
iMac G5 Developer Note

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Apple Inc.
1 Infinite Loop
Cupertino, CA 95014
408-996-1010

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Introduction to iMac G5 Developer Note

This developer note gives a technical description of the 17" and 20" iMac G5. The note provides information about the computer's internal design, input-output features, and expansion capabilities.

This developer note is intended to help hardware and software developers design products that are compatible with the products described here. If you are not already familiar with Macintosh computers or if you would simply like additional technical information, you should refer to ["Supplemental Reference Documents"](#) (page 49).

Organization of This Document

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

- [Chapter 1, "Overview of the iMac G5"](#), (page 11) introduces the configurations, describes the 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 for the computer.
- [Chapter 4, "RAM Expansion"](#), (page 45) includes development guidelines for the RAM expansion modules for the computer.
- [Appendix A, "Supplemental Reference Documents"](#), (page 49) tells where to find more information about specific technologies used in the iMac G5.
- [Appendix B, "Abbreviations"](#), (page 55) lists the standard units and abbreviations used in this developer note.

Overview of the iMac G5

This chapter provides an overview of the hardware and software features of the current models of the iMac G5.

Feature Set

Below is a list of the features of the iMac G5. Each feature is described in more detail in a later section and the various configurations are summarized in [Table 1-1](#) (page 13).

- **Processor speed:** The microprocessor in the iMac G5 is a PowerPC G5 with a clock speed of 1.6 GHz or 1.8 GHz. For more information, see [“PowerPC G5 Microprocessor”](#) (page 49).
- **Processor system bus:** The processor interface system bus runs at one-third the speed of the system processor. For more information, see [“Memory Controller”](#) (page 19).
- **Cache:** The backside 512 KB L2 cache is included on the microprocessor IC and has the same clock speed as the microprocessor.
- **Memory:** The computer comes with 256 MB of DDR400 (PC3200) SDRAM installed in one 184-pin DIMM expansion slot; a second slot is available for expansion. The maximum supported memory is 2 GB. For more information, see [“Main Memory Bus”](#) (page 20).
- **Hard disk storage:** The education configuration has a 5400 rpm, built-in UATA/100 hard disk with a capacity of 40 GB. The retail configurations have a 7200 rpm, built-in Serial ATA (SATA) hard disk with a capacity of 80 GB or 160 GB with a build-to-order option of 250 GB. For more information, see [“Hard Disk Drive”](#) (page 32).
- **SuperDrive:** The 20” configuration and some 17” configurations of the iMac G5 have a SuperDrive. The education configuration does not have an optical drive. For more information, see [“SuperDrive”](#) (page 33).
- **Combo drive:** One 17” configuration of the iMac G5 have a combination CD-RW/DVD-ROM drive. The education configuration does not have an optical drive. For more information, see [“Combo Drive”](#) (page 33).
- **Display:** The iMac G5 has a built-in 20-inch widescreen flat-panel or a 17-inch widescreen flat-panel (measured diagonally). For more information, see [“Flat Panel Display”](#) (page 34).
- **USB 2.0 ports:** The computer has three USB 2.0 ports; see [“PCI USB Controller”](#) (page 21).
- **Graphics acceleration:** The computer has an AGP 3.0 8x accelerated graphics IC installed. For more information, see [“Accelerated Graphics Port Bus”](#) (page 20).
- **Graphics IC:** The retail configurations have the NVIDIA GeForce FX 5200 Ultra with 64 MB RAM; the education configuration has the NVIDIA GeForce4 MX with 32 MB RAM. For more information, see [“Graphics ICs”](#) (page 24).

- **External video port:** The external display connector supports VGA, composite and S-video formats for devices such as monitors, projectors, and television sets. Available separately are the Apple VGA adapter to connect with a VGA display and a video adapter with composite and S-video connectors. For more information, see [“Video Monitor Port”](#) (page 35).
- **FireWire 400 ports:** The iMac G5 has two IEEE-1394a FireWire 400 ports, which support transfer rates of 100, 200, and 400 Mbps. For more information, see [“FireWire 400 Connector”](#) (page 27).
- **Target disk mode:** The computer can be configured like a FireWire storage device connected to another computer. See [“Target Disk Mode”](#) (page 29).
- **Modem:** The retail configurations of the computer have a built-in 56 Kbps modem supporting K56flex, V.90, and V.92 modem standards. The education configuration does not have a modem. For more information, see [“Internal Modem”](#) (page 31).
- **Ethernet:** The iMac G5 has a built in Ethernet port for a 10Base-T and 100Base-TX operation. For more information, see [“Ethernet Port”](#) (page 29).
- **AirPort Extreme (optional):** A 54 Mbps AirPort Extreme Card is available as a build-to-order option or as a user-installable upgrade. For more information, see [“Wireless LAN Module”](#) (page 22).
- **Bluetooth (optional):** Fully-integrated Bluetooth is available as a build-to-order option to enable short-range wireless connections between desktop and laptop computers and a host of other peripheral devices. For more information, see [“Bluetooth Technology”](#) (page 32).
- **Sound:** The iMac G5 includes built-in stereo speakers and microphone, combination stereo headphone jack and S/PDIF output jack, and analog audio line-in. For more information, see [“Sound System Overview”](#) (page 23).
- **Keyboard:** The iMac G5 comes with an Apple Keyboard. The keyboard is also a USB hub with two USB 1.1 ports. For more information, see [“Keyboard Features”](#) (page 37).
- **Mouse:** The iMac G5 comes with an Apple Mouse, a USB mouse with optical tracking. For more information, see [“Mouse”](#) (page 40).
- **Power supply:** The computer comes with a 180 W power supply.
- **Energy saving:** Processor performance can be set to automatic (default), highest, or reduced via the Energy Saver pane in System Preferences.
- **Energy saving:** The system can be set to go to sleep at a determined idle time.

Note: While in sleep mode, the computer emits no noise and the power light pulses slowly. When the display is asleep, the power light stays on.

- **Wireless keyboard and mouse:** The Apple wireless keyboard and mouse are available as build-to-order options and require built-in Bluetooth.

Configuration Summary

The table below summarizes the main features of the iMac G5 features.

Table 1-1 iMac G5 Configuration Summary

	Education config	17" config	17" config	20" config
Processor	1.6 GHz			1.8 Hz
Frontside bus	533 MHz			600 MHz
Memory	256 MB of PC3200 (400 MHz) DDR SDRAM; supports up to 2 GB			
Hard drive	40 GB UATA/100	80 GB SATA 7200 rpm		160 GB SATA 7200 rpm
Optical drive	none	slot-loading Combo drive	slot-loading SuperDrive	
Display	17" widescreen, TFT active-matrix, 1440x900 pixels			20" widescreen, TFT active-matrix, 1680x1050 pixels
Graphics support	NVIDIA GeForce4 MX with 32 MB RAM	NVIDIA GeForce FX 5200 Ultra with 64 MB RAM		
Comm ports	two FireWire 400, three USB 2.0, two USB 1.1 (on keyboard)			
Networking	built-in 10/100BASE-T Ethernet and 56K V9.2 modem			
Wireless support	AirPort Extreme ready; internal Bluetooth module available as build-to-order option			

System Software

The iMac G5 comes with Mac OS X version 10.3.5 installed. The classic environment can be used to run Mac OS 9 applications. Install the Classic application from the "Additional Hardware and Apple Software Test" CD shipped with your computer. For more information about Mac OS X, see the reference listed in "[Mac OS X](#)" (page 50).

Machine Identification

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

Asset management software that reports the kind of machine it is run on can obtain the value of the property at `Devices:device-tree:compatible` in the IODeviceTree Plane of the IO Registry. The model string is the first program-usable string in the array of C strings in the `compatible` field. The value of the string in the `compatible` property is `PowerMac8,1`.

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

Power Management

The power management techniques implemented in the iMac G5 are described in the following paragraphs.

Processor Power Step

To lower power consumption, the iMac G5 computer incorporates an automatic power management technique called power stepping. Power stepping is designed to run at high processor and bus speeds and high voltage when the demand on the processor is high, and to run at low processor and bus speeds and low voltage when the demand on the processor is low. The stepped processor speed is either 900 MHz or 1.8 GHz for the 1.8 GHz processor or 800 MHz or 1.6 GHz for the 1.6 GHz processor. Switching between different processor/bus speeds and voltages is achieved by a very fast transition that is designed to minimally impact system or application performance and typically operates seamlessly to the user.

