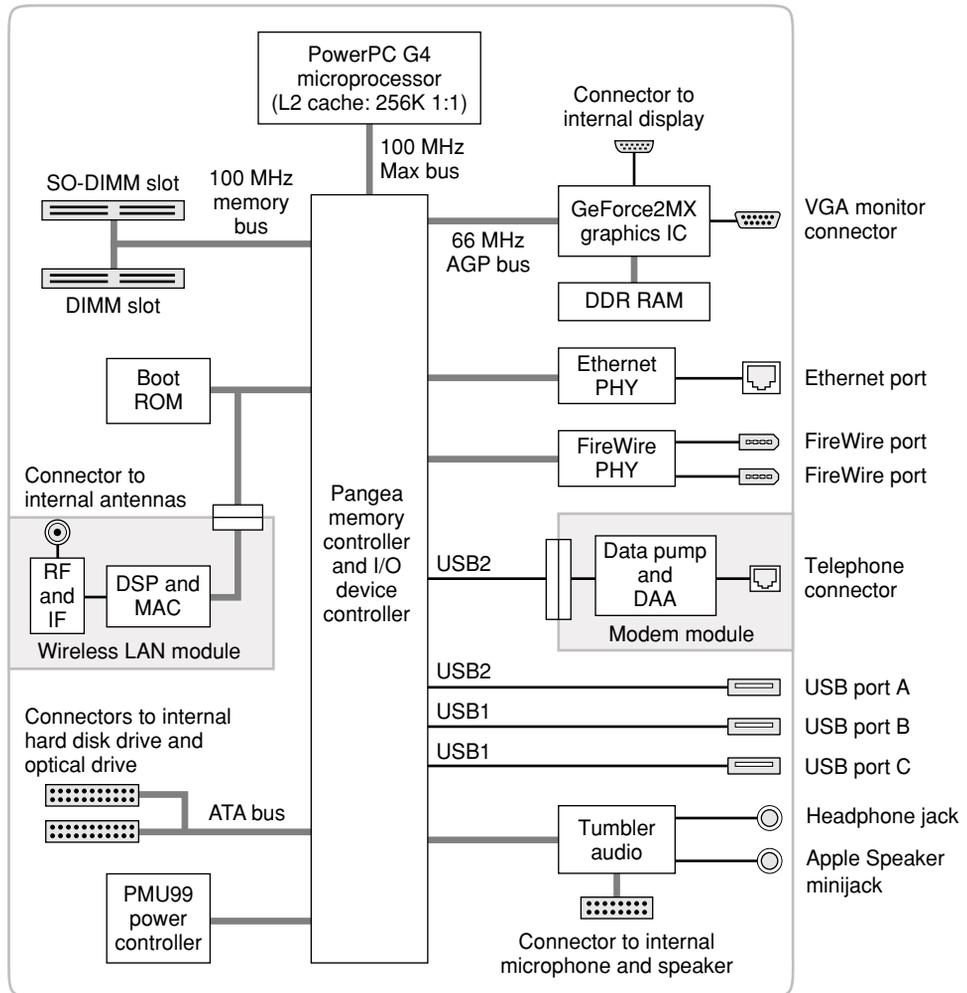
Block Diagram and Buses

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

Block Diagram

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

Figure 2-1 Block diagram



Main ICs and Buses

The architecture of iMac (Flat Panel) computer is designed around the PowerPC G4 microprocessor and a custom IC: the Pangea memory controller and the I/O device controller. The Pangea IC occupies the center of the block diagram.

Architecture

The PowerPC G4 microprocessor is connected to the Pangea IC by a MaxBus bus with 64 data lines and a bus clock speed of 100 MHz. The Pangea IC 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.

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

Microprocessor and Cache

The microprocessor runs at a clock speed of 700 or 800 MHz. The microprocessor is a PowerPC G4 with a built-in level 2 (L2) cache.

PowerPC G4 Microprocessor

The PowerPC G4 microprocessor has many powerful features, including a pipelined system bus, called MaxBus, that is more efficient than the system bus on the PowerPC G3 microprocessors.

