

Developer Note

eMac



October 2002

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Contents

Figures and Tables 7

Preface About This Developer Note 9

Chapter 1 Introduction 11

New Features 11
All Features 12
External Features 15
System Software 16
 Computer Identification 16
 Velocity Engine Acceleration 16

Chapter 2 Architecture 19

Block Diagram and Buses 19
 Block Diagram 19
 Main ICs and Buses 20
Microprocessor and Cache 21
 PowerPC G4 Microprocessor 21
 Level 2 Cache 22
Uni-N Bridge and Memory Controller 22
 Processor Bus 22
 Main Memory Bus 23
 Accelerated Graphics Port Bus 23
 Video Display Subsystem 24
 PCI Bus 24
 Boot ROM 24
 Ethernet Controller 25
 FireWire Controller 25

C O N T E N T S

KeyLargo I/O Controller	25
DMA Support	26
Interrupt Support	26
USB Interface	26
Ultra DMA Interface	27
Enhanced IDE Interface	27
Modem Slot Support	27
Wireless LAN Module	28
Sound Circuitry	28
Power Controller	29

Chapter 3 Devices and Ports 31

USB Ports	31
USB Connectors	31
USB Features	32
Wake Up From Sleep	33
Connect and Resume	33
USB Storage Devices	33
USB Controller	33
FireWire Ports	33
FireWire Device Programming	34
FireWire Connector	34
Target Disk Mode	36
Ethernet Port	37
Internal Modem	38
AirPort Card	38
Data Security	39
AirPort Hardware	39
AirPort Software	39
Hard Disk Drive	40
Combo Drive DVD-ROM/CD-RW	40
SuperDrive DVD-R/CD-RW Drive	41
CD-RW Drive	42
Video Display	43
Video Monitor Port	44
Video Display Connector	44

C O N T E N T S

Keyboard	45
Keyboard Features	45
Keyboard Layout	46
MultiMedia Control Keys	47
Keyboard and USB	47
Mouse	47
Sound System	48
Sound Inputs	48
Built-in Microphone	48
External Sound Input Jack	49
Sound Outputs	49
Internal Speakers	49
Headphone Jack	49
Sound Specifications	50

Chapter 4 RAM Expansion 53

RAM Expansion Slots	53
RAM Expansion Modules	54
Mechanical Design of RAM DIMMs	54
Electrical Design of RAM DIMMs	54
DIMM Configurations	55
RAM Addressing	56

Appendix A Supplemental Reference Documents 59

Apple Technical Notes	59
3D Graphics	60
PowerPC G4 Microprocessor	60
Velocity Engine (AltiVec)	60
Mac OS X	61
Mac OS 9.2.2	61
I/O Kit	62
RAM Expansion Modules	62
ATA Interface	63
USB Interface	63

C O N T E N T S

FireWire Interface	64
Target Disk Mode	64
Wireless Networks	65

Appendix B Abbreviations	67
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Index	71
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Figures and Tables

Chapter 1 Introduction 11

Table 1-1 Feature comparison 14

Chapter 2 Architecture 19

Figure 2-1 Block diagram 20

Chapter 3 Devices and Ports 31

Figure 3-1 USB Type A port and pins 32

Figure 3-2 FireWire connector 35

Figure 3-3 Video display connector 44

Figure 3-4 ANSI keyboard layout 46

Table 3-1 Signals on the USB port 32

Table 3-2 Signals on the FireWire connector 35

Table 3-3 Signals on the Ethernet connector 37

Table 3-4 Types of media read and written by the DVD-ROM/CD-RW drive 41

Table 3-5 Types of media read and written by the SuperDrive (DVD-R/CD-RW) drive 42

Table 3-6 Display resolutions and pixel depths 43

Table 3-7 Video signals for a VGA display 45

Table 3-8 Distortion specifications 50

Table 3-9 SNR specifications 51

Chapter 4 RAM Expansion 53

Table 4-1 Sizes of RAM expansion devices and DIMMs 55

Table 4-2 Address multiplexing modes for SDRAM devices 57

F I G U R E S A N D T A B L E S

About This Developer Note

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

This developer note is intended to help hardware and software developers design products that are compatible with the products described here. If you are not already familiar with Macintosh computers or if you would simply like additional technical information, refer to [Appendix A, "Supplemental Reference Documents"](#) (page 59), for details.

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

- [Chapter 1, "Introduction"](#) (page 11), introduces the eMac computer, describes its features, and mentions a few software issues of interest to developers.
- [Chapter 2, "Architecture"](#) (page 19), 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 31), describes the I/O ports and the built-in I/O devices.
- [Chapter 4, "RAM Expansion"](#) (page 53), includes development guidelines for the RAM expansion modules.
- [Appendix A, "Supplemental Reference Documents"](#) (page 59), provides sources of additional information about the technologies used in the eMac.
- [Appendix B, "Abbreviations"](#) (page 67), lists standard units of measure and other abbreviations used in this developer note.

P R E F A C E

About This Developer Note

Introduction

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

New Features

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

- **Microprocessor:** The eMac computer has a PowerPC G4 microprocessor running at a clock speed of 700 or 800 MHz. For more information, see [“PowerPC G4 Microprocessor”](#) (page 21).
- **Memory:** The computer comes with 128 or 256 MB of SDRAM installed. For more information, see [“RAM Expansion Modules”](#) (page 54).
- **Hard disk storage:** The built-in hard disk drive has a capacity of 40 GB for the Combo drive and 60 GB for the SuperDrive drive. For more information, see [“Hard Disk Drive”](#) (page 40).
- **Combo (DVD-ROM/CD-RW) drive:** One configuration has a combination DVD-ROM/CD-RW drive. For more information, see [“Combo Drive DVD-ROM/CD-RW”](#) (page 40).
- **SuperDrive (DVD-R/CD-RW) drive:** One configuration has a SuperDrive (DVD-R/CD-RW) drive. For more information, see [“SuperDrive DVD-R/CD-RW Drive”](#) (page 41).

