iBook G4 Developer Note

Hardware & Drivers > Apple Hardware

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Figures and Tables

Introduction to iBook G4 Developer Note

This developer note gives a technical description of the new iBook G4. The note provides information about the computer's internal design, input-output features, and expansion capabilities.

> **Note:** This developer note has been updated to include information about the latest product features and configurations.

This developer note is intended to help hardware and software developers design products that are compatible with the Macintosh products described here. For additional technical information on Macintosh computers, refer to "Supplemental Reference Documents" (page 57).

Organization of This Document

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

- Chapter 1, "Introduction," (page 11) introduces the iBook G4 and describes its features, with emphasis on the changes since the previous model.

- Chapter 2, "Architecture," (page 19) describes the internal logic of the iBook G4, including the main ICs that appear in the block diagram.

- Chapter 3, "Devices and Ports," (page 27) describes the standard I/O ports and the built-in I/O devices.

- Chapter 4, "RAM Expansion," (page 51) describes the RAM expansion module.

- Appendix A, "Supplemental Reference Documents," (page 57) tells where to find more information about specific technologies used in the iBook G4.

- Appendix B, "Conventions and Abbreviations," (page 61) lists the standard units and abbreviations used in this developer note.

Overview of iBook G4

The iBook G4 is a portable computer for the consumer and education markets. This chapter lists the computer's features, with emphasis on the changes from the previous models.

New Features

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

- **Processor speed**: The clock speed of the Power PC G4 microprocessor is 800 MHz, 933 MHz, or 1 GHz. See "PowerPC G4 Microprocessor" (page 22).

- **System bus**: The maximum speed of the system bus is 133 MHz, with a variable-speed bus slewing option.

- **Bus slewing**: This feature automatically adjusts the processor and bus speed to conserve battery power. For more information, see "Power Management" (page 15).

- **System RAM**: The computer comes with 128 MB of soldered down RAM; some configurations have an additional 128 MB offboard RAM. The expansion slot capacity is an additional 128, 256, or 512 MB, supporting a maximum of 640 MB. For more information, see "RAM Expansion" (page 51).

- **Graphics IC**: The display controller is an ATI Mobility Radeon 9200 with 32 MB of graphics DDR SDRAM. See "Graphics IC" (page 22).

- **Battery**: The computer has one battery bay. The 50 watt-hour battery in the 12.1-inch display models uses six lithium ion cells and provides up to 6 hours of operation, depending on configuration and usage. The 61 watt-hour battery in the 14.1-inch display model uses eight lithium ion cells and provides up to 6 hours of operation, depending on configuration and usage.

- **USB 2.0 ports**: The computer has two external USB 2.0 ports. See "USB Ports" (page 27).

- **AirPort Extreme Card**: An AirPort Extreme Card is available as a build-to-order option or as a user-installable upgrade. See "AirPort Extreme" (page 31).

- **Bluetooth**: Available as a build-to-order option, fully-integrated Bluetooth enables short-range wireless connections between desktop and laptop computers and a host of other peripheral devices. For more information, see "Bluetooth Technology" (page 33).

- **Hard disk storage**: Depending on the configuration, the iBook G4 has a hard disk drive with a storage capacity of 30 GB, 40 GB, or 60 GB. For more information and developer guidelines for alternative hard drives, see "Hard Disk Drive" (page 33).

- **CD-ROM drive**: Some configurations of the computer have a built-in, slot-loading, 24x-speed CD-ROM drive. See "CD-ROM Drive" (page 38).

- **Combination DVD-ROM/CD-RW drive**: Some configurations of the computer have a built-in, slot-loading, combination DVD-ROM/CD-RW drive. For more information, see "DVD-ROM/CD-RW Combo Drive" (page 37).

■ **Weight**: With the battery installed, the 12.1-inch display models weigh approximately 2.2 kg (4.9 pounds) and the 14-1-inch display model weighs approximately 2.6 kg (5.9 pounds). The exact weight depends on the configuration.

■ **Size**: The 12.1-inch display models are 28.50 cm (11.2 inches) wide, depth 23.03 cm (9.06 inches) deep, and 3.42 cm (1.35 inches) thick. The 14.1-inch display model is 32.3 cm (12.7 inches) wide, 25.8 cm (10.2 inches) deep, and 3.42 cm (1.35 inches) thick.

All Features

Here is a list of the features of the iBook G4. Each feature is described in a later chapter, as indicated in the list.

■ **Processor speed**: The clock speed of the Power PC G4 microprocessor is 800 MHz, 933 MHz, or 1 GHz. See "PowerPC G4 Microprocessor" (page 22).

■ **System bus**: The maximum speed of the system bus is 133 MHz, with a variable-speed bus slewing option.

■ **Bus slewing**: This feature automatically adjusts the processor and bus speed to conserve battery power. For more information, see "Power Management" (page 15).

■ **Cache**: The microprocessor has a built-in L2 cache consisting of 256 KB of fast static RAM. The clock speed for the backside cache is the same as the clock speed of the microprocessor. See "L2 Cache" (page 20).

■ **System RAM**: The computer comes with 128 MB of soldered down RAM; some configurations have an additional 128 MB offboard RAM.The expansion slot capacity is an additional 128, 256, or 512 MB, supporting a maximum of 640 MB. For more information, see "RAM Expansion" (page 51).

■ **Hard disk storage**: Depending on the configuration, the iBook G4 has a hard disk drive with a storage capacity of 30 GB, 40 GB, or 60 GB. For more information and developer guidelines for alternative hard drives, see "Hard Disk Drive" (page 33).

■ **CD-ROM drive**: Some configurations of the computer have a built-in, slot-loading, 24x-speed CD-ROM drive. See "CD-ROM Drive" (page 38).

■ **Combination DVD-ROM/CD-RW drive**: Some configurations of the computer have a built-in, slot-loading, combination DVD-ROM/CD-RW drive. For more information, see "DVD-ROM/CD-RW Combo Drive" (page 37).

■ **Display**: Two TFT display sizes are available: a 12.1-inch and a 14.1-inch. Both displays have XGA (1024x768) resolution. See "Flat Panel Display" (page 45).

■ **External display connector**: The external display connector supports VGA, composite, and S-video formats for devices such as monitors and projectors. See "External Display Port" (page 46).

■ **Graphics IC**: The display controller is an ATI Mobility Radeon 9200 with 32 MB of graphics DDR SDRAM. See "Graphics IC" (page 22).

■ **Microphone**: The computer has a built-in microphone. See "Sound System" (page 48).

■ **Battery**: The computer has one battery bay. The 50 watt-hour battery in the 12.1-inch display models uses six lithium ion cells and provides up to 6 hours of operation, depending on configuration and usage. The The 61 watt-hour battery in the 14.1-inch display model uses eight lithium ion cells and provides up to 6 hours of operation, depending on configuration and usage.

- **USB 2.0 ports**: The computer has two external USB 2.0 ports. See "USB Ports" (page 27).

- **FireWire 400 port**: The computer has an IEEE-1394a FireWire 400 high-speed serial port. See "FireWire 400 Port" (page 28).

- **Target disk mode**: The computer can act like a FireWire storage device connected to another computer. See "Target Disk Mode" (page 17).

- **Modem**: The computer has a built-in modem that supports 56 Kbps data rate with V.92 modem standards. See "Internal Modem" (page 31).

- **Ethernet**: The computer has a built in Ethernet port for 10Base-T and 100Base-T operation. See "Ethernet Port" (page 30).

- **AirPort Extreme Card**: An AirPort Extreme Card is available as a build-to-order option or as a user-installable upgrade. See "AirPort Extreme" (page 31).

- **Bluetooth**: Available as a build-to-order option, fully-integrated Bluetooth enables short-range wireless connections between desktop and laptop computers and a host of other peripheral devices. For more information, see "Bluetooth Technology" (page 33).

- **Sound**: The computer has a built-in microphone and stereo speakers; it provides stereo output signals on the audio minijack. See "Sound System" (page 48).

- **Keyboard**: The keyboard has function keys and inverted-T arrow keys. Some of the function keys are used to control the brightness and sound and to eject a disk. The keyboard also includes an embedded numeric keypad. See "Keyboard" (page 38).

- **Trackpad**: The integrated trackpad includes tap/double tap and drag features. See "Trackpad" (page 38).

- **Weight**: With the battery installed, the 12.1-inch display models weigh approximately 2.2 kg (4.9 pounds) and the 14-1-inch display model weighs approximately 2.6 kg (5.9 pounds). The exact weight depends on the configuration.

- **Size**: The 12.1-inch display models are 28.50 cm (11.2 inches) wide, depth 23.03 cm (9.06 inches) deep, and 3.42 cm (1.35 inches) thick. The 14.1-inch display model is 32.3 cm (12.7 inches) wide, 25.8 cm (10.2 inches) deep, and 3.42 cm (1.35 inches) thick.

- **Security slot**: The iBook G4 has a slot for attaching a Kensington security cable.

Appearance

Figure 1-1 is a front view of the iBook G4; Figure 1-2 (page 14) provides a side view showing the I/O ports.

