Developer Note

Macintosh PowerBook G3 Series

Developer Note

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Figures and Tables

About This Developer Note

This developer note is a concise description of the Macintosh PowerBook G3 Series computers, with the emphasis on the features that are new or different from those of earlier Macintosh PowerBook computers.

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 simply like additional technical information, you may wish to read the supplementary reference documents described in this preface.

Contents of This Note

The information in this note is arranged in four chapters.

- Chapter 1, “Introduction,” introduces the Macintosh PowerBook G3 Series computers and describes their features.
- Chapter 2, “Architecture,”describes the internal logic of the computers, including the main ICs.
- Chapter 3, “I/O Features,”describes the standard I/O ports and the built-in I/O devices.
- Chapter 4, “Expansion Features,” describes the expansion features of interest to developers. It includes development guides for expansion-bay devices, the RAM expansion modules, and the PC card slot.

Supplemental Reference Documents

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 8.1. The technote is available on the Technote web site at

http://devworld.apple.com/dev/technotes.shtml

For the latest 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://www.devworld.apple.com/dev/technotes/tn/tn1098.html

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

Printed copies of the technotes are available from Field Copy and Printing, telephone 1-415-323-3155. The technotes are also available on the reference library issues of the developer CD.

For more information about the PowerPC 750™ microprocessor used in the Macintosh PowerBook G3 Series computers, developers may wish to refer to the standard reference, *PowerPC 740/750 Microprocessor Implementation Definition Book IV*. Information about the PowerPC 750 and other G3 microprocessors is also available on the World Wide Web at

http://www.mot.com/SPS/PowerPC/index.html

Developers should also have copies of the relevant books of the *Inside Macintosh* series, available in technical bookstores.

Conventions and Abbreviations

This developer note uses the following typographical conventions and abbreviations.

Typographical Conventions

Computer-language text—any text that is literally the same as it appears in computer input or output—appears in `Courier` font.

Hexadecimal numbers are preceded by a dollar sign ($). For example, the hexadecimal equivalent of decimal 16 is written as $10.]

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. ▲

▲ **WARNING**
Warnings like this direct your attention to something that could cause injury to the user, damage to either hardware or software, or loss of data. ▲

Standard Abbreviations

Standard units of measure used in this note include

A	amperes	MHz	megahertz
dB	decibels	mm	millimeters
GB	gigabytes	ms	milliseconds
Hz	hertz	mV	millivolts
K	1024	µF	microfarads
KB	kilobytes	µW	microwatts
kbps	kilobits per second	ns	nanoseconds
kHz	kilohertz	Ω	ohms
kΩ	kilohms	pF	picofarads
M	1,048,576	V	volts
mA	milliamperes	VAC	volts alternating current
MB	megabytes	VDC	volts direct current
Mbps	megabits per second	W	watts

Other abbreviations used in this note include

$*n*	hexadecimal value *n*
AC	alternating current
ADB	Apple Desktop Bus
API	application program interface
ASIC	application-specific integrated circuit
ATA	AT attachment

ATAPI	ATA packet interface
AUI	auxiliary unit interface
BCD	binary coded decimal
BGA	ball grid array
CAS	column address strobe (a memory control signal)
CCFL	cold cathode fluorescent lamp
CD	compact disc
CIS	card information structure
CLUT	color lookup table
CMOS	complementary metal oxide semiconductor
CPU	central processing unit
DAA	data access adapter (a telephone line interface)
DAC	digital-to-analog converter
DC	direct current
DCE	device control entry (a data structure)
DDC	display data channel
DDM	driver descriptor map
DMA	direct memory access
DMF	distribution media format
DOS	disk operating system
DRAM	dynamic RAM
DSP	digital signal processor
DSVD	digital simultaneous voice and data
EDO	extended data out
EIDE	extended IDE
FIFO	first in, first out
FPU	floating-point unit
HBA	host bus adapter
IC	integrated circuit
IDE	integrated device electronics

I/O	input/output
IR	infrared
IrDA	Infrared Data Association
L2	level 2 or second level, a type of cache
LCD	liquid crystal display
LS TTL	low-power Schottky TTL
LVDS	low voltage differential signaling
MMU	memory management unit
NiCad	nickel cadmium
NiMH	nickel metal hydride
PC card	an expansion card conforming to the specifications of the PCMCIA
PCI	Peripheral Component Interconnect
PCMCIA	Personal Computer Memory Card International Association
PDS	processor-direct slot
PGA	pin grid array
PLL	phase-locked loop
PMU	power management unit
PQFP	plastic quad flatpack package
PROM	programmable read-only memory
PWM	pulse width modulation
RAM	random-access memory
RAMDAC	random-access memory, digital to analog converter
RAS	row address strobe
RGB	red-green-blue
RISC	reduced instruction set computing
rms	root-mean-square
ROM	read-only memory
SCC	Serial Communications Controller
SCSI	Small Computer System Interface
SGRAM	synchronous graphics RAM

SNR	signal-to-noise ratio
SO DIMM	small outline dual inline memory module
SOJ	small outline J-lead package
SOP	small outline package
SPD	Serial Presence Detect, a feature of the SO DIMM
STN	supertwist nematic (a type of LCD)
SVGA	super video graphics adapter
TDM	time division multiplexing
TFT	thin-film transistor (a type of LCD)
TQFP	thin quad flatpack package
TSOP	thin small outline package
TTL	transistor-transistor logic
VCC	positive supply voltage (voltage for collectors)
VGA	video graphics adapter
VRAM	video RAM; used for display buffers
WRAM	window RAM; used for display buffers
XGA	extended video graphics adapter

CHAPTER 1

Introduction

The Macintosh PowerBook G3 Series computers have a scalable design that encompasses a high-performance laptop computer as well as a low-cost laptop computer with many of the same features. This chapter summarizes the features of the Macintosh PowerBook G3 Series computers, lists available peripheral devices, and points out issues affecting compatibility.

Features

Here is a list of the features of the Macintosh PowerBook G3 Series computers. Each feature is described in a later chapter, as indicated in the list.

- **Processor:** The microprocessor in the Macintosh PowerBook G3 Series computers is a PowerPC G3 microprocessor running at a clock speed of 233, 250, or 292 MHz. See “G3 Microprocessor” (page 22).
- **Cache:** The 250- and 292-MHz models have a backside L2 cache consisting of 1 MB of fast static RAM. The clock speed for the backside cache is half the clock speed of the microprocessor. See “Backside Cache” (page 24).
- **Memory:** The Macintosh PowerBook G3 Series computers have two standard SO-DIMM expansion slots for SDRAM modules. The computers come with 16, 32, or 64 MB of SDRAM installed. RAM is expandable up to 192 MB total, using presently available memory devices. See “RAM Expansion Slots” (page 76).
- **Hard disk storage:** The Macintosh PowerBook G3 Series computers have built-in hard disk drives with capacities of 2, 4, or 8 GB. The hard drive is removable. For more information and developer guidelines for alternative hard drives, see “Hard Disk Drive” (page 30).
- **Display:** The Macintosh PowerBook G3 Series computers have either a 13.3- or 14.1-inch TFT display with XGA resolution (1024 x 768 pixels) or a 12.1-inch STN display with SVGA resolution (800 x 600 pixels). Each display is backlit by a cold cathode fluorescent lamp (CCFL). See “Flat Panel Display” (page 39).
- **External monitor:** All configurations have a standard VGA video connector for an external video monitor with XGA resolution (up to 1280 x 960 pixels). In addition, the 13.3- and 14.1-inch models have an S-video connector that supports PAL and NTSC video monitors. See “External Video Connectors” (page 39).

- **Video RAM:** The Macintosh PowerBook G3 Series computers come with 2 or 4 MB of video SGRAM, which supports up to millions of colors on an external monitor. See “Flat Panel Display” (page 39) and “External Video Connectors” (page 39).
- **Graphics acceleration**: The video circuits provide built-in 2D and 3D acceleration. See “Video Controller IC” (page 27).
- **Expansion bays:** All configurations have two expansion bays for batteries, floppy disk drive, CD-ROM drive, DVD drive, and other IDE or PCI devices. Storage devices in the expansion bays can be removed and replaced while the computer is operating. See “Expansion Bays” (page 58).
- **CardBus slot:** All configurations have a CardBus slot that accepts one Type III or two Type II CardBus cards or PC Cards. The cards can be removed and replaced while the computer is operating. The slot supports Zoomed Video. See “CardBus Slot” (page 81).
- **Standard I/O ports:** All configurations have the standard Macintosh input and output ports:
  - External SCSI with an HDI-30 connector; see “SCSI Port” (page 48)
  - Serial port with GeoPort capability; see “Serial Port” (page 47)
  - Audio input and output ports; see “Sound System” (page 51)
  - ADB port for external keyboard or mouse; see “ADB Port” (page 49)
- **Modem**: Some configurations have a built-in modem with K56flex data rate. See “Internal Modem” (page 55).
- **Ethernet:** All configurations have a built in Ethernet port with a 10BaseT connector. See “Ethernet Port” (page 54)
- **Infrared link:** All configurations have an infrared link for up to 4 Mbit-per-second IrDA data transfer. See “Infrared Communication Link” (page 51)
- **Sound:** All configurations have a built-in microphone and speakers as well as a line-level stereo input jack and a stereo headphone jack. See “Sound System” (page 51)
- **Keyboard:** The keyboard is a new design with an embedded numeric keypad and inverted-T arrow keys. See “Keyboard” (page 37).
- **Trackpad:** The integrated flat pad includes tap / double tap and drag features. See “Trackpad” (page 36).

- **Weight:** A Macintosh PowerBook G3 Series computer weighs 3.45 kg (7.6 pounds) with the battery and CD-ROM drive installed in the expansion bays.
- **Size:** A Macintosh PowerBook G3 Series computer is 323 mm (12.83 inches) wide, 265 mm (10.43 inches) deep, and 51 mm (2.01 inches) thick.