The PowerPC G4 used in the iMac computer has the following features:

- 32-bit PowerPC implementation
- superscalar PowerPC core
- Velocity Engine (AltiVec technology): 128-bit-wide vector execution unit
- high bandwidth MaxBus
- dual 32 KB instruction and data caches (level one)
- on-chip second level (L2) cache consisting of 256 KB with a clock speed ratio of 1:1

To find more information, see the reference at [“PowerPC G4 Microprocessor”](#) (page 19).

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 Pangea memory and I/O device controller IC combines several functions into a single IC. It contains the memory controller, the PCI bus bridge, the Ethernet and FireWire interfaces, the USB interface, and the AGP interface.

In addition to the buses listed in [Table 2-1](#) (page 20), the Pangea IC also has separate interfaces to the physical layer (PHY) ICs for Ethernet and FireWire and an I2C interface that is used for configuring the memory subsystem.

Table 2-1 Buses supported by the Pangea IC

Name of bus	Destinations	Width of data path	Bus clock speed
MaxBus	Microprocessor	64 bits	100 MHz
Memory bus	System RAM	64 bits	100 MHz
AGP 2x bus	Graphics IC	32 bits	66 MHz
Ultra ATA bus	Hard drive and optical drive	16 bits	66 MHz

The Pangea IC 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.

Architecture

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

The following sections describe the subsystems that are connected to the Pangea IC.

System RAM

The memory subsystem in the iMac supports two slots: one for a 168-pin DIMMs (dual inline memory module) and one for a 144-pin SO-DIMM. The data bus to the RAM and DIMM is 64 bits wide, and the memory interface is synchronized to the MaxBus interface at 100 MHz.

Note: Only the SO-DIMM slot is accessible by the user. See “RAM Expansion” (page 45)

Boot ROM

The boot ROM is a 1 M by 8 bit device. It is connected to the Pangea IC by way of a CardBus interface.

FireWire Controller

The Pangea IC includes an IEEE 1394 FireWire controller with a maximum data rate of 400 Mbits (50MBytes) per second. The Pangea 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 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 Pangea IC includes an ethernet media access controller (MAC) that implements the Link layer. As a separate channel connected directly to the Pangea logic, it can operate at its full capacity without degrading the performance of other peripheral devices. The Pangea 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 30).

Video Display Subsystem

The display subsystem consists of a graphics controller ASIC and 32 MB of DDR RAM on the main logic board. The graphics controller IC is an NVIDIA GeForce2 MX. It contains 2D and 3D acceleration engines, front-end and back-end scalars, a display controller, and an AGP 2x bus interface with bus master capability.

The graphics IC supports a display size of 1024 by 768 pixels. The graphics IC also has a scaling mode that displays a 640-by-480 or 800-by-600 pixel image on the full screen.

The display generated for the flat panel display is simultaneously available for an external monitor. See “[Video Monitor Port](#)” (page 37).

The interface between the graphics IC and the rest of the system is an AGP (accelerated graphics port) 2x bus on the Pangea 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 DDR RAM and the main memory.

For information about the display and supported resolutions, see “[Flat Panel Display](#)” (page 36) and “[Video Monitor Port](#)” (page 37).

USB Interface

The Pangea IC implements two independent USB controllers (root hubs), each with two ports, for a total of four ports. The internal modem and the external USB port nearest the mini-VGA connector are connected to one controller; the other two USB ports are connected to the other controller.

Each USB controller provides a 12 Mbps data transfer rate that is shared between the two devices connected to it. The two USB ports that are connected to separate controllers can support high data rate devices at the same time with no degradation of their performance. Thus, if a user connects a high-speed (12 Mbps) device to USB port 1 and another high-speed device to the port 2, both devices can operate at their full data rates.

All three 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 25).

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. To obtain that document, please see the references at “USB Interface” (page 56).

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 ATA Interface

In the iMac, the Pangea IC provides an Ultra ATA channel that is connected to the internal hard disk drive and the optical drive. The Pangea IC provides DB-DMA (descriptor-based direct memory access) support for the Ultra DMA interface.