Figure 1-1   Front view of the computer
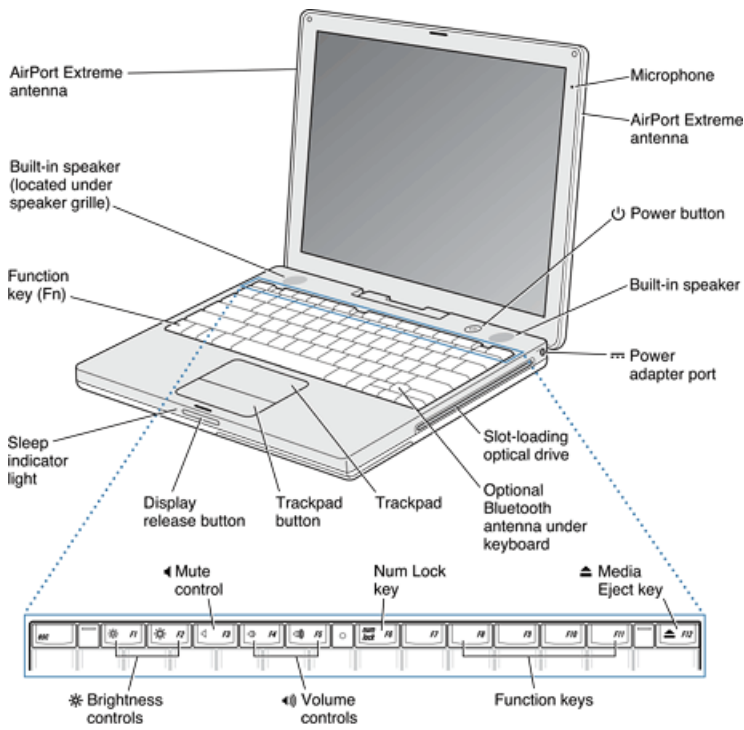
Figure 1-2   Side view showing I/O ports
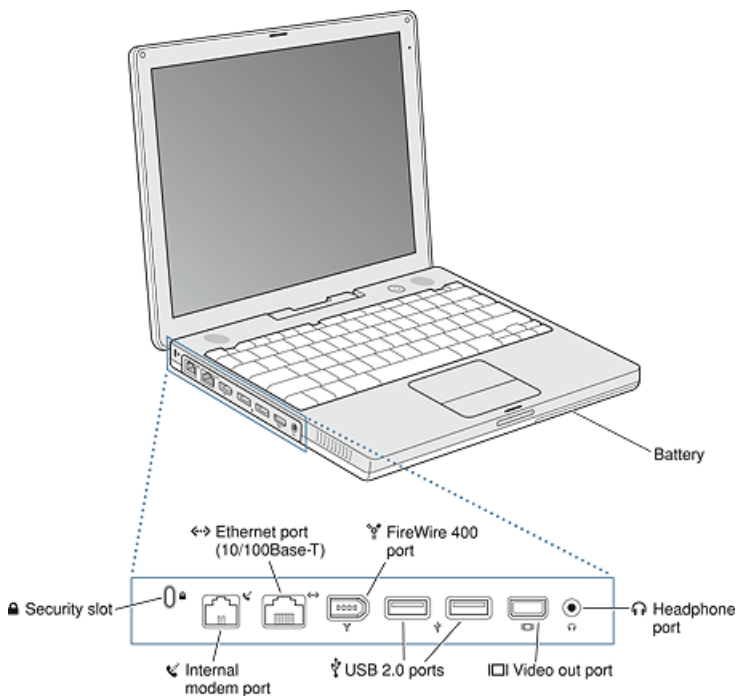
Peripheral Devices

In addition to the devices that are included with the computer, several peripheral devices are available separately:

- The AirPort Extreme Card wireless LAN module is available separately as a user-installable option.

- The battery is available separately as an additional or replacement battery.

- The power adapter, which comes with the computer, is also available separately. The adapter can recharge the internal battery in less than six hours while the computer is running or in three and a half hours while the computer is shut down or in sleep mode.

- A video adapter with composite and S-video connectors is available separately.

- A VGA adapter with a 15-pin VGA connector, included with the computer, is also available separately.

- Additional Apple Memory Module SO-DIMM SDRAM memory cards are available.

System Software

The iBook G4 comes with Mac OS X v. 10.3 installed as the default system and runs Mac OS 9 applications in Classic mode. For more information about Mac OS X, see the reference listed in "Mac OS X" (page 58).

Machine Identification

Current and recent Macintosh ROMs share the same BoxFlag. The intent is for applications to use properties in the Open Firmware device tree rather than checking BoxFlag to find out the features of the machine. On all these machines, a call to `gestaltMachineType` returns the value 406 ($196).

Asset management software that reports the kind of machine it is run on can obtain the value of the property at `Devices:device-tree:compatible` in the name registry. The model string is the first program-usable string in the array of C strings in the `compatible` field. For the iBook G4, the `model` property value is `PowerBook6,3`.

The string obtained from the `compatible` property cannot be displayed to the computer user. If 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.

Applications should not use either of these results to infer the presence of certain features; instead, applications should use Gestalt calls to test for the features they require.

Power Management

Apple's power management techniques for the iBook G4 are described in the following paragraphs.

Operating States

The power management protocols on the iBook G4 support two power-saving states: idle and sleep.

- Idle: The system is idling with the main processor stopped in a halted, low-power state. All clocks are running; the system can return to running code within a few nanoseconds. Cache coherency is maintained in this state.

- Sleep: The system is completely shut down, with only the DRAM state preserved for quick recovery. All processors are powered off with their state preserved in DRAM. All clocks in the system are suspended except for the 32.768 kHz timebase crystal on the PMU99 IC.

The computer automatically enters idle state after several seconds of inactivity. If the computer is attached to a network, it is able to respond to service requests and other events directed to the computer while it is in idle state.

While it is connected to an AC power supply, the computer can also respond to network activity when it is in sleep state. The user can enable this feature by selecting Wake-on-LAN in the Energy Saver panel in System Preferences.

When operating on the battery in sleep state, the computer consumes less than 1 watt of power, meeting the Energy Star power-saving standard. When operating on the power adapter in sleep state, the combined computer and adapter consume 3 to 4 watts of power.

Processor and Bus Slewing

To lower power consumption and heat generation, the iBook G4 incorporates an automatic power management technique called bus slewing. Bus slewing is designed to run at high processor speed, bus speeds, and voltage when the demand on the processor is high, and to run at low processor speed, bus speeds, and voltage when the demand on the processor is low. Switching between different processor/bus speeds and voltages is achieved by a transition that operates seamlessly to the user and should not impact system or application performance.

The iBook G4 allows the user to control bus slewing mode. The options for specifying either high, reduced, or automatic processor and bus speeds are located at System Preferences>Energy Saver>Show Details>Options>Processor Performance; then select Automatic, Highest, or Reduced. Slewing is enabled with the automatic setting, which is the system default.

If the iBook G4 detects a system temperature that is too high, due to high ambient temperatures or other factors, it will automatically force the system to slew to reduced mode regardless of the selected setting.

When the iBook G4 is in slewing mode, the processor, processor bus, and memory bus dynamically adjust their speeds based on the current needs of the system. In the 1.0 GHz configuration, the processor speed will switch between 1 GHz and 765 MHz. In the 933 MHz configuration, the processor speed will switch between 933 MHz and 714 MHz. In the 800 MHz configuration, the processor speed will switch between 800 MHz and 612 MHz. In all configurations, the processor bus and memory bus will switch between 133 MHz and 102 MHz.

Target Disk Mode

The user has the option at boot time to put the iBook G4 into a mode of operation called target disk mode (TDM). When the iBook G4 is in target disk mode and connected to another Macintosh computer by a FireWire cable, the iBook G4 operates like a FireWire mass storage device with the SBP-2 (Serial Bus Protocol) standard. Target disk mode has two primary uses:

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

The iBook G4 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 iBook G4 into target disk mode, restart the computer and hold down the T key until the FireWire icon appears on the display. Then connect a FireWire cable from the iBook G4 to the other computer. When the other computer completes the FireWire connection, a hard disk icon appears on its desktop.

If the iBook G4 is turned off or the FireWire cable is disconnected while in target disk mode, an alert appears on the other computer. Disconnecting while the disk is in use can cause loss of data on the target disk.

To dismount the iBook G4 out of target disk mode, drag the hard disk icon of the targeted computer to the trash on the main computer. When the computer is fully dismounted, press the power button on the targeted computer.

> **Note:** When serving as host in target disk mode, the iBook G4 runs at reduced bus speed, as described in "Processor and Bus Slewing" (page 16).

Architecture

This chapter describes the architecture of the iBook G4.

Block Diagram and Buses

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

Block Diagram

Figure 2-1 (page 19) is a simplified block diagram of the main logic board. The diagram shows the input and output connectors, the main ICs, and the buses that connect them together.