All Features

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

- **Processor:** The eMac computer has a PowerPC G4 microprocessor running at a clock speed of 700 MHz or 800 MHz. For more information, see “PowerPC G4 Microprocessor” (page 21).
- **Cache:** The 256-kB backside L2 cache is included on the microprocessor IC and has the same clock speed as the microprocessor. For more information, see “Level 2 Cache” (page 22).
- **Memory:** The eMac computer comes with 128 or 256 MB of SDRAM installed in one of two standard 168-pin DIMM expansion slots. The RAM slots can support up to 512 MB each for a maximum total of 1 GB. For more information, see “RAM Expansion Modules” (page 54).
- **Hard disk storage:** The built-in hard disk drive has a capacity of 40 GB for the Combo drive and 60 GB for the SuperDrive. For more information, see “Hard Disk Drive” (page 40).
- **CD-RW drive:** One configuration has a CD-RW drive. For more information, see “CD-RW Drive” (page 42).
- **Combo DVD-ROM/CD-RW drive:** One configuration has a combination DVD-ROM/CD-RW drive. For more information, see “Combo Drive DVD-ROM/CD-RW” (page 40).
- **SuperDrive (CD-RW/DVD-R) drive:** One configuration has a SuperDrive (CD-RW/DVD-R) drive. For more information, see “SuperDrive DVD-R/CD-RW Drive” (page 41).
- **External video monitor:** The eMac has a mini-VGA port for connecting an external video monitor. For more information, see “Video Monitor Port” (page 44).
- **Graphics acceleration:** The video circuits provide built-in 2D and 3D acceleration using an NVidia GeForce2 MX IC. For more information, see “Video Display Subsystem” (page 24).

Introduction

- **Video RAM:** The video hardware includes 32 MB of video DDR, which supports 3D features and millions of colors in all resolutions. For more information, see “Video Display Subsystem” (page 24) and “Video Display” (page 43).
- **USB ports:** The eMac has three USB ports on the main chassis and two more on the keyboard. For more information, in “USB Ports” (page 31).
- **FireWire ports:** The eMac 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 33).
- **Target Disk Mode:** The computer can act like a FireWire storage device connected to another computer. See “Target Disk Mode” (page 36).
- **Modem:** The Combo drive and CD-RW models have a built-in V.92 fax modem with a 56 Kbps data rate. For more information, see “Internal Modem” (page 38).
- **Ethernet:** The eMac has a built-in Ethernet port for a 10Base-T and 100Base-TX operation. For more information, see “Ethernet Port” (page 37).
- **AirPort Card slot:** 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 38).
- **Sound:** The eMac has a built-in microphone and two stereo speakers, a line-level stereo input jack, and a stereo headphone jack. For more information, see “Sound System” (page 48).
- **Keyboard:** The eMac comes with an Apple Pro Keyboard. The keyboard is also a USB hub with two USB ports. For more information, see “Keyboard” (page 45).
- **Mouse:** The computer comes with an Apple Pro Mouse, a USB mouse with optical tracking. For more information, see “Mouse” (page 47).
- **Size and weight:** The eMac computer is 40.6 cm (15.8 inches) high, 40.6 cm (15.8 inches) wide, and 40.7 cm (15.9 inches) deep; it weighs 22.7 kg (50.0 pounds).
- **Display:** The eMac computer has a built-in 17-inch flat color CRT monitor with a 16-inch viewable diagonal. For more information, see “Video Display” (page 43). For a comparison with the 15-inch CRT iMac, see Table 1-1.

C H A P T E R 1

Introduction

Table 1-1 provides a quick comparison of the features of the eMac computer with those of the iMac 15-inch CRT models introduced in May, 2001.

Table 1-1 Feature comparison

	iMac 15-inch CRT models	eMac computer
Processor and speed	500, 600, or 700 MHz PPC G3	700 or 800 MHz PPC G4
L2 cache speed	500, 600, or 700 MHz	700 or 800 MHz
System bus speed	100 MHz	100 MHz
Main memory	128 or 256 MB, expandable up to 1 GB	128 or 256 MB, expandable up to 1 GB
Display	15-inch CRT (13.8 inch viewable)	17-inch flat CRT (16-inch viewable)
Graphics IC	ATI RAGE 128 Ultra	NVidia GeForce2 MX
Graphics memory	16 MB, plus AGP expansion	32 MB DDR
Video Output	Mirrored VGA	Mirrored VGA
Hard disk drive	20, 40, or 60 GB IDE drive	40 or 60 GB IDE drive
Optical drive	Slot-load CD-RW drive	Tray-load CD-RW, DVD-ROM/CD-RW, or DVD-R/CD-RWdrive
Data ports	Four USB ports (two on the keyboard); two FireWire ports	Five USB ports (two on the keyboard); two FireWire ports
Communication features	10/100 Ethernet; 56 Kbps fax modem; optional AirPort card	10/100 Ethernet; 56 Kbps fax modem (on Combo drive and SuperDrive models); optional AirPort Card
Sound features	Stereo, with built-in speakers, microphone, and I/O jacks	Stereo, with built-in speakers, microphone, sound input jack, and headphone jack
Keyboard	Apple Pro Keyboard (USB)	Apple Pro Keyboard (USB)
Mouse	Apple Pro Mouse (USB)	Apple Pro Mouse (USB)

External Features

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

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

- Tray-loading CD-RW, SuperDrive, or Combo drive, in the center
- Access to Airport card slot
- Stereo speakers, one on either side
- Power-on light, located near the speaker on the right side; the light has a steady white glow when on; it pulses in Sleep mode.