In addition, the iMac G5 computer allows the user to control speed of the processor and bus. The options for specifying either high, reduced, or automatic processor and bus speeds are located at System Preferences>Energy Saver>Options; then select Automatic (default), Highest, or Reduced.

Note: For best performance when using professional applications with high demand on the system (such as Final Cut Pro or Logic), you may want to set the processor/bus speed option to highest.

If the iMac G5 computer detects a system temperature that is too high, due to high ambient temperatures or other factors, it will automatically reduce the processor and bus speed regardless of the selected setting. If the temperature continues to be too high, the operating system will cause the system to enter sleep mode.

Processor States

The following processor states are defined:

- **Run:** The system is running at maximum processing capacity with the processor running at full speed.
- **Idle:** The system is idling; this is the default state. All clocks are running and the system can return to running code within a few nanoseconds. If the system has no work to do, it will be in idle mode.

From idle, the processor will enter deep nap state when the system is power-stepped to half frequency. In this state, the processor's internal frequency is reduced to 1/64 of the maximum frequency. The processor frequency is returned to normal on exit from idle. The exit from idle takes a bit longer than the regular idle nap but is still in the nanoseconds.

System Modes

The Macintosh system has the following power-saving modes, which are set in the Energy Saver pane. If the system does not support full sleep, it will use the less efficient doze mode.

- **Run:** The system is fully functional in normal operating mode with all components powered and operating.
- **Doze (default):** The power to the disk drive motors and the display is turned off, but the power supply and fans are still on.
- **Full sleep:** The main power supply is shut down. A trickle supply provides auxiliary power and keeps the DRAM state preserved for a quick recovery. The processor is powered off with its state preserved in DRAM. All non-essential clocks in the system are suspended. This mode allows the computer to meet

Energy Star sleep requirements while providing the ability to start up without rebooting. This system may be awakened by administrative network packets, keyboard or mouse activity, USB device insertion or removal, or SMU scheduled wakeup.

- Off: The iMac G5 meets FEMP (Federal Energy Management Program) requirements and supports FireWire ports functioning as repeaters when operating on AC power.

Velocity Engine Acceleration

The Velocity Engine (an implementation of AltiVec) is the vector processing unit in the PowerPC G5 microprocessor. Some system software has been modified to take advantage of the accelerated processing that the Velocity Engine makes possible. System software has also been modified to support low-level operations using the Velocity Engine.

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

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

For more information, please see the references at “[Velocity Engine](#)” (page 49).

Architecture

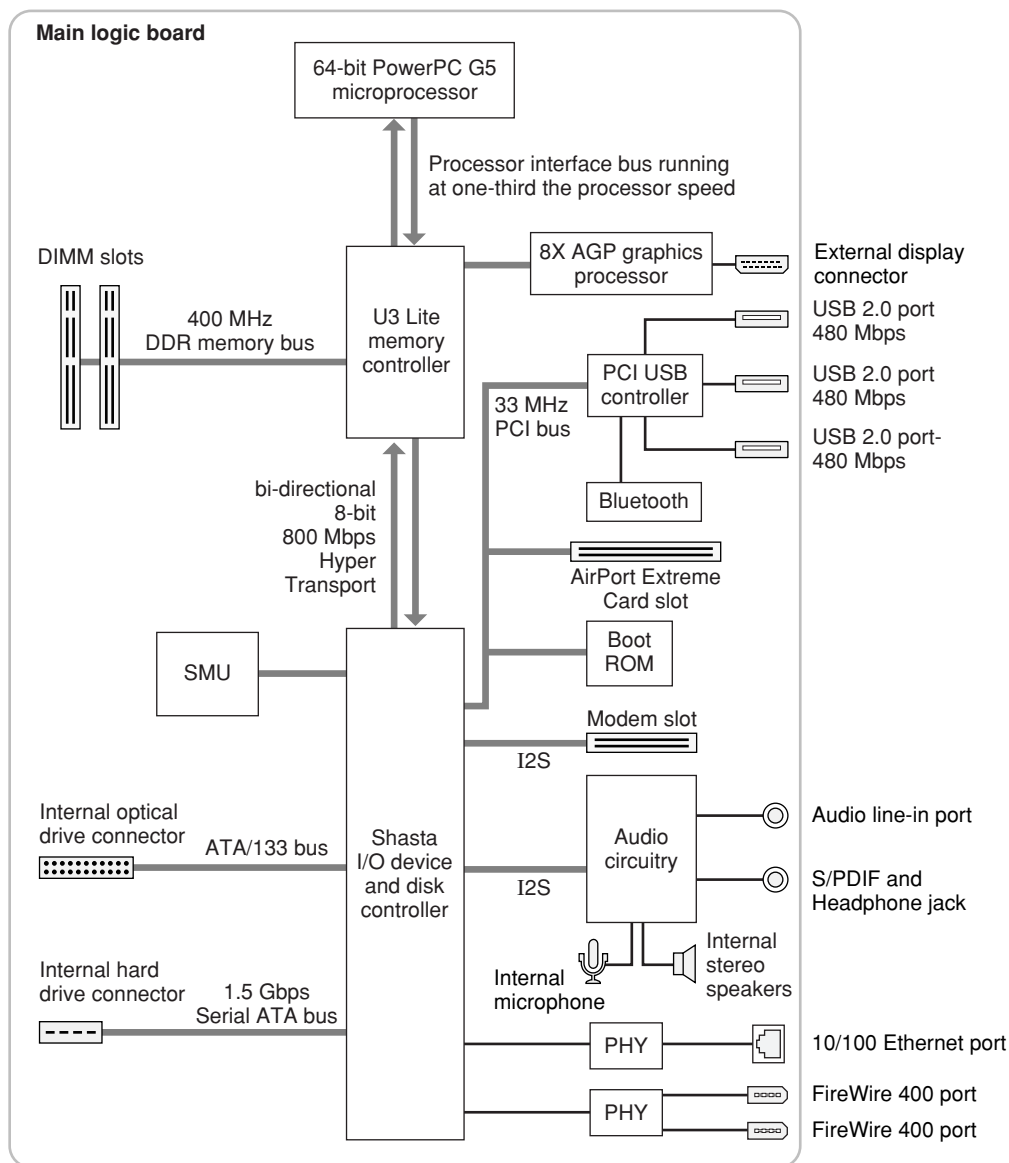
This chapter describes the architecture of the iMac G5. It includes information about the major components on the main logic board: the microprocessor, the other main ICs, and the buses that connect them to each other and to the I/O interfaces.

Block Diagram and Buses

The architecture of the iMac G5 is based on the PowerPC G5 microprocessor, and two custom ICs: the U3L memory controller and the Shasta I/O controller.

[Figure 2-1](#) (page 18) provides a simplified block diagram of the U3L and Shasta ICs and the buses that connect them together.

Figure 2-1 Block diagram



The iMac G5 has the following data buses, not counting the processor's dedicated interface to the backside cache.

- Processor bus: up to 600 MHz (running at one-third the speed of the processor), 2 unidirectional buses that deliver 64-bit data throughput connecting the processor to the U3L IC
- Memory bus: 400 MHz, bus connecting the main DDR SDRAM memory to the U3L IC is 64-bit if only one DIMM is installed, two 64-bit buses if two non-identical DIMMs are installed, or 128-bit if two identical DIMMs are installed (for additional information, refer to ["RAM Expansion"](#) (page 45))
- 8x AGP bus: 533 MHz, 32-bit bus connecting the AGP graphics IC to the U3L IC
- Internal PCI bus: 33 MHz, 32-bit bus supports the Shasta I/O controller, the boot ROM, the AirPort Extreme Card slot, and the USB controller

- Serial ATA (SATA) buses: non-education configurations support 1.5 Gbps internal hard drive connector
- Ultra ATA/133 bus: supports internal optical drive or hard drive. The education configuration has a factory-installed Ultra ATA/100 hard drive and no optical drive.
- HyperTransport: high-speed, bidirectional, point-to-point link for integrated circuits supports bidirectional data rates up to 800 MBps

The remainder of this chapter describes the architecture of the U3L memory controller, the Shasta I/O controller IC, and the USB controller.