The internal hard disk drive is connected as device 0 (master) in an ATA Device 0/1 configuration; the optical drive is connected as device 1 (slave). The internal hard disk drive uses the ATA5 protocol and the CD-RW drive uses the ATA4 protocol.

Modem Support

One of the USB ports on the Pangea IC is used for the interface to the modem. The Pangea IC provides DB-DMA support for the modem interface. The modem provides digital call progress signals to the Tumbler sound circuits.

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 33).

Sound Circuitry

The sound circuitry in the iMac computer is called Tumbler. The Tumbler circuitry exchanges audio data with the Pangea IC over a standard I2S bus and receives commands from the Pangea IC over an I2C bus. The Pangea IC provides DB-DMA (descriptor-based direct memory access) support for the I2S bus.

The Tumbler 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 Tumbler circuitry performs analog-to-digital conversion for the internal microphone. Tumbler also performs 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 Speaker minijack.

For a description of the features of the sound system, see “[Sound System](#)” (page 41).

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.

AirPort Card Support

An AirPort Card, Apple’s internal wireless LAN module, is available as an option. The connector for the AirPort Card uses the CardBus interface. A separate connector is used for the cable to the antennas, which are built into the computer’s enclosure. For information about the operation of the AirPort Card, see “[AirPort Card](#)” (page 31).

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 (Flat Panel) 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 low-speed storage devices. Three USB ports are on the iMac itself; two more are on the keyboard.

The first USB port (the one nearest the mini-VGA connector) and the internal modem share one USB root hub; the second and third USB ports share a second USB hub. Each hub provides a 12 Mbps data transfer rate that is shared between the devices connected to it. See “USB Interface” (page 56).

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 56).

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 26) is an illustration of a Type A port; [Table 3-1](#) (page 26) shows the signals and pin assignments.

Figure 3-1 USB Type A port and pins

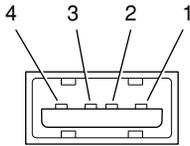


Table 3-1 Signals on the USB port

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.

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 Macintosh USB system software 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.

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 Pangea 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 iMac has two external FireWire IEEE 1394 ports. The features of the FireWire ports are:

Devices and Ports

- Support serial I/O at 100, 200, and 400 Mbps (megabits per second)
- Share 6 watts of power (8 W peak) when the computer system is on
- 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, which comes installed on the iMac. A driver for mass storage devices is included in the system software.

FireWire Connector

The FireWire connector has six contacts, as shown in [Table 3-2](#) (page 29). The connector signals and pin assignments are shown in [Table 3-2](#) (page 29).

Figure 3-2 FireWire connector

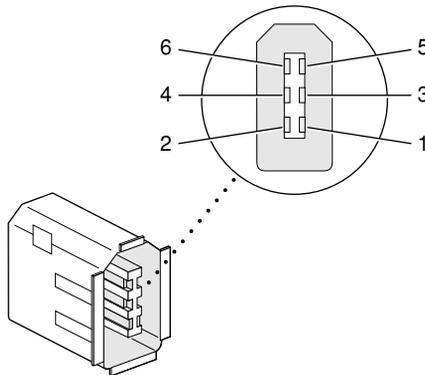


Table 3-2 Signals on the FireWire connector

Pin	Signal name	Description
1	Power	regulated, 12 VDC
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 regulated voltage of 12 V and 6 W total power (8 W peak), 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 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 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 56).

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

To put the 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 cable from the iMac to the other computer. When the other computer completes the FireWire connection, a hard disk icon appears on its desktop.

If you disconnect the FireWire 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 .

For more information about Target Disk Mode, see the section “Target Mode” in Technote 1189, The Monster Disk Driver Technote. For information about obtaining the Technote, see “[Apple Technotes](#)” (page 51).

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.

Devices and Ports

The connector for the Ethernet port is an RJ-45 connector located on the I/O panel. [Table 3-3](#) (page 31) 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.