Peripheral Devices

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

- The Macintosh PowerBook G3 Series Floppy Disk Drive is available separately for models that do not include it.
- The Macintosh PowerBook G3 Series DVD-ROM drive module, which fits into the right expansion bay, is available at the time of purchase as a build-to-order option.
- The Macintosh PowerBook G3 Series Intelligent Lithium Ion Battery is available separately as an additional or replacement battery.
- The Macintosh PowerBook 45W AC 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.

Compatibility Issues

While the Macintosh PowerBook G3 Series computers have many new features, there should be no compatibility problems with applications and peripherals that operate correctly with earlier PowerBook models, with the exceptions described in this section.

Expansion Bay Modules

The expansion bays in the Macintosh PowerBook G3 Series computers are not the same as those in the PowerBook G3 and PowerBook 3400 computers. Expansion bay modules designed for earlier PowerBook computers will not fit

in the Macintosh PowerBook G3 Series computers. For more information, see “Expansion Bays” (page 58).

RAM Expansion Modules

For RAM expansion, the Macintosh PowerBook G3 Series computers use standard SO-DIMMs that contain SDRAM devices. For information, see “RAM Expansion Slots” (page 76).

IMPORTANT

The RAM DIMMs in the Macintosh PowerBook G3 Series computers must be SO-DIMMs that use SDRAM devices. SO-DIMMs that use EDO devices will not work. ▲

Machine Identification

The Macintosh PowerBook G3 Series computers have two new machine ID values. For the models with 13.3- and 14.1-inch displays, the Gestalt Manager returns a `gestaltMachineType` value of 312 (hexadecimal 138). For the 12.1-inch model, the `gestaltMachineType` value is 314 (hexadecimal 13A). *Inside Macintosh: Overview* describes the Gestalt Manager and tells how to use the `gestaltMachineType` value to obtain the machine name string.

System Software

The system software that comes with the Macintosh PowerBook G3 Series computers is Mac OS 8.1 with the addition of the extensions and control panels required by product-specific features. For a description of the general Mac OS 8.1 release, developers should refer to the Technote for Mac OS 8.1, available on the Technote web site at

http://devworld.apple.com/dev/technotes.shtml

▲ **WARNING**

There are several types of programs that may be incompatible with Mac OS 8.1 and the new Mac OS Extended format: utilities that check the integrity of a disk volume, programs that provide password security for volumes, and other programs that write data directly to a volume. The use of these programs with a disk that has been formatted in the extended format may result in loss of data. ▲

CHAPTER 2

Architecture

The architecture of the Macintosh PowerBook G3 Series computers is designed around two main circuit boards: the system module and the I/O board. The devices on the system module communicate with the devices on the I/O board by way of the PCI bus. Figure 2-1 is a block diagram showing the major components and the relationship of the system module and the I/O board.

System Module

The system module contains the high-speed components: the microprocessor, the backside cache, the main memory, and the IC that contains the memory controller and the PCI bus bridge.

This section includes a description of the microprocessor, the cache, and the memory controller IC. For a description of the SO-DIMMs that contain the main memory, please see the section “RAM Expansion Slots” (page 76).

G3 Microprocessor

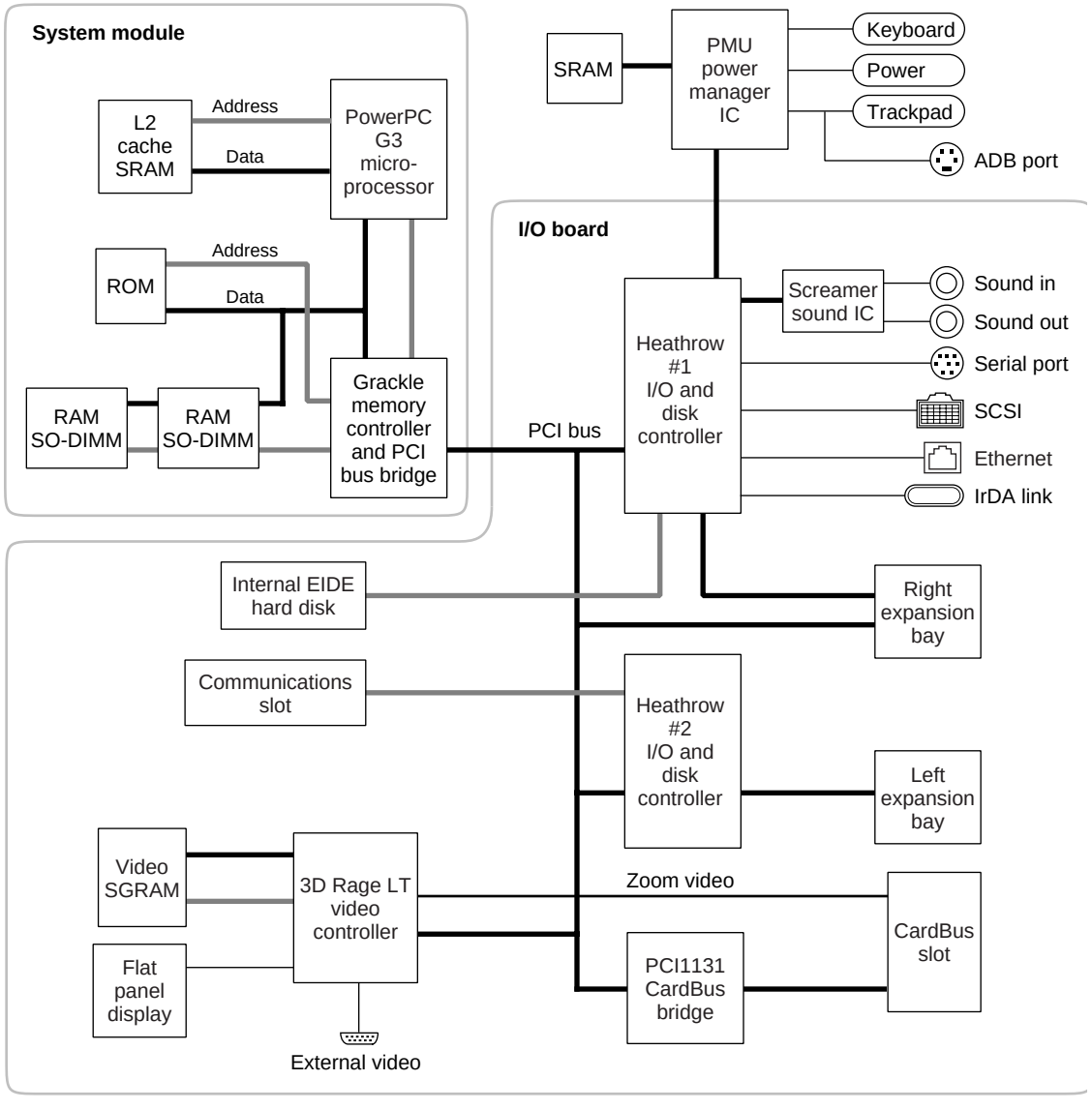
The latest family of PowerPC microprocessor designs is called “G3,” for “generation three.” The G3 microprocessors have several features that contribute to improved performance, including:

- larger on-chip (L1) caches, 32 KB each for instruction cache and data cache
- a built-in cache controller and cache tag RAM for the second level (L2) cache
- a separate backside bus for the L2 cache, providing faster clock speed and overlapped bus transactions
- a microprocessor core optimized for Mac OS applications

The G3 microprocessor in the Macintosh PowerBook G3 Series computers runs at a clock speed of either 233, 250, or 292 MHz, depending on the model. Table 2-1 (page 24) shows how the speeds of the CPU clock, the backside cache, and the main memory bus are related.

The PowerPC G3 family of microprocessors includes the PowerPC 740™ and the PowerPC 750™; the Macintosh PowerBook G3 Series computers use the PowerPC 750.

Figure 2-1 Block diagram



Backside Cache

The backside cache controller and the cache tag storage are built into the microprocessor chip. The cache controller includes bus management and control hardware that allows the cache to run at an independent sub-multiple of the processor's clock speed, rather than at the clock speed of the main system bus. In the Macintosh PowerBook G3 Series computers, the clock speed of the backside cache is half that of the microprocessor.

The data storage for the backside L2 cache consists of 1 MB of fast static RAM on the system module.

Note
The 233-MHz model does not include a backside cache.

Bus Clock Speeds

Table 2-1 shows the clock speeds for the microprocessor, the backside cache, and the main buses in the Macintosh PowerBook G3 Series computers.

Table 2-1 Clock speeds

Bus or device	Clock speeds		
G3 microprocessor	233.3 MHz	250.0 MHz	291.6 MHz
Backside L2 cache	—	125.0 MHz	145.8 MHz
System bus	66.7 MHz	83.3 MHz	83.3 MHz
PCI bus	33.3 MHz	33.3 MHz	33.3 MHz

Memory Controller and PCI Bridge

The memory controller and PCI bus bridge IC is a Motorola MPC106, also called Grackle. The Grackle IC provides the bus bridge between the processor bus used on the system module and the PCI bus used for the I/O controllers on the I/O board. The Grackle IC also contains the controller for the main memory.

To enhance performance, the Grackle IC supports concurrent transactions on the main memory bus and the PCI bus.

I/O board

All the I/O interfaces, the video and display support, the expansion bays, and the CardBus slots are on the I/O board. The controller ICs on the I/O board are connected to the PCI bus.

I/O Controller ICs

The Macintosh PowerBook G3 Series computers have two Heathrow I/O controller ICs. The Heathrow IC is an integrated I/O controller and DMA engine for use in Power Macintosh computers with a PCI bus. It integrates most of the standard Macintosh I/O controllers, including SCSI, SCC, IDE, floppy disk, sound, Ethernet, and VIA.

