

Developer Note

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# Apple iBook Computer



**Developer Note**

September 2000

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# About This Developer Note

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This developer note is a technical description of the iBook computer. It has been updated to include information about the latest product configurations.

This developer note is intended to help hardware and software developers design products that are compatible with the Macintosh products described here. If you are not already familiar with Macintosh computers or if you would like additional technical information, you should refer to Appendix A, “Supplemental Reference Documents,”

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

- Chapter 1, “Introduction,” introduces the iBook and describes its features.
- Chapter 2, “Architecture,” describes the internal logic of the iBook, including the main ICs that appear in the block diagram.
- Chapter 3, “Devices and Ports,” describes the standard I/O ports and the built-in I/O devices.
- Chapter 4, “RAM Expansion,” describes the RAM expansion module.
- Appendix A, “Supplemental Reference Documents,” tells where to find more information about specific technologies used in the iBook.
- Appendix B, “Abbreviations,” lists the standard units and abbreviations used in this developer note.



# Introduction

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The iBook is Apple's portable computer for the consumer and education markets. This chapter lists the computer's features, with emphasis on the changes from the previous models. It also provides information about compatibility issues.

## New Features

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

- **Processor speed:** The microprocessor clock speed is 366 or 466 MHz. For more information, see "G3 Microprocessor" (page 21).
- **PowerStep:** The 466-MHz model allows the user to set the processor speed to 366 MHz to conserve power. For more information, see "PowerStep" (page 16).
- **Cache:** The microprocessor has a built-in L2 cache consisting of 256 KB of fast static RAM. The clock speed for the L2 cache is the same as the clock speed of the microprocessor. See "Backside (L2) Cache" (page 21).
- **Graphics IC:** The display controller in the iBook is an ATI RAGE Mobility 128. See "Graphics IC" (page 23)
- **Video RAM:** The display controller in the iBook includes 8 MB of video RAM, which supports millions of colors on the display. See "Flat Panel Display" (page 51).
- **External video:** The computer provides a composite video output on a special A/V jack, along with the stereo audio signals. See "Composite Video Output" (page 52).

## Introduction

- **Hard disk storage:** The capacity of the built-in hard disk drive is 10 GB. (A 20 GB drive is also available.) For more information, see “Hard Disk Drive” (page 36).
- **FireWire port:** The iBook has an IEEE-1394 FireWire high-speed serial port. For more information, see “FireWire Port” (page 30)
- **Target Disk Mode:** The iBook can act like a FireWire storage device connected to another computer. See “Target Disk Mode” (page 16).
- **DVD-ROM drive:** The DV SE configuration comes with a built-in 6x-speed DVD-ROM drive. See “DVD-ROM Drive” (page 41).
- **Battery:** The computer has an improved battery with higher capacity (48 WHr).

Table 1-1 provides a side-by-side comparison of the features that have changed with those of the previous model.

**Table 1-1** Feature comparison

Feature	Previous model	Latest model
CPU speed	300 or 366 MHz	366 or 466 MHz
L2 cache size, location, and speed	512 KB external, 150 or 183 MHz	256 KB internal, 366 or 466 MHz
Graphics IC	ATI RAGE Mobility	ATI RAGE Mobility 128
Graphics memory	4 MB VRAM	8 MB VRAM
Graphics display	internal flat panel	internal flat panel and external composite video
Hard disk drive	6 GB	10 GB (20 GB available)
CD or DVD drive	24x CD-ROM drive	24x CD-ROM drive or 6xDVD-ROM drive
Data ports	1 USB port	1 USB port, 1 FireWire port
Battery	45 WHr	48 WHr

## All Features

---

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

- **Processor:** The iBook has a PowerPC G3 microprocessor running at a clock speed of 366 MHz in the base configuration or 466 MHz in the DV SE. For more information, see “G3 Microprocessor” (page 21).
- **PowerStep:** The DV SE model allows the user to slow down the processor speed from 466 to 366 MHz to conserve power. For more information, see “PowerStep” (page 16).
- **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 “Backside (L2) Cache” (page 21).
- **Memory:** The iBook has 64 MB of SDRAM installed on the main logic board and one standard SO-DIMM slot for memory expansion up to 320 MB total. See “RAM Expansion” (page 55).
- **Hard disk storage:** The iBook has a built-in hard disk drive with a capacity of 10 GB. A 20 GB is also available. For more information and developer guidelines for alternative hard drives, see “Hard Disk Drive” (page 36).
- **CD-ROM drive:** The base configuration has a built-in 24x-speed CD-ROM drive. See “CD-ROM Drive” (page 41).
- **DVD-ROM drive:** The DV SE configuration has a built-in 6x-speed DVD-ROM drive. See “DVD-ROM Drive” (page 41).
- **Display:** The iBook has a 12.1-inch TFT display with SVGA resolution (800 by 600 pixels). See “Flat Panel Display” (page 51).
- **External video:** The computer provides a composite video output on a special A/V jack, along with the stereo audio signals. See “Composite Video Output” (page 52).
- **Graphics IC:** The display controller in the iBook is an ATI RAGE Mobility 128. See “Graphics IC” (page 23).

- **Video RAM:** The display controller in the iBook includes 8 MB of video RAM, which supports millions of colors on the display. See “Flat Panel Display” (page 51).
- **Battery:** The iBook has one battery bay. The battery uses lithium ion cells and has a capacity of 3600 mAh at a nominal 14.2 V. Battery life under normal use is up to 6 hours.
- **USB port:** The iBook has one USB port for an external keyboard, a mouse, a hub, or other USB device, described in “USB Port” (page 27).
- **FireWire port:** The iBook has an IEEE-1394 FireWire high-speed serial port. For more information, see “FireWire Port” (page 30).
- **Target Disk Mode:** The iBook can act like a FireWire storage device connected to another computer. See “Target Disk Mode” (page 16).
- **Modem:** The iBook has a built-in modem that supports 56 Kbps data rate. For more information, see “Internal Modem” (page 34).
- **Ethernet:** The iBook has a built in Ethernet port for 10Base-T and 100Base-T operation. For more information, see “Ethernet Port” (page 33).
- **Wireless LAN:** An internal wireless LAN module is available as a build-to-order option or as a user-installable upgrade. For more information, see “AirPort Card Wireless LAN Module” (page 34).
- **Sound:** The iBook has a single built-in speaker and provides stereo output signals on an A/V jack. See “Sound System” (page 52).
- **Keyboard:** The keyboard has function keys and inverted-T arrow keys. Some of the function keys are used to control the brightness and sound; the other function keys are user programmable to open applications or files. The keyboard also includes an embedded numeric keypad. See “Keyboard” (page 42).
- **Trackpad:** The integrated trackpad includes tap/double tap and drag features. For more information, see “Trackpad” (page 42).
- **Weight:** With the battery installed, the base model iBook weighs 3.0 kg (6.6 pounds); the DV SE model weighs 3.2 kg (6.8 pounds).
- **Size:** The iBook is 34.4 cm (13.5 inches) wide and 29.4 cm (11.6 inches) deep. Its thickness varies from 3.1 to 5.2 cm (1.24 to 2.06 inches); the average thickness is 4.6 cm (1.8 inches).