Figure 2-1   Block diagram
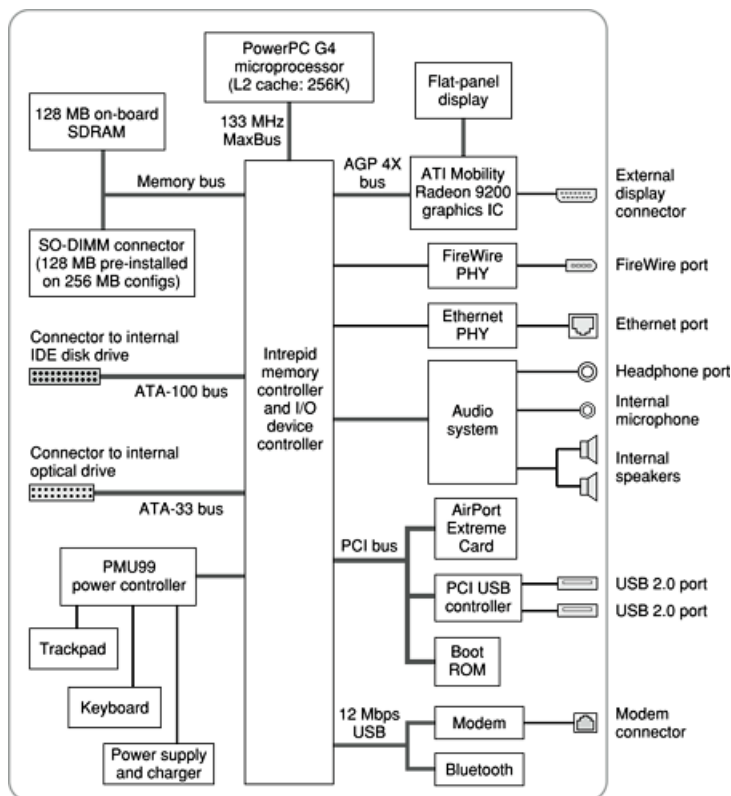
Main ICs and Buses

The architecture of the iBook G4 is designed around the PowerPC G4 microprocessor and the Intrepid IC, which provides the functions of a memory controller and an I/O device controller.

The PowerPC G4 microprocessor is connected to the Intrepid IC by a MaxBus. The maximum bus clock speed is 133 MHz. Additional buses implemented by the Intrepid IC are summarized in Table 2-1 (page 21).

The Intrepid IC has a 32-bit PCI bus with a bus clock speed of 33 MHz. The PCI bus also connects to the Boot ROM and the wireless LAN module. The Intrepid IC has other buses that connect with the hard disk drive, the optical drive, the power controller IC, the sound IC, and the internal modem module.

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

Microprocessor and Cache

The microprocessor communicates with the rest of the system by way of a 64-bit MaxBus bus to the Intrepid IC. The microprocessor has a separate bus to its internal second-level cache.

PowerPC G4 Microprocessor

The PowerPC G4 microprocessor used in the iBook G4 has many powerful features, including an efficient pipelined system bus called MaxBus.

Features of the PowerPC G4 include

- 32-bit PowerPC implementation
- superscalar PowerPC core
- Velocity Engine (AltiVec technology): 128-bit-wide vector execution unit
- dual 32 KB instruction and data caches
- an on-chip level 2 (L2) cache consisting of 256 KB with a clock speed ratio of 1:1
- high bandwidth MaxBus (also compatible with 60x bus)
- fully symmetric multiprocessing capability

The PowerPC G4 microprocessor in the iBook G4 runs at a maximum clock speed of 800 MHz, 933 MHz, or 1 GHz.

L2 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 and tag storage. The built-in L2 cache runs at the same clock speed as the microprocessor.

Intrepid Memory and I/O Device Controller

The Intrepid memory and I/O device controller IC provides cost and performance benefits by combining many functions into a single IC. It also contains the PCI bus bridge, the Ethernet, FireWire, and USB interfaces, and the AGP port.

In addition to the buses listed in Table 2-1 (page 21), the Intrepid IC has separate interfaces to the physical layer (PHY) ICs for Ethernet and FireWire. Also, Intrepid has an I2C interface to configure the memory subsystem and an OHCI USB controller to connect the internal modem and Bluetooth modules.

Table 2-1   Buses supported by the Intrepid IC

Bus	Destinations	Width of data path	Max bus clock speed
MaxBus	Microprocessor	64 bits	133 MHz
Memory	System RAM	64 bits	133 MHz
AGP4X	Graphics IC	32 bits	66 MHz
Ultra ATA-100	Hard drive	16 bits	100 MBps
ATA-33	Optical drive	16 bits	33 MHz

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

The microprocessor is described in its own section. The following sections describe the other subsystems that are connected to the Intrepid IC.

System RAM

The memory subsystem in the iBook G4 consists of 128 MB of DDR266B (PC2100) SDRAM soldered on the main logic board. Some configurations come standard with an additional 128 MB DDR SDRAM in the expansion slot for a total of 256 MB. The expansion slot capacity is an additional 128, 256, or 512 MB, supporting a maximum of 640 MB.

The data bus to the RAM and SO-DIMM is 64 bits wide, and the memory interface is synchronized to the MaxBus interface at maximum speed of 133 MHz. For more information, see "RAM Expansion" (page 51).

Boot ROM

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.

The boot ROM is connected to the card slot interface of the Intrepid IC. The boot ROM is a 1 M by 8 bit flash device and can be updated in the field.

Ethernet Controller

The Intrepid IC includes an Ethernet media access controller (MAC) that implements the link layer. As a separate channel connected directly to the Intrepid logic, it can operate at its full capacity without degrading the performance of other peripheral devices.

The controller is connected to a PHY interface IC that is capable of operating in either 10-BaseT or 100-BaseTX mode. The actual speed of the link is automatically negotiated by the PHY and the bridge or router to which it is connected. For information about the connector and the operation of the port, see "Ethernet Port" (page 30).

FireWire 400 Controller

The Intrepid IC includes an IEEE 1394a FireWire 400 controller with a maximum data rate of 400 Mbits (50 MBytes) per second. The Intrepid IC provides DMA (direct memory access) support for the FireWire400 interface. The FireWire controller complies with the Open Host Controller Interface (OHCI) specification.

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 is the interface to the external connector. For information about the connector and the operation of the port, see "FireWire 400 Port" (page 28).

Graphics IC

The graphics IC is an ATI Mobility Radeon 9200. It provides video for both the internal flat panel display and an external video display. The signals to the external display can be either VGA, composite video, or S-video; for more information, see"External Display Port" (page 46).

The signal generated for the flat panel display is simultaneously available for an external display. The external display mirrors the built-in display. For more information, see "External Display Port" (page 46).

The Mobility Radeon IC includes 32 MB of DDR SDRAM. The graphics IC supports a display size of 1024x768 pixels and also has a scaling mode that displays a 640x480 or 800x600 pixel image on the full screen.

The Mobility Radeon 9200 IC also has a 3D graphics engine for fast rendering of 3D objects.

Because the graphics IC uses the AGP bus, it can use part of main memory as additional graphics storage. The computer's virtual memory system organizes main memory as randomly-distributed 4 KB pages, so DMA transactions for more than 4 KB of data would have to perform scatter-gather operations. The AGP logic in the Intrepid IC uses a graphics address remapping table (GART) to translate a linear address space for AGP transactions into physical addresses in main memory.

DMA Support

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

■ Ultra DMA ATA interface to the the internal hard drive

■ IIS channel to the sound IC

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

Ultra DMA/100 Interface

The Intrepid IC provides an Ultra DMA/100 channel that is connected to the internal hard disk drive. The Intrepid IC provides DB-DMA (descriptor-based direct memory access) support for the Ultra DMA interface.

The internal hard disk drive is connected as device 0 (master) in an ATA Device 0/1 configuration.

ATA-33 Interface

The Intrepid IC provides an EIDE ATA-33 interface (ATA bus) that supports the optical drive. The optical drive is an ATAPI drive and is device-selected as master in an ATA device configuration.

USB 1.1 Controllers

The external USB interface is via the PCI USB controller; see "PCI USB 2.0 Controller" (page 25).

The Intrepid IC has three independent USB 1.1 host controllers each with a maximum data rate of 12 Mbps. The controllers comply with USB Open Host Controller Interface (OHCI).

In the iBook G4, only one of the Intrepid USB host controllers is used for the internal modem and Bluetooth adapter. The other host controllers are disabled for power savings reasons.

Modem Support

The internal modem is connected to an internal USB port. The internal modem is a separate module that contains the datapump IC and the interface to the telephone line (DAA). The controller functions are performed by the main processor. See "Internal Modem" (page 31).

Sound Circuitry

The iBook G4 has sound circuitry that is connected to the Intrepid IC by a standard I2S bus. The Intrepid IC provides DB-DMA (descriptor-based direct memory access) support for the I2S port.

The sound circuitry includes a signal processing IC that handles the equalization and volume control functions and a codec IC that performs A-to-D and D-to-A conversion.

All audio is handled digitally inside the computer. The sound circuitry performs digital-to-analog conversion for the audio signals to the internal speakers and the headphone mini-jack. The sound circuitry also provides parametric equalization for the internal speakers.

Modem progress audio is connected as a digital input to the sound circuitry so that it can be mixed into the sound output stream. The modem progress audio is processed as play-through only, not as a digital sound source.

The iBook G4 has no dedicated sound input jack. The sound system supports the built-in microphone and other sound input by way of a USB microphone or other USB audio device. For information about sound system operation, see "Sound System" (page 48).

Power Control IC

The power manager IC in the iBook G4 is a Mitsubishi M16C/62F microprocessor, also called the PMU99. It operates with its own RAM and ROM. The functions of the PMU99 include:

- controlling the sleep and power on and off sequences

- controlling power to the other ICs

- monitoring the battery charge level

- controlling battery charging

- supporting the interface to the built-in keyboard and trackpad

- keeping track of real time clock operations, including date and time

The iBook G4 can operate from a 15-volt power outlet on an airliner, however for safety reasons the computer will not allow battery charging. In order for the computer to detect the connection to airline power, the airline power cable (available separately) should have a sense resistor of 24.3K ohms connected between the power plug's shell and ground.