Functions of the I/O Controllers

Heathrow number 1 provides the interface and control signals for

- the serial port
- the infrared link
- the Ethernet port
- the Screamer sound IC
- the internal IDE hard drive
- the external SCSI port
- the right expansion bay, including enhanced IDE, floppy disk, and PCI interfaces
- the power manager IC, described in “Power Management Unit” (page 27)
- SPD (serial presence detect) for the bottom SDRAM SO-DIMM and the configuration ROM

Heathrow number 2 provides the interface and control signals for

- the communications card
- the left expansion bay, including enhanced IDE and floppy disk drives

- SPD (serial presence detect) for the top SDRAM SO-DIMM

Note
For detailed descriptions of the expansion bays, please see “Expansion Bays” (page 58).

Features of the I/O Controllers

Here are the features of the Heathrow ICs.

- A 33MHz PCI Bus interface with both master and slave transactions
- A Gated Clocks PCI arbiter
- An SCSI controller implemented using the Mesh design
- Two Enhanced IDE channels
- An 85C30 SCC cell that supports GeoPort™ and has additional support for LocalTalk
- An SWIM3 unit that supports 3.5-inch floppy drives and off-loads time-critical low-level tasks from the CPU.
- The interface to the Screamer external sound chip
- A VIA cell
- The interface to the PMU, described in “Power Management Unit” (page 27)
- A general purpose, 16-bit parallel port that supports the sound multiplex controller, the expansion bay, and the IDE channels.
- A DMA controller with a channel dedicated to each I/O port. The DMA controller performs scatter/gather transfers based on a buffer list in main memory.
- Certain control functions including media bay support and sleep mode.
- Desktop functions including support for front panel push-buttons and control of screen illumination and fan speed.
- A 10 Mbit-per-second Ethernet interface.

The Heathrow IC includes all the features of the O’Hare I/O controller used in the PowerBook 3400 and the PowerBook G3, along with a few new features. Here are the differences between the Heathrow and O’Hare ICs:

- Heathrow includes support for 10Mbit Ethernet; O'Hare does not include Ethernet support.
- Heathrow supports Enhanced IDE; O'Hare supports IDE but not EIDE.
- Heathrow uses the Gated Clocks PCI arbiter; O'Hare uses a sub-set of the Gated Clocks PCI arbiter.
- Heathrow supports additional interrupts.
- Heathrow includes an MFM floppy-disk controller.

Video Controller IC

The video controller in the Macintosh PowerBook G3 Series computers is an ATI RAGE LT IC operating on the PCI bus. The RAGE LT IC has the following features:

- It supports the flat-panel displays: the 12.1-inch at SVGA (800 x 600) resolution and the 13.3 and 14.1-inch at XGA (1024 x 768) resolution. The interface to the displays uses LVDS (low voltage differential signaling).
- It supports an external monitor at resolutions up to 1280 by 960.
- It controls a frame buffer with 4 MB of storage.
- It provides 2D and 3D acceleration.
- It provides color space conversions and video scaling for use with QuickTime and MPEG decompressors.
- It supports the Zoomed Video port from the CardBus slot.
- With some external circuitry, it supports NTSC and PAL external monitors.

Power Management Unit

The power manager IC in the Macintosh PowerBook G3 Series computers is a 68HC05 microprocessor, also called the PMU. It operates with its own RAM and ROM. The functions of the PMU include:

- controlling the sleep and power on and off sequences
- controlling power to the other ICs
- controlling the brightness of the display

- supporting the ADB, which is the interface to the trackpad and the external ADB port
- monitoring battery charge level
- controlling battery charging

The PMU is not mounted on the I/O board but is connected to it by a flex cable.

Screamer Sound IC

The Screamer sound IC is a custom IC that combines a waveform amplifier with a 16-bit digital sound encoder and decoder (codec). It is similar to the AWAC IC used in older PowerBook models, with three main differences:

- It has better analog performance
- It has a low-power mode
- It includes a separate input used for the modem call progress sound from a PC Card modem.

The Screamer IC is not soldered directly to the I/O board but is on a small card mounted on the I/O board. The sound outputs from the Screamer IC are connected to a pair of LM4861 power amplifier ICs that provide power to drive the speakers.

CardBus Controller IC

The CardBus controller IC in the Macintosh PowerBook G3 Series computers is a PCI1131 device designed by Texas Instruments. It supports both 16-bit PC Cards and 32-bit CardBus Cards.

CHAPTER 3

I/O Features

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:

- “Hard Disk Drive”
- “Trackpad”
- “Keyboard”
- “Flat Panel Display”
- “External Video Connectors”
- “Serial Port”
- “SCSI Port”
- “ADB Port”
- “Infrared Communication Link”
- “Sound System”
- “Ethernet Port”
- “Internal Modem”

Hard Disk Drive

The Macintosh PowerBook G3 Series computers have an internal hard disk drive. The drive uses the extended IDE (integrated drive electronics) interface, which is also referred to as the ATA interface. The implementation of the ATA interface on these computers 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 the same as that in previous Macintosh PowerBook models with internal IDE drives and includes DMA support. For the latest information about that software, see *Technote #1098, ATA Device Software Guide Additions and Corrections*, available on the world wide web at

http://www.devworld.apple.com/dev/technotes/tn/tn1098.html

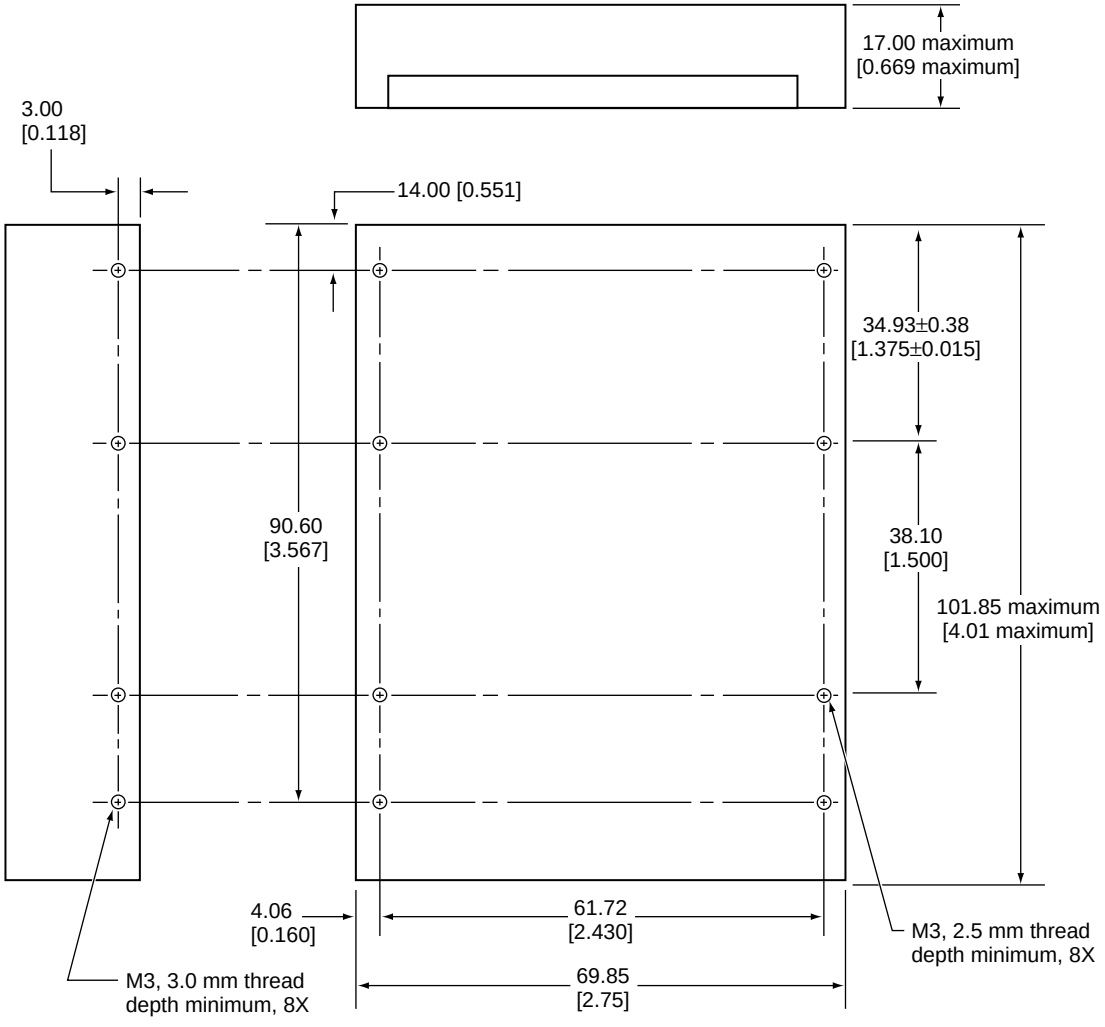
The web page for Technote #1098 includes a link to a downloadable copy of *ATA Device Software Guide*.