## Peripheral Devices

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

- The AirPort 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 four hours while the computer is running or in two hours while the computer is shut down or in sleep mode.

## System Software

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The system software that comes with the iBook computer is Mac OS 9 with the addition of the extensions and control panels required for product-specific features. For more information, see the references in “Mac OS 9”.

Like the system software on other Macintosh models since the introduction of the iMac, system software for the iBook has Open Firmware booting and Mac OS ROM in RAM. For more information, see the references in “Open Firmware” and “ROM-in-RAM Architecture”.

### Machine Identification

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All Macintosh ROMs based on Open Firmware and ROM in RAM 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. As with other computers that use ROM-in-RAM, a call to `gestaltMachineType` returns the value 406 (\$196).

**IMPORTANT**

Programs such as control panels and installers that use Box Flag to verify that this is a valid CPU on which to execute need to be changed to verify the existence of the hardware they require. Developers should look for the features they need, rather than reading the box flag and then making assumptions about the computer's features. ▲

Asset management software that reports the kind of machine it is run on can obtain the value of the property at `Devices:device-tree:compatible` in the name registry. The model string is the first program-usable string in the array of C strings in the `compatible` field. For the iBook, the `model` property value is `PowerBook2,2`.

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

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 requires.

## PowerStep

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PowerStep is a feature of the DV SE model that allows the user to change the processor's clock speed, either slowing down (to 366 MHz) to conserve power or speeding up when the full 466-MHz speed is needed. The user interface for this feature is a check box labeled Reduce Processor Speed in the Advanced Settings panel of the Energy Saver control panel.

## Target Disk Mode

---

The user has the option at boot time to put the computer into a mode of operation called Target Disk Mode (TDM). This mode is similar to SCSI Disk mode on a PowerBook computer equipped with a SCSI port, except it uses a FireWire cable instead of a special SCSI cable.

When the iBook computer is in Target Disk Mode and connected to another Macintosh computer by a FireWire cable, the iBook operates like a FireWire

## Introduction

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 can operate in Target Disk Mode as long as the other computer has a FireWire port and the FireWire 2.3 or newer driver.

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

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

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

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



# Architecture

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This chapter describes the architecture of the iBook computer.

## Block Diagram and Buses

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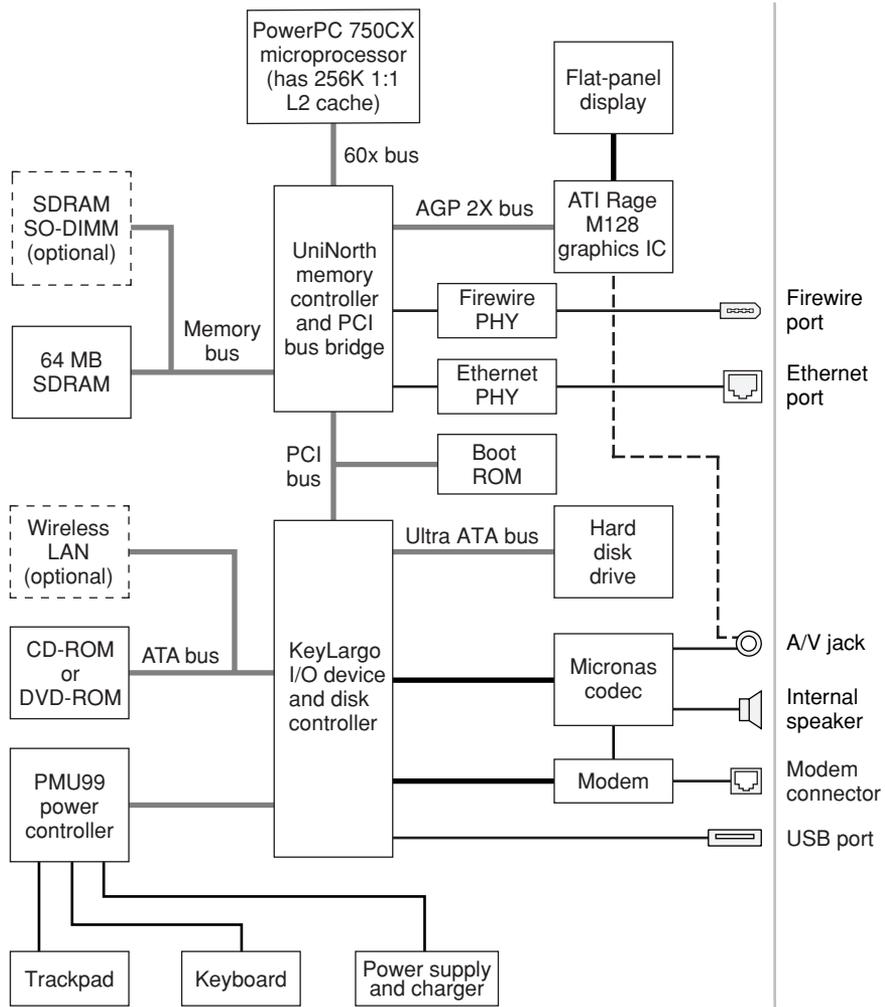
Figure 2-1 is a simplified block diagram of the iBook computer. The diagram shows the main ICs and the buses that connect them together.

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

The microprocessor is connected to the Uni-N memory controller and bus bridge IC by a 60x bus with 64 data lines and a bus clock speed of 66 MHz. The Uni-N IC has other buses that connect with the KeyLargo IC, the main system RAM, the graphics IC, and the Ethernet and FireWire PHY ICs. The buses implemented by the Uni-N IC are summarized in Table 2-1, which is in the section “Memory Controller and Bus Bridge”.

The Uni-N IC is connected to the KeyLargo I/O controller IC by a 32-bit PCI bus that has a bus clock speed of 33 MHz. That PCI bus also connects to the Boot ROM. The KeyLargo IC has other buses that connect with the hard disk drive, the power controller (PMU99), the sound IC, the internal modem, the CD-ROM or DVD-ROM drive, and the optional wireless LAN module.

**Figure 2-1** Block diagram



## Microprocessor and Cache

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The microprocessor communicates with the rest of the system by way of a 66-MHz, 64-bit 60x bus to the Uni-N IC. The backside cache is built into the microprocessor.

### G3 Microprocessor

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The current family of PowerPC microprocessor designs is called “G3,” for “generation three.” The microprocessor used in the iBook is a PowerPC 750CX microprocessor. It has several features that contribute to improved performance, including:

- large on-chip (L1) caches, 32 KB each for instruction cache and data cache
- a built-in 256-MB L2 cache running at the processor’s clock speed.
- a microprocessor core optimized for Mac OS applications

The PowerPC 750CX microprocessor in the iBook runs at a clock speed of 366 or 466 MHz.

### Backside (L2) Cache

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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.

## Memory Controller and Bus Bridge

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

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

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

Name of bus	Destinations	Width of data path	Bus clock speed
60x bus	Microprocessor	64 bits	66 MHz
Memory bus	System RAM	64 bits	66 MHz
PCI bus	KeyLargo IC and Boot ROM	32 bits	33 MHz
AGP 2X bus	Graphics IC	32 bits	66 MHz

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

## System RAM

The memory subsystem in the iBook consists of 64 MB of SDRAM on the main logic board and one expansion slot for an SO-DIMM. The data bus to the RAM and DIMM is 64 bits wide, and the memory interface is synchronized to the 60x bus interface at 66 MHz. See also “RAM Expansion” (page 55).