The PMU99 also provides the hardware interface to the keyboard and trackpad. Software in the PMU99 IC scans the keyboard and receives data from the trackpad, then sends the data to the system in packets like those from the ADB. To the system, the keyboard and trackpad behave as if they were ADB devices.

AirPort Extreme Interface

AirPort Extreme contains a media access controller (MAC), a digital signal processor (DSP), and a radio-frequency (RF) section.

Two antennas are built into the computer's case. To improve reception, a diversity module between the antennas and the card measures the signal strength from both antennas and selects the stronger signal for AirPort Extreme.

AirPort Extreme is based on the IEEE 802.11 g standard. The card transmits and receives data at up to 54 Mbps and is compatible with 802.11 b-standard 11 Mbps systems and older 802.11 b-standard systems. For information about its operation, see "AirPort Extreme" (page 31).

PCI USB 2.0 Controller

The iBook G4 CPU uses a PCI USB controller with one Enhanced Host Controller Interface (EHCI) function and two Open Host Controller Interface (OHCI) functions. The controller supports two external USB 2.0 ports.

The two external 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 27).

The two external USB 2.0 connectors support USB devices with data transfer rates of up to 480 Mbps. For more information about the connectors, see "USB Connector" (page 27).

All USB devices connected to the iBook G4 are required to support USB-suspend mode as defined in the USB specification. For additional reference information, see "USB Interface" (page 59).

The USB ports on the iBook G4 comply with the Universal Serial Bus Specification 2.0. The USB controllers comply with the EHCI specification; the companion controllers comply with the OHCI specification.

For information on the Intrepid USB 1.1 interface, see "USB 1.1 Controllers" (page 13).

PCI USB 2.0 Controller

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 iBook G4 has two external USB 2.0 ports that can be used to connect additional I/O devices such as a USB mouse, printers, scanners, and storage devices.

The USB ports on the iBook G4 comply with the Universal Serial Bus Specification 2.0. For more information about USB on Macintosh computers, consult the references at "USB Interface" (page 59).

> **Note:** Some self-powered USB devices inadvertantly violate electrical specifications for self-powered USB devices. For details and ways to avoid this design issue, refer to http://developer.apple.com/qa/hw/hw82.html.

USB Connector

The USB port uses a USB Type A connector, which has four pins. Two of the pins are used for power and two for data. Figure 3-1 (page 27) is an illustration of a Type A USB port. Table 3-1 (page 27) shows the pin assignments.

Figure 3-1   USB Type A connector
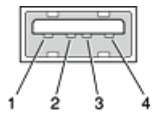
Table 3-1   Pin assignments on the USB port

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

The iBook G4 provides power for the USB ports at 5 V and up to 500 mA each.

Each USB port supports low-, full-, and high-speed data transfers at rates of 1.5 Mbps, 12 Mbps, and 480 Mbps, respectively. All cables and peripherals should be compliant with the USB specification.

The Macintosh USB system software that comes with the iBook G4 supports all four data transfer types defined in the USB specification.

USB Device Programming

Mac OS X includes support for a variety of USB Class Compliant devices and provides to access vendor specific devices. Developers can use the built-in support or provide additional applications and drivers.

In Mac OS X, The USB Family (IOUSBFamily) handles device plug and unplug andsupplies IOKit with a USB-specific matching method. The general services publish information about the bus and the devices in the IO Registry, so that IO Kit can match drivers to each connected USB device.

In the iBook G4, Mac OS X provides the following USB class compliant drivers:

- Audio
- Bluetooth
- CDC (Communication Data Class)
    - modem (abstract control model only)
- HID (Human Interface Device)
    - boot protocol
    - report protocol
- HUB
- Mass storage
- MIDI
- Printer
- Still image/PTP (digital still cameras)

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

For information about USB support on the Macintosh, see the references in "USB Interface" (page 59).

FireWire 400 Port

The iBook G4 has one external FireWire 400 IEEE 1394a port. The FireWire 400 port

- supports serial I/O at 100, 200, and 400 Mbps (megabits per second)
- provides up to 7 watts of peak power when the computer system is on or the power adapter is connected

- supports booting the system from a mass storage device

- supports target disk mode (TDM)

The FireWire 400 hardware and software provided with the iBook G4 are capable of all asynchronous and isochronous transfers defined by IEEE standard 1394.

FireWire 400 Connector

The FireWire 400 connector has six contacts, as shown in Figure 3-2 (page 29). The connector pin assignments are shown in Table 3-2 (page 29).

Figure 3-2   FireWire 400 connector
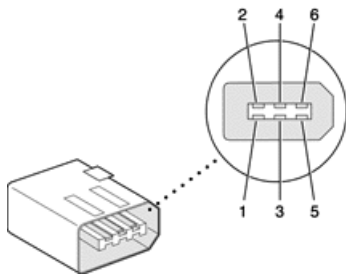
Table 3-2   Pin assignments on the FireWire 400 connector

Pin	Signal name	Description
1	Power	Unregulated DC; 12.0–16.8 V no load when operating with battery or power adapter
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 or the power adapter is connected, the power pin provides a maximum voltage of 16.8 V (no load) and up to 7 W peak power.

Pin 2 of the 6-pin FireWire 400 connector is ground for both power and the inner cable shield. If a 4-pin connector is used on the other end of the FireWire 400 cable, its shell should be connected to the wire from pin 2.

The signal pairs are crossed in the cable itself so that pins 5 and 6 at one end of the cable connect with pins 3 and 4 at the other end. When transmitting, pins 3 and 4 carry data and pins 5 and 6 carry clock; when receiving, the reverse is true.

FireWire 400 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 iBook G4 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 17)), 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/.

For additional information about the FireWire 400 interface, refer to the resources listed in "FireWire 400 Interface" (page 60).

Ethernet Port

The iBook G4 has a built-in 10/100 Mbps Ethernet port. The user can connect it to either a 10Base-T or a 100Base-T hub; the port will automatically sense which type of hub is connected.

The connector for the Ethernet port is a shielded RJ-45 connector near the left rear corner of the computer. Table 3-3 (page 30) shows the signals and pins 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

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

When connecting two computers using Ethernet, a crossover cable is not required; circuits in the PHY detect the type of connection and switch the signal configuration as required.

The Ethernet interface in the iBook G4 conforms to the ISO/IEC 802.3 specification, where applicable.

Internal Modem

The iBook G4 comes with a built-in modem.The connector for the modem is an RJ-11 connector on the left rear corner of the computer.

The modem has the following features:

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

■ 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.

AirPort Extreme

The iBook G4 computer supports the AirPort Extreme Card, an internal wireless LAN module based on the IEEE 802.11g standard. By communicating wirelessly with a base station, AirPort Extreme 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, or a standard telephone line using the optional 56K modem that is built-in on some models.

AirPort Extreme transmits and receives data at speeds up to 54 Mbps, comparable to wired networking speeds. Airport Extreme is also compatible with other devices that follow the IEEE 802.11b standard, including PC's. For more information about compatibility, see the reference at "Wireless Networks" (page 60).

AirPort Extreme Card is a build to order option on the iBook G4.

> **Note:** As is the case with the existing IEEE 802.11 b standard, actual data throughput speeds will be lower than the indicated maximum connection speeds. Inherent in wireless LAN systems, bandwidth overhead is required for wireless routing, scrambling, security error correction, and other processes.

Data Security

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

■ In 802.11 b mode, 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 an Access Control List of authentic network client ID values (wireless and MAC addresses) to verify each client's identity before granting access to the network.

■ When communicating with a base station, AirPort Extreme uses 64-bit and 128-bit WEP encryption to encode data while it is in transit. Additional security features may be available via firmware upgrades as 802.11 enhancements are ratified by IEEE.

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

■ The AirPort Extreme Base Station can authenticate users by their unique Ethernet IDs, preventing unauthorized computers from logging into your network. Network administrators can take advantage of RADIUS compatibility, used for authenticating users over a remote server. Smaller networks can offer the same security using a local look-up table located within the base station.

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

AirPort Extreme Hardware

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

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

AirPort Extreme Software

The iBook G4 includes software for setting up and using AirPort Extreme:

■ AirPort Extreme Setup Assistant, an easy-to-use program that guides users through the steps necessary to set up AirPort Extreme or set up an AirPort Extreme Base Station.

■ Users can switch between wireless networks and can create and join peer-to-peer networks. These functions are accessed via the AirPort Extreme status menu.

■ AirPort Extreme Admin Utility, a utility for advanced users and system administrators. With it the user can edit the administrative and advanced settings needed for some advanced configurations.

Bluetooth Technology

In the iBook G4, Bluetooth is a 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.

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.

When the Bluetooth option is installed, the Bluetooth antenna is located under the lower right side of the keyboard.

For more information on Bluetooth technology, refer to "Bluetooth" (page 60).

Hard Disk Drive

Depending on the configuration, the storage capacity of the internal hard disk drive is 30 GB, 40 GB, or 60 GB. The drive uses the Ultra ATA-100 (IDE, integrated drive electronics) interface and, depending on the configuration, is ATA-5 or ATA-6 compatible. Data Transfer Mode for the drive is ATA-100.

The software that supports the internal hard disk is similar to that in previous models with internal IDE drives and includes DMA support. For the information about that software, see the references in "ATA Devices" (page 59).

Hard Disk Dimensions

Figure 3-3 (page 34) shows the maximum dimensions of the hard disk and the location of the mounting holes. The minimum clearance between any conductive components on the drive and the bottom of the mounting envelope is 0.5 mm.