Hard Disk Specifications

Figure 3-1 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 3-1 Maximum dimensions of the internal hard disk

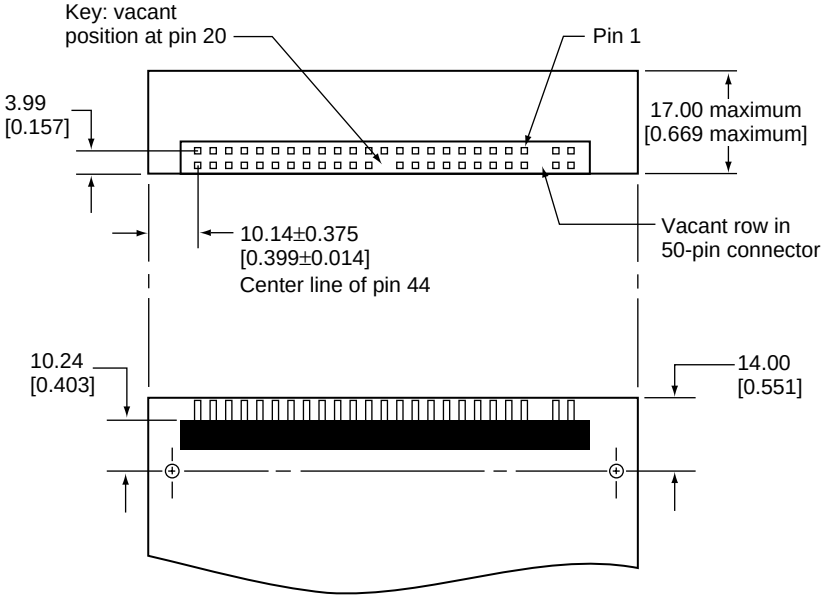


Note: Dimensions are in millimeters [inches].

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 3-2. The remaining pins are in two groups: pins 1–44, which carry the signals and power, and pins 46–48, 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 3-2 Hard disk connector and location



Note: Dimensions are in millimeters [inches].

Signal Assignments

Table 3-1 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 3-1 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	IORDY	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

Table 3-1 Pin assignments on the ATA hard disk connector (continued)

Pin number	Signal name	Pin number	Signal name
41	+5V LOGIC	42	+5V LOGIC
43	GROUND	44	Reserved

NOTE CSEL, /DASP, /IOCS16, and /PDIAG are not used; see Table 3-2

ATA Signal Descriptions

Table 3-2 describes the signals on the ATA hard disk connector.

Table 3-2 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.
/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.

Table 3-2 Signals on the ATA hard disk connector (continued)

Signal name	Signal description
/IOCS16	I/O channel select; not used on this computer (pulled low by 1 kΩ).
/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.
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 and ATA devices in the expansion bay are separately connected to the I/O bus through bidirectional bus buffers.

Trackpad

The pointing device in the Macintosh PowerBook G3 Series computers 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 ADB commands.

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

On the Macintosh PowerBook G3 Series computers, the keyboard has a new layout with an embedded numeric keypad. The embedded keypad is activated by a new function key that is located in the lower left corner of the keyboard.

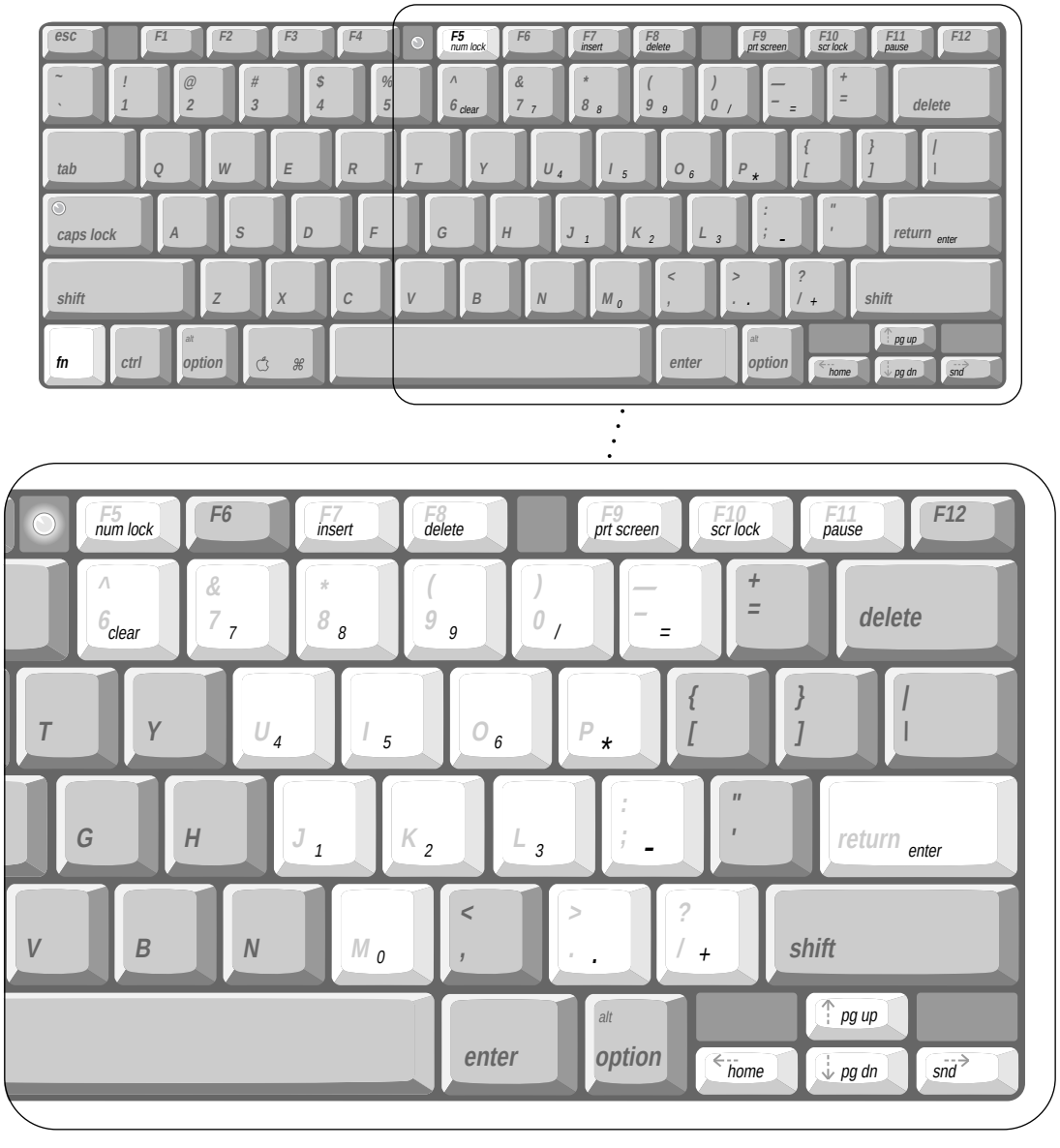
To activate the embedded numeric keypad, the user holds down the function key and presses the F5 (num lock) key. The num lock LED comes on to indicate that the numeric keypad is active. In that mode of operation, only the numeric keypad, the modifier keys, and certain other special functions are active, as shown in Figure 3-3. While the keyboard is in the keypad mode, the user can type alphabetical information by holding down the function key.

In addition to the embedded numeric keypad, the keypad mode gives several other keys special functions. Figure 3-3 highlights the keys that are functional when the keypad mode is active. To see the effects of the keypad mode on individual keys, the user can use the Key Caps item in the Apple menu.

The Macintosh PowerBook G3 Series computers use a new key combination for forcing a reset and power off. The user holds down the shift, function, and control keys and presses the power key. This key combination also forces a reset of the parameter RAM, so it should be used only as a last resort. To force a reset without turning off the power, the user holds down the control and command keys and presses the power key.

The keyboard is removable to allow access to the internal components and expansion connectors inside the computer. The keyboard is held in place by two catches that are accessible through the expansion bay openings. After removing the modules from the expansion bays, the user can insert a finger into each bay and release the catches.

Figure 3-3 Keyboard and embedded keypad



Flat Panel Display

The Macintosh PowerBook G3 Series computers have built-in color flat panel displays that are backlit by a cold cathode fluorescent lamps (CCFL). Three sizes of displays are available.

The Macintosh PowerBook G3 Series includes models with three different sizes of displays: 12.1, 13.3, and 14.1 inches, measured diagonally. The 12.1-inch display contains 800 by 600 pixels and can show up to thousands of colors. The display technology used for the 12.1-inch display is STN (supertwist nematic). The 13.3- and 14.1-inch displays contain 1024 by 768 pixels and can show up to millions of colors. Those displays use TFT (thin-film transistor) technology for high contrast and fast response. Table 3-3 lists the display resolution and display technology for each size of display.

Table 3-3 Types of displays

Display size	Display resolution	Display technology	Maximum number of colors
12.1 inches	800 by 600 (SVGA)	STN	Thousands
13.3 inches	1024 by 768 (XGA)	TFT	Millions
14.1 inches	1024 by 768 (XGA)	TFT	Millions

External Video Connectors

The Macintosh PowerBook G3 Series computers have a built-in connector for an external VGA or SVGA monitor. An optional adapter allows the user to attach a standard Apple video cable. The 13.3- and 14.1-inch models also have an S-video connector that supplies a video signal for an NTSC or PAL video monitor or VCR. The connectors and adapter are described in the sections

Monitors Supported

With the adapter, the Macintosh PowerBook G3 Series computers can display on any Apple monitor, including the AV monitors and the 17-inch and 20-inch multiple scan monitors. The computers also support VGA and SVGA monitors and PAL and NTSC television monitors, as shown in Table 3-4 and Table 3-5.

The Macintosh PowerBook G3 Series computers include either 2 or 4 MB of SGRAM. Table 3-4 lists the pixel depths supported with either 2 MB or 4 MB of SGRAM for each picture size available. The letter codes are used to identify the picture sizes supported by the monitors listed in Table 3-5.