## Boot ROM

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

The boot ROM is a flash device and can be updated in the field.

## Ethernet PHY IC

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The Ethernet link layer is built into the Uni-N IC. The physical layer IC, called the PHY, contains both the physical layer and the transceiver and filter circuits. The interface supports both 10Base-T and 100Base-TX protocols.

## FireWire PHY IC

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The Uni-N IC implements the FireWire link layer. The physical layer IC (PHY) implements the electrical signalling protocol of the FireWire interface. The PHY supports the FireWire port by way of the external connector.

## Graphics IC

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The graphics IC in the iBook computer is a RAGE Mobility 128 IC made by ATI. It provides video for both the internal flat panel display and an external composite video monitor.

The graphics IC includes 8 MB of VRAM, which enables it to provide a display size of 800 by 600 at pixel depths of 8, 16, and 24 bits per pixel. The graphics IC also has a scaling mode that displays a 640-by-480 pixel image on the full screen.

The display generated for the flat panel display is simultaneously available as composite video for an external monitor. See “Composite Video Output” (page 52).

Because it uses the AGP bus, the graphics IC 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. To avoid this necessity for graphics storage, the AGP logic in the Uni-N IC uses a graphics address remapping table (GART) to translate a linear address space for AGP transactions into physical addresses in main memory.

## I/O Device Controller

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

The KeyLargo IC contains a PCI bus arbiter and an interrupt controller. It also provides the interface and control signals for the following devices:

“Ultra ATA Hard Drive”

“ATA CD-ROM or DVD-ROM Drive”

“USB Port”

“Built-In Modem”

“Sound IC”

“Power Controller IC”

“AirPort Card Wireless LAN Module”

### Ultra ATA Hard Drive

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The interface to the internal hard drive is an Ultra ATA bus on the KeyLargo IC.

### ATA CD-ROM or DVD-ROM Drive

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The interface to the CD-ROM or DVD-ROM drive is an E-IDE interface (ATA bus) on the KeyLargo IC. Digital audio data from the drive is processed by the Sound Manager and then sent out through the KeyLargo IC to the sound IC.

### USB Port

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The KeyLargo IC provides a USB controller for the USB port. The external USB connector supports USB devices with data transfer rates of 1.5 Mbps and 12 Mbps. For more information, see “USB Port” (page 27).

## Architecture

The USB ports comply with the Universal Serial Bus Specification 1.1 Final Draft Revision. The USB register set complies with the Open Host Controller Interface (OHCI) specification.

## Built-In Modem

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The KeyLargo IC provides an SCC (Serial Communications Controller) that communicates with the built-in hardware modem. The modem hardware is a set of ICs including a modem controller, data pump, and DAA.

## Sound IC

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The sound IC is a DAC3550A made by Micronas-Intermetall ([www.intermetall.de](http://www.intermetall.de)). The KeyLargo IC communicates with the sound IC using the I<sup>2</sup>S bus for digital data and the I<sup>2</sup>C bus for control signals. The digital audio data is converted to analog signals by the sound IC and sent to the speaker and the A/V jack.

Modem progress audio is connected as an analog input to the sound IC 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 has no microphone or dedicated sound input jack. For information about sound system operation and outputs, see “Sound System” (page 52).

## Power Controller IC

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The power manager IC in the iBook computer 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 ADB interface to the built-in keyboard and trackpad

The iBook computer does not contain an Apple Desktop Bus; instead, the PMU99 provides the hardware interface to the keyboard and trackpad.

## Architecture

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 Card Wireless LAN Module

---

The AirPort Card wireless LAN module shares the E-IDE interface (ATA bus) to the KeyLargo IC with the CD-ROM drive.

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

The AirPort Card is based on the IEEE 802.11 standard. The card transmits and receives data at up to 11 Mbps and is compatible with older 802.11-standard systems that operate at 2 or 1 Mbps. For information about its operation, see "AirPort Card Wireless LAN Module" (page 34).

# Devices and Ports

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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 Port

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The iBook computer has a Universal Serial Bus (USB) port that can be used to connect additional I/O devices such as a USB mouse, printers, scanners, and low-speed storage devices.

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".

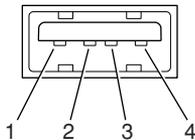
## USB Connector

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The USB port is located on the left side of the computer. It 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 is an illustration of a Type A USB port. Table 3-1 shows the pin assignments.

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**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 provides power for the USB port at 5 V and up to 500 mA.

The USB port supports both low-speed and high-speed data transfers, at up to 1.5 Mbps and 12 Mbps, respectively. High-speed operation requires the use of shielded cables.

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

## USB Compatibility Issues

The following sections describe compatibility issues regarding legacy I/O (ADB and serial ports) as well as new functionality of the USB port.

“ADB Compatibility”

“Serial Port Compatibility”

“Power Off During Sleep”

“Macintosh-To-Macintosh Connections”

“USB Storage Devices”

“USB Controller”

## ADB Compatibility

Apple is providing an ADB/USB shim to support processes that control ADB devices by making calls to the ADB Manager and the Cursor Device Manager. The ADB/USB shim makes it possible for processes that support an ADB keyboard to work with the USB keyboard equivalent.

**Note**

The iBook does not support the power-on key found on some Apple USB keyboards. ◆

Keyboards other than the Apple USB keyboard can be used with the iBook computer, but they will be treated as having an ADB device ID of 2.

**IMPORTANT**

The ADB/USB shim does not support USB devices other than the keyboard and mouse. ▲

**Note**

The ADB/USB shim is built into the Mac OS ROM image on the iBook and on other Macintosh computers that have USB ports. For information about USB support on the Macintosh, see the references in “USB Interface” (page 64). ◆

### Serial Port Compatibility

---

The latest release of the Mac OS USB DDK includes a universal Serial/USB shim that allows processes that use the Communications Toolbox CRM to find and use a USB modem device. The shim is called SerialShimLib and is available as part of the Mac OS 8.6 release. For more information about the shim, and a sample modem driver that shows how to use it, please refer to the Mac OS USB DDK, available from the website listed in “USB Interface” (page 64).

Apple also provides a USB Communication Class driver, so modem vendors whose devices comply with the USB Communication Class specification do not need to write their own vendor-specific USB class drivers.

### Power Off During Sleep

---

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

## Macintosh-To-Macintosh Connections

---

USB is a serial communications channel, but it does not replace LocalTalk functionality on Macintosh computers; you cannot connect two Macintosh computers together using the USB. The best method for networking iBook computers is through the Ethernet port or AirPort wireless LAN. For transferring files between two computers, you can use “Target Disk Mode” (page 16).

## USB Storage Devices

---

The Macintosh USB software supports booting from an external USB storage device.

Class drivers are software components that are able to communicate with many USB devices of a particular kind. If the appropriate class driver is present, any number of compliant devices can be plugged in and start working immediately without the need to install additional software. The Mac OS for the iBook computer includes USB Mass Storage Support 1.3, a class driver that supports devices that meet the USB Mass Storage Class specification. For information about USB support on the Macintosh, see the references in “USB Interface” (page 64).