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

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

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

- Power button
- Kensington lock attachment point

Introduction

The back portion of the bottom of the enclosure has a door that can be opened for access to the expansion RAM. For more information, see “RAM Expansion Slots” (page 53).

System Software

The eMac computer comes with both Mac OS X (version 10.2) and Mac OS 9.2.2 installed. Mac OS X is the default system. (A configuration with Mac OS 9 as the default system is also available for education customers.)

For more information about Mac OS X, see the reference listed in “Mac OS X” (page 61). For the latest information about Mac OS 9.2.2, see the reference listed in “Mac OS 9.2.2” (page 61).

Computer Identification

Rather than reading the box flag or the model string and then making assumptions about the computer’s features, applications that need to find out the features of the computer should use IORegistry calls to test for the features they require. IORegistry calls are part of the I/O Kit API. For more information, see the references listed at “I/O Kit” (page 62).

Asset management software that reports the kind of computer it is run on can obtain the value of the model property from the IOService plane of the IORegistry. For the eMac, the value of the string in the `compatible` property is `PowerMac4,4`.

Velocity Engine Acceleration

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

C H A P T E R 1

Introduction

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

<http://developer.apple.com/hardware/ve/>

and

<http://developer.apple.com/techpubs/macosx/CoreTechnologies/vDSP/vDSP.html>

C H A P T E R 1

Introduction

Architecture

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

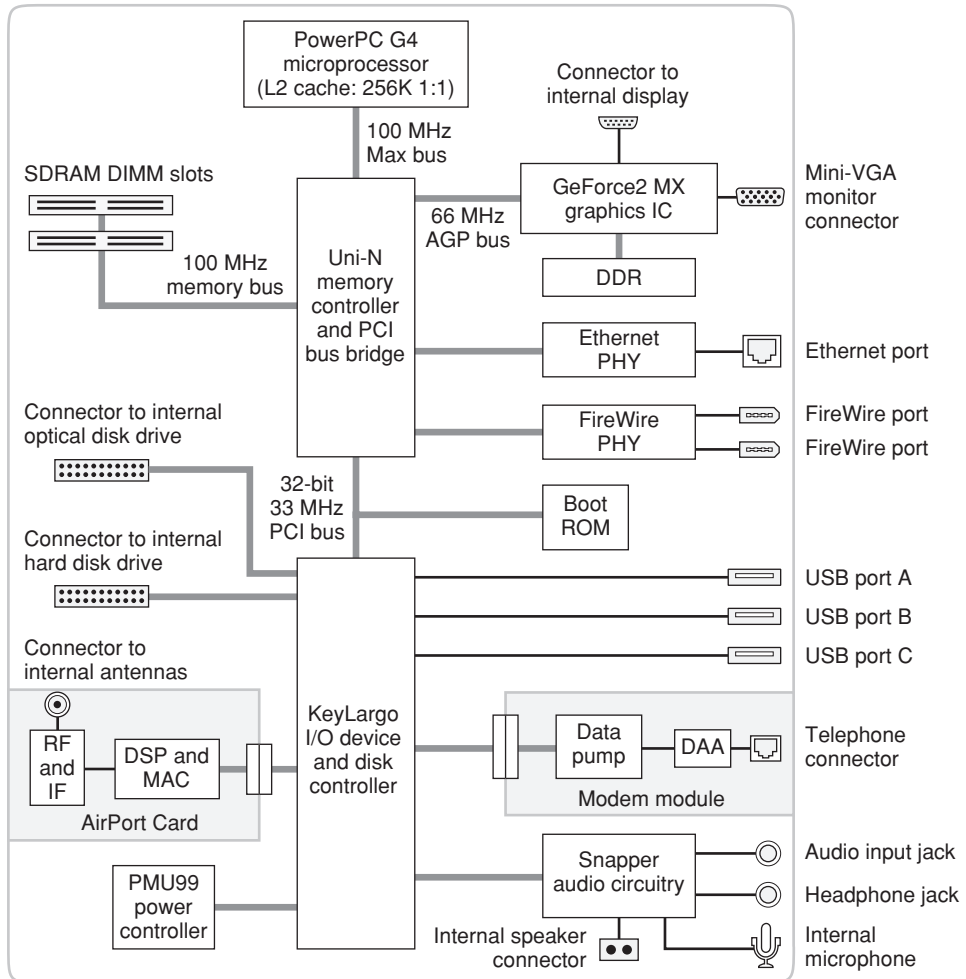
Block Diagram and Buses

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

Block Diagram

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

Figure 2-1 Block diagram



Main ICs and Buses

The architecture of the eMac is designed around the PowerPC G4 microprocessor and two custom ICs: the Uni-N memory controller and bus bridge, and the KeyLargo I/O controller.

Architecture

The eMac computer has four major buses.

- processor bus: 100 MHz, 64-bit bus connecting the processor module to the Uni-N IC
- memory bus: 100 MHz, 64-bit bus connecting the main memory to the Uni-N IC
- AGP bus: 66 MHz, 32-bit bus connecting the AGP card to the Uni-N IC
- PCI bus: 33 MHz, 32-bit bus connecting the boot ROM to the KeyLargo I/O controller.

The remainder of this chapter describes the architecture in three sections centered around the processor module, the Uni-N memory controller and bridge IC, and the KeyLargo I/O controller IC.

Microprocessor and Cache

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

PowerPC G4 Microprocessor

The PowerPC G4 microprocessor used in the eMac computer has many powerful features, including a pipelined system bus called MaxBus.

The PowerPC G4 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 1)
- built-in 256 KB backside L2 cache

To find more information, see the reference at “PowerPC G4 Microprocessor” (page 60).