Figure 3-3   Maximum dimensions of the internal hard disk

Hard Disk Connector

The internal hard disk has a 48-pin connector that carries both the ATA signals and the power for the drive. The connector has the dimensions of a 50-pin connector, but with one row of pins removed, as shown in Figure 3-4 (page 35). The remaining pins are in two groups: pins 1–44, which carry the signals and power, and pins 45–48, which are reserved. Pin 20 has been removed, and pin 1 is located nearest the gap, rather than at the end of the connector.

Figure 3-4   Hard disk connector and location

Note: Dimensions are in millimeters [inches].
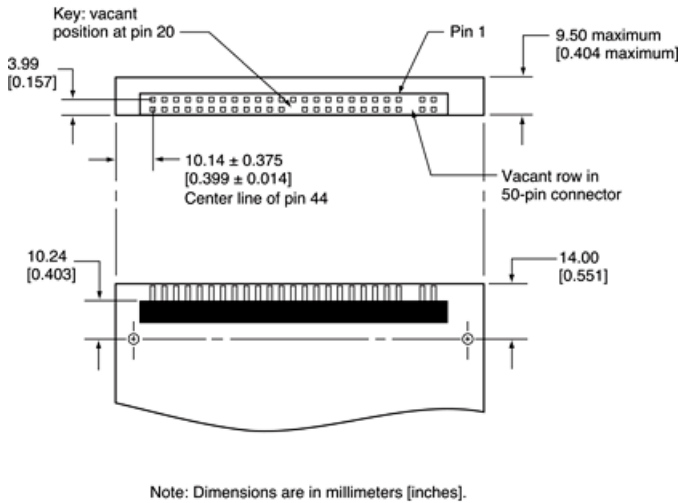
Signal Assignments

Table 3-4 (page 35) shows the signal assignments on the 44-pin portion of the hard disk connector. A slash (/) at the beginning of a signal name indicates an active-low signal.

Table 3-4   Pin assignments on the ATA hard disk connector

Pin number	Signal name	Pin number	Signal name
1	/RESET	2	GROUND
3	DD7	4	DD8
5	DD6	6	DD9
7	DD5	8	DD10
9	DD4	10	DD11
11	DD3	12	DD12
13	DD2	14	DD13
15	DD1	16	DD14
17	DD0	18	DD15
19	GROUND	20	KEY
21	DMARQ	22	GROUND
23	/DIOW, /STOP	24	GROUND
25	/DIOR, /HDMARDY, HSTROBE	26	GROUND

Pin number	Signal name	Pin number	Signal name
27	IORDY, /DDMARDY, DSTROBE	28	CSEL
29	/DMACK	30	GROUND
31	INTRQ	32	/IOCS16
33	/DA1	34	/PDIAG, /CBLID
35	/DA0	36	/DA2
37	/CS0	38	/CS1
39	/DASP	40	GROUND
41	+5V LOGIC	42	+5V MOTOR
43	GROUND	44	Reserved
/IOCS16 is not used; see Table 3-5			

ATA Signal Descriptions

Table 3-5 (page 36) describes the signals on the ATA hard disk connector.

Table 3-5   Signals on the ATA hard disk connector

Signal name	Signal description
/DA(0–2)	Device address; used by the computer to select one of the registers in the ATA drive. For more information, see the descriptions of the CS0 and CS1 signals.
DD(0–15)	Data bus; buffered from IOD(16–31) of the computer's I/O bus. DD(0–15) are used to transfer 16-bit data to and from the drive buffer. DD(8–15) are used to transfer data to and from the internal registers of the drive, with DD(0–7) driven high when writing.
/CBLID	The host checks this signal after Power On or hardware reset to detect whether an 80-conductor cable is present.
/CS0	Register select signal. It is asserted low to select the main task file registers. The task file registers indicate the command, the sector address, and the sector count.
/CS1	Register select signal. It is asserted low to select the additional control and status registers on the ATA drive.
CSEL	Cable select; not available on this computer (n.c.).
/DASP	Device active or slave present; not available on this computer (n.c.).
/DDMARDY	Drive ready to receive Ultra DMA data.
/DIOR	I/O data read strobe.

Signal name	Signal description
/DIOW	I/O data write strobe.
/DMACK	Used by the host to initiate a DMA transfer in response to DMARQ.
DSTROBE	Strobe for Ultra DMA data transfers to host.
/HDMARDY	Ultra DMA data ready.
HSTROBE	Strobe for Ultra DMA data transfers from host.
IORDY	I/O ready; when driven low by the drive, signals the CPU to insert wait states into the I/O read or write cycles.
/IOCS16	I/O channel select; not used on this computer (pulled low by a 1 kilohm resistor).
DMARQ	Asserted by the device when it is ready to transfer data to or from the host.
INTRQ	Interrupt request. This active high signal is used to inform the computer that a data transfer is requested or that a command has terminated.
/PDIAG	Asserted by device 1 to indicate to device 0 that it has completed the power-on diagnostics; not available on this computer (n.c.).
/RESET	Hardware reset to the drive; an active low signal.
/STOP	Stop request; an active low signal.
Key	This pin is the key for the connector.

The built-in ATA devices are connected to the I/O bus through bidirectional bus buffers.

DVD-ROM/CD-RW Combo Drive

Some configurations of the computer have a slot-loading, combination DVD-ROM and CD-RW drive.

The drive can read DVD media and read and write CD media, as shown in Table 3-6 (page 37). The DVD-ROM/CD-RW Combo drive also provides DVD-Video playback with DVD MPEG2 decode.

Table 3-6   Types of media read and written by the DVD-ROM/CD-RW drive

Media type	Maximum reading speed	Maximum writing speed
DVD-ROM	8x (CAV)	–
CD-R	24x (CAV)	24x (CLV) Zone
CD-RW	24x (CAV)	10x (CLV)
CD or CD-ROM	24x (CAV)	–

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

CD-ROM Drive

Some configurations of the iBook G4 have an internal, slot-loading CD-ROM drive. The drive supports a maximum 24X data transfer rates using constant angular velocity (CAV).

The CD-ROM drive supports the worldwide standards and specifications for CD-ROM and CD-digital audio discs described in the Sony/Philips Yellow Book and Red Book. The drive can read CD-ROM, CD-ROM XA, CD-I, PhotoCD, and Video CD discs as well as play standard audio discs.

Digital audio signals from the CD-ROM can be played through the sound outputs under the control of the System Preferences.

Trackpad

The pointing device in the iBook G4 is a trackpad. The trackpad is a solid-state device that emulates a mouse by sensing the motions of the user's finger over its surface and translating those motions into cursor movements.

The user makes selections either by pressing the trackpad button (below the trackpad) or by tapping and double tapping on the pad itself. The trackpad responds to one or two taps on the pad itself as one or two clicks of the button. The user can tap and drag on the trackpad in much the same manner as clicking and dragging with the mouse. The tap and double-tap functions are optional; the user activates or deactivates them by means of the keyboard and mouse pane in System Preferences.

The trackpad on the iBook G4 has palm-rejection capabilities that help prevent unintended trackpad input while typing is being performed. When the "Ignore trackpad while typing" checkbox is selected on the mouse pane of Systems Preferences, the system software attempts to filter out unintended contact with the trackpad. The trackpad will not respond when a mouse is present and the "Ignore trackpad when mouse is present" checkbox is selected on the keyboard mouse pane of Systems Preferences. The default setting is for all gestures to be turned off.

> **Note:** If the trackpad is not responding to intended input, check to see if the "Ignore trackpad while typing" checkbox is selected.

Keyboard

The keyboard is a compact, low-profile design with a row of function keys and inverted-T cursor motion keys.

Removing the Keyboard

The keyboard is removable to allow access to the internal components and expansion connectors inside the computer. The keyboard is held in place by a locking screw and two latches.

To unlock the keyboard, the user turns a slotted screw that is part of the Num Lock LED, which is between the F5 and F6 function keys. Turning the screw 180 locks or unlocks the keyboard.

Note: The iBook G4 leaves the factory with keyboard locking screw in the unlocked position.

The two latches are between the ESC key and the F1 key and between the F11 and F12 keys. The user can release the latches by pulling them toward the front of the computer; see Figure 3-5 (page 39).

Figure 3-5   Unlocking the keyboard

Important: When replacing the keyboard, make sure the latches at the top line up with the corresponding slots in the case and that the bottom tabs are aligned correctly and completely seated before tilting the keyboard into place. See Figure 3-6 (page 39).

Figure 3-6   Replacing the keyboard
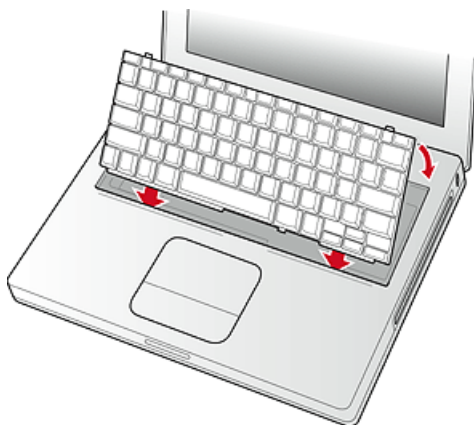
Getting access to the AirPort Extreme Card and memory card in the RAM expansion slot takes further steps. For a full description, see "The RAM Expansion Slot" (page 51).

Keyboard Illustrations

Figure 3-7 (page 40) shows the appearance of the keyboard. Figure 3-8 (page 41) shows the alternate modes of operation of the function and control keys. Figure 3-9 (page 42) shows the embedded numeric keypad.