## USB Controller

---

The iBook computer 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 Port

---

The iBook computer has one external FireWire IEEE 1394 port. The FireWire port

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

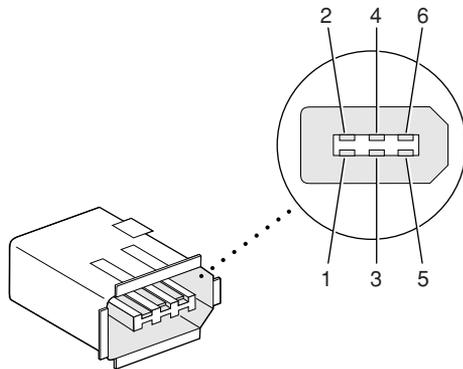
- supports booting the system from a mass storage device
- supports Target Disk Mode (TDM)

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

## FireWire Connector

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

**Figure 3-2** FireWire connector



**Table 3-2** Pin assignments on the FireWire connector

Pin	Signal name	Description
1	Power	Unregulated DC; 13-17 V no load when operating with battery; 13-24 V when using 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

**Table 3-2** Pin assignments on the FireWire connector (continued)

Pin	Signal name	Description
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 7 W power. The power is shared with the USB port, which can use up to 2.5 W. The power available for FireWire is reduced by the power consumed by the USB port.

Pin 2 of the 6-pin FireWire 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 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 Device Programming

Developers of FireWire peripherals are required to provide device drivers. A driver for DV (digital video) is included in QuickTime 4.0.

The iBook 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](mailto:dts@apple.com).

When connected to another computer by a FireWire bus, the iBook can operate as a mass storage device. See “Target Disk Mode” (page 16).

For additional information about the FireWire interface and the Apple APIs for FireWire device control, refer to the resources listed in “FireWire Interface” (page 65).

## Ethernet Port

---

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

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

**Table 3-3** Signals on the Ethernet connector

---

<b>Pin</b>	<b>Signal name</b>	<b>Signal definition</b>
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 iBook computer conforms to the ISO/IEC 802.3 specification, where applicable.

## Internal Modem

---

The iBook computer 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.90 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. The modem provides a sound output for monitoring the progress of the modem connection.

## AirPort Card Wireless LAN Module

---

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

By communicating wirelessly with a base station, the AirPort Card can be used for internet access, email access, and file exchange. A base station provides the connection to the internet or the bridge between the wireless signals and a wired LAN. Software included with the AirPort Card enables a Macintosh computer that has an AirPort Card installed to act as a base station. The user also has the option of purchasing an AirPort Base Station that can be connected to the wired LAN or to a telephone line by way of its built-in 56k hardware modem.

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

## Data Security

---

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

- 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, the system encrypts the data using Wired Equivalent Privacy (WEP) with a 40-bit security key.

## Hardware Components

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

The AirPort Card contains a media access controller (MAC), a digital signal processor (DSP), and a radio-frequency (RF) section. The antennas are built into the computer's cover, on either side of the flat-panel display.

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

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

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

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

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

## Software Components

---

Software that is provided with the AirPort Card includes

- AirPort Setup Assistant, a standalone assistant that takes users through the steps necessary to set up the AirPort Card, set up an AirPort Base Station, or set up a software base station.
- AirPort Application, an application that allows users to switch between wireless networks and to create and join peer-to-peer networks.
- AirPort Control Strip Module, which provides a signal strength indication and most of the functions of the AirPort Application.
- AirPort Utility, a utility for the advanced user. With it the user can edit the administrative and advanced settings for a hardware or software base station. It can also be used to determine the location for the base station that gives the best reception.

## Hard Disk Drive

---

The capacity of the internal hard disk drive is 10 GB. (A 20 GB drive is also available.) The drive uses the Ultra IDE (integrated drive electronics) interface, which is also referred to as the Ultra ATA interface. The implementation of the ATA interface on the iBook computer is a subset of the ATA/IDE specification, ANSI proposal X3T10/0948D, Revision 2K (ATA-2).

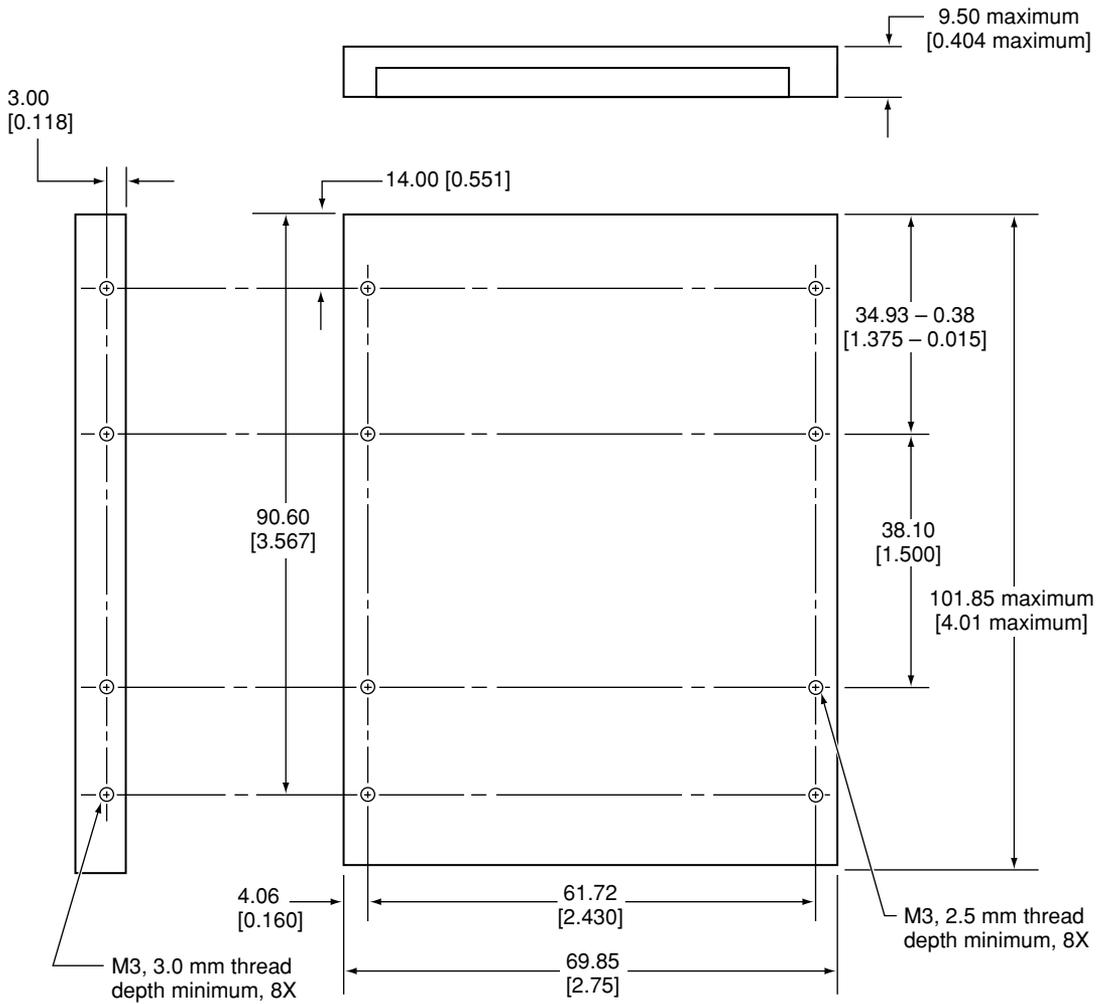
The software that supports the internal hard disk is similar to that in previous Macintosh PowerBook models with internal IDE drives and includes DMA support. For the information about that software, see the references in “ATA Devices” (page 64).