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.

Uni-N Bridge and Memory Controller

The Uni-N custom IC is at the heart of the computer. It provides the bridging functionality between the processor, the memory system, the PCI-based I/O system, the AGP slot, and the FireWire and Ethernet interfaces.

Processor Bus

The processor bus is a 100 MHz, 64-bit bus connecting the processor module to the Uni-N IC. In addition to the increased bus clock speed, the bus uses MaxBus protocols, supported by the Uni-N IC, for improved performance.

The MaxBus protocol includes enhancements that improve bus efficiency and throughput over the 60x bus. The enhancements include

- out of order completion
- address bus streaming
- intervention

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 DRAM read can pass a slow PCI read, potentially enabling the processor to do more before it has to wait on the PCI data.

Address bus streaming allows a single master on the bus to issue multiple address transactions back-to-back. This means that a single master can post addresses at the rate of one every two clocks, rather than one every three clocks, as it is in the 60x bus protocol.

Architecture

Intervention is a cache-coherency optimization that improves performance for dual processor systems. If one processor modifies some data, that data first gets stored only in that processor's cache. If the other processor then wants that data, it needs to get the new modified values. In previous systems, the first processor must write the modified data to memory and then the second processor can read the correct values from memory. With intervention, the first processor sends the data directly to the second processor, reducing latency by a factor of ten or more.

Main Memory Bus

The main memory bus is a 100 MHz, 64-bit bus connecting the main memory to the Uni-N IC. The memory interface is synchronized to the 60x bus interface at 100 MHz.

Main memory is provided by one or two PC-133 DIMMs (dual inline memory modules). For more information about memory DIMMs, see "RAM Expansion" (page 53).

Accelerated Graphics Port Bus

The accelerated graphics port (AGP) bus is a 66 MHz, 32-bit bus connecting the AGP IC to the Uni-N IC. The AGP bus provides faster access to main memory than previous designs using the PCI bus.

The AGP bus is a superset of the PCI bus, with the addition of separate address lines so it does not multiplex address and data when running in AGP mode. Having a separate address bus allows the AGP bus to pipeline addresses, thereby improving performance.

To further improve the performance of the AGP bus, the Uni-N 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 Uni-N to translate a linear address space for AGP transactions into physical addresses in main memory.

Video Display Subsystem

The display subsystem consists of a graphics controller IC and 32 MB of DDR 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 scalers, a CRT controller, and an AGP bus interface with bus master capability.

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

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

For information about the display and supported resolutions, see “Video Display” (page 43).

PCI Bus

The PCI bus connects the Uni-N IC to the boot ROM and the KeyLargo I/O controller. The PCI bus is a 33 MHz, 64-bit bus.

The Uni-N IC used in the eMac computer supports a PCI feature called write combining. This feature allows sequential write transactions involving the Memory Write or Memory Write and Invalidate commands to be combined into a single PCI transaction. The memory write transactions being combined must be to sequential, ascending, and non-overlapping PCI addresses. Placing an `eiio` or `sync` command between the write commands prevents any write combining.

Boot ROM

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

Ethernet Controller

The Uni-N IC includes an Ethernet media access controller (MAC). As a separate I/O channel on the Uni-N IC, it can operate at its full capacity without degrading the performance of other peripheral devices. The MAC also provides DMA support for the Ethernet interface.

The MAC implements the link layer. It is connected to a PHY interface IC that provides 10Base-T or 100Base-T operation over a standard twisted-pair interface. The operating speed of the link is automatically negotiated by the PHY and the bridge or router to which the Ethernet port is connected. For information about the port, see “Ethernet Port” (page 37).

FireWire Controller

The Uni-N IC includes an IEEE 1394 FireWire controller that implements the FireWire link layer. The controller supports a maximum data rate of 400 Mbits (50 MBytes) per second.

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.

The PHY is powered as long as the computer is connected to AC power. While the PHY is operating, it acts as a repeater from one port to another so that the FireWire bus remains connected. For more information, see “FireWire Ports” (page 33).

KeyLargo I/O Controller

The KeyLargo custom IC is the third major component of the architecture. It provides all the I/O functions except Ethernet and FireWire. The KeyLargo IC provides two USB root hubs, an Ultra DMA/66 interface, and support for the communication slot and the sound IC.

DMA Support

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

- Ultra DMA/66 interface
- communication slot interface
- IIS channel to the sound subsystem

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.

Interrupt Support

The interrupt controller for the eMac computer is an MPIC cell in the KeyLargo IC. In addition to accepting all the KeyLargo internal interrupt sources, the MPIC controller accepts external interrupts from dedicated interrupt pins and serial interrupts from the Uni-N serial interrupt stream. The signals from the Uni-N IC are synchronized to the operation of the MPIC circuitry, so there is no additional interrupt latency on the Uni-N interrupts.

USB Interface

The KeyLargo IC implements two independent USB root hubs. USB port A is connected to one controller and the other two USB ports are connected to the other. The use of two independent hubs allows both USB ports to 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 A and another high-speed device to the port B, both devices can operate at their full data rates.

Internally, the second port of one controller is routed to the modem slot for an internal USB modem. The second port of the other controller is connected to the third external USB port.

The 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 31).

Architecture

USB devices connected to the eMac 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 63).

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

Ultra DMA Interface

In the eMac computer, the KeyLargo IC provides an Ultra DMA IDE (integrated drive electronics) channel that is connected to the internal hard disk drive. The Ultra DMA IDE interface, also called Ultra-DMA/66 and ATA-5, is an improved version of the EIDE interface.

The KeyLargo IC provides DB-DMA (descriptor-based direct memory access) support for the Ultra DMA interface.

The cable is wired to select the internal hard disk drive as device 0 (master) in an ATA Device 0/1 configuration.