PowerPC G5 Processor

The PowerPC G5 used in the iMac G5 has the following features:

- 64-bit PowerPC implementation with 42-bit physical memory addressing
- core runs at three times the bus speed
- superscalar execution core supporting more than 200 in-flight instructions
- two independent double-precision floating point units
- Velocity Engine: 128-bit-wide vector execution unit
- 64K L1 instruction cache, 32K L1 data cache
- built-in 512 KB backside L2 cache
- two independent, unidirectional up to 600 MHz frontside buses supporting 4.8 GBps data throughput

For more information, see the reference at [“PowerPC G5 Microprocessor”](#) (page 49).

Memory Controller

The U3L custom IC provides the bridging functionality among the processor, the memory system, HyperTransport bus, and the AGP bus.

Processor Bus

The processor bus is an up to 600 MHz bus connecting the processor to the U3L IC. The bus has 32-bit wide data running in both directions. The processor has 42-bit wide addresses.

The iMac G5 system controller is built with 90-nanometer SOI technology. This point-to-point architecture provides each subsystem with dedicated bandwidth to main memory. The U3L I/O implements an independent processor interface. The processor clock rate is either 900 MHz or 1.8 GHz for the 1.8 GHz processor or 800 MHz or 1.6 GHz for the 1.6 GHz processor and connects to the I/O through the processor interface. The processor clock is derived from a PLL which multiplies the reference clock by preset intervals of 12 times.

Out-of-order completion allows the memory controller to optimize the data bus efficiency by transferring whichever data is ready, rather than having to pass data across the bus in the order the transactions were posted on the bus. This means that a fast DDR SDRAM read can pass a slow PCI read, potentially enabling the processor to do more before it has to wait on the PCI data.

Main Memory Bus

The iMac G5 main memory bus connects the main memory to the U3L IC via the 128-bit data bus. The memory modules are 400 MHz (PC3200) DDR SDRAM DIMMs. Maximum system memory is 2 GB.

Standard supported DIMM sizes are 128, 256, 512 MB, and 1 GB. The DIMMs must be unbuffered.

For more information about memory DIMMs and installation, see [“RAM Expansion”](#) (page 45).

Accelerated Graphics Port Bus

The accelerated graphics port (AGP 8x) bus is a 533 MHz, 32-bit bus connecting the AGP IC to the U3L IC. DDR data is transmitted at both edges of the clock for peak transfers of 2.1 GBps.

The AGP bus is an enhanced PCI bus with extra functionality to burst texture data and other graphics across the port up to 8 times faster than a 66 MHz PCI port. The iMac G5 computer’s AGP implementation is compatible with version 3 of the AGP specification and with the Pro version of AGP. AGP 3.0 enables deeply pipelined memory read and write operations and demultiplexing of address and data on the bus.

To further improve the performance of the AGP bus, the U3L IC supports a graphics address remapping table (GART). Because the virtual memory system organizes main memory as randomly distributed 4 KB pages, DMA transactions for more than 4 KB of data must perform scatter-gather operations. To avoid this necessity for AGP transactions, the GART is used by the AGP bridge in the U3L to translate a linear address space for AGP transactions into physical addresses in main memory.

The U3L IC also supports a DMA Address Relocation Table (DART) that provides the same functions for AGP as does the GART, except that the functions are for devices attached to HyperTransport. Most device drivers do not require special knowledge of the DART because IOKit will configure it automatically if the driver uses `IOMemoryDescriptors`.

For more information on the graphics IC installed in the AGP bus, refer to [“Graphics ICs”](#) (page 24).

Internal PCI Bus

An internal 33 MHz PCI bus connects the Shasta I/O controller to the boot ROM, the AirPort Extreme Card slot, and the USB controller. The U3L IC used in the iMac G5 supports the PCI write combining feature. This feature allows sequential write transactions involving the Memory Write or Memory Write and Invalidate commands to be combined into a single PCI transaction. For memory write transactions to be combined, they must be sequential, ascending, and non-overlapping PCI addresses. Placing an `eiio` or `sync` command between the write commands prevents any write combining.

HyperTransport Technology

The DDR HyperTransport is an advanced chip-to-chip communications technology that provides a high-speed, high-performance, point-to-point link for integrated circuits. HyperTransport provides a universal connection that reduces the number of buses within a system.

The HyperTransport bus between the U3L IC and the Shasta IC is 400 MHz DDR, 8 bits wide in both directions, supporting total of 800 MBps bidirectional throughput.

For more information on the HyperTransport technology, go to the World Wide Web at

<http://www.hypertransport.org>

PCI USB Controller

The iMac G5 CPU uses a PCI USB controller ASIC with one Enhanced Host Controller Interface (EHCI) function and two Open Host Controller Interface (OHCI) functions. The controller has a total of four ports available to support three external USB ports and the Bluetooth module.

The four USB ports comply with the Universal Serial Bus Specification 2.0. The USB register set complies with the EHCI and OHCI specifications. For more information, see “USB Ports” (page 25).

Shasta I/O Controller

The functions of the Shasta I/O controller are described in the following sections.

DMA Support

The Shasta ICs provide DB-DMA (descriptor-based direct memory access) support for the following I/O channels:

- Ultra ATA/133 bus
- Ethernet interface
- FireWire interface
- I2S channel to the sound subsystem
- Serial ATA

The DB-DMA 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.

Wireless LAN Module

The optional AirPort Extreme wireless LAN module connects via the PCI interface.

The AirPort Extreme Card wireless LAN module contains a media access controller (MAC), a digital signal processor (DSP), and a radio-frequency (RF) section. The module connects to an internal antenna.

The AirPort Extreme Card is compliant with the IEEE 802.11g standard. The card transmits and receives data at up to 54 Mbps and is compatible with Apple AirPort systems as well as other 802.11b and 802.11g Wi-Fi certified products. For information about its operation, see [“AirPort Extreme Card”](#) (page 30).

The build-to-order Bluetooth connectivity comes off the USB controller. See [“Bluetooth”](#) (page 52) for more information.

Modem Slot Support

The Shasta IC supports the modem and provides DB-DMA (descriptor-based direct memory access) support for the modem slot interface. The modem is connected via an I2S interface.

The internal hardware modem is a separate module that contains a modem controller IC, a data pump, and the interface to the telephone line (DAA). For more information about the modem, see [“Internal Modem”](#) (page 31).

Boot ROM

The boot ROM consists of 1 MB of on-board flash EEPROM. The boot ROM includes the hardware-specific code and tables needed to start up the computer using Open Firmware, to load an operating system, and to provide common hardware access services.

Ethernet Controller

The Shasta IC provides the Ethernet functions and includes an Ethernet media access controller (MAC) and PHY.

The MAC implements the link layer. It is connected to a PHY that is internal to Shasta and provides 10Base-T/UTP or 100Base-TX operation over a standard twisted-pair interface. The Ethernet port is auto-sensing and self-configuring to allow use of either a cross-over or straight-through cable. The operating speed of the link is automatically negotiated by the PHY and the bridge, router, hub, switch, or other Mac or PC to which the Ethernet port is connected.

For information about the Ethernet port, see [“Ethernet Port”](#) (page 29).

FireWire Controllers

The Shasta IC provides the FireWire functions and includes a FireWire controller that supports IEEE 1394a (FireWire 400) with a maximum data rate of 400 Mbps (50 MBps). The Shasta IC provides DMA (direct memory access) support for the FireWire interface.

The controller in the Shasta IC implements the FireWire link layer. Vesta is a PHY that implements the electrical signaling protocol of the FireWire interface and provides the electrical signals to the ports.

For more information, see [“FireWire 400 Ports”](#) (page 27).

Interrupt Support

The interrupt controller for the iMac G5 system is an MPIC cell in the Shasta IC. In addition to accepting internal interrupt sources from the I/O, the MPIC controller accepts internal interrupts from U3L and dedicated interrupt pins.