Table 3-4 Picture sizes supported

Letter code	Picture size, in pixels	Frame rate	Maximum pixel depth (2 MB)	Maximum pixel depth (4 MB)
A	512 by 384	60 Hz	24	24
B	640 by 480	60 Hz	24	24
C	640 by 480*	67 Hz	24	24
D	640 by 480*	72 Hz	24	24
E	640 by 480*	75 Hz	24	24
F	640 by 480*	85 Hz	24	24
G	640 by 870	75 Hz	16	24
H	800 by 600	56 Hz	16	24
I	800 by 600	60 Hz	16	24
J	800 by 600	72 Hz	16	24
K	800 by 600	75 Hz	16	24
L	800 by 600	85 Hz	16	24
M	832 by 624	75 Hz	16	24
N	1024 by 768	60 Hz	16	24
O	1024 by 768	70 Hz	16	24
P	1024 by 768	72 Hz	16	24

Table 3-4 Picture sizes supported (continued)

Letter code	Picture size, in pixels	Frame rate	Maximum pixel depth (2 MB)	Maximum pixel depth (4 MB)
Q	1024 by 768	75 Hz	16	24
R	1024 by 768	85 Hz	16	24
S	1152 by 870	75 Hz	8	24
T	1280 by 960	75 Hz	8	16
U	1280 by 1024	60 Hz	8	16
V	1280 by 1024	60 Hz	8	16

Table 3-5 lists the picture sizes available for each type of monitor that is supported by the Macintosh PowerBook G3 Series computers. The letter codes in the table correspond to picture sizes and frame rates listed in Table 3-4.

Table 3-5 Monitors and picture sizes

Monitor type	Picture sizes listed in Table 3-5
12-inch RGB	A
13-inch RGB	C
VGA, SVGA, and XGA	All except A and G
15-inch multiple scan	B, C, E, I, J, M, N, S
17-inch multiple scan	A, B, C, D, E, H, I, J, K, M, N, O, P, Q
20-inch multiple scan	B, C, D, E, F, H, I, J, K, M, N, O, P, Q, S, T, U, V
Apple two page	S
Apple 21-inch RGB	S
Portrait	G

Note
The Macintosh PowerBook G3 Series computers do not provide displays with 2 bits per pixel. ◆

If the external monitor can display the same size picture as the computer, the computer can display simultaneously on both the external monitor and the flat panel display. This mode of display, called *Simulscan*, provides the same information on both displays. On the 13.3- and 14.1-inch models, Simulscan is available at 1024 x 768 pixels; on the 12.1-inch models, Simulscan is available at 800 x 600 pixels.

Monitor Connector

The connector is a standard DB9/15 connector for use with a VGA, SVGA, or XGA monitor. Figure 3-4 shows the pin configurations and Table 3-6 lists the signal pin assignments.

Figure 3-4 Signal pins on the video connector

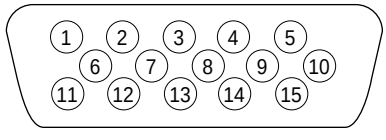


Table 3-6 Signals on the video connector

Pin	Signal name	Description
1	RED	Red video signal
2	GREEN	Green video signal
3	BLUE	Blue video signal
4	MONID(0)	Monitor ID signal 0
5	GND	DDC return
6, 7, 8	AGND_VID	Analog video ground
9	+5V_IO	5 V power for I/O device

Table 3-6 Signals on the video connector (continued)

Pin	Signal name	Description
10	GND	HSYNC and VSYNC ground
11	VGA_ID	VGA ID signal
12	MONID(2)	Monitor ID signal 2
13	HSYNC	Horizontal synchronization signal
14	VSYNC	Vertical synchronization signal
15	MONID(1)	Monitor ID signal 1

Monitor Adapter

An optional monitor adapter allows the user to connect a standard Apple monitor cable to the computer. The adapter enables the computer to recognize a wide range of monitor types. The Apple part number for the adapter is 590-1118.

Monitor Sense Codes

To identify the type of monitor connected, the computer first determines whether the adapter is connected. It does this by checking pin 11; on the new adapter, this pin is connected to the VSYNC signal. If the adapter is not found, the computer next checks to determine whether a DDC-type monitor is connected. DDC is the interface that provides monitor ID signals for VGA and SVGA monitors.

If the computer does not detect a DDC-capable monitor, it uses the Apple monitor sense codes on the signals MONID(0–2) in Table 3-6. Table 3-7 shows the sense codes and the extended sense codes for each of the monitors the card can support.

For a complete description of the sense code system, developers should refer to Technote *HW 30 - Sense Lines*. To find out how to obtain Apple Computer's Technotes, see "Supplemental Reference Documents" (page ix).

Table 3-7 Monitor sense codes

Monitor type	Standard sense code	Extended sense code		
	(S2–0)	(S1,0)	(S2,0)	(S2,1)
Macintosh 21-inch Color Display	0 0 0	—	—	—
Macintosh Portrait Display	0 0 1	—	—	—
Macintosh 12-inch RGB Display	0 1 0	—	—	—
Apple Two-Page Monochrome Monitor	0 1 1	—	—	—
NTSC monitor	1 0 0	—	—	—
15-inch RGB monitor	1 0 1	—	—	—
Apple Multiple Scan 14 and 15 Displays	1 1 0	0 0	0 0	1 1
Apple Multiple Scan 17 and 1705 Displays	1 1 0	0 0	1 0	1 1
Apple Multiple Scan 20 Display	1 1 0	1 0	0 0	1 1
AppleVision 850, 850av, 1710, and 1710av Displays, Macintosh 12-inch Monochrome Display, or AppleColor High Resolution RGB Monitor	1 1 0	1 0	1 0	1 1
PAL monitor	1 1 1	0 0	0 0	0 0
NTSC monitor, with convolution	1 1 1	0 1	0 1	0 0
VGA or SVGA monitor	1 1 1	0 1	0 1	1 1
Macintosh 16-inch Color Display	1 1 1	1 0	1 1	0 1
PAL monitor, with convolution	1 1 1	1 1	0 0	0 0
19-inch RGB monitor	1 1 1	1 1	1 0	1 0
No monitor connected	1 1 1	1 1	1 1	1 1

Note
VGA, SVGA, and XGA monitors all have the same sense code. The first time the user starts up with an SVGA or XGA monitor, the video card treats it as a VGA monitor and shows a 640-by-480 pixel display. The user can switch to a larger display mode from the Monitors control panel; when that happens, the computer changes the display to the larger mode immediately and uses that mode the next time it is started up. ◆

External Video Connector

The Macintosh PowerBook G3 Series computer have an S-video connector for composite video output to a PAL or NTSC video monitor or VCR. The video output connector is a 7-pin S-video connector. Figure 3-5 shows the arrangement of the pins and Table 3-8 shows the pin assignments on the S-video connector.

Figure 3-5 S-video connector

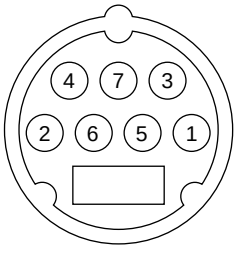


Table 3-8 Pin assignments for the S-video output connector

Pin number	S-video output connector
1	Analog GND
2	Analog GND
3	Video Y (luminance)
4	Video C (chroma)
5	Composite video
6	Unused
7	Unused

An adapter is available that can be plugged into the S-video connector and accepts an RCA plug from a composite video monitor.

The Macintosh PowerBook G3 Series computers provide composite video output at picture sizes and frame rates compatible with the NTSC and PAL standards; the picture sizes are listed in Table 3-9. Those picture resolutions produce underscanned displays on standard monitors.

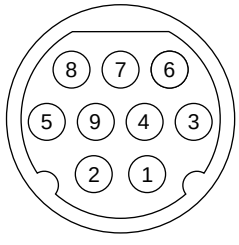
Table 3-9 Picture sizes for composite video output

Picture size	Pixel depth (2 MB SGRAM)	Pixel depth (4 MB SGRAM)
512 by 384	24	24
640 by 480	24	24
800 by 600	16	24
832 by 624	16	24

Serial Port

The Macintosh PowerBook G3 Series computers have a standard Macintosh serial port for use with a printer or an external modem. The 9-pin circular mini-DIN socket on the back panel is the same as those on other Macintosh computers. The serial port socket accepts either 8-pin or 9-pin plugs. Figure 3-6 shows the connector.

Figure 3-6 Serial port connector



The serial port can be programmed for asynchronous or synchronous communication formats up to 4 Mbps, including AppleTalk and the full range of Apple GeoPort protocols. With an external module connected to the serial port, the computer can communicate with a variety of ISDN and other telephone transmission facilities. For more information, refer to Macintosh Technote Number 1018, *Serial DMA*.

Table 3-10 shows the signal assignments for the serial port.

Table 3-10 Pin assignments on the serial port connector

Pin	Name	Function
1	HSKo	Handshake output
2	HSKi	Handshake input or external clock (up to 4 Mbps)
3	TxD–	Transmit data –

Table 3-10 Pin assignments on the serial port connector

Pin	Name	Function
4	Gnd	Ground
5	RxD–	Receive data –
6	TxD+	Transmit data +
7	GPi	General-purpose input (wake up CPU or perform DMA handshake)
8	RxD+	Receive data +
9	+5V	Power to external device (300 mA maximum)

SCSI Port

The SCSI port uses an HDI-30 connector and supports the SCSI interface as defined by the American National Standards Institute (ANSI) X3T9.2 committee.

The external HDI-30 connector is identical to those used in other PowerBook models. The data and control signals on the SCSI bus are active low signals that are driven by open drain outputs. The SCSI bus has built-in active termination.

Table 3-11 shows the signal assignments for the external SCSI connector. Pin 1 of the external SCSI connector is the /SCSI.DISK.MODE signal. When this signal is asserted at startup time, the computer operates in disk mode instead of starting up the Mac OS.