Enhanced IDE Interface

In the eMac computer, the KeyLargo IC provides an enhanced IDE (EIDE) interface that supports the internal Combo (DVD-ROM and CD-RW) disk drive.

The EIDE interface uses multiword DMA. The Combo drive is connected as device 0 (master) in an ATA Device 0/1 configuration.

For information about the Combo drive, see “Combo Drive DVD-ROM/CD-RW” (page 40).

Modem Slot Support

The KeyLargo IC has a traditional Macintosh serial port that is connected to the modem slot. The KeyLargo IC also provides digital audio to the slot in the form of an IIS port that shares pins with the serial port.

Architecture

The KeyLargo IC provides DB-DMA (descriptor-based direct memory access) support for the modem slot interface.

The internal hardware modem is a separate module that contains the datapump IC and the interface to the telephone line (DAA). For more information about the modem, see “Internal Modem” (page 38).

Wireless LAN Module

The interface between the wireless LAN module and the KeyLargo IC is similar to a PC Card interface.

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

The wireless LAN module is based on the IEEE 802.11 standard. The wireless LAN module transmits and receives data at up to 11 Mbps and is compatible with older systems that operate at 1 or 2 Mbps. For information about its operation, see “AirPort Card” (page 38).

Sound Circuitry

The sound circuitry is designed around a set of ICs called Snapper and is connected to the KeyLargo IC by standard IIC and IIS buses. The IIC bus provides configuration access to the Snapper ICs and the IIS bus is used for data transfers. The KeyLargo IC provides DB-DMA (descriptor-based direct memory access) support for the IIS port.

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

Stereo signals from the sound input jack drive Snapper’s A-to-D converter. Audio data from the KeyLargo IC drives Snapper’s D-to-A converter. Analog output from the D-to-A converter is routed to the headphone jack and the audio power amplifier.

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

C H A P T E R 2

Architecture

For a description of the features of the sound system, see “Sound System” (page 48).

Power Controller

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

C H A P T E R 2

Architecture

Devices and Ports

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

USB Ports

The eMac has three Universal Serial Bus (USB) ports. The USB ports are connected to two separate USB root hubs, allowing two of the USB ports to support 12 Mbps devices at the same time with no degradation of their performance. See “Uni-N Bridge and Memory Controller” (page 22).

Note: The keyboard also contains a USB hub and two more USB ports. See “Keyboard and USB” (page 47).

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 63).

USB Connectors

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

Figure 3-1 USB Type A port and pins

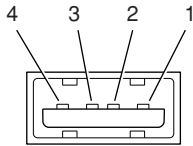


Table 3-1 Signals on the USB port

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

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

USB Storage Devices

The eMac 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. Mac OS 9 and later includes a class driver that supports devices that meet the USB Mass Storage Class specifications.

USB Controller

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

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

Devices and Ports

- Share up to 8 watts of power when the computer system is on
- Support up to 62 devices

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

FireWire Device Programming

A generic driver for mass storage devices is included in the system software. This driver is used only when a vendor-specific driver cannot be found. Apple recommends that users install vendor-provided drivers for maximum performance and functionality.

A driver for DV (digital video) is included in QuickTime 4.0 and later versions.

The eMac computer can boot from a FireWire storage device that implements SBP-2 (Serial Bus Protocol) with the RBC (reduced block commands) command set. Detailed information is available only under non-disclosure agreement; contact Developer Technical Support at dts@apple.com.

When connected to another computer by a FireWire bus, the eMac computer can operate as a mass storage device. See “[Target Disk Mode](#)” (page 36).

For additional information about the FireWire interface and the Apple APIs for FireWire device control, refer to the resources listed in “[FireWire Interface](#)” (page 64).

FireWire Connector

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

Figure 3-2 FireWire connector

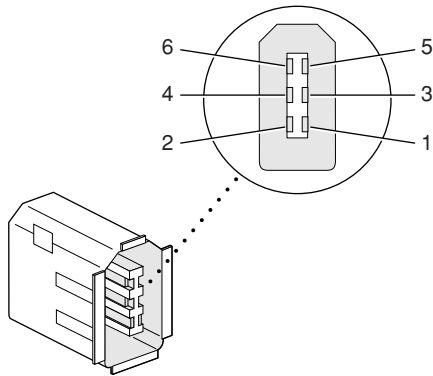


Table 3-2 Signals on the FireWire connector

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

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

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

Devices and Ports

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 64).

Target Disk Mode

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

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

- high-speed data transfer between computers
- diagnosis and repair of a corrupted internal hard drive

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

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

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

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

For more information about Target Disk Mode, see the section “Target Mode” in TN 1189, *The Monster Disk Driver Technical Note*. For information about obtaining the Technical Note, see “[Apple Technical Notes](#)” (page 59).

Ethernet Port

The eMac has a built-in 10/100 Mbps Ethernet port. The user can connect it to an Ethernet cable from a hub, switch, or router, or to another Macintosh computer using a cross-connect cable. The connected device can be either a 10Base-T or a 100Base-TX device; the port automatically detects which type of device is connected.

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

Table 3-3 Signals on the Ethernet connector

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

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

Internal Modem

The Combo and SuperDrive models of eMac come with a built-in fax modem. The telephone connector for the modem is an RJ-11 connector on the I/O panel. A telephone cable is included with the computer.

The modem has the following features:

- modem bit rates up to 56 Kbps (supports V.92 and K56flex modem standards)
- Group 3 fax modem bit rates up to 14.4 Kbps

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

AirPort Card

The eMac computer supports the AirPort Card, Apple's internal wireless LAN module. The AirPort Card is available as a build-to-order option or as a user-installable upgrade.

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 56 Kbps modem.