## Hard Disk Dimensions

---

Figure 3-3 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

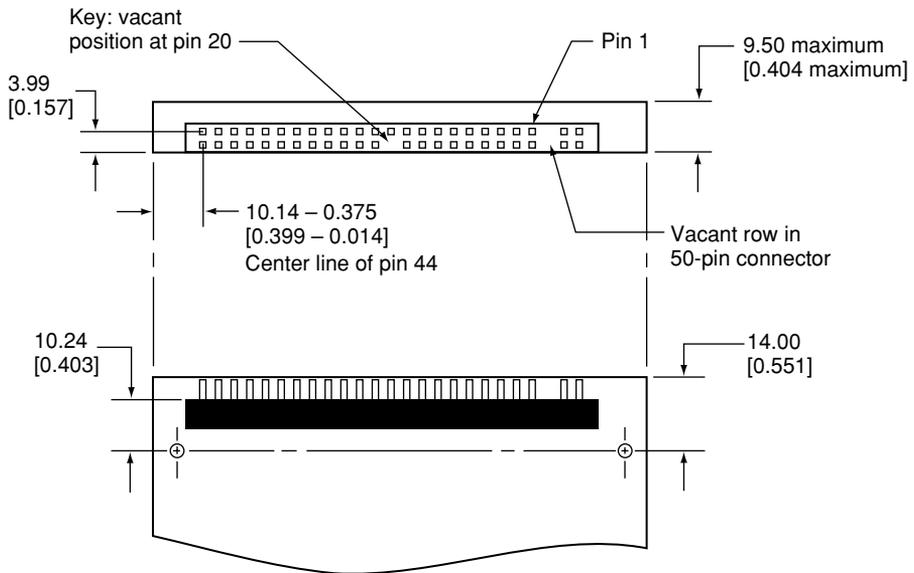


Note: Dimensions are in millimeters [inches].

## 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. 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



## Signal Assignments

Table 3-4 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	24	GROUND
25	/DIOR	26	GROUND
27	IRDY	28	CSEL
29	/DMACK	30	GROUND
31	INTRQ	32	/IOCS16
33	DA1	34	/PDIAG
35	DA0	36	DA2
37	/CS0	38	/CS1
39	/DASP	40	GROUND
41	+5V LOGIC	42	+5V MOTOR
43	GROUND	44	Reserved

NOTE CSEL, /DASP, /IOCS16, and /PDIAG are not used; see Table 3-5

## ATA Signal Descriptions

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Table 3-5 describes the signals on the ATA hard disk connector.

**Table 3-5** Signals on the ATA hard disk connector

---

<b>Signal name</b>	<b>Signal description</b>
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.
/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.).
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).
/DIOR	I/O data read strobe.
/DIOW	I/O data write strobe.
/DMACK	Used by the host to initiate a DMA transfer in response to DMARQ.
DMARQ	Asserted by the device when it is ready to transfer data to or from the host.

**Table 3-5** Signals on the ATA hard disk connector (continued)

Signal name	Signal description
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.
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.

## CD-ROM Drive

---

The iBook base configuration has an internal CD-ROM drive with a sliding tray to hold the disc. The drive features a mechanism that supports 4x, 8x, 12x, and 24x data transfer rates and a data buffer that further enhances performance.

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

## DVD-ROM Drive

---

The DV SE configuration comes with a built-in 6x-speed DVD-ROM drive with a sliding tray to hold the disc. The drive is fully compatible with existing CD-ROM media; it supports CD-ROM at 24X speed maximum and DVD at 6X

constant linear velocity (CLV). The DVD-ROM drive supports the following disc formats:

- DVD-ROM (one- or two-layer, one- or two-sided)
- CD-ROM (Modes 1 and 2) and CD-ROM XA (Mode 2, Forms 1 and 2)
- CD-Audio, Photo CD, CD-RW (read only), CD-R (read only), and CD-Extra
- CD-I (Mode 2, Forms 1 and 2), CD-I Ready, and CD-I Bridge
- Video CD

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

## Trackpad

---

The pointing device in iBook computer 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 digital signals.

A single button below the trackpad is used to make selections. Alternatively, the user can tap and double tap on the pad itself. As described in the user's manual, 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.

## Keyboard

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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 F4 and F5 function keys. Turning the screw 180° locks or unlocks the keyboard.

**Note**

The iBook computer 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 F8 and F9 keys. The user can release the latches by pulling them toward the front of the computer.

## Changing the Operation of the Keyboard

---

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.
- The other function keys can be set by the user to open applications, documents, or AppleScripts.
- 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, the Num Lock key, and the Function Keys checkbox in the Keyboard control panel.

## Keyboard Illustrations

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Figure 3-5 shows the actual appearance of the keyboard. Figure 3-6 shows the alternate modes of operation of the function and control keys. Figure 3-7 shows the embedded numeric keypad.

**Figure 3-5** Keyboard layout

Figure 3-6 and Figure 3-7 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 actual appearance of the keyboard, refer to Figure 3-5.