Table 3-11 SCSI connector signals

Pin	Signal name	Pin	Signal name
1	/SCSI.DISK.MODE	16	/DB6
2	/DB0	17	GND
3	GND	18	/DB7

Table 3-11 SCSI connector signals (continued)

Pin	Signal name	Pin	Signal name
4	/DB1	19	/DBP
5	TERMPWR (not used; reserved)	20	GND
6	/DB2	21	/REQ
7	/DB3	22	GND
8	GND	23	/BSY
9	/ACK	24	GND
10	GND	25	/ATN
11	/DB4	26	/C/D
12	GND	27	/RST
13	GND	28	/MSG
14	/DB5	29	/SEL
15	GND	30	/I/O

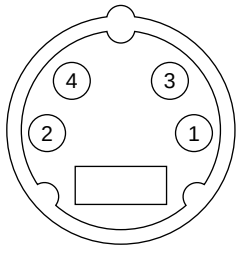
ADB Port

The Apple Desktop Bus (ADB) port on the Macintosh PowerBook G3 Series computers is functionally the same as on other Macintosh computers. The connector is located on the back of the computer.

Unlike earlier ADB-equipped computers, the Wall Street computers allow the user to unplug and replace ADB devices while the computer is operating.

The ADB connector is a 4-pin mini-DIN connector. Figure 3-7 shows the arrangement of the pins on the ADB connector.

Figure 3-7 ADB connector



The ADB is a single-master, multiple-slave serial communications bus that uses an asynchronous protocol and connects keyboards, graphics tablets, mouse devices, and other devices to the computer. The custom ADB microcontroller drives the bus and reads status from the selected external device. A 4-pin mini-DIN connector connects the ADB controller to the outside world. Table 3-12 lists the ADB connector pin assignments. For more information about the ADB, see *Guide to the Macintosh Family Hardware,* second edition.

Table 3-12 ADB connector pin assignments

Pin number	Name	Description
1	ADB	Bidirectional data bus used for input and output; an open collector signal pulled up to +5 volts through a 470-ohm resistor on the main logic board.
2	PSW	Power-on signal; generates reset and interrupt key combinations.
3	+5V	+5 volts from the computer.
4	GND	Ground from the computer.

IMPORTANT

The total current available for all devices connected to the +5-V pins on the ADB is 100 mA. ▲

Infrared Communication Link

The computer has a directed infrared (IR) communication link connected internally to serial port B. When the computer is placed within range of another device with an IR interface, it can send and receive serial data using one of several communications protocols. The other device may be another IR-equipped PowerBook, a desktop computer with an IR communications link, or some other device that complies with the Infrared Data Association (IrDA) standard. The minimum range of the IR link is approximately 2 inches, and the maximum range is 34 inches for IrDA compliant devices and 6 feet for PowerBooks.

The IR link in the Macintosh PowerBook G3 Series computers supports the following communications methods:

- IRTalk (LocalTalk over IR)
- IrDA at up to 4.0 Mbps

For LocalTalk operation, the IR link takes serial bits from the SCC and transmits them using a modified form of pulse encoding called PPM-4. This method of encoding uses four cycles of a 3.92-MHz carrier for each pulse, which increases the system's immunity to interference from ambient light sources. Two serial bits are encoded as a symbol consisting of a start pulse followed by either a second pulse in one of three possible positions or no second pulse.

The IrDA modulation method complies with the IrDA physical layer standard, which can be found at ftp://irda.org.

Sound System

The 16-bit stereo audio circuitry provides high-quality sound input and output through the built-in microphone and speakers. The user can also connect external input and output devices by way of the sound input and output jacks.

The sound system is based on the Screamer codec IC along with input and output amplifiers and signal conditioners. In the Macintosh PowerBook G3 Series computers, the Screamer codec supports three channels of digital sound:

two stereo channels plus a multiplexed channel. The sound system supports sample sizes up to 16 bits and sample rates of 11.025 kHz, 22.05 kHz, and 44.1 kHz.

The frequency response of the sound circuits, not including the microphone and speakers, is within plus or minus 2 dB from 20 Hz to 20 kHz. Total harmonic distortion and noise is less than 0.05 percent with a 1-V rms sine wave input. The signal-to-noise ratio (SNR) is 85 dB, with no audible discrete tones.

Note
All sound level specifications in this section are rms values. ◆

Sound Inputs

The sound system accepts inputs from six possible sources:

- built-in microphone
- external stereo sound input jack
- 1-bit sound from the CardBus sockets
- sound from the communication (modem) slot
- sound from the expansion bays
- sound from a Zoomed Video device in the lower CardBus socket

The microphone and the sound input jack have dedicated input channels on the Screamer IC; the sound input from the PC Card slot has its own input, and the other three inputs share an input on the IC. Those three inputs are switched on and off by the hardware; they can be selected one at a time for play-through or recording.

Built-in Microphone

The sound signal from the built-in microphone goes through a dedicated preamplifier that raises its nominal 30-mV level to the 0.6-V level of the codec circuits in the Screamer IC.

External Sound Input

The external sound input jack is located on the back of the computer near the left corner.The sound input jack accepts line-level stereo signals or an Apple PlainTalk microphone. When a connector is plugged into the external sound input jack, the computer turns off the sound input from the built-in microphone. The input jack has the following electrical characteristics:

- input impedance: 6.8k
- maximum level: 2.0 V rms

Note
The sound input jack accepts the maximum sound output of an audio CD without clipping. When working with sound sources that have significantly lower levels, you may wish to increase the signal gain of the sound input circuit. You can do that using the Sound Manager as described in *Inside Macintosh: Sound.* ◆

Expansion Bay Sound Input

The sound inputs from the expansion bays have the following electrical characteristics:

- input impedance: 3.2k
- maximum level: 0.5 V rms

CardBus Sound Input

Each CardBus socket has one sound output pin (SPKR_OUT) and the computer accepts either one or two cards. The one-bit digital signals from the sound output pins are exclusive-ORed together and routed to the Screamer IC, which sends them to the built-in speaker and the external sound output jack.

Sound Outputs

The sound system sends computer-generated sounds or sounds from an expansion-bay device or CardBus card to the built-in speakers, the communication slot, and the external sound output jack.

External Sound Output

The sound output jack is located on the back of the computer at the left corner. The sound output jack provides enough current to drive a pair of low-impedance headphones. The sound output jack has the following electrical characteristics:

- output impedance: 33 Ω
- minimum recommended load impedance: 32 Ω
- maximum level: 1 V rms
- maximum current: 32 mA peak

Internal Speakers

The computer has two internal speakers. The computer turns off the sound signals to the internal speakers when an external device is connected to the sound output jack and during power cycling.

Communication Slot

Sound output signals are provided for the internal communications slot. The sound signals are at an audio level of 0.5V RMS.

Ethernet Port

Macintosh PowerBook G3 Series computers have a built-in Ethernet port. The Ethernet port provides a 10 Mbps Ethernet interface with a 10BaseT connection.

The Ethernet interface conforms to the ISO / IEC 8802-3 specification, where applicable.

Internal Modem

Some configurations of the Macintosh PowerBook G3 Series computers come with a modem card installed in the internal communication slot. The modem card has an RJ-45 connector that is accessible through an opening in the left side of the computer's case.

The modem card has the following features:

- K56flex technology
- modem bit rates up to 56 Kbps
- fax modem bit rates up to 14.4 Kbps

Facsimile applications must support Class 1 fax; a Class 1 fax application comes with the computer.

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

CHAPTER 4

Expansion Features

This chapter consists of three sections, each of which describes one of the expansion features of the Macintosh PowerBook G3 Series computers:

- “Expansion Bays”
- “RAM Expansion Slots”
- “CardBus Slot”

Expansion Bays

The expansion bays are openings on the right and left sides of the computer that accept expansion modules containing either power devices or storage devices. Either expansion bay can accommodate a battery, a floppy-disk drive, or some other 3.5-inch storage device.The expansion bay on the right side can also accommodate a 5.25-inch device such as a CD-ROM drive or a DVD-ROM drive.

The expansion bays are similar in that both have battery connectors and both support IDE devices such as a 3.5-inch floppy disk drive. In the 13.3- and 14.1-inch models, the expansion bay on the right side supports PCI-based devices as well as IDE devices, though not at the same time. Table 4-1 lists the types of devices supported by each expansion bay.

Table 4-1 Devices supported by the expansion bays

Left Expansion Bay	Right Expansion Bay
Battery	Battery
Floppy-disk drive	Floppy-disk drive
IDE drive up to 3.5 inches	IDE drive up to 5.25 inches
	PCI device up to 5.25 inches (only on 13.3- and 14.1-inch models)

Mechanical Design of Expansion Bay Modules

The primary dimensions of an expansion bay module for the Macintosh PowerBook G3 Series computers are:

Width: 106 mm; 128 mm extension in right bay only

Length: 140 mm

Thickness: 17 mm

Batteries may exceed the 17 mm thickness specification by as much as 3 mm, but only on the top and only away from the edges, which must not exceed 17 mm in thickness.

To accommodate 5.25-inch devices, a module with a 5.25-inch device can extend an additional 22 mm toward the back of the computer when the module is installed in the right expansion bay. Even with the 22 mm extension, the bottom of the module is still only 106 mm wide; the added width does not extend all the way to the bottom of the module. The extension forms a sort of shelf on one side of the module.

The right expansion bay has a hinged door that covers the extension part of the opening when a battery or other 3.5-inch device is installed.

Each expansion module has a notch on the side for the latching mechanism, which is on the front of the computer. Expansion modules that can be installed in either bay must have the notch on both sides. Modules that can only be installed in the right bay have the notch only on the side that faces the front of the computer when the module is installed.

To request manufacturing specifications for the expansion bay module, send email to powerbook_dev@apple.com.

Expansion Bay Connectors

Each expansion bay has two connectors: a five-contact connector for batteries and a 90-pin connector for data devices. This section describes only the 90-pin data connector.