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 PCs. For more information about Wi-Fi and compatibility, see the reference at "[Wireless Networks](#)" (page 65).

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 data while it is in transit.
- The AirPort Base Station can be configured to act as a firewall, protecting data from would-be Internet hackers.
- The AirPort Base Station can authenticate users by their unique Ethernet IDs, preventing unauthorized machines from logging into a network. Network administrators can take advantage of RADIUS compatibility, used for authenticating users over a remote server. Smaller networks can offer the same security using a local look-up table located within the base station.

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, one above and the other below the CRT. 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 the user through the steps necessary to set up the AirPort Card or set up an AirPort Base Station.

Devices and Ports

- Users can switch between wireless networks and can create and join peer-to-peer networks. In Mac OS X, these functions are accessed via the AirPort- Menu-Extra pulldown. In Mac OS 9, these functions are available through the AirPort application.
- 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.

Hard Disk Drive

The internal hard disk drive has a storage capacity of 40 GB for the Combo drive and 60 GB for the SuperDrive. The drive uses the Ultra DMA IDE interface, which is also referred to as the ATA-5 interface. The internal hard disk drive is connected as device 0 (cable-select as 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 63).

Combo Drive DVD-ROM/CD-RW

A combination DVD-ROM and CD-RW drive is available as an option. The drive has a tray for loading the disc.

Devices and Ports

The Combo drive can read DVD media and read and write CD media, as shown in Table 3-4. The DVD-ROM/CD-RW drive also provides DVD-Video playback.

Table 3-4 Types of media read and written by the DVD-ROM/CD-RW drive

Media type	Reading speed	Writing speed
DVD-ROM	8x (CAV)	–
CD-R	32x (CAV)	12x (CLV)
CD-RW	24x (CAV)	8x (CLV)
CD-ROM	32x (CAV)	–

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

The DVD-ROM/CD-RW drive is an ATAPI drive and is cable-selected as device 0 (master) in an ATA Device 0/1 configuration.

SuperDrive DVD-R/CD-RW Drive

A combination CD-RW and DVD-R drive is available as an option. 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 3-5](#) (page 42). The SuperDrive also provides DVD-Video playback with DVD MPEG 2 decode.

Table 3-5 Types of media read and written by the SuperDrive (DVD-R/CD-RW) 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 ATA-4 protocol and is device-select jumpered as Device 1 (slave) in an ATA Device 0/1 configuration.

CD-RW Drive

One configuration of the eMac has an internal CD-RW drive. The drive has a tray for loading the disc. The drive is capable of writing at 24x speed, rewriting at 10x speed, and reading at 32x speed.

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 is an ATAPI drive and is device-select jumpered as Device 0 (master) in an ATA Device 0/1 configuration.

Video Display

The built-in video display uses a 17-inch CRT (16-inch viewable diagonal). The CRT uses shadow-mask technology and has a dot pitch of 0.25 mm. The display has a fixed horizontal scan rate (72 kHz) and supports five resolutions. [Table 3-6](#) lists the resolutions and the vertical scan rates supported.

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

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

Table 3-6 Display resolutions and pixel depths

Resolution	Vertical rate	Pixel depth
640 by 480	138 Hz	24 bits
800 by 600	112 Hz	24 bits
1024 by 768	89.0 Hz	24 bits
1152 by 864	80.0 Hz	24 bits
1280 by 960	72.0 Hz	24 bits

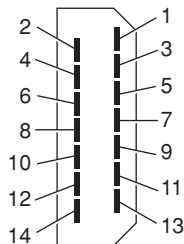
Video Monitor Port

The eMac 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 resolutions that are available on the internal monitor, as shown in [Table 3-6](#).

Video Display Connector

The video display connector is a 14-pin rectangular connector, Hosiden TCX3143. The connector pins are identified in [Figure 3-3](#).

Figure 3-3 Video display connector



Devices and Ports

The eMac computer detects the type of display adapter that is plugged in and programs the graphics IC to route the appropriate video signals to the connector. The signal assignments on the video connector are shown in Table 3-7.

Table 3-7 Video signals for a VGA display

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

Keyboard

The eMac 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.

The keyboard also provides two additional USB ports; see “Keyboard and USB” (page 47).

Keyboard Features

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

Devices and Ports

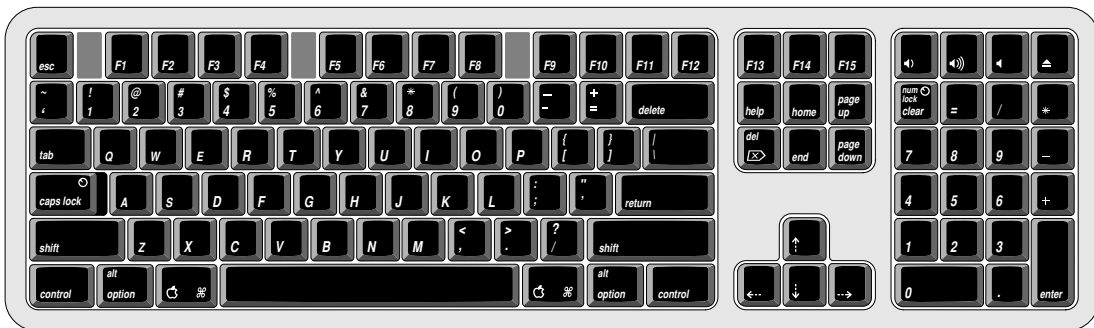
- Slope settable to either 0 or 6 degrees by a flip-out foot
- 108 keys (on the ANSI versions)
- 15 function keys
- 6 editing keys (Page Up, Page Down, Home, End, Forward Delete, and Help)
- USB HID Consumer Page Usage multimedia control keys
- Full travel, standard pitch keys on alphanumeric, editing, and keypad sections, including function keys and cursor position keys
- Localized worldwide: 33 versions, 3 standard layouts (ANSI, JIS, ISO)
- LED indicators in the Caps Lock and Num Lock keys
- USB hub functionality with two Type A USB bus-powered ports

Note: There is no power key on this keyboard.