Serial ATA Interface

Based on the Serial ATA 1.0 specification, Serial ATA (SATA) is a disk-interface technology that delivers up to 1.5 Gbps of performance to an independent drive bus on the iMac G5. It provides a scalable, point-to-point connection that allows multiple ports to be aggregated into a single controller. Serial ATA uses a thin, point-to-point cable connection that enables easy routing within a system, avoiding master/slave, daisy-chaining, and termination issues and enabling better airflow within a system.

For information about the drive bay, see [“Hard Disk Drive”](#) (page 32).

Ultra ATA/133 Interface

In the iMac G5 computer, the Shasta IC provides an Ultra ATA/133 interface to support an optical drive or hard drive. For information about specific drives, see [“Hard Disk Drive”](#) (page 32).

Sound System Overview

The sound circuitry is connected to the Shasta IC by a standard I2S (inter-IC sound) bus. The Shasta IC provides DB-DMA (descriptor-based direct memory access) support for the I2S port.

The iMac G5 circuitry is implemented with an analog/digital audio CODEC IC (CODEC) and supporting input/output circuitry. The CODEC includes a microphone preamp, an A/D converter, a D/A converter, and a S/PDIF (Sony/Phillips Digital Interface) digital audio transmitter.

The CODEC connects to Shasta over the I2S bus. Stereo signals from the audio input jack are routed to an analog line input amplifier that drives the internal A/D converter in the CODEC. The output of the A/D converter in the CODEC is routed to the Shasta IC over the I2S bus. Digital audio data from the Shasta IC is routed to the D/A converter in the analog CODEC over the I2S bus. The analog audio output from the D/A converter in the CODEC is routed to separate amplifiers that drive the headphones output and internal speakers.

The iMac G5 has a built-in microphone located at the bottom of the display. The analog signal from the microphone is routed to the microphone preamp in the CODEC, which is then routed to the A/D converter in the CODEC.

For more detail on the audio, see [“Audio”](#) (page 40).

Graphics ICs

The iMac G5 the graphics IC is an NVIDIA GeForce4 MX with 32 MB DDR RAM in the education configuration or an NVIDIA GeForce FX 5200 Ultra with 64 MB DDR RAM in the retail configurations. Both graphics controllers contain 2D and 3D acceleration engines, front-end and back-end scalars, a display controller, and an AGP 3.0 8x bus interface with bus master capability.

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

The display generated for the flat panel display is simultaneously available for an external monitor in mirror mode; see ["Video Monitor Port"](#) (page 35). For information about the display and supported resolutions, see ["Flat Panel Display"](#) (page 34). Composite video and S-video signals can be displayed on either an NTSC display or a PAL display; see ["Video Display Adapter"](#) (page 37).

System Management Unit

The iMac G5 uses an advanced system management unit (SMU) to manage the thermal and power conditions, while keeping the acoustic noise to a minimum.

Note: There is a separate real time clock that has 56 bytes of battery backed up RAM.

The iMac G5 system employs advanced thermal and power management to keep acoustic noise to a minimum. The system brings in cool air from the bottom of the enclosure, directing it over system components and exhausting it out the top. Temperature and power consumption are monitored by the operating system which communicates with the SMU, which in turn controls and monitors fan operation. If Mac OS X is not booted, thermal management must be provided by the alternate development operating system.

Note: If Mac OS X is not booted and the alternate development operating system does not manage the fans, the fans go into an unmanaged state and run at full speed.

The SMU controls the fans in the iMac G5 and regulates the speeds to run each fan. The SMU derives fan speed from sensors, some of which monitor thermal only, while others monitor both thermal and power.

If the SMU does not receive an update from the operating system within two minutes, it begins to ramp up the speed of the fans to full speed.

Devices and Ports

This chapter describes both the built-in I/O devices and the ports for connecting external I/O devices on the iMac G5. Each of the following sections describes an I/O port or device.

USB Ports

The iMac G5 has three external Universal Serial Bus (USB) 2.0 ports on the enclosure and an internal connection supports the Bluetooth module. The external USB ports are off of the USB controller connected to the PCI bus, bridged by Shasta. In addition, there are two USB 1.1 ports on the keyboard. The USB ports are used for connecting the keyboard and mouse as well as additional I/O devices such as printers, scanners, and storage devices.

The three external USB ports on the iMac G5 are fully compliant with the USB 2.0 specification, including support for high-speed (480 Mbps) devices using an Enhanced Host Controller Interface (EHCI). Ports are automatically routed to a companion OHCI controller when a classic-speed (full-speed or low-speed) USB device is attached to a root hub port.

The three external USB ports comply with the Universal Serial Bus Specification 2.0. The two ports on the keyboard comply with the Universal Serial Bus Specification 1.1 Final Draft Revision. For low-speed and full-speed devices, the USB register set complies with the Open Host Controller Interface (OHCI) specification. For high-speed devices, the USB register set complies with the Enhanced Host Controller Interface (EHCI) specification.

For more information about USB on Macintosh computers, please refer to Apple Computer's *Accessing Hardware from Applications* and the other sources listed in ["USB Interface"](#) (page 51).

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 25) 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

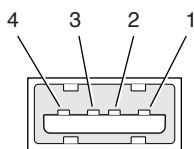


Table 3-1 Signals on the USB port

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

The iMac G5 provides 5-volt power to the USB 2.0 ports. The maximum current available is 500 mA on each port.

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

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

USB Features

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

Wake Up From Sleep

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

Connect and Resume

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

USB Device Drivers

Class drivers are software components that are able to communicate with many USB devices of a particular kind. If the appropriate class driver is present, any number of compliant devices can be plugged in and start working immediately without the need to install additional software. The Mac OS for the iMac G5 supports USB Mass Storage specification.

USB Controller

The iMac G5 uses an Open Host Controller Interface (OHCI) controller for USB communication. Some early USB devices (most notably keyboards) can't interoperate with an OHCI controller. Those devices are not supported by the Macintosh USB system software. The USB 2.0 controllers comply with the Enhanced Host Controller Interface (EHCI) specification.

FireWire 400 Ports

The iMac G5 has two external FireWire 400 IEEE 1394a ports. The features of the FireWire 400 ports are:

- Support serial I/O at 100, 200, and 400 Mbps (megabits per second)
- Share 8 watts of power when the computer system is on
- Support up to 62 devices

The FireWire hardware and software provided with the iMac G5 are capable of all asynchronous and isochronous transfers defined by IEEE standard 1394a.

FireWire 400 Connector

The FireWire 400 connector has six contacts, as shown in [Figure 3-2](#) (page 27). The connector signals and pin assignments are shown in [Table 3-2](#) (page 27).

Figure 3-2 FireWire 400 connector

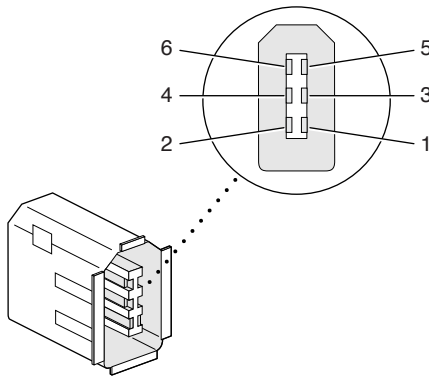


Table 3-2 Signals on the FireWire 400 connector

Pin	Signal name	Description
1	Power	approximately 24 V DC, unregulated within the FireWire spec
2	Ground	Ground return for power and inner cable shield
3	TPB–	Twisted-pair B, differential signals
4	TPB+	Twisted-pair B, differential signals
5	TPA–	Twisted-pair A, differential signals
6	TPA+	Twisted-pair A, differential signals
Shell	—	Outer cable shield

When the computer is on, the power pins provide a regulated power and 8 W shared between two ports.

Important: The FireWire PHY on the iMac G5 does not operate from external bus power. As long as the computer is plugged into an active AC power outlet, the FireWire PHY is active and the FireWire bus remains connected. If AC power is interrupted, the PHY will stop operating and data on the bus cannot be repeated.

Pin 2 of the 6-pin FireWire 400 connector is ground for both power and inner cable shield. If a 4-pin connector is used on the other end of the FireWire 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 52).