The connector in the left expansion bay is mechanically the same as the one in the right expansion bay, but electrically it provides only IDE support and does not support the PCI bus.

Even though the connectors are the same as those in the expansion bay in the PowerBook 3400 computer, expansion modules for that computer will not work

in a Macintosh PowerBook G3 Series computer. The expansion-bay connector pins marked ADAPTER_PWR in the Macintosh PowerBook G3 Series computers are similar to the pins marked RAW_BAT on the PowerBook 3400 computer. Their function is the same: to accept power input from a power adapter.

The expansion bay connector is a 90-pin shielded connector with two rows of pins. The rows of pins are divided into two groups by a gap that occurs between pins 11 and 12 in one row and between pins 56 and 57 in the other row.

The connector used on the expansion modules is AMP part number 787481-1. For a specification sheet or information about obtaining this connector, contact AMP at

AMP, Inc.

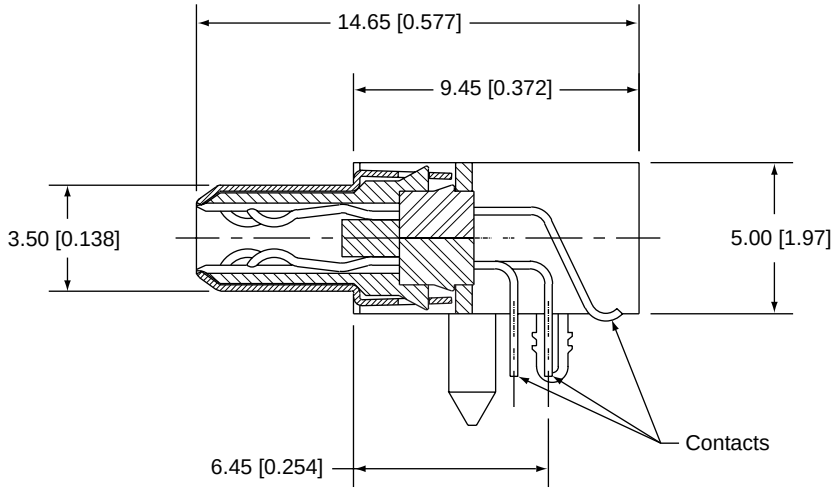
19200 Stevens Creek Blvd.

Cupertino, CA 95014-2578

408-725-4914

Figure 4-1 (page 61) shows a section through the expansion bay connector and gives its dimensions.

Figure 4-1 Section through expansion bay connector



Note: Dimensions are in millimeters [inches].

IMPORTANT

The expansion bay connectors are designed so that when a module is inserted into either expansion bay, the first connection is the ground by way of the connector shells, then the power pins make contact, and last of all the signal lines. ▲

Either expansion bay connector can be used for different kinds of devices. The values of the device ID signals DEV_ID(2–0) determine how the other signals are connected, as shown in Table 4-2 (page 62). A value of 0 corresponds to a device ID line connected to ground; a value of 1 corresponds to an open line.

IMPORTANT

An expansion bay module must never tie or pull up any device ID line to any power main.

Table 4-2 Device ID signals and types of devices

DEV_ID(2)	DEV_ID(1)	DEV_ID(0)	Type of device
0	0	0	MFM / GCR floppy disk, auto eject
0	0	1	Reserved
0	1	0	Reserved
0	1	1	ATA device; if the device supports DMA operation, DEV_ID(1) and DEV_ID(0) are connected together
1	0	0	Reserved
1	0	1	PCI device
1	1	0	Power input device
1	1	1	No device installed

ATA and Floppy Disk Signals on the Expansion Bay Connector

Table 4-3 shows the signal assignments on the left expansion bay connector and on the right expansion bay connector when it is used with an ATA device or a floppy disk drive. Signal names that begin with a slash (/) are active low.

Note
The table shows the signals in the same arrangement as the pins on the connector; that is, with pin 1 next to pin 46 and pin 45 next to pin 90. ◆

Table 4-3 ATA and floppy disk signals on the expansion bay connector

Pin	Direction	Signal name	Pin	Direction	Signal name
1	–	n.c.	46	–	n.c.
2	–	n.c.	47	–	n.c.
3		A3.3V	48	I	SND_IN_L
4	I	SND_IN_RET	49	I	SND_IN_R

continued

Table 4-3 ATA and floppy disk signals on the expansion bay connector (continued)

Pin	Direction	Signal name	Pin	Direction	Signal name
5	R	Reserved	50	R	Reserved
6	R	Reserved	51	R	ADAPTER_PWR
7		GND	52	R	ADAPTER_PWR
8	R	Reserved	53	–	n.c.
9	I	/DEV_IN	54	I/O	DEV_ID(0)
10	I/O	DEV_ID(1)	55	I/O	DEV_ID(2)
11		GND	56		Reserved
—	—	(Gap)	—	—	(Gap)
12		+5V	57	–	n.c.
13	O	/WRREQ	58		GND
14	O	PHASE(0)	59	O	PHASE(1)
15		+5V	60	O	PHASE(2)
16	O	PHASE(3)	61		LONG GND
17	O	WRDATA	62		+5V
18	I	RDDATA	63	O	/FL_ENABLE
19	O	HDSEL	64	O	/IDE_RST
20		GND	65	–	Reserved
21	–	Reserved	66	–	Reserved
22	–	Reserved	67		+5V
23	–	Reserved	68	–	Reserved
24	I	IOCHRDY	69	I/O	IDE_D(0)
25		GND	70	I/O	IDE_D(1)
26	I/O	IDE_D(2)	71	I/O	IDE_D(3)
27		+3V	72	I/O	IDE_D(4)

continued

Table 4-3 ATA and floppy disk signals on the expansion bay connector (continued)

Pin	Direction	Signal name	Pin	Direction	Signal name
28	I/O	IDE_D(5)	73	I/O	IDE_D(6)
29	I/O	IDE_D(7)	74		GND
30	I/O	IDE_D(8)	75	I/O	IDE_D(9)
31	I/O	IDE_D(10)	76	I/O	IDE_D(11)
32		+3V	77	I/O	IDE_D(12)
33	I/O	IDE_D(13)	78	I/O	IDE_D(14)
34	I/O	IDE_D(15)	79		GND
35	O	/DIOR	80	O	/DIOW
36	O	/CS3FX	81	O	/CS1FX
37		+3V	82	O	IDE_ADDR(0)
38	O	IDE_ADDR(1)	83	O	IDE_ADDR(2)
39	O	/DMACK	84		GND
40	I	DMARQ	85	I	IDE_INTRQ
41		Reserved	86		Reserved
42		+3V	87		Reserved
43		Reserved	88		Reserved
44		Reserved	89		GND
45		ADAPTER_PWR	90		ADAPTER_PWR

ATA and Floppy Disk Signal Definitions

The signals on the expansion bay connector are of three types: expansion bay audio and control signals, floppy disk signals, and ATA signals. The next three tables describe the three types of signals: Table 4-4 (page 65) describes the audio and control signals, Table 4-5 (page 65) describes the floppy disk signals, and Table 4-6 (page 66) describes the ATA signals.

Table 4-4 Audio and control signals on the expansion bay connector

Signal name	Signal description
DEV_ID(0–2)	These three signal lines identify the type of expansion bay device. Table 4-2 (page 62) shows the identification codes for different devices.
/DEV_IN	This signal should be low whenever a device is installed in the expansion bay; it is used by the Heathrow IC to determine when a device has been inserted or removed. The expansion bay module should connect this pin to ground.
/IDE_RST /BUF_PCI_RST	Reset signals.

Table 4-5 Floppy disk signals on the expansion bay connector

Signal name	Signal description
FD_RD	Read data from the floppy disk drive.
/FL_ENABLE	Floppy disk drive enable.
PHASE(0–3)	Phase(0–2) are state-control lines to the drive; Phase(3) is the strobe signal for writing to the drive's control registers.
WRDATA	Write data to the floppy disk drive.
/WRREQ	Write data request signal.

Table 4-6 ATA signals on the expansion bay connector

Signal name	Signal description
/CS1FX	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.
/CS3FX	Register select signal. It is asserted low to select the additional control and status registers on the IDE drive.
/DIOR	I/O data read strobe.
/DIOW	I/O data write strobe.
DMARQ	DMA request signal.
DMACK	DMA acknowledge signal.
IDE_ADDR(0–2)	IDE device address; used by the computer to select one of the registers in the drive. For more information, see the descriptions of the /CS1FX and /CS3FX signals.
IDE_D(0–15)	IDE data bus, buffered from IOD(16–31) of the controller IC. IDE_D(0–15) are used to transfer 16-bit data to and from the drive buffer. IDE_D(0–7) are used to transfer data to and from the drive's internal registers, with IDE_D(8-15) driven high when writing.
IOCHRDY	I/O channel ready; when driven low by the IDE drive, signals the CPU to insert wait states into the I/O read or write cycles.
IDE_INTRQ	IDE interrupt request. This active high signal is used to inform the computer that a data transfer is requested or that a command has terminated.
/MB_IDE_RST	Hardware reset to the IDE drive.

Note

Signal names that begin with a slash (/) are active low. ◆

Unused IDE Signals on the Expansion Bay Connector

Several signals defined in the standard interface for the IDE drive are not used by the expansion bay. Those signals are listed in Table 4-7 along with any action required for the device to operate in the expansion bay.

Table 4-7 Unused IDE signals on the expansion bay connector

Signal name	Comment
CSEL	This signal must be tied to ground to configure the device as the master in the default mode.
IOCS16	No action required.
PDIAG	No action required; the device is never operated in master-slave mode.
DAS	No action required.

Power on the Expansion Bay Connector

Table 4-8 describes the power lines on the expansion bay connector. The MB_+5V and MB_+3V lines are controlled by the /MB_PWR signal from the Heathrow IC.