Figure 3-7   Keyboard layout

Figure 3-8 (page 41) and Figure 3-9 (page 42) include duplicate versions of some keys in order to show their alternate modes of operation. In some cases, the alternate key captions shown in the figures do not appear on the keyboard. For the basic appearance of the keyboard, refer to Figure 3-7 (page 40).

Figure 3-8   Alternate operations of function and control keys
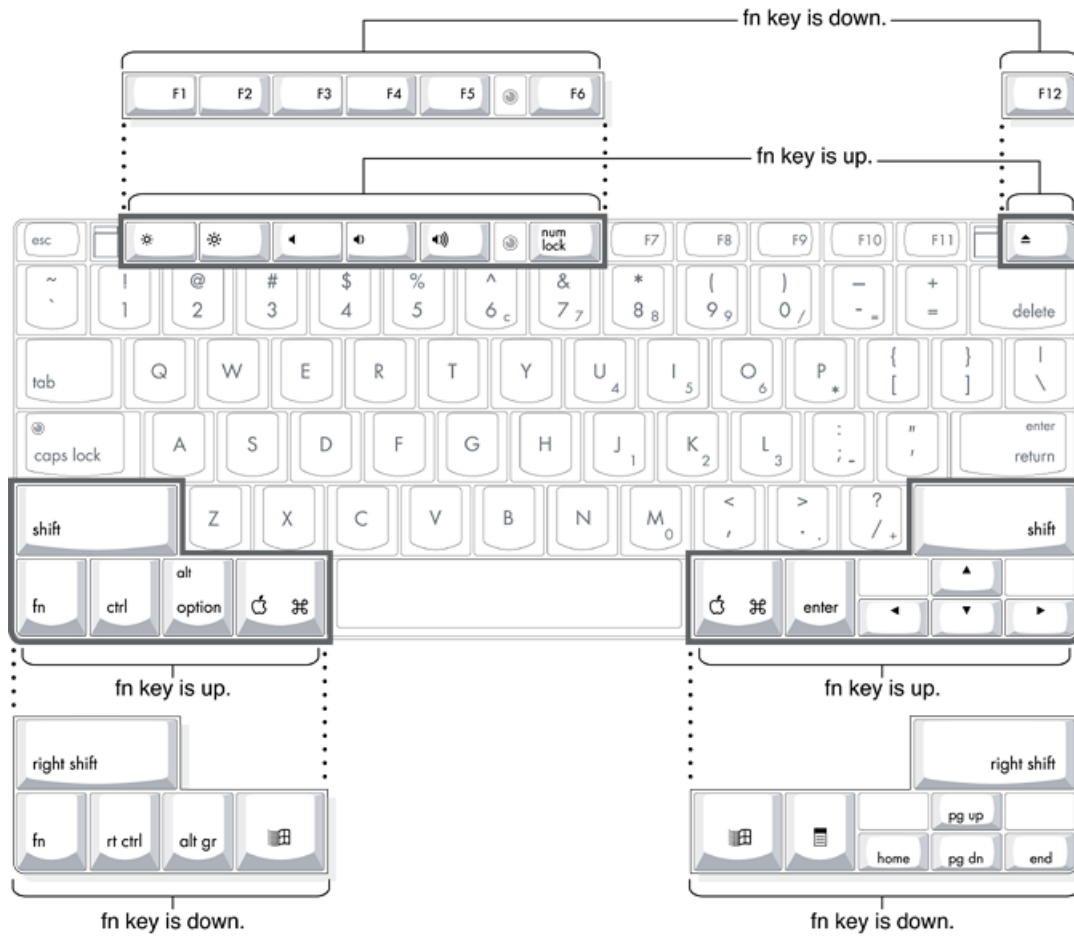
Figure 3-9   Embedded numeric keypad operation
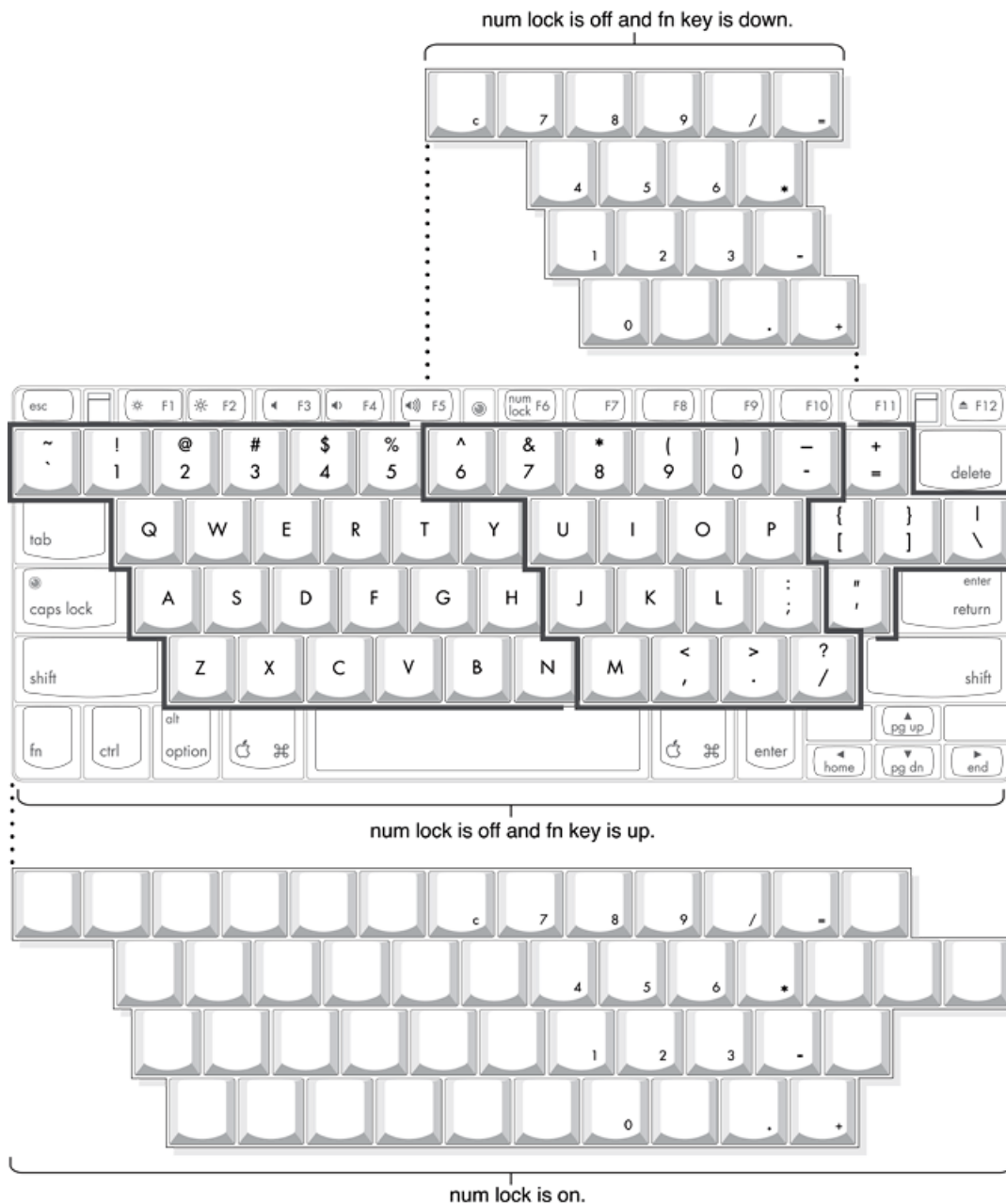
Keyboard Operations

Several of the keys on the keyboard have more than one mode of operation.

■   Function keys F1–F6 can also control the display brightness, speaker volume, and the Num Lock function; function key F12 is also the media eject key.

■   Certain control keys can be used as page-control keys.

■   The keys on the right side of the keyboard can be used as a numeric keypad.

The next sections describe these groups of keys and the way their alternate modes of operation are selected by using the Fn key and the Num Lock key.

Using the Fn Key

Pressing the Fn key affects three sets of keys: the function keys F1–F12, the embedded numeric keypad, and certain modifier keys.

- It toggles the function keys between their control-button operation and their F1–F12 functions, as shown in Table 3-9 (page 45) and Figure 3-8 (page 41).

- It selects the embedded numeric keypad on the right portion of the alphanumeric keys, as shown in Table 3-7 (page 43) and Figure 3-9 (page 42).

- It changes certain control keys, including the cursor control keys, to page control keys, as shown in Table 3-9 (page 45) and Figure 3-9 (page 42).

> **Note:** Mac OS X supports user-programmable function key assignments.

Using the Num Lock Key

Pressing the Num Lock key affects two sets of keys: the embedded keypad and the rest of the alphanumeric keys.

- It selects the embedded numeric keypad, as shown in Table 3-7 (page 43) and Figure 3-9 (page 42).

- It makes the rest of the alphanumeric keys functionless (NOPs), as shown in Figure 3-9 (page 42).

The Embedded Keypad

A certain group of alphanumeric keys can also function as an embedded keypad. The user selects this mode by using the Fn key or the Num Lock key. Figure 3-9 (page 42) shows the keys making up the embedded keypad and Table 3-7 (page 43) lists them.