AirPort Card

The iMac computer supports the AirPort Card, an internal wireless LAN module. The AirPort Card is available as a build-to-order option or as a user-installable upgrade through The Apple Store.

By communicating wirelessly with a base station, the AirPort 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 Base Station has connectors for a wired LAN, a DSL or cable modem, and a standard telephone line using its built-in 56k modem.

Devices and Ports

AirPort transmits and receives data at speeds up to 11 Mbps, comparable to wired networking speeds. AirPort is Wi-Fi Certified, which means it is fully compatible with other devices that follow the IEEE 802.11b standard, including PC's. For more information about Wi-Fi and compatibility, see the reference at "[Wireless Networks](#)" (page 57).

Data Security

AirPort 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 multi-bit spreading code that effectively scrambles the data for any receiver that lacks the corresponding code.
- The system 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, AirPort uses up to 128-bit encryption to encode your data while it is in transit.
- The AirPort Base Station can be configured to act as a firewall, protecting your data from would-be Internet hackers.
- The AirPort Base Station can authenticate users by their unique Ethernet IDs, preventing unauthorized machines from logging into your network. Network administrators can take advantage of RADIUS compatibility, used for authenticating users over a remote server. Smaller networks can offer the same security using a local look-up table located within the base station.

AirPort Hardware

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 802.11b standard and use DSSS.

Two AirPort antennas are built into the computer's flat-panel display, one on either side. One antenna is always used for transmitting. Either of the two antennas may be used for receiving. Using a diversity technique, the AirPort Card selects the antenna that gives the best reception.

AirPort Software

Software that is provided with the AirPort Card includes

- AirPort Setup Assistant, an easy-to-use program that guides you through the steps necessary to set up the AirPort Card or set up an AirPort Base Station.
- AirPort Application, an application that allows users to switch between wireless networks and to create and join peer-to-peer networks.
- AirPort 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.90 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.

Hard Disk Drive

The internal hard disk drive has a storage capacity of 40 or 60 GB. The drive uses the Ultra ATA/66 interface. The internal hard disk drive uses the ATA5 protocol and 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 Interface” (page 55).

CD-RW Drive

One configuration of the iMac (Flat Panel) computer has an internal CD-RW drive with a tray for loading the disc. The drive is capable of writing CD-R media at 16x speed and CD-RW media at 12x speed. It can read CD-ROM media at 24x speed.

Table 3-4

Media type	Reading speed	Writing speed
CD-R	32x	24x
CD-RW	32x	10x
CD or CD-ROM	32x	–

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

The CD-RW drive uses the ATA4 protocol and is device-select jumpered as Device 1 (slave) in an ATA Device 0/1 configuration.

Combo (CD-RW/DVD-ROM) Drive

One configuration of the iMac (Flat Panel) computer 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 35). 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)	–
CD-R	24x (CAV)	12x (CLV)
CD-RW	24x (PCAV)	8x (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.

The Combo drive uses the ATA4 protocol and is device-select jumpered as Device 1 (slave) in an ATA Device 0/1 configuration.

SuperDrive (CD-RW/DVD-R) Drive

One configuration of the iMac (Flat Panel) computer has a SuperDrive: a combination CD-RW and DVD-R drive. The drive uses tray loading of the disc.

Devices and Ports

The drive can read and write DVD media and CD media, as shown in Table 3-6 (page 36). The SuperDrive also provides DVD-Video playback with DVD MPEG2 decode.

Table 3-6 Types of media read and written by the SuperDrive (CD-RW/DVD-R) drive

Media type	Reading speed	Writing speed
DVD-R	2x	2x
DVD-ROM	6x (single layer), 2x (dual layer)	–
CD-R	24x	8x
CD-RW	24x	4x
CD or CD-ROM	24x	–

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

The SuperDrive uses the ATA4 protocol and is device-select jumpered as Device 1 (slave) in an ATA Device 0/1 configuration.

Flat Panel Display

The iMac (Flat Panel) computer has a built-in color flat panel 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 display is 15 inches in size, measured diagonally. The display contains 1024 by 768 pixels (XGA) and can show up to millions of colors.