FireWire Device Programming

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

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

The specific device and protocol support in Mac OS X as provided with the iMac G5 includes the following:

- General services for Serial Bus Protocol 2 (SBP-2) and support for most mass storage devices using SBP-2, such as hard disk drives, optical drives, flash card readers, Target Disk Mode (see “[Target Disk Mode](#)” (page 29), and the iPod. Mac OS X can boot from most of these devices.
- General services for the Audio Video Control (AV/C) protocol and support for most digital video (DV) cameras and decks using this protocol, including video capture through standard QuickTime APIs.
- A QuickTime device driver for IIDC/DCAM type cameras such as the iSight.
- A network device driver supporting IP (Internet Protocol) over FireWire according to IEEE RFC 2734.
- Additional services for user-space and kernel access to all FireWire resources.

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

Bootting from a FireWire Device

The iMac G5 can boot from a FireWire storage device that implements SBP-2 (Serial Bus Protocol) with the RBC (reduced block commands) command set.

For additional information about the FireWire interface and the Apple API for FireWire device control, see the references shown in “[FireWire Interface](#)” (page 52).

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 G5 is in Target Disk Mode and connected to another Macintosh computer by a FireWire cable, the iMac G5 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 G5 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 G5 into Target Disk mode, restart the iMac G5 and hold down the T key until the FireWire icon appears on the display. Then connect a FireWire cable from the iMac G5 to the other computer. When the other computer completes the FireWire connection, a hard disk icon appears on its desktop.

If the FireWire cable is disconnected or the iMac G5 is turned off while in Target Disk Mode, an alert appears on the other computer.

To take the iMac G5 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 G5.

Ethernet Port

The iMac G5 has a built-in 10/100 Mbps Ethernet port. The user can connect it to either a 10Base-T or a 100Base-TX hub; the port will automatically sense which type of hub is connected.

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

Note: When connecting a iMac G5 computer directly to another computer without using an Ethernet hub, a crossover cable is not required; circuits in the PHY detect the type of connection and switch the signal configuration as required.

The connector for the Ethernet port is a an RJ-45 connector located on the I/O panel. [Table 3-3](#) (page 29) 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)

Pin	Signal name	Signal definition
4	–	Not used
5	–	Not used
6	RXN	Receive (negative lead)
7	–	Not used
8	–	Not used

The Ethernet interface in the iMac G5 conforms to the ISO/IEC 802.3 specification, where applicable.

AirPort Extreme Card

The iMac G5 supports the optional AirPort Extreme Card, an internal wireless LAN module. The AirPort Extreme Card is available as a build-to-order option or as a user-installable upgrade.

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

The AirPort Extreme antenna is internal to the enclosure on all configurations regardless of whether the AirPort Extreme option is installed.

Complying with the IEEE 802.11g standard, AirPort Extreme transmits and receives data at rates up to 54 Mbps. AirPort Extreme is also compatible with other Wi-Fi certified devices that comply with the IEEE 802.11b standard, including PC's. For more information about Wi-Fi and compatibility, see the reference at [“Wireless Networks”](#) (page 52).

Note: As is the case with the existing IEEE 802.11b standard, actual data throughput will be lower than the indicated maximum connection speeds.

Data Security

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

- The system uses direct-sequence spread-spectrum (DSSS) technology that uses a multibit spreading code that effectively scrambles the data for any receiver that lacks the corresponding code.
- The system can use an Access Control List of authentic network client ID values or MAC addresses (Ethernet or AirPort IDs) to verify each client's identity before granting access to the network.
- When communicating with a base station, AirPort Extreme uses up to 128-bit encryption to encode data while it is in transit.

- The AirPort Extreme Base Station can be configured to use NAT (Network Address Translation), protecting data from would-be Internet hackers.
- The AirPort Extreme Base Station can authenticate users by their unique MAC addresses (AirPort IDs), preventing unauthorized computers from logging into a network. Network administrators can take advantage of RADIUS compatibility, used for authenticating users over a remote server.

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

AirPort Extreme Hardware

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

The AirPort Extreme wireless interface is on the PCI bus.

AirPort Extreme Software

Software that is provided with the AirPort Extreme Card includes

- AirPort Setup Assistant (located in the Applications/Utilities folder), is an easy-to-use program that guides the user through the steps necessary to set up the AirPort Extreme Card or set up an AirPort Extreme Base Station or an AirPort Express Base Station.
- Users can switch between wireless networks and can create and join peer-to-peer networks. These functions are accessed via the AirPort - Menu-Extra pulldown, which is enabled by a checkbox in System Preferences.
- AirPort Admin Utility (located in the Applications/Utilities folder), is 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

Retail configurations of the iMac G5 come 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, V.92, and K56flex modem standards)
- Group 3 fax modem bit rates up to 14.4 Kbps

The modem appears to the system as an I2S device that responds to the typical AT commands. The modem provides an analog sound output for monitoring the progress of the modem connection.

Bluetooth Technology

Available as a fully-integrated, build-to-order option, Bluetooth is an open specification that enables short-range wireless connections between desktop and laptop computers and a host of other peripheral devices. Bluetooth support is built into Mac OS X and compliant with Bluetooth specification v1.1. It operates on a globally available 2.4 GHz frequency band (ISM band) for worldwide compatibility and has a maximum throughput of 1Mbps.

The Bluetooth technology supports the following profiles:

- synchronization —enables synchronization of devices over Bluetooth
- serial —provides a wireless serial connection to other Bluetooth devices
- dial-up networking (DUN) — enables a mobile phone to act as a modem
- object push —enables the transfer of files between Bluetooth devices
- human interface device (HID) — enables the use of Bluetooth input devices (keyboards and mice)
- Bluetooth file transfer profile (FTP) — enables browsing of the file system of other Bluetooth devices which support Bluetooth FTP.
- hardcopy cable replacement profile (HCRP) — describes how to send rendered data over a Bluetooth link to a device, such as a printer. Although other profiles can be used for printing, the HCRP is specially designed to support hardcopy applications. Note: currently, to use this profile, Apple's Bluetooth Update Version 1.5 must be installed.
- headset profile (HSP) — enables the use of Bluetooth-enabled wireless headsets for applications such as iChat. This profile does not enable use of Apple Speech Recognition due to the fact that it is a low-precision audio channel. Note: currently, to use this profile, Apple's Bluetooth Update Version 1.5 as well as Firmware Update Version 1.1 must be installed.
- synchronous, connection-oriented (SCO) — enables isochronous and voice communication, including most Bluetooth headsets.

Bluetooth is available as a build-to-order option, which is installed by Apple at the time of purchase as a fully integrated module. Accessing the Bluetooth capabilities without purchasing the integrated module will require a third-party dongle that may not support all present and future features supported by the internal module.

When the Bluetooth option is included on the factory order, the Bluetooth antenna is internal to the enclosure.

For more information on Bluetooth technology, refer to “Bluetooth” (page 52).

Hard Disk Drive

Depending on the configuration, the iMac G5 supports either a UATA/100 drive in the education configuration or a Serial ATA (SATA) drive in the retail configurations.

The education configuration has an internal 5400 rpm Ultra ATA/100 hard disk drive with a storage capacity of 40 GB. It conforms to a subset of ATA/ATAPI-6 and -5 protocols and is connected as Cable Select (CS) in an ATA Device 0/1 configuration. The software that supports the internal hard disk is similar to that in previous Macintosh models and includes DMA support. To obtain information about that software and about the ANSI standard for the Ultra DMA ATA interface, see [“ATA Devices”](#) (page 51).

The retail configurations support a 7200 rpm SATA hard disk drive with a capacity of 80 GB or 160 GB and a build-to-order option of 250 GB. For references to SATA website information, refer to [“Serial ATA”](#) (page ?).

SuperDrive

The 20” configuration and some 17” configurations of the iMac G5 have a slot-loading, combination DVD-R and CD-RW SuperDrive.

The drive can read and write DVD media and CD media, as shown in [Table 3-4](#) (page 33).

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

Media type	Reading speed	Writing speed
DVD-R	6x	4x, 2x, 1x depending on media
DVD-ROM	8x	–
DVD-RW	6x	2x, 1x depending on media
CD-R	24x max	16x
CD-RW	24x max	8x, 4x depending on media
CD-ROM	24x max	–

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

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

Combo Drive

Some 17” configurations of the iMac G5 have a slot-loading combination CD-RW and DVD-ROM drive.

The drive can read DVD media and read and write CD media, as shown in [Table 3-5](#) (page 33).