**Figure 3-6** Alternate operations of function and control keys

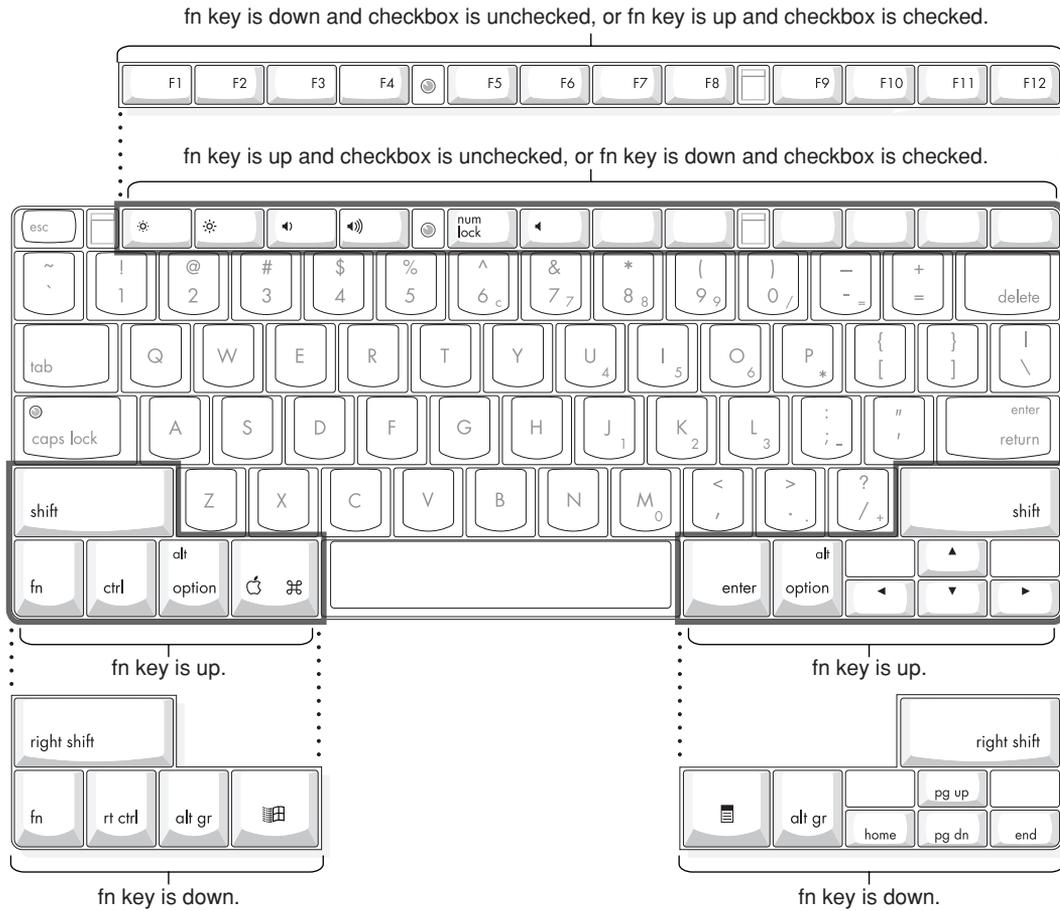
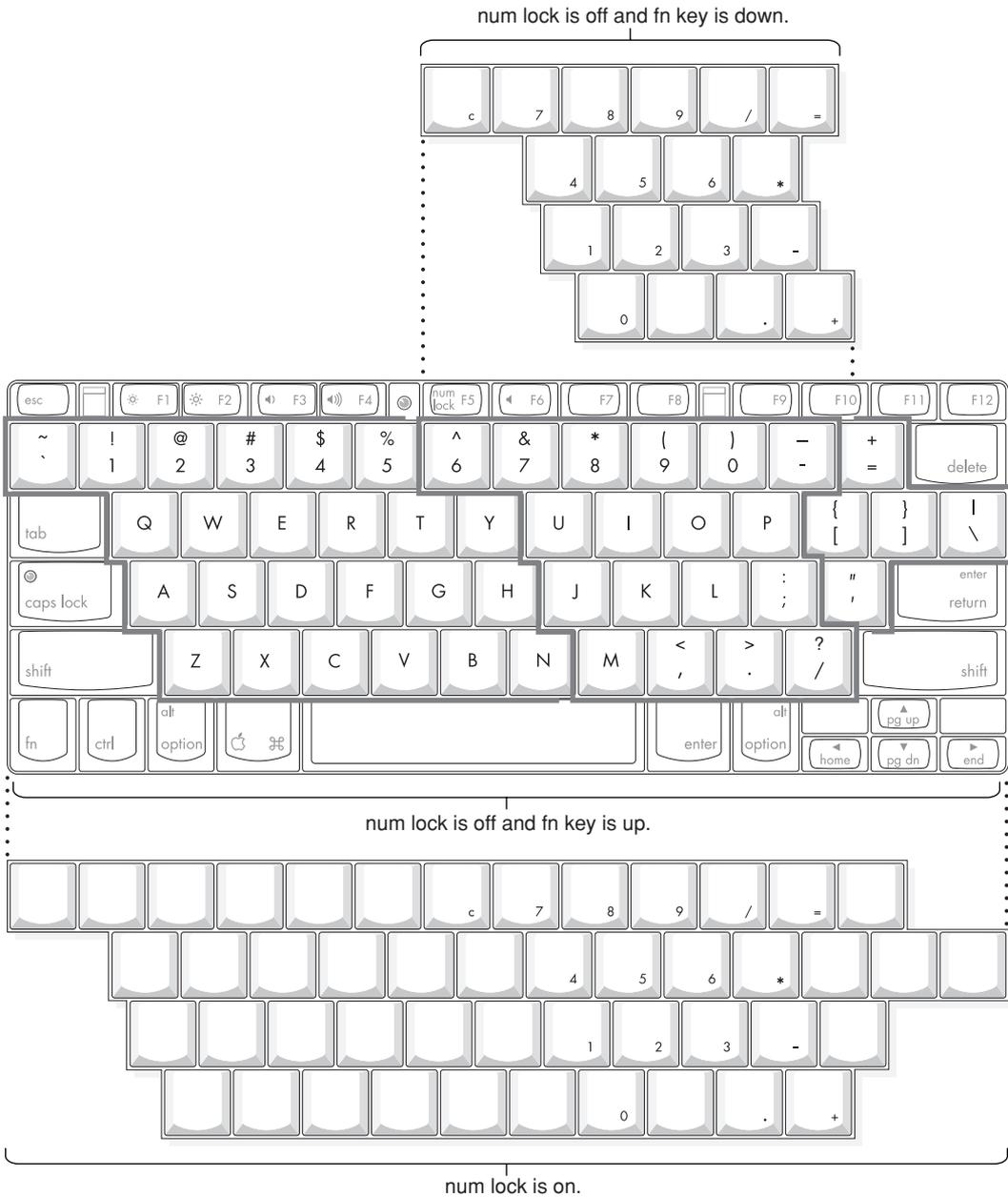


Figure 3-7 Embedded numeric keypad operation



## 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 3-7 and Figure 3-6. The user selects the default modes of operation of those keys as described in the section “The Function-Keys Checkbox”.
- It selects the embedded numeric keypad on the right portion of the alphanumeric keys, as shown in Table 3-8 and Figure 3-7.
- It changes certain control keys, including the cursor control keys, to page control keys, as shown in Table 3-9 and Figure 3-7.

## 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 3-8 and Figure 3-7.
- It makes the rest of the alphanumeric keys functionless (NOPs), as shown in Figure 3-7.

## The Function-Keys Checkbox

---

The Fn key lets the user switch the mode of operation of the function keys at any time. The user selects the default mode of the function keys by means of the Function-keys checkbox in the Keyboard Control Panel.

The Function-keys checkbox lets the user choose whether the function key operations are primary or secondary. “Function keys primary” means the function keys are normally in their F1–F12 mode of operation and pressing the Fn key selects their control-button mode. “Function keys secondary” means the function keys are normally in their control-button mode and pressing the Fn key selects their function-key mode.

In other words, pressing the Fn key reverses the mode of operation of the function keys from the default mode set by the checkbox. Table 3-6 summarizes the checkbox settings and the operation of the Fn key. The operations of the individual function keys are shown in Table 3-7 and Figure 3-6.