Table 3-7   Embedded keypad keys

Key name	Keypad function
6	Clear
7	7
8	8
9	9
0	/ (divide)
-	= (equals)
U	4

Key name	Keypad function
I	5
O	6
P	* (multiply)
J	1
K	2
L	3
;	– (subtract)
M	0
,	NOP
.	. (decimal)
/	+ (add)

When the embedded keypad is made active by the Num Lock key, the other alphanumeric keys have no operation (NOP), as shown in . The affected keys include certain special character keys: plus and equal sign, right and left brackets, vertical bar and backslash, and straight apostrophe.

Operations of the Function Keys

Function keys F1 through F6 are used as control buttons for the display and sound and F12 is used for media eject (hold down F12 button for one or 2 seconds). is a list of the function keys and their operations as control buttons.

Table 3-8   The function keys as control buttons

Key name	Control button
F1	Decrease display brightness
F2	Increase display brightness
F3	Mute the speaker
F4	Decrease speaker volume
F5	Increase speaker volume
F6	Num Lock
F12	Media Eject

Other Control Keys

The cursor control keys can also be used as page control keys. Other control keys can take on the functions of certain keys on a PC keyboard, for use with PC emulation software. The Fn key controls the modes of operation of this group of keys. Table 3-9 (page 45) is a list of these keys and their alternate functions. These control keys are also show in Figure 3-9 (page 42).

Table 3-9   Control keys that change

Key name	Alternate function
Shift	Right shift key
Control	Right control key
Option	Alt gr (right Alt key)
Command	Windows¬® key
Enter	Menu key (for contextual menus)
Left arrow	Home
Up arrow	Page up
Down arrow	Page down
Right arrow	End

Flat Panel Display

The iBook G4 has a built-in color flat panel display. The display is backlit by a cold cathode fluorescent lamp (CCFL). The display uses TFT (thin-film transistor) technology for high contrast and fast response.

Depending on the model, the display is either 12.1 or 14.1 inches in size, measured diagonally. The display contains 1024x768 pixels (XGA) and can show up to millions of colors.

The graphics controller IC is an ATI Mobility Radeon 9200. The graphics IC has 32 MB of video DDR SDRAM on the chip. It supports 3D acceleration and display depths up to 24 bits per pixel. For more information, see "Graphics IC" (page 22).

The graphics IC includes a scaling function that expands smaller-sized images to fill the screen. By means of the scaling function, the computer can show full-screen images at 1024x768, 800x600, or 640x480 pixels.

External Display Port

The iBook G4 has a video output port for connecting an external video monitor or projector. The port supports both RGB and composite/S-video signals (for VGA and video) by means of adapters. The port detects the type of adapter connected to it and programs the graphics IC to provide the appropriate type of video signals, as shown in the table below.

Table 3-10   Display adapters

Adapter type	Video signals	Connector type(s)
VGA	RGB	VGA 15-pin miniature D-type
Video	Composite and S-video TV signals	RCA and S-video

Resolutions supported are 640x480, 800x600, and 1024x768 pixels. When either type of display adapter is connected, the settings for the resolutions are selectable in the Systems Preferences Display pane.

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 video adapter, the computer detects the type of adapter and enables the composite and S-video outputs. The settings for the resolutions and standards (NTSC or PAL) are then selectable in the Systems Preferences Display pane.

The video output mirrors the flat panel display: internal and external video share the same buffer, and the hardware sends the image to both displays.

Video Display Connector

The video display connector is a 14-pin rectangular connector, Hosiden TCX3143, or compatible. The connector pins are identified in Figure 3-10 (page 46).

Figure 3-10   Video display connector
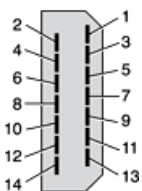
The iBook G4 detects the type of display adapter that is plugged in and programs the graphics IC to route the appropriate video signals to the connector. The signal assignments on the video connector are shown in Table 3-11 (page 46). The signal assignments for the video adapter are shown in Table 3-12 (page 47).

Table 3-11   Video signals for a VGA display

Pin	Signal name	Pin	Signal name
1	Ground	8	+5 volts

Pin	Signal name	Pin	Signal name
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

Table 3-12   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

The cable detect function on pin 13 is implemented by connecting pin 13 to ground in the display cable. The computer detects the video adapter by reading its EDID (Extended Display Identification Data) via DDC (pins 10 and 11).

The video display connector is compliant with the VESA specification (DDC version 3).

Older Monitors Not Supported

The computer supports current video monitors. The detection scheme on some older monitors are not supported and will use default configurations, including the following Apple monitors:

- Multiple Scan 17
- Multiple Scan 20
- AudioVision 14
- Apple Hi-Res RGB
- Apple 16" Color
- Apple Hi-Res Monochrome

■   Macintosh 12" RGB

Sound System

The 16-bit stereo audio circuitry provides sound input through the built-in microphone and the USB port and sound output through the built-in stereo speakers and the audio minijack.

All audio is handled digitally inside the computer, including audio data from the DVD-ROM/CD-RW Combo drive or CD-ROM drive, the modem, and devices connected to the USB and FireWire ports. Sound data is converted to analog form only for output to the internal speakers and the headphone jack.

The sound circuitry handles audio data as 44.1 kHz 16-bit samples. If audio data sampled at a lower rate on another computer is played as output, the Sound Manager transparently upsamples the data to 44.1 kHz prior to sending the audio data to the sound circuitry.

Audio Headphone Jack

The audio headphone jack is located on the left side of the computer at the left palm rest. The jack accepts a standard stereo mini-plug.

The stereo audio signals at the jack are configured to drive a pair of low-impedance stereo headphones. External powered speakers may also be connected to the headphone jack.

The audio signals on the audio minijack have the following electrical characteristics:

■   output impedance: 16 ohms each channel

■   minimum recommended load impedance: 32 ohms each channel

■   maximum level: 1.5 V rms (4.4 V P-P)

■   signal to noise ratio (SNR): greater than 98 dB (A)

■   THD+N: less than 0.005%

Internal Microphone

The computer has a built-in microphone located at the upper right hand corner of the display.

Internal Speakers

The computer has a stereo pair of speakers located between the keyboard and the display. The sound system provides parametric equalization for the speakers. The computer turns off the sound signal to the speakers when headphones are connected to the audio mini-jack and when USB speakers are active.

Sound effects and output from other audio sources can be specified in the System Preferences Sound panel. An output device is displayed on the Sound panel when the computer detects that it is plugged in. The system default setting is the internal audio controller. Once the default is changed to a different device, it will remain the default as long as the device is plugged in.

Note: Unlike Mac OS 9, Mac OS X does not automatically switch to USB audio when the device is attached.

Internal Modem

Digital audio data from the modem is read from the USB interface, processed by the audio software, and transferred by the DMA through the I2S interface of the Intrepid IC to the sound system.

CD Audio

Digital audio data from the CD or Combo drive is read using the ATA interface, processed by the audio software, and then transferred by DMA through the I2S interface of the Intrepid IC to the sound system or sent to USB speakers.

RAM Expansion

This chapter tells how to gain access to the RAM expansion slot in the iBook G4 and then describes the RAM expansion module.

The RAM Expansion Slot

The iBook G4 has one RAM expansion slot. To get access to the RAM expansion slot, the user must open up the computer. Below is an overview of the steps for opening the computer; for complete instructions, refer to your *iBook G4 User Guide*.

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

1. Shut down the computer.

2. Unplug the AC adapter from the computer.

3. Remove the battery from the computer.

4. Release the two plastic tabs located at the top of the keyboard and pull only on the latches (not on the keys) to lift the keyboard up and turn it over, without disconnecting the keyboard's membrane cable. See Figure 3-5 (page 39).

5. Remove the AirPort Extreme Card, if present, by unlatching the formed wire holder on the card, then pulling the flex tab to remove the module. The antenna cable should remain attached to the card. See Figure 4-1 (page 52).

6. Remove the four screws that secure the metal RAM shield plate and slide the plate toward the rear of the computer, then lift it up and out of the computer. See Figure 4-2 (page 52).

7. If this is a 256-MB configuration, remove the 128-MB SO-DIMM currently occupying the memory expansion slot.

Figure 4-1   The AirPort Extreme Card and antenna cable
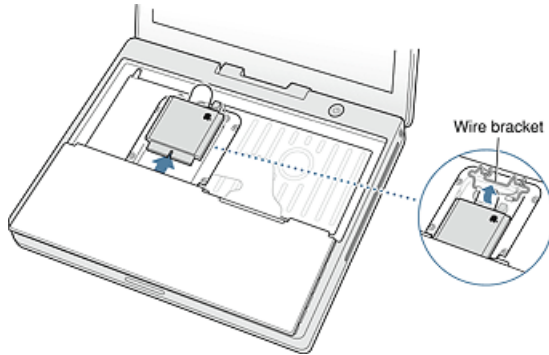
Figure 4-2   The RAM shield plate
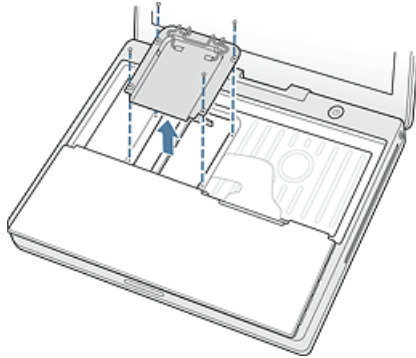
Once the RAM expansion module has been installed in the slot, the user must close up the computer by performing these steps in reverse order. Be careful to replace the shield plate properly so that the AirPort Extreme Card will fit.