Keyboard Layout

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

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

W A R N I N G

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

Apple provides a HID class driver for the Apple USB keyboard, which supports the USB boot protocol. Other keyboards intended for use on the Macintosh platform must support the HID boot protocol, as defined in the USB Device Class Definition for Human Interface Devices (HIDs). For information about the USB HID definition, see the HID reference in “USB Interface” (page 63).

Mouse

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

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

Sound System

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

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

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

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

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

Sound Inputs

The sound system accepts inputs from five possible sources:

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

Built-in Microphone

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

External Sound Input Jack

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

The sound input jack signal connections are:

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

The sound input jack has the following electrical characteristics:

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

Sound Outputs

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

- built-in stereo speakers
- headphone jack

Internal Speakers

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

- when headphones are plugged into the headphone jack
- when external USB speakers are connected
- during Sleep mode

Headphone Jack

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

Devices and Ports

The headphone jack has the following electrical characteristics:

- output impedance: 5.0 ohms (nominal)
- maximum level: 1.0 V_{rms} (2.8 V peak-to-peak)

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

Sound Specifications

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

Total harmonic distortion plus noise (THD+N) as a percentage of full scale are shown in [Table 3-8](#).

Table 3-8 Distortion specifications

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

C H A P T E R 3

Devices and Ports

The signal-to-noise ratios (SNR) for various inputs and outputs are shown in [Table 3-9](#). The values shown are unweighted.

Table 3-9 SNR specifications

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

C H A P T E R 3

Devices and Ports

RAM Expansion

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

RAM Expansion Slots

The eMac has two RAM expansion slots. The slots accept standard PC-133, 168-pin DIMMs (dual inline memory modules) that use SDRAM devices. A DIMM for a eMac can contain either 64, 128, 256, or 512 MB of memory.

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

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

Important

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

RAM Expansion Modules

The RAM expansion modules for the eMac are 168-pin SDRAM DIMMs that are 3.3 volt, unbuffered, 8-byte, non-parity, and PC-133 compliant. The speed of the SDRAM devices must be rated at 125 MHz (8 ns) or faster.

Important

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

Mechanical Design of RAM DIMMs

The mechanical characteristics of the RAM expansion DIMM are given in the JEDEC specification for the 168-pin 8-byte DRAM DIMM. The specification number is JEDEC MO-161-D. To obtain a copy, see the reference information at “RAM Expansion Modules” (page 62).

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

Electrical Design of RAM DIMMs

The electrical characteristics of the RAM DIMM are given in section 4.5.6 of the JEDEC Standard 21-C. The specification is available from the Electronics Industry Association’s website. The specification defines several attributes of the DIMM, including storage capacity and configuration, connector pin assignments, and electrical loading. To obtain a copy, see the reference information at “RAM Expansion Modules” (page 62).

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

RAM Expansion

The RAM DIMMs are required to be PC-133 compliant. To obtain information about the PC-133 specification, see the reference information at “RAM Expansion Modules” (page 62).

The SDRAM devices used in the RAM expansion modules must be self-refresh type devices for operation from a 3.3-V power supply. The speed of the SDRAM devices must be 125 MHz or greater, corresponding to a cycle time of 8 ns or less, as required by the PC-133 specification.

DIMM Configurations

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

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

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

Table 4-1 Sizes of RAM expansion devices and DIMMs

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

RAM Expansion

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

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

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

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

RAM Addressing

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

C H A P T E R 4

RAM Expansion

Important

The eMac supports only the types of SDRAM devices listed in [Table 4-2](#). Other types of DRAM devices should not be used with this computer.

Table 4-2 Address multiplexing modes for SDRAM devices

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

C H A P T E R 4

RAM Expansion

Supplemental Reference Documents

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

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

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

Relevant books describing the system software for Macintosh computers are available in technical bookstores and on the World Wide Web at

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

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

Apple Technical Notes

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

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

3D Graphics

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

Information is available on the World Wide Web at

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

Developer support and documentation is available at

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

PowerPC G4 Microprocessor

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

<http://e-www.motorola.com/webapp/sps/site/taxonomy.jsp?nodeId=01M98653>

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/ve/index.html>

Supplemental Reference Documents

and

<http://developer.apple.com/techpubs/macosx/CoreTechnologies/vDSP/vDSP.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 through the Motorola AltiVec site on the World Wide Web, at

<http://e-www.motorola.com/brdata/PDFDB/docs/ALTIVECPEM.pdf>

Mac OS X

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

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

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.

Mac OS 9.2.2

Mac OS 9 is also included with the eMac computer. Programming information about Mac OS 9 is available in technical bookstores and (for free download) on the World Wide Web at

<http://developer.apple.com/techpubs/macosx/Carbon/carbon.html>

You can find additional information in Apple Technical Notes at

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

I/O Kit

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

<http://developer.apple.com/techpubs/macosx/Darwin/index.html/>

RAM Expansion Modules

The eMac uses 168-pin SDRAM DIMMs. The mechanical characteristics of the DIMM are given in the JEDEC specification for the 168-pin 8-byte DRAM DIMM. The specification can be found by using the search string MO161 on the Electronics Industry Association's website at

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

The electrical characteristics of the DIMM are given in section 4.5.6 of the 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 DIMMs are required to be the PC-133 compliant. Information about the PC-133 specification is available from Intel's website, 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-5 specification (ANSI NCITS 340-2000 AT Attachment - 5 with Packet Interface). 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 TN #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 TN #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>