**Table 3-6** Setting the default behavior of the function keys

<b>Make Function Keys Primary checkbox</b>	<b>Operations of function keys</b>	
		Fn key up
Checked	F1–F12 functions	Control buttons
Not checked	Control buttons	F1–F12 functions

**Table 3-7** The function keys as control buttons

<b>Key name</b>	<b>Control button</b>
F1	Decrease display brightness
F2	Increase display brightness
F3	Decrease speaker volume
F4	Increase speaker volume
F5	Num Lock
F6	Mute the speaker
F7	User definable
F8	User definable
F9	User definable
F10	User definable
F11	User definable
F12	User definable

## Operations of the Function Keys

---

Function keys F1 through F6 are used as control buttons for the display and sound; function keys F7 through F12 are open for the user to define. The operations of the function keys are controlled by the Function keys checkbox and the Fn key. Table 3-7 is a list of the function keys and their operations as control buttons. The Keyboard Control Panel allows the user to assign operations to function keys F7 through F12. Operations that can be assigned include

- opening an application
- opening a document
- evoking an AppleScript
- logging on to a FileServer by way of an alias

## 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 3-7 shows the keys making up the embedded keypad and Table 3-8 lists them.

**Table 3-8** Embedded keypad keys

---

Key name	Keypad function
6	Clear
7	7
8	8
9	9
0	/ (divide)
-	= (equals)
U	4
I	5
O	6
P	* (multiply)

**Table 3-8** Embedded keypad keys (continued)

---

<b>Key name</b>	<b>Keypad function</b>
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 Figure 3-7. The affected keys include certain special character keys: plus and equal sign, right and left brackets, vertical bar and backslash, and straight apostrophe.

### 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 is a list of these keys and their alternate functions. These control keys are also show in Figure 3-7.

**Table 3-9** Control keys that change

---

<b>Key name</b>	<b>Alternate function</b>
Shift	Right shift key
Control	Right control key
Option	Alt gr (right Alt key)
Command	Windows <sup>®</sup> 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 computer has a built-in color flat panel display that is 12.1 inches in size, measured diagonally. The display contains 800 by 600 pixels and can show up to millions of colors. The display is backlit by a cold cathode fluorescent lamp (CCFL). The display uses TFT (thin-film transistor) technology for high contrast and fast response.

The graphics controller IC, a ATI Rage Mobility 128, includes 8 MB of VRAM, which supports 3D acceleration and display depths up to 24 bits per pixel. When more graphics storage is needed, the graphics IC can also use part of main memory. For more information, see “Graphics IC” (page 23).

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

## Composite Video Output

---

The combined audio and video output jack on the iBook computer provides a composite video signal for a TV monitor. 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.

The A/V jack on the iBook computer is the same size and location as the headphone jack on previous models. The jack still accepts a standard stereo mini-plug, but it also accepts a special mini-plug that has an additional contact for the video signal; see “A/V Jack” (page 53). An adaptor cable with separate RCA-type connectors for stereo audio and composite video outputs is available.

Two display sizes are supported: 640 by 480 and 800 by 600 pixels. The composite video can be displayed on either an NTSC monitor or a PAL monitor. When a monitor is connected by way of the A/V jack, the computer detects the presence of the A/V mini-plug and enables the composite video output. The settings for the display sizes and standards (NTSC or PAL) are then selectable in the Monitor control panel or control strip.

## Sound System

---

The 16-bit stereo audio circuitry provides sound output through the built-in speaker and the A/V jack.

### **IMPORTANT**

The iBook computer does not have a microphone or sound input jack. The USB port can be used for sound input from a USB microphone. ▲

The sound system is implemented by a Micronas-Intermetall DAC3550A stereo digital-to-analog converter. It contains an output analog source selector, analog gain adjuster, and output amplifiers that system software configures as headphone drivers or internal speaker drivers. The sound system supports a sample rate of 44.1 kHz and sample sizes up to 16 bits.

The frequency response of the sound circuits, not including the speaker, has minus 3 dB points of 20 Hz and 20 kHz. Total harmonic distortion and noise is less than 0.03 percent. The signal-to-noise ratio (SNR) is 90 dB or better, with no audible discrete tones.

## A/V Jack

---

The A/V jack is located on the left side of the computer at the left palm rest. The jack accepts either a stereo mini-plug or a special plug that has an additional contact ring that carries the composite video output signal. See also “Composite Video Output” (page 52).

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 A/V jack.

The audio signals on the A/V jack have the following electrical characteristics:

- output impedance: 47 ohms each channel
- minimum recommended load impedance: 32 ohms each channel
- maximum level: 1.0 V rms(2.8 V P-P)

## Internal Speaker

---

The computer has one speaker located between the keyboard and the display. The computer turns off the sound signal to the speaker when headphones are connected to the A/V jack.

## Internal Modem

---

The sound system receives call progress audio from the internal modem so the user can hear the status of a dial-up modem connection. The level of the call progress audio is fixed.

## CD Audio

---

Digital audio data from the CD-ROM drive is processed by the Sound Manager. The data is then transferred by DMA through the I<sup>2</sup>S interface of the Key Largo IC to the DAC3550A sound IC. The digital data is converted to analog signals by the sound IC and sent to the speaker and the A/V jack.

# RAM Expansion

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

## The RAM Expansion Slot

---

The iBook computer has one RAM expansion slot. To get access to the RAM expansion slot, the user must open up the computer by performing the following operations.

**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. Unlock the keyboard by turning the slotted screw that is part of the Num Lock LED, which is between the F4 and F5 function keys. Turning the screw 180° locks or unlocks the keyboard. (The locking screw may already be in the unlocked position.)
5. Release the two latches located at the top of the keyboard. One latch is between the ESC key and the F1 key; the other is between the F8 and F9 keys. The user can release the latches by sliding them toward the front of the computer.
6. Lift the keyboard up and turn it over, without disconnecting the keyboard's membrane cable.

7. Remove the wireless LAN module, if present, by unlatching the formed wire holder on the module, then pulling the flex tab to remove the module. The antenna cable should remain attached to the module.
8. Using a Phillips head screwdriver, remove the two screws that secure the metal RAM shield plate. The screws are to the right of the wireless LAN module.
9. Slide the metal RAM shield plate toward the rear of the computer, then lift it up and out of the computer.

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 LAN card will fit properly.

## The RAM Expansion Module

---

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

### **IMPORTANT**

A RAM expansion SO-DIMM for the iBook computer must use SDRAM devices. If the user installs an SO-DIMM that uses EDO or SGRAM devices, the computer will beep several times when the user attempts to restart the computer. ▲

An SO-DIMM for the iBook computer can contain either 32, 64, 128, or 256 MB of memory. Total RAM capacity using devices currently available is 320 MB and is limited by the space available for the SO-DIMM. The slot can accommodate an SO-DIMM up to 1.35 inches high.

### Mechanical Design of the RAM SO-DIMM

---

The mechanical characteristics of the RAM expansion module are given in the JEDEC specification for the 144-pin 8-byte DRAM SO-DIMM. The specification number is JEDEC MO-190-C. To find out how to obtain the specification, see “RAM Expansion Modules” (page 63).

## RAM Expansion

The specification defines SO-DIMMs with nominal heights of 1.0, 1.25, 1.5, or 2.0 inches. The iBook can accommodate standard SO-DIMMs with a height of 1.0 or 1.25 inches. It can accommodate an SO-DIMM up to 1.35 inches high, absolute maximum.