The graphics IC includes a scaling function that expands smaller-sized images to fill the screen. By means of the scaling function, the computer can show full-screen images at 1024 by 768, 800 by 600, or 640 by 480 pixels.

Devices and Ports

The graphics subsystem uses an NVIDIA GeForce2 MX and 32 MB of DDR RAM. It supports 3D acceleration and display depths up to 24 bits per pixel. When more graphics storage is needed, the graphics IC can also use part of main memory. For more information, see “[Video Display Subsystem](#)” (page 22).

Video Monitor Port

The iMac (Flat Panel) computer has 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; the sizes and refresh rates are shown in [Table 3-7](#) (page 37).

Table 3-7 Display sizes and refresh rates

Display size	Refresh rate
640 by 480	60 Hz
800 by 600	75 Hz
1024 by 768	75 Hz

Monitor Connector

The connector for the analog video monitor is a custom 14-pin connector. The pins and signals are listed in Table 3-8 (page 38). An adapter is available for use with monitors with VGA 15-pin miniature D-type connectors.

Table 3-8 Signals on the monitor connector

Pin	Signal name	Pin	Signal name
1	GND	8	DDC_VCC_5
2	/VSYNC	9	ANALOG_BLU
3	/HSYNC	10	VGA_EIC_DAT
4	RED_RTN	11	VGA_EIC_CLK
5	ANALOG_RED	12	GND
6	GRN_RTN	13	MON_DETECT
7	ANALOG_GRN	14	BLU_RTN

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)

Devices and Ports

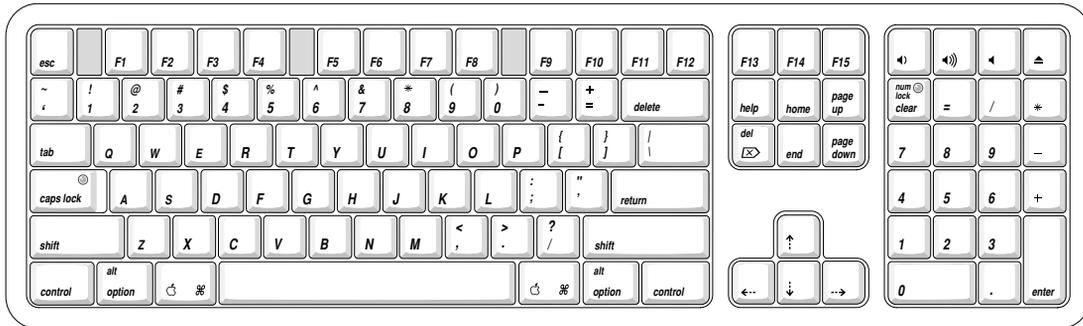
- 15 function keys, programmable by the user
- 6 editing keys (Page Up, Page Down, Home, End, Forward Delete, and Help)
- USB multi-media control keys (Volume Up, Volume Down, and Mute)
- Media eject key
- Full travel, standard pitch keys on alphanumeric, editing, and keypad sections, including function 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 3-3](#) (page 40) 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 3-3 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 keyboard has four multi-media keys: Volume Up, Volume Down, Mute, and Eject. They provide direct control of 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.

Devices and Ports

WARNING

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

The standard NMI and reset key combinations are available, but the keys are decoded in software and may not be available under some crashed conditions.

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 56).

Mouse

The iMac comes with an Apple Pro Mouse. 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 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 Speaker minijack, and the USB ports.

Note: Some configurations come with Apple Pro Speakers.

Devices and Ports

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 four 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

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 Tumbler audio circuitry.

The nominal SNR of the internal microphone is 65 dB.

Sound Outputs

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

- internal speaker
- Apple Speaker minijack
- stereo headphone jack
- USB audio devices connected to the USB ports

Internal Speaker

The iMac computer 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 Speaker Minijack

The Apple 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.

W A R N I N G

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 speaker minijack. Doing so could cause damage to the devices.