Table 3-5 Types of media used in the Combo drive

Media type	Reading speed	Writing speed
DVD-ROM	8x (CAV)	–

Media type	Reading speed	Writing speed
DVD-R	4x max (CAV)	–
CD-R	24x (CAV)	24x max
CD-RW	20x (CAV)	16x max (CLV) ultra speed media
CD or CD-ROM	24x (CAV)	–

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

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

Flat Panel Display

The iMac G5 supports the following three graphics configurations: the 17" with the NVIDIA GeForce4 MX with 32 MB RAM, the 17" with the NVIDIA GeForce FX 5200 Ultra with 64 MB RAM, and the 20" with the NVIDIA GeForce FX 5200 Ultra with 64 MB RAM.

Measured diagonally, the flat-panel iMac G5 has a built-in 20-inch widescreen or a 17-inch widescreen display. The display is backlit by a cold cathode fluorescent lamp (CCFL). The display uses TFT (thin-film transistor) technology for high contrast and fast response.

The 17-inch display contains 1440x900 pixels and the 20-inch display contains 1680x1050 pixels. Both graphics subsystems can show up to millions of colors.

Both displays support 3D acceleration and display depths up to 24 bits per pixel at all screen resolutions. For more information, see ["Graphics ICs"](#) (page 24).

Both graphics ICs include a scaling function that expands smaller-sized images to fill the screen. By means of the scaling function, the iMac G5 can show full-screen images at the resolutions listed in [Table 3-6](#) (page 34) for the 20" model and [Table 3-7](#) (page 35) for the 17" model.

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

Resolution	Aspect ratio	Notes
640 by 480	4:3	*
640 by 480	4:3	*stretched to fit full screen
800 by 500	16:10	*
800 by 600	4:3	
800 by 600	4:3	stretched to fit full screen
840 by 524	4:3	

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

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

Resolution	Aspect ratio	Notes
640 by 480	4:3	*
640 by 480	4:3	*stretched to fit full screen
800 by 500	16:10	*
800 by 600	4:3	
800 by 600	4:3	stretched to fit full screen
1024 by 640	16:10	
1024 by 768	4:3	
1024 by 768	4:3	stretched to fit full screen
1152 by 720	16:10	
1440 by 900	16:10	
* not recommended		

Video Monitor Port

The iMac G5 has a port for an external video monitor and supports video mirroring mode. Video mirroring mode displays the same information on both monitors, enabling the control of a presentation on one display, while allowing an audience to watch the presentation on a second display or projector.

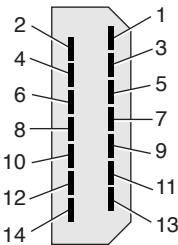
Due to display mirroring, the external monitor could have black borders during mirroring, depending on the supported timings between the two displays and on the monitor's selection algorithm. Both displays show full-sized images only when the display resolution for the second monitor is set to the first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

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

Monitor Connector

The video display connector is a 14-pin rectangular connector, Hosiden TCX3143, or compatible. The connector accepts either a VGA adapter or a composite adapter. The system requires a composite adapter to use composite output over this connector. The connector pins are identified in [Table 3-3](#) (page 29).

Figure 3-3 Video display connector



The pins and signals are listed in Table 3-8. An adapter is available for use with monitors with VGA 15-pin miniature D-type connectors.

Table 3-8 Video signals for a VGA R-G-B display

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

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

The video display connector is compliant with the VESA specification.

Video Display Adapter

The iMac G5 detects the type of display adapter that is plugged in and programs the graphics IC to route the appropriate video signals to the connector. The signal assignments on the video connector when the composite adapter is attached are shown in [Table 3-9](#) (page 37).

Table 3-9 Video signals for a TV display

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

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

Keyboard

The iMac G5 comes with an Apple Keyboard. It is a full-size keyboard with function keys and separate numeric keypad and editing sections.

The keyboard has an attached 1-meter cable and comes with a 1-meter extender cable for installations where the computer is located away from the immediate desktop area. The iMac G5 supports the Apple wireless keyboard as a build to order option, which requires built-in Bluetooth.

Keyboard Features

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

- sloped design
- 109 keys (on the ANSI versions)
- 16 function keys
- 6 editing keys (Page Up, Page Down, Home, End, Forward Delete, and Help)
- USB HID Consumer Page Usage multimedia control keys

- full travel, standard pitch keys on alphanumeric, editing, and keypad sections, including function keys and cursor-position keys
- localized worldwide: 33 versions, standard layouts (including: ANSI, JIS, ISO)
- LED indicator on the Cap Lock key
- USB hub functionality with two USB 1.1 sockets

Note: There is no power key on this keyboard.

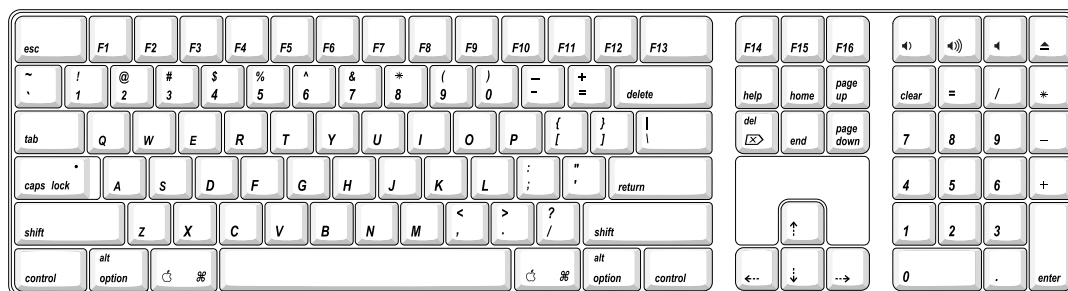
Keyboard Layout

There are localized versions of the Apple Keyboard for use in different parts of the world. The three standards used are ANSI (US and North America), JIS (Japan), and ISO (Europe).

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

Figure 3-4 (page 38) shows the keyboard layout for the ANSI keyboard.

Figure 3-4 ANSI keyboard layout



MultiMedia Control Keys

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

Keyboard and USB

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



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

Apple provides a HID class driver for the Apple Keyboard, which supports the USB boot protocol. Other keyboards intended for use on the Macintosh platform must support the HID boot protocol, as defined in the USB Device Class Definition for Human Interface Devices (HIDs).

Programmer's Switches

The list below provides helpful keyboard shortcuts to the Apple menu.

- Control-Command-Eject: restart
- Control-Command-Option-Eject: shut down
- Control-Eject: display the dialog for shutdown, restart, and sleep
- Option-Command-Eject: put system to sleep

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

NMI without Programmer's Switch

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

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

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

```
% nvram boot-args
```

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

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

After the `DB_NMI` bit in the debug parameter is set, reboot the machine. After reboot, pressing the power button for approximately 3 seconds will generate an NMI.

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

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

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

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

Mouse

The iMac G5 comes with the Apple Mouse, which uses optical tracking in place of the traditional rolling ball. It works on almost any surface, though non-reflective, opaque surface without repetitive patterns work best. The iMac G5 supports the Apple wireless mouse as a build to order option, which requires built-in Bluetooth.

Audio

The iMac G5 sound system supports analog recording and both digital and analog playback.

The iMac G5 sound system features a “Combo Output Jack” that supports both analog Headphones Output and Digital Output connectivity. Since a single connector is provided to support both Headphones Output and Digital Output connectivity, support of the Headphones Output and Digital Output is mutually exclusive. Audio output port selection is automatic. When no device is inserted into the “Combo Output Jack,” Internal Speakers are selected. When an optical cable is connected to the “Combo Out” jack then the Digital Output is selected. When an analog device is connected to the “Combo Out” jack then the Headphones Output is selected. It is not possible to simultaneously select or use more than one output at a time. Encoded audio, such as AC3, can be streamed only to the digital audio output. A mute control for the current active output port can be accessed in the Output section of the Sound panel in the System Preferences.

Digital playback features Sony / Philips Digital Interface (S/PDIF) when an optical cable is connected to the audio output combo jack. S/PDIF technology results in a clean audio signal with no added noise to or from the external audio device. The Digital Output supports both PCM and AC3 formats. Digital output encoding conforms to IEC 60958-3. The IEC 60958-3 category code encoding for non-encoded (i.e. PCM) audio formats indicates an Optical Laser – CD device. The IEC 60958-3 category code encoding for encoded (i.e. AC3) audio formats indicates an Optical Laser – DVD device.