Supplemental Reference Documents

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 website 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

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

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

Target Disk Mode

For more information about Target Disk mode, see the section "Target Mode" in TN 1189, The Monster Disk Driver Technical Note. The note is available on the technical note 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 website of the Wireless Ethernet Compatibility Alliance, at

<http://www.wirelessethernet.org/OpenSection/index.asp>

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

Other abbreviations used in this note include:

\$n	hexadecimal value n
10Base-T	an Ethernet standard for data transmission at 10 Mbits per second
100Base-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

A P P E N D I X B

Abbreviations

CAS	column address strobe
CAV	constant angular velocity
CD	compact disc
CD-ROM	compact disc read-only memory
CLV	constant linear velocity
CPU	central processing unit
D/A	digital to analog
DAA	data access adapter
DB-DMA	descriptor-based direct memory access
DDR	double data rate, a type of SDRAM
DIMM	Dual Inline Memory Module
DMA	direct memory access
DRAM	dynamic random-access memory
EDO	extended data out
EEPROM	electrically erasable programmable ROM
G4	Generation 4, the fourth generation of PowerPC microprocessors, incorporating AltiVec technology
GART	graphics address remapping table
GND	ground
HFS	hierarchical file system
HID	human interface device, a class of USB devices
IC	integrated circuit
IDE	integrated device electronics
IEC	International Electrotechnical Commission
IIC	inter IC control bus
IIS	inter IC sound bus
I/O	input and output
IR	infrared
ISO	International Organization for Standardization
JEDEC	Joint Electron Device Engineering Council
L1	level 1 or first level

A P P E N D I X B

Abbreviations

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

A P P E N D I X B

Abbreviations

Index

Numerals

3D graphics 60

A

accelerated graphics port bus. *See* AGP bus

AGP bus 21, 23, 24

AirPort Admin Utility 40

AirPort Application 40

AirPort Base Station 38, 39

AirPort Card 28, 38–40

 hardware components 39

 security features 39

 software components 39

AirPort Setup Assistant 39

AltiVec 16, 60

ATA device configuration 27

ATA Device Software Guide 63

ATA disk interface 42

ATA interface 40, 63

B

block diagram 19, 20

boot ROM 24

booting from a FireWire device 34

buses 19, 20

 AGP bus 21, 23

 memory bus 21, 23

 PCI bus 21, 24

 processor bus 21, 22

C

cache 22

cache. *See* L2 cache

case. *See* enclosure

CD-RW drive 42

CD-RW/DVD-R drive 41

clock speeds 21

Combo Drive 40

Combo drive 11

computer identification 16

connectors

 Ethernet 37

 external video display 44

 FireWire 34

 headphone 49

 sound input 49

 USB 31

custom ICs

 KeyLargo I/O controller 25

 Uni-N bridge and memory controller 22

D

DIMMs, for RAM expansion 53

 capacities 55

 electrical design of 54

 JEDEC specifications 54, 62

 mechanical design of 54

 specifications 62

DMA support 26

DVD-R. *See* SuperDrive (CD-RW/DVD-R) drive

DVD-ROM/CD-RW drive 40

INDEX

E

EIDE interface 27
enclosure 15
Ethernet controller 25
Ethernet port 37
external features 15

F

features list 12
FireWire connector 34
FireWire controller 25
FireWire device programming 34
FireWire interface 64
FireWire ports 33–37
 booting from 34
 device drivers 34
 Target Disk mode 36

G

G4. *See* PowerPC G4 microprocessor
graphics address remapping table (GART) 24
graphics IC 24

H

hard disk drive 40
headphone jack 49

I

I/O Kit 62
IDE hard disk 40
IDE interface 27
IDE interface. *See* ATA interface
input and output ports

Ethernet 37
FireWire 33
USB 31
 video monitor 44
interrupts 26
IORegistry 16

J

JEDEC specifications for RAM DIMMs 54, 62

K

keyboard 45–47
KeyLargo I/O controller IC 25

L

L2 cache 22

M

Mac OS X 61
Max Bus 22
memory bus 21, 23
memory expansion. *See* DIMMs
memory interleaving not supported 56
microprocessor 21, 60
microprocessor clock speeds 21
modem 38
modem slot 27
mouse 47

N

new features 11

INDEX

O

OHCI controller for USB 33

P, Q

PCI bus 21, 24
PCI write combining 24
power controller IC 29
power indicator 15
power saving modes 29
PowerPC G4 microprocessor 21, 60
processor bus 21, 22

R

RAM DIMMs. *See* DIMMs
RAM expansion 53–57
RAM Expansion Modules. *See* DIMMs
RAM expansion slots 53
ROM in RAM
 boot ROM 24

S

sound circuitry 28
sound system 48–51
 input sources 48
 built-in microphone 48
 external input 49
 output devices 49
 headphone jack 49
 internal speakers 49
 specifications 50
speakers 49
SuperDrive 11, 40, 41
SuperDrive (CD-RW/DVD-R) drive 41
SuperDrive (DVD-R/CD-RW) 11
system software 16–??

T

Target Disk Mode 36
Theater Mode 43

U

Uni-N bridge and memory controller IC 22
Universal Serial Bus. *See* USB
USB controller IC 27
USB features 32–33
USB interface 26, 63
USB ports 31–33
 booting from 33
 connectors 31
 controller type 33
 data transfer speeds 26, 32
 suspend mode 33
 wakeup from Sleep mode 33
USB suspend mode 27
USB with keyboard 47

V

Velocity Engine 16, 60
video display 43
 controller IC 24
 subsystem architecture 24
video display connector 44
video monitor port 44

W, X, Y, Z

wireless LAN module 28, ??–40
wireless LAN module. *See* AirPort Card 38
write combining 24

INDEX