The Apple Speakers include an internal ROM that enables the computer to identify the speakers. Speakers other than the Apple Speakers should not be connected to the Apple Speaker minijack.

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 Speaker minijack are disconnected.

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

- output level 2.0 V peak-to-peak (0.7 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 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 3-9](#) (page 44).

Table 3-9 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 3-10](#) (page 44). The values shown are unweighted.

Table 3-10 SNR specifications

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

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. One of the slots accepts a standard PC133 168-pin DIMM (dual inline memory modules) and is occupied by the factory-installed RAM. The other slot accepts a standard PC133 144-pin SO-DIMM and is normally used for added RAM.

Note: Only the SO-DIMM slot is accessible by the user. (The access panel is on the bottom of the computer.)

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 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.

RAM Expansion Modules

The iMac (Flat Panel) computer uses two types of RAM expansion modules: one 168-pin DIMM and one 144-pin SO-DIMM. Both expansion modules for the iMac are 3.3 volt, unbuffered, 8-byte, non-parity, and PC133 compliant. The speed of the SDRAM devices must be rated at 125 MHz (8 ns) or faster.

A DIMM for the iMac computer can contain either 128, 256, or 512 MB of memory; an SO-DIMM can contain either 64, 128, 256, or 512 MB of memory.

Important

RAM expansion DIMMs for the iMac must be PC133 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.

The sections that follow describe the 144-pin SO-DIMM for the user-accessible expansion slot. Because the 168-pin DIMM slot is not accessible to the user, its specifications are not given here.

Mechanical Design of the SO-DIMM

The mechanical characteristics of the SO-DIMM are given in the JEDEC specification for the 144-pin 8-byte DRAM SO-DIMM. The specification number is JEDEC MO-190-C. To find out how to obtain the specification, see [“RAM Expansion Modules”](#) (page 46).

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 any height up to the maximum specified.

The JEDEC specification defines the maximum depth or thickness of an SO-DIMM as 3.8 mm. That specification is also a maximum: Modules that exceed the specified thickness can cause reliability problems.

Electrical Design of the SO-DIMM

The SO-DIMM is required to be PC133 compliant. For information about the PC133 SDRAM specification, see the references at “RAM Expansion Modules” (page 54).

The electrical characteristics of the RAM SO-DIMM are given in section 4.5.6 of the JEDEC Standard 21-C, release 7. To obtain a copy of the specification, see the references listed at “RAM Expansion Modules” (page 54).

The JEDEC and PC133 specifications define several attributes of the DIMM, including storage capacity and configuration, connector pin assignments, and electrical loading. The specifications support 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 Macintosh computers 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 (144 Pin SDRAM SO-DIMM, PD INFORMATION) of the JEDEC standard 21-C specification, release 7.

Capacitance of the data lines must be kept to a minimum. Individual DRAM devices should have a pin capacitance of not more than 5 pF on each data pin.

SDRAM Devices in the SO-DIMM

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 100 MHz or greater.

The devices are programmed to operate with a CAS latency of 3. At that CAS latency, the access time from the clock transition must be 6 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.

RAM Expansion

Configuration of RAM SO-DIMM

Table 4-1 (page 48) shows information about the different sizes of SDRAM devices used in the SO-DIMM. The first two columns show the memory size and configuration of the SO-DIMMs. The next two columns show the number and configuration of the SDRAM devices making up the memory modules.

Table 4-1 Sizes of RAM expansion modules and devices

SO-DIMM size	SO-DIMM configuration	Number of devices	Device configuration	Number of banks
64 MB	8 M x 64	8	8 M x 8	1
64 MB	8 M x 64	8	4 M x 16	2
64 MB	8 M x 64	4	8 M x 16	1
128 MB	16 M x 64	8	16 M x 8	1
128 MB	16 M x 64	8	8 M x 16	2
256 MB	16 M x 64	16	16 M x 8	2
256 MB	16 M x 64	16	8 M x 16	4
256 MB	32 M x 64	8	32 M x 8	1
256 MB	32 M x 64	8	16 M x 16	2
512 MB	64 M x 64	16	32 M x 8	2

SO-DIMM Address Multiplexing

Signals A[0] – A[12] and BA[0] – BA[1] on each SO-DIMM make up a 15-bit multiplexed address bus that can support several different types of SDRAM devices. Table 4-2 (page 49) lists the types of devices that can be used in the SO-DIMM slot by size, configuration, and sizes of row, column, and bank addresses.