Under control of the system software, the sound circuitry digitally creates and records sounds. The iMac G5 can receive input only from one of two analog input sources which includes a built-in microphone and Line Input. Hardware input gain control is supported over a range of –4dB to +20dB. The input gain control can be accessed using the Audio MIDI Setup application included in the “Applications/Utilities” folder.

The sound circuitry and audio device drivers support audio data in multiple formats. Both digital and analog outputs support PCM audio at 16 and 24 bits with sample rates of 32.000 KHz, 44.100 KHz, 48.000 KHz, 64.000 KHz, 88.200 KHz and 96.000 KHz. In addition, the Digital Output also supports AC3 audio at 16 bits with sample rates of 32.000 KHz, 44.100 KHz, 48.000 KHz, 64.000 KHz, 88.200 KHz and 96.000 KHz.

If audio data recorded on another computer at a sample rate not supported by the iMac G5 hardware is played on the iMac G5, the Core Audio (Mac OS X’s OS Level Audio API) transparently sample rate converts the data to the current sample rate that has been selected on the iMac G5. To maximize audio fidelity, the Core Audio samples are stored as 32-bit floating point. The Sound Manager exists as a Carbon compatibility layer, but developers are encouraged to move their applications to Core Audio for maximum performance and fidelity, because the Sound Manager is not capable of supporting bit depths greater than 16 bits or sample rates greater than 48.000 KHz. Sample rates of 64.000 KHz, 88.200 KHz and 96.000 KHz are not supported by the Sound Manager. Bit depths of 24 bits are not supported by the Sound Manager.

For more information about audio APIs on Mac OS X, visit the Apple audio technologies developer web page at

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

Digital Audio Output

Digital audio data is transmitted from the iMac G5 using an optical cable, commonly referred to as a TOSLink cable. The digital audio output format conforms to IEC60874-17.

The audio output connector on the iMac G5 is a 3.5mm electrical/optical combination (“combo”) jack. The combo jack accepts standard electrical audio cables with a 3.5 mm stereo plug, and standard TOSLink optical cables that have a 3.5 mm optical plug. Typically, TOSLink optical cables are available with standard friction-lock ktype F05 plugs on each end. Adapters are available that attach to the F-05 plug and convert it to a 3.5 mm optical plug. TOSLink cables are available from pro-audio, musician’s supply, hi-fi and other retailers.

For details on the S/PDIF digital output format and performance specifications, refer to “[Digital Audio Output Specifications](#)” (page 41).

Digital Audio Output Specifications

During playback of a 1KHz, full-scale sine wave (S/PDIF output format, 44.1KHz output sample rate, 24-bit sample depth, unless otherwise specified) the digital audio output has the following nominal specifications:

- Jack Type: 3.5mm Analog/Optical Combo Jack
- Output Data Formats: S/PDIF (IEC60958-3), AC3
- Output Sample Rates: 32KHz, 44.1KHz, 48KHz, 64KHz, 88.2KHz, 96KHz
- Bits per Sample: 16 or 24 (S/PDIF), 16 (AC3)
- Frequency Response: 20Hz – 20KHz, +/-0dB
- Signal-to-Noise Ratio (SNR): >130dB
- Total Harmonic Distortion + Noise (THD+N): <-130dB (0.00003%)
- Channel Separation: >130dB

Audio Line Input Specifications

The iMac G5 has a stereo audio line input jack on the back panel. The audio input is designed to accept audio signals with input levels ranging from 150mVRMS (-14.3dBu) to 3VRMS (+11.8dBu). The input gain should be set according to the input level so as not to clip the input to the A/D converter in the CODEC. Input gain control is supported over a range of -4dB to +20dB. The input gain control can be accessed using the Audio Midi Setup application included in the “Applications/Utilities” folder. The default input gain setting is 0dB, which will accommodate an input level of 2VRMS (+8.2dBu), which is the typical output level from CD players, DVD players and other consumer audio equipment. With an input gain setting of 20dB, the minimum recommended input level is 150mVRMS (-14.3dBu), which will correspond to 3dB below full-scale on the A/D converter in the CODEC.

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

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

During input of a 1KHz, full-scale sine wave (44.1KHz input sample rate, 24-bit sample depth, unless otherwise specified) the audio line input has the following nominal specifications:

- Jack Type: 3.5mm Analog Jack
- Input Sample Rates: 32KHz, 44.1KHz, 48KHz, 64KHz, 88.2KHz, 96KHz
- Bits per Sample: 16 or 24
- Input Impedance: > 20K Ohms
- Input Gain Range: -4dB to +20dB
- Typical Input Level (Input Gain = 0dB): 2VRMS (+8.2 dBu)
- Maximum Input Level (Input Gain = -4dB): 3VRMS (+11.8dBu)
- Minimum Input Level to Achieve Full Scale on A/D (Input Gain = 20dB): 200mVRMS (-11.8dBu)
- Minimum Recommended Input Level (Input Gain = 20dB): 150mVRMS (-14.3dBu)
- Frequency Response: 20Hz – 20KHz, +/-0.5dB
- Signal-to-Noise Ratio (SNR): >90dB
- Total Harmonic Distortion + Noise (THD+N): <-85dB (0.006%)
- Channel Separation: > 85dB

Headphone Output Specifications

The iMac G5 has a stereo audio output jack on the back of the enclosure. The audio headphones output is suitable for connecting amplified external speakers, audio equipment, or headphones.

The audio output connector on the iMac G5 is a 3.5 mm electrical/optical combination (“combo”) jack with the electrical signals connected as follows:

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

Note: : For best results, equipment plugged into the headphones jack should not connect the audio ground to other grounds, such as the chassis or “green-wire” ground.

During playback of a 1KHz, full-scale sine wave (44.1KHz output sample rate, 24-bit sample depth, 100K ohm load, unless otherwise specified) the audio line output has the following nominal specifications:

- Jack Type: 3.5mm Analog/Optical Combo Jack
- Output Sample Rates: 32KHz, 44.1KHz, 48KHz, 64KHz, 88.2KHz, 96KHz
- Bits per Sample: 16 or 24
- Output Impedance: <50 Ohms
- Output Level: 1.75VRMS (+7.1 dBu)
- Frequency Response: 20Hz – 20KHz, +/-0.5dB
- Signal-to-Noise Ratio (SNR): >90dB
- Total Harmonic Distortion + Noise (THD+N): <-85dB (0.006%)
- Channel Separation: >85dB
- Output Power (Into 16 ohm Headphones): 60mW

RAM Expansion

This chapter describes the DDR SDRAM expansion features of the iMac G5 computer.

Note: For detailed instructions on accessing the expansion slots, refer to the *iMac G5 Setup Guide* that shipped with the computer or see the following Apple website: <http://www.info.apple.com/usen/cip>.


RAM Expansion

The main logic board of the iMac G5 computer has two DDR SDRAM expansion slots for unbuffered DDR400 (PC3200) dual in-line memory modules (DIMMs) for a maximum memory of 2 GB.

Each memory slot can contain 256 MB, 512 MB, or 1 GB of double data rate synchronous dynamic RAM (DDR SDRAM). The iMac G5 contains 256 MB of factory installed DIMM. The iMac G5 supports CAS latencies of 2, 2.5, 3, 4, and 5.

Additional DIMMs can be installed. The combined memory of all of the DIMMs installed is configured as a contiguous array of memory. The throughput of the 400 MHz memory bus is dependent on the DIMMs installed. If only one DIMM is installed, the memory bus is 64-bit. If two non-identical DIMMs are installed, there are two 64-bit memory buses. If two identical DIMMs are installed, the memory bus is 128-bit. Identical DIMM pairs have the same size and composition and provide the fastest and most efficient throughput.

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

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

DIMM Specifications

The RAM expansion slots accept 184-pin DDR SDRAM DIMMs that are 2.5 volt, unbuffered, 8-byte, nonparity, and DDR400-compliant (PC3200). The iMac G5 only supports DIMMs up to 1.25" in height.

Important: DDR266 (PC2200) or slower DIMMs do not work in the iMac G5 computer.