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

## Electrical Design of the 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 63).

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 are required to have the SPD feature. Information about the required values to be stored in the presence detect EEPROM is in section 4.1.2.5 and Figure 4.5.6–C (144 Pin SDRAM SO-DIMM, PD INFORMATION) of the JEDEC standard 21-C specification, release 7.

Because the SO-DIMM connector has only two clock lines, and each clock line is limited to only 4 loads, an SO-DIMM with more than 8 SDRAM devices must have buffers on the clock lines. The buffers must be zero-delay type, such as phase-lock loop (PLL), which regenerates the clock signals. For example, the computer can support a 128-MB SO-DIMM using 16 devices and a PLL clock buffer.

## SDRAM Devices

---

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 66 MHz or greater, corresponding to a cycle time of 15 ns or less.

## RAM Expansion

**Note**

The computer may have 100-Mhz parts installed. This is normal, and does not indicate that the memory bus is running faster than the specified 66 MHz. ♦

The devices are programmed to operate with a CAS latency of 2. At that CAS latency, the access time from the clock transition must be 7 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 shows information about the different sizes of SO-DIMMs used in the iBook computer. The first two columns show the memory size and configuration of the SO-DIMMs. The next two columns show the number and configuration of the SDRAM devices making up the memory modules.

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

---

SO-DIMM		SDRAM Devices		
Size	Configuration	Number	Configuration	Banks
16 MB	2 M x 64	2	2 M x 32	1
32 MB	4 M x 64	4	4 M x 16	1
32 MB	4 M x 64	4	2 M x 32	2
64 MB	8 M x 64	8	8 M x 8	1
64 MB	8 M x 64	8	4 M x 16	2
64 MB	8 M x 64	4	8 M x 16	1
128 MB	16 M x 64	8	16 M x 8	1
128 MB	16 M x 64	8	8 M x 16	2
256 MB	16 M x 64	16	16 M x 8	2
256 MB	16 M x 64	16	8 M x 16	4
256 MB	32 M x 64	8	32 M x 8	1
256 MB	32 M x 64	8	16 M x 16	2

## Address Multiplexing

---

Signals A[0] – A[12] and BA[0] – BA[1] on each RAM SO-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 iBook by size, configuration, and sizes of row, column, and bank addresses.

### IMPORTANT

The iBook computer supports only the types of SDRAM devices specified in Table 4-2. Other types of DRAM devices should not be used with this computer. ▲

**Table 4-2** Types of DRAM devices

---

<b>Device size</b>	<b>Device configuration</b>	<b>Row address bits</b>	<b>Column address bits</b>
64 Mbits	2 M x 8 x 4*	12	9
64 Mbits	1 M x 16 x 4	12	8
64 Mbits	512 K x 32 x 4	11	8
128 Mbits	4 M x 8 x 4*	12	10
128 Mbits	2 M x 16 x 4	12	9
128 Mbits	1 M x 32 x 4	12	8
256 Mbits	8 M x 8 x 4*	13	10
256 Mbits	4 M x 16 x 4	13	9

NOTE The use of 8x4 device configurations leads to excessive loading and so is not recommended; see “RAM SO-DIMM Electrical Limits”.

## RAM SO-DIMM Electrical Limits

---

Each RAM SO-DIMM must not exceed the following maximum current limits on the +3 V supply:

Active      1.2 A (8 devices at 150 mA each)

Sleep      6 mA per bank

The maximum current specified for active operation generally rules out the use of 4-bit-wide SDRAM devices in a RAM expansion module. Such a module would have 16 such devices, 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 SDRAM devices.

## Supplemental Reference Documents

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

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

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

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

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

## 3D Graphics

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

Information is available on the World Wide Web at

[www.apple.com/opengl](http://www.apple.com/opengl)

Developer support and documentation is available at

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

## PowerPC G3 Microprocessor

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For more information about the PowerPC 750CX microprocessor used in the iBook computer, developers may wish to refer to the standard reference, *PowerPC 740/750 Microprocessor Implementation Definition Book IV*. Information

## Supplemental Reference Documents

about the PowerPC 750CX microprocessor is available on the World Wide Web at

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

## Mac OS 9

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

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

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

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

## ROM-in-RAM Architecture

---

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

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

## Open Firmware

---

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

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

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

## Supplemental Reference Documents

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

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

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

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

The NewWorld software architecture embodied in the new Mac OS software follows some of the standards defined by the Open Firmware IEEE 1274-1995 specification and the CHRP binding.

The basis for the bootinfo file format and use is the document *PowerPC™ Microprocessor Common Hardware Reference Platform (CHRP™) System binding to: IEEE Std 1275-1994 Standard for Boot (Initialization, Configuration) Firmware*. A bootinfo file contains Open Firmware script, a description, information for individual operating systems, icons, and other information. A bootinfo file can be extended to contain non-Open Firmware information, such as “Trampoline” code and the ToolBox ROM Image.

Other Open Firmware references of possible interest include:

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

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

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

*Open Firmware Recommended Practice: Interrupt Mapping (Version 0.9)*

## RAM Expansion Modules

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The mechanical characteristics of the RAM SO-DIMM are given in JEDEC specification number JEDEC MO-190-C. The specification is available from the Electronics Industry Association’s website at

<http://www.jedec.org/download/pub95/>

The electrical characteristics of the RAM SO-DIMM are given in section 4.5.6 of the JEDEC Standard 21-C, release 7. These specifications are available from the Electronics Industry Association’s web site at

<http://www.jedec.org/download/pub21/>

## ATA Devices

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For information about the system software for ATA devices such as the IDE drive, see *Technote #1098, ATA Device Software Guide Additions and Corrections*, available on the world wide web at

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

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

## USB Interface

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

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

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

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

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

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

## FireWire Interface

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

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

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

<http://standards.ieee.org/catalog/bus.html>

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

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



# Abbreviations

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Standard units of measure used in this note include:

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

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
ADB	Apple Desktop Bus
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
BIOS	basic input/output system
CAS	column address strobe, a memory control signal

## A P P E N D I X B

### Abbreviations

CD	compact disc
CD-ROM	compact disc read-only memory
CPU	central processing unit
DAA	data access adapter (a telephone line interface)
DAC	digital-to-analog converter
DIMM	Dual Inline Memory Module
DMA	direct memory access
DSP	digital signal processor
DSSS	direct-sequence spread-spectrum
EDO	extended data out
G3	Generation 3, the third generation of PowerPC microprocessors
GND	ground
HFS	hierarchical file system
HID	human interface device, a class of USB devices
I <sup>2</sup> C	inter IC control bus
I <sup>2</sup> S	inter IC sound bus
IC	integrated circuit
IDE	integrated device electronics
IIC	inter IC control bus (same as I <sup>2</sup> C)
IIS	inter IC sound bus (same as I <sup>2</sup> S)
I/O	input and output
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

## A P P E N D I X B

### Abbreviations

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
PCI	Peripheral Component Interconnect
PHY	physical layer
PLL	phase-locked loop
POST	power-on self test
RAM	random-access memory
RF	radio frequency
rms	root mean square
ROM	read-only memory
SCC	Serial Communications Controller
SCSI	Small Computer System Interface
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)
WEP	Wired Equivalent Privacy
WLAN	wireless LAN



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