RAM Expansion

Important

The SO-DIMM slot in the iMac computer supports only the types of SDRAM devices specified in [Table 4-2](#) (page 49). Other types of devices should not be used.

Table 4-2 Types of DRAM devices

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

C H A P T E R 4

RAM Expansion

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/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>

Apple Technotes

Apple Technotes answer many specific questions about the operation of Macintosh computers and the Mac OS. The technotes are available on the Technote 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://www.mot.com/SPS/PowerPC/index.html>

Velocity Engine (AltiVec)

Velocity Engine is Apple's name for the AltiVec vector processor in the PowerPC G4 microprocessor. Apple provides support for developers who 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/hardware/altivec/index.html>

Supplemental Reference Documents

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.mot.com/SPS/PowerPC/AltiVec/facts.html>

Mac OS X

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

<http://developer.apple.com/macosx/>

Mac OS 9.2

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 9.2. 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>

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>

Another Technote tells how to debug open firmware code. Please refer to TN 2004: Debugging Open Firmware Using Telnet, available on the Technote web site at

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

RAM Expansion Modules

The iMac uses a 168-pin SDRAM DIMM and a 144-pin SO-DIMM for memory expansion.

The mechanical characteristics of the DIMM are given in the JEDEC specification number JEDEC MO-161. The specification can be found by using the search string MO161 on the Electronics Industry Association's website at

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

Supplemental Reference Documents

The mechanical characteristics of the DIMM and the SO-DIMM are given in JEDEC specification MO-190. The specification can be found by using the search string MO190-C 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. 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>

The RAM DIMM and SO-DIMM are required to be the PC133 compliant. Information about the PC133 specification is available from Intel's web site, at

<http://developer.intel.com/technology/memory/pcsdram/>

ATA Interface

The implementation of the ATA interface on recent Macintosh computers is a subset of the ATA/ATAPI-4 specification (ANSI NCITS 317-1998 AT Attachment - 4 with Packet Interface Extension). That specification is maintained by the National Committee on Information Technology Standards (NCITS) Technical Committee T13. More information is available on their website at

<http://www.t13.org/>

ATA Manager 4.0 supports driver software for internal IDE drives and includes DMA support. For the latest information about ATA Manager 4.0, see Technote #1098, ATA Device Software Guide Additions and Corrections, available on the world wide web at

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

The web page for Technote #1098 includes a link to a downloadable copy of ATA Device Software Guide.

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>

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

<http://www.usb.org/developers/hidpage.html>

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/>

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://developer.apple.com/hardware/FireWire/index.html>

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

http://standards.ieee.org/reading/ieee/std_public/description/busarch/1394-1995_desc.html

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

<http://www.1394ta.org/>

Target Disk Mode

For more information about Target Disk mode, see the section “Target Mode” in Technote 1189, The Monster Disk Driver Technote. The technote is available on the Technote website at

<http://developer.apple.com/technotes/tn/tn1189.html>

Wireless Networks

More information about Wi-Fi and wireless networks using the IEEE 802.11 standard is available on the web site of the Wireless Ethernet Compatibility Alliance, at

<http://www.wirelessethernet.org/index.html>

A P P E N D I X A

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

A P P E N D I X B

Abbreviations

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-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
DDR	double data rate, a type of SDRAM
DSSS	direct-sequence spread-spectrum
DV	digital video
EDO	extended data out
EEPROM	electrically erasable programmable ROM
G3	Generation 3, the third generation of PowerPC microprocessors
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

A P P E N D I X B

Abbreviations

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
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

A P P E N D I X B

Abbreviations

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
Wi-Fi	Logo used by the Wireless Ethernet Compatibility Alliance for certification of interoperability of 802.11 products

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