Important: DIMMs with any of the following features are not supported in the computer: registers or buffers, PLLs, ECC, parity, or EDO RAM.

Mechanical Specifications

The mechanical design of the DDR SDRAM DIMM is defined by the JEDEC specification JESD21-C, MODULES4_20_4, Release 11b. To find this specification on the World Wide Web, refer to [“RAM Expansion Modules”](#) (page 51).

Electrical Specifications

The electrical design of the SDRAM DIMM is defined by the JEDEC specification JESD21-C, MODULES4_20_4, Release 11b. To find this specification on the World Wide Web, refer to [“RAM Expansion Modules”](#) (page 51).

The Serial Presence Detect (SPD) EEPROM specified in the JEDEC standard is required and must be set to properly define the DIMM configuration. The EEPROM is powered on 2.5 V. Details about the required values for each byte on the SPD EEPROM can be found on pages 68–70 of the JEDEC specification.

Important: For a DIMM to be recognized by the startup software, the SPD feature must be programmed properly to indicate the timing modes supported by the DIMM.

DIMM Configurations

The largest DIMM supported is 1 GB. The maximum number of devices per DIMM is 16.

Important: Power is delivered to the iMac G5 during sleep mode, so do not remove DIMMs while in sleep mode. A green LED on the logic main board is illuminated when power is present.

[Table 4-1](#) (page 46) shows information about the different sizes of DDR SDRAM devices used in the memory modules. The memory controller supports 256 Mbit, 512 Mbit, and 1Gbit DDR SDRAM devices. 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 first column in [Table 4-1](#) (page 46) shows the memory size of the largest DIMM with that device size that the computer can accommodate. The third column 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.

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

DIMM size	Device size	Configuration	Devices per rank	Rank size	# of ranks
128 MB	256 Mb	4 M x 16 x 4	4	128 MB	1

DIMM size	Device size	Configuration	Devices per rank	Rank size	# of ranks
256 MB	256 Mb	4 M x 16 x 4	4	128 MB	2
256 MB	256 Mb	8 M x 8 x 4	8	256 MB	1
256 MB	512 Mb	8 M x 16 x 4	4	256 MB	1
512 MB	256 Mb	8 M x 8 x 4	8	256 MB	2
512 MB	512 Mb	8 M x 16x 4	4	256 MB	2
512 MB	512 Mb	16 M x 8 x 4	8	512 MB	1
512 MB	1 Gb	16 M x 16 x 4	4	512 MB	1
1 GB	512 Mb	16 M x 8 x 4	8	512 MB	2
1 GB	1 Gb	16 M x 16x 4	4	512 MB	2
1 GB	1 Gb	32 M x 8 x 4	8	1 GB	1

RAM Addressing

Signals A[0–12] on each SDRAM DIMM make up a 13-bit multiplexed address bus that can support several different sizes of SDRAM devices. [Table 4-2](#) (page 47) shows the address multiplexing modes used with the devices.

Table 4-2 Address multiplexing modes for SDRAM devices

Device size	Device configuration	Size of row address	Size of column address
256 Mb	4 M x 16x 4	13	9
256 Mb	8 M x 8 x 4	13	10
512 Mb	8 M x 16 x 4	13	10
512 Mb	16 M x 8 x 4	13	11
1 Gb	16 M x 16x 4	14	10
1 Gb	32 M x 8x 4	14	11

Supplemental Reference Documents

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

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

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

Apple Technical Notes

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

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

3D Graphics

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

Developer support and documentation is available at

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

PowerPC G5 Microprocessor

Information about the PowerPC G5 microprocessor is available on the World Wide Web at

<http://www-306.ibm.com/chips/techlib/techlib.nsf/techdocs/AE818B5D1DBB02EC87256DDE00007821>

Velocity Engine

Velocity Engine is Apple's vector processor in the PowerPC G5 microprocessor. Apple provides support for developers who are starting to use the Velocity Engine in their applications. Documentation, development tools, and sample code are now available on the World Wide Web, at

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

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

<http://www.freescale.com/>

Mac OS X

The iMac G5 ships with Mac OS X version 10.3.5 installed. To run Mac OS 9 applications, install the Classic application from the “Additional Hardware and Apple Software Test” CD shipped with your computer. For access to Apple’s developer documentation for Mac OS X, see the Apple Developer Connection (ADC) website at

<http://developer.apple.com/documentation/MacOSX/MacOSX.html>

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

Open Firmware

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

TN1061: Open Firmware, Part I, available at

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

TN1062: Open Firmware, Part II, available at

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

TN1044: Open Firmware, Part III, available at

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

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

TN2000: PCI Expansion ROMs and You, at

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

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

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

TN2004: Debugging Open Firmware Using Telnet, available at

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

RAM Expansion Modules

The iMac G5 uses DDR400 PC3200-compliant, 184-pin DDR SDRAM DIMMs.

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

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

ATA Devices

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

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

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

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

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

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

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

Serial ATA

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

<http://www.serialata.org>

USB Interface

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

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

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

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

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

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

Ethernet

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

<http://standards.ieee.org/>

FireWire Interface

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

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

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

<http://shop.ieee.org/store/>

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

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

Wireless Networks

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

<http://www.wi-fi.org>

Bluetooth

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

Bluetooth specification:

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

Bluetooth SIG:

<http://www.bluetooth.org>

Bluetooth developer tools on the Apple web site at:

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

Abbreviations

Standard units of measure used in this developer note include:

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

Other abbreviations used in this note include:

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

CD-ROM	compact disc read-only memory
CD-RW	compact disc-rewritable
CLV	constant linear velocity
CPU	central processing unit
CRM	Communications Resource Manager
D/A	digital to analog
DAA	data access adapter
DART	DMA Address Relocation Table
DBDMA	descriptor-based direct memory access
DDC	display data channel
DDR	double data rate, a type of SDRAM where data is clocked on rising and falling clock edges
DIMM	Dual Inline Memory Module
DMA	direct memory access
DRAM	dynamic random-access memory
DSSS	direct-sequence spread-spectrum
DV	digital video
DVD	digital video disc
DVD-R	digital video disc-recordable
DVD-ROM	digital video disc read-only memory
DVD-RW	digital video disc-rewritable
EEPROM	electrically erasable programmable ROM
G5	Generation 5, the fifth generation of PowerPC microprocessors
GART	graphics address remapping table
GND	ground
HFS	hierarchical file system
HID	human interface device, a class of USB devices
I2C	same as IIC
I2S	same as IIS

IC	integrated circuit
IDE	integrated device electronics
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IEEE 1275	the official specification for Open Firmware
IEEE 1394a	the official specification for FireWire 400 (400 Mbps)
IIC	inter-IC (an internal control bus)
IIS	inter-IC sound bus
I/O	input and output
ISO	International Organization for Standardization
JEDEC	Joint Electron Device Engineering Council
L1	level 1 or first level
L2	level 2 or second level
LAN	local area network
LED	light emitting diode
MAC	media access controller
Mac OS	Macintosh Operating System
MPEG	Motion Picture Experts Group
modem	modulator-demodulator
NMI	nonmaskable interrupt
NV-RAM	nonvolatile random-access memory
OFDM	orthogonal frequency-division multiplexing
OHCI	Open Host Controller Interface, USB 1.1 specification
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
RAS	row address strobe
RCA	Radio Corporation of America
rms	root mean square
ROM	read-only memory
RTAS	run-time abstraction services
SATA	serial ATA bus for hard disk drives
SBP	Serial Bus Protocol
SCC	Serial Communications Controller
SDRAM	synchronous dynamic RAM
SGRAM	synchronous graphics RAM
Shasta	I/O device and disk controller
SMU	system management unit
SNR	signal to noise ratio
SPD	Serial Presence Detect
THD	total harmonic distortion
THD+N	total harmonic distortion plus noise
TMDS	transition minimized differential signaling
U3L	memory controller light version
USB	Universal Serial Bus
VCC	positive supply voltage (voltage for collectors)
VIA	versatile interface adapter
VESA	Video Electronics Standards Association
VRAM	video RAM; used for display buffers
Wi-Fi	Logo used by the Wireless Ethernet Compatibility Alliance for certification of interoperability of 802.11 products

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