Important: When replacing the keyboard, make sure the latches at the top line up with the corresponding slots in the case.

If AC and battery power are removed for longer than ten minutes, the user may need to reset the computer's clock (using the Data and Time pane in Systems Preferences) when the computer is turned back on.

The RAM Expansion Module

The RAM expansion slot accommodates a standard DDR266B (PC2100) SO-DIMM (small outline, dual inline memory module) that uses SDRAM devices.

> **Important:** A RAM expansion SO-DIMM for the iBook G4 must use DDR SDRAM devices. If the user installs an SO-DIMM that uses EDO or SGRAM devices, the computer will beep twice when the user attempts to restart the computer.

An SO-DIMM for the iBook G4 can contain either 128, 256, or 512 MB of memory. Maximum supported RAM capacity is 640 MB and is limited by the space available for the SO-DIMM.

Mechanical Design of the RAM SO-DIMM

The mechanical characteristics of the RAM expansion module are given in the JEDEC specification JESD95 for the 200-pin 8-byte DRAM SO-DIMM. To find out how to obtain the specification, see "RAM Expansion Modules" (page 59).

The specification defines SO-DIMMs with nominal heights of 1.0, 1.25, 1.5, or 2.0 inches. The iBook G4 can accommodate standard SO-DIMMs with a height of 1.0 or 1.25 inches.

The JEDEC specification defines the maximum depth or thickness of an SO-DIMM as 4.0 mm . That specification is also a maximum; modules that exceed the specified thickness can cause reliability problems.

Electrical Design of the RAM SO-DIMM

The electrical characteristics of the RAM SO-DIMM are given in section 4.5.6 of the JEDEC Standard 21-C, release 7. To find out how to obtain the specification, see "RAM Expansion Modules" (page 59).

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

The JEDEC specification for the SO-DIMM defines a Serial Presence Detect (SPD) feature that contains the attributes of the module. SO-DIMMs for use in the iBook G4 are required to have the SPD feature. Information about the required values to be stored in the presence detect EEPROM is in section 4.1.2.5 and Figure 4.5.6–C (200-pin SDRAM SO–DIMM, PD INFORMATION) of the JEDEC standard 21-C specification, release 7.

DDR SDRAM Devices

The DDR SDRAM devices used in the RAM expansion modules must be self-refresh type devices for operation from a 2.5 V power supply. The maximum speed of the DDR SDRAM devices must be 133 MHz or greater and operate at a minimum speed of 102 MHz.

The devices are programmed to operate with a CAS latency of 2.5 or 3. At these CAS latencies, the access time from the clock transition must be 7.5 ns or less. The burst length must be at least 4 and the minimum clock delay for back-to-back random column access cycles must be a latency of 1 clock cycle.

Configuration of RAM SO-DIMMs

Table 4-1 (page 23) shows information about the different sizes of SO-DIMMs used in the iBook G4. The first three columns show the memory size, configuration, and number of banks in the SO-DIMMs. The other three columns show the number, density, and configuration of the DDR SDRAM devices making up the memory modules.

Table 4-1   Sizes of RAM expansion modules and devices

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

Address Multiplexing

Signals A[0] – A[12] and BA[0] – BA[1] on each DDR SDRAM SO-DIMM make up a 15-bit multiplexed address bus that can support several different types of DDR SDRAM devices. Table 4-2 (page 54) lists the types of devices that can be used in the iBook G4 by size, configuration, and sizes of row, column, and bank addresses.

Important: The iBook G4 supports only the types of DDR SDRAM devices specified in Table 4-2 (page 54). Other types of DRAM devices should not be used with this computer.

Table 4-2   Types of DDR DRAM devices

Device size	Device configuration (bytes x bits x banks)	Row address bits	Column address bits
128 Mbits	4 M x 8 x 4	12	10
128 Mbits	2 M x 16 x 4	12	9
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
512 Mbits	16 M x 8x 4	13	11

DDR RAM SO-DIMM Electrical Limits

Each RAM SO-DIMM must not exceed the following maximum current limits on the +2.5 V supply:

Active: 1.2 A (maximum of 8 devices per bank, 150 mA per device)

Sleep: 12 mA (total for all banks)

The maximum current specified for active operation generally rules out the use of 4-bit-wide DDR SDRAM devices in a RAM expansion module. Such a module would have 16 such devices per bank, and the 1.2 A maximum current would allow only about 75 mA per device. To stay within the current limits, RAM expansion modules should use only 8-bit or 16-bit DDR SDRAM devices.

Supplemental Reference Documents

This section contains additional information about the technologies mentioned in this developer note by providing references to helpful websites.

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 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.

General information on OpenGL is available on the World Wide Web at

http://www.apple.com/macosx/technologies/graphics.html

and

http://www.opengl.org

Developer support and documentation is available at

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

PowerPC G4 Microprocessor

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

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

Mac OS X

Mac OS X version 10.3 is installed by default on the iBook G4 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.

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/documentation/Darwin/Darwin.html

Open Firmware

The following technical notes provide an introduction to Open Firmware on the Macintosh platform:

TN1061: Open Firmware, Part I, available on the technical note web site at

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

TN1062: Open Firmware, Part II, available on the technical note web site at

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

TN1044: Open Firmware, Part III, available on the technical note web site at

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

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

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

Another technical note tells how to debug open firmware code. Please refer to *TN2004: Debugging Open Firmware Using Telnet*, available on the technical note web site at

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

RAM Expansion Modules

The mechanical characteristics of the DDR RAM SO-DIMM are given in JEDEC specification number JESD95. The specification can be found by using the search string JESD95 on the Electronics Industry Association's website at

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

The electrical characteristics of the DDR RAM SO-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

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

http://www.t13.org/

USB Interface

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

http://developer.apple.com/hardware/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, refer to the USB Implementers Forum on the World Wide Web, at:

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

FireWire 400 Interface

For additional information about the FireWire 400 IEEE 1394a interface and the Apple APIs for FireWire 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

Useful information is also available 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 web site of the Wireless Ethernet Compatibility Alliance, at

http://www.wi-fi.org

Bluetooth

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

Bluetooth specification:

http://www.bluetooth.com/

Bluetooth SIG:

http://www.bluetooth.org

Bluetooth developer tools on the Apple web site at:

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

Conventions and Abbreviations

This developer note uses the following typographical conventions and abbreviations.

Typographical Conventions

> **Note:** A note like this contains information that is of interest but is not essential for an understanding of the text.

> **Important:** A note like this contains important information that you should read before proceeding.

Abbreviations

When unusual abbreviations appear in this developer note, the corresponding terms are also spelled out. Standard units of measure and other widely used abbreviations are not spelled out.

Here are the standard units of measure used in developer notes:

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

Other abbreviations used in developer notes include these:

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
ADB	Apple Desktop Bus
ADC	Apple Display Connector
AGP	accelerated graphics port
AIM	ATA Interface Module
AP	access point, for a wireless LAN
API	application programming interface
ASIC	application-specific integrated circuit
ATA	AT attachment
ATAPI	AT Attachment Packet Interface
CAS	column address strobe, a memory control signal
CAV	constant angular velocity
CD	compact disc
CD-ROM	compact disc read-only memory
CLV	constant linear velocity
CPU	central processing unit
DAA	data access adapter (a telephone line interface)
DAC	digital-to-analog converter
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
DSP	digital signal processor
DSSS	direct-sequence spread-spectrum
EDID	Extended Display Identification Data
EDO	extended data out
G4	Generation 4, the fourth generation of PowerPC microprocessors
GND	ground

HFS	hierarchical file system
HID	human interface device, a class of USB devices
I2C	inter IC control bus
I2S	inter IC sound bus
IC	integrated circuit
IDE	integrated device electronics
IIC	inter IC control bus (same as I2C)
IIS	inter IC sound bus (same as I2S)
I/O	input and output
ISO	International Organization for Standardization
JEDEC	Joint Electron Device Engineering Council
L1	level 1 or first level, a type of CPU cache
L2	level 2 or second level, a type of CPU cache
LAN	local area network
LED	light emitting diode
MAC	media access controller
Mac OS	Macintosh Operating System
modem	modulator-demodulator, a data communications interface for use with analog telephone lines
NMI	nonmaskable interrupt
NOP	no operation
NTSC	National Television System Committee; the standard system used for broadcast TV in North America and Japan
NV-RAM	nonvolatile random-access memory
OHCI	Open Host Controller Interface
OS	operating system
PAL	Phase Alternate Lines; the standard for broadcast TV in most of Europe, Africa, South America, and southern Asia
PCAV	partial constant angular velocity (CLV at small radius, CAV at large radius)
PCI	Peripheral Component Interconnect

PHY	physical layer
PLL	phase-locked loop
POST	power-on self test
RADIUS	Remote Authentication Dial-In User Service
RAM	random-access memory
RF	radio frequency
rms	root mean square
ROM	read-only memory
SCC	Serial Communications Controller
SDRAM	synchronous dynamic RAM
SNR	signal to noise ratio
SO-DIMM	small outline dual inline memory module
SPD	Serial Presence Detect, a feature of the SO-DIMM
USB	Universal Serial Bus
TDM	target disk mode
VCC	positive supply voltage (voltage for collectors)
VESA	Video Electronics Standards Association
VGA	video graphics adapter
WEP	Wired Equivalent Privacy
Wi-Fi	Logo used by the Wireless Ethernet Compatibility Alliance for certification of interoperability of 802.11 products
WLAN	wireless LAN