Table 4-8 Power lines on the expansion bay connector

Signal name	Signal description
GND	Ground.
MB_+5V	5 V power; maximum total current is 1.0 A.
MB_+3V	3 V power; maximum total current is 1.5 A.
ADAPTER_PWR	Power input from a power adapter.

IMPORTANT

The maximum combined total power available from the MB_+5V and MB_+3V lines is 5 W. ▲

PCI Signals on the Right Expansion Bay Connector

Table 4-9 (page 68) shows the signal assignments on the right expansion bay connector when it is used with a PCI device. Signal names that begin with a slash (/) are active low.

Note
The table shows the signals in the same arrangement as the pins on the connector; that is, with pin 1 next to pin 46 and pin 45 next to pin 90. ◆

Table 4-9 PCI signals on the expansion bay connector

Pin	Direction	Signal name	Pin	Direction	Signal name
1		n.c.	46		n.c.
2		n.c.	47		n.c.
3		A3.3V	48	I	SND_IN_L
4	I	SND_IN_RET	49	I	SND_IN_R
5	R	Reserved	50	R	Reserved
6	R	Reserved	51	O	ADAPTER_PWR
7		GND	52	O	ADAPTER_PWR
8	O	MB_PCI_IDSEL	53		n.c.
9	I	/DEV_IN	54	I/O	DEV_ID(0)
10	I/O	DEV_ID(1)	55	I/O	DEV_ID(2)
11		GND	56	O	PCI_CLK
—	—	(Gap)	—	—	(Gap)
12		+5V	57		n.c.
13	I	/INTA	58		GND
14	I/O	/C/BE(0)	59	I/O	/C/BE(1)
15		+5V	60	I/O	/C/BE(2)

continued

Table 4-9 PCI signals on the expansion bay connector (continued)

Pin	Direction	Signal name	Pin	Direction	Signal name
16	I/O	/C/BE(3)	61		GND
17	I	/REQ	62		+5V
18	O	/GNT	63	I/O	/PERR
19	I/O	PAR	64	O	/BUF_PCI_RST
20		GND	65	I/O	/IRDY
21	I/O	/TRDY	66	I/O	/FRAME
22	I/O	/SERR	67		+5V
23	I/O	/DEVSEL	68	I/O	/LOCK
24	I/O	/STOP	69	I/O	AD(0)
25		GND	70	I/O	AD(1)
26	I/O	AD(2)	71	I/O	AD(3)
27		+3V	72	I/O	AD(4)
28	I/O	AD(5)	73	I/O	AD(6)
29	I/O	AD(7)	74		GND
30	I/O	AD(8)	75	I/O	AD(9)
31	I/O	AD(10)	76	I/O	AD(11)
32		+3V	77	I/O	AD(12)
33	I/O	AD(13)	78	I/O	AD(14)
34	I/O	AD(15)	79		GND
35	I/O	AD(16)	80	I/O	AD(17)
36	I/O	AD(18)	81	I/O	AD(19)
37		+3V	82	I/O	AD(20)
38	I/O	AD(21)	83	I/O	AD(22)
39	I/O	AD(23)	84		GND

continued

Table 4-9 PCI signals on the expansion bay connector (continued)

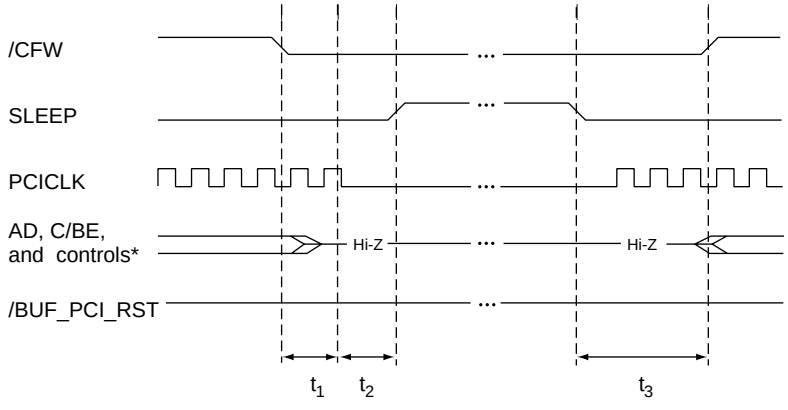
Pin	Direction	Signal name	Pin	Direction	Signal name
40	I/O	AD(24)	85	I/O	AD(25)
41	I/O	AD(26)	86	I/O	AD(27)
42		+3V	87	I/O	AD(28)
43	I/O	AD(29)	88	I/O	AD(30)
44	I/O	AD(31)	89		GND
45		ADAPTER_PWR	90		ADAPTER_PWR

PCI Control Signals in Sleep Mode

The following PCI control signals are disconnected from the expansion bay during sleep: /DEVSEL, /FRAME, /GRANT, /INT, /IRDY, /LOCK, /PERR, /REQ, /SERR, /STOP, and /TRDY. PCI devices on a module in the expansion bay should have these signals pulled up through 100 KΩ resistors to the PCI device Vcc.

Figure 4-2 (page 71) shows the timing of the control signals on the expansion bay connector as the computer goes into and emerges from sleep mode.

Figure 4-2 Timing of expansion bay control signals for sleep mode



t_1 = 16 ms min. /CFW to clocks stopped

t_2 = 16 ms min. Clocks stopped to system sleep

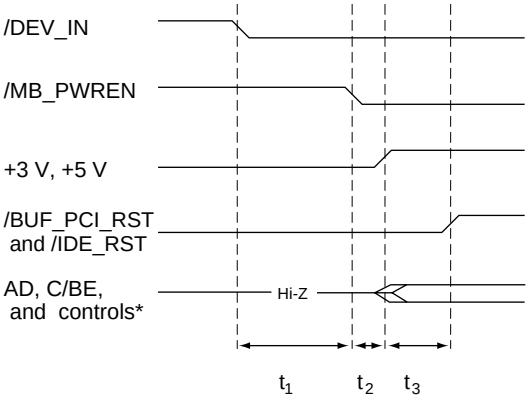
t_3 = 50 ms min. Clocks started to clock valid

*/DEVSEL, /FRAME, /GRANT, /INT, /IRDY, /LOCK, /PERR, /REQ, /SERR, /STOP, and /TRDY

PCI Signals During Power On and Off

Figure 4-3 (page 72) shows the timing of the control signals on the expansion module during the power-on sequence. Figure 4-4 (page 72) shows the timing of the control signals on the expansion module during the power-off sequence.

Figure 4-3 Timing of the expansion bay control signals during power on



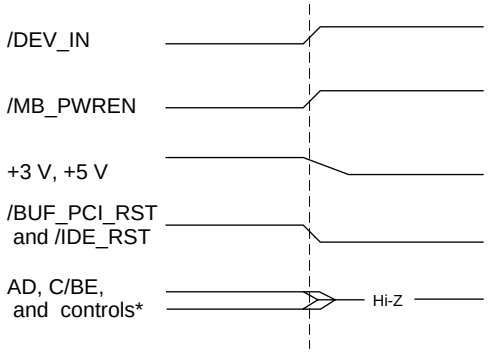
t_1 = 250 ms min.

t_2 = 5 ms min.

t_3 = 10 ms min.

*/DEVSEL, /FRAME, /GRANT, /INT, /IRDY, /LOCK, /PERR, /REQ, /SERR, /STOP, and /TRDY

Figure 4-4 Timing of the expansion bay control signals during power off



*/DEVSEL, /FRAME, /GRANT, /INT, /IRDY, /LOCK, /PERR, /REQ, /SERR, /STOP, and /TRDY

Power Sequences

Here are the sequences of events on the power supply and PCI control signals when the operating mode of the computer changes. Knowledge of these sequences will help developers design devices that operate properly when the computer switches from one power mode to another.

Power Sequence From Off to On

Here is the sequence of states and events when the computer switches from off to on:

1. The computer is in the power-off mode.
2. The PMU detects power on.
3. The main power supplies (+5V, +3.3V, and +2.6V) switch on.
4. The clocks begin operating.
5. The /CFW signal changes to high (inactive).
6. The /RESET signal changes to high (inactive).
7. The processor starts executing the ROM code.
8. If a module is installed in the expansion bay, power to the expansion bay switches on and the port is opened.
9. The computer loads and launches the operating system from the available mass storage device.
10. The computer is in the on (normal operating) mode.

Power Sequence From On to Sleep

Here is the sequence of states and events when the computer switches from on to sleep:

1. The computer is in the on (normal operating) mode.
2. The SLEEP mode is initiated by the user or by some predetermined condition.
3. The processor stops running.
4. The /CFW signal changes to low (active).
5. There is a time delay of 16 ms.

6. The clocks stop operating.
7. The SLEEP signal switches to high (active), which switches off the power to unused circuitry.
8. If a PCI device is installed in the expansion bay, power to the expansion bay remains on.
9. If the expansion bay does not have a PCI device installed in it, power to the expansion bay switches off and the port is closed.
10. The computer is in sleep mode.

Power Sequence From Sleep to On

Here is the sequence of states and events when the computer switches from sleep to on:

1. The computer is in sleep mode.
2. The PMU detects keyboard activity or the power-on switch.
3. The SLEEP signal changes to low (inactive).
4. The clocks begin operating.
5. The /CFW signal changes to high (inactive).
6. An interrupt is sent to the main processor.
7. The processor starts executing code.
8. If power to the expansion bay was off and an expansion bay module is still present, expansion bay power switches to on and the port is opened.
9. The display buffer is reloaded.
10. The computer is in the on (normal operating) mode.

Power Sequence From On to Off

Here is the sequence of states and events when the computer switches from on to off:

1. The computer is in the on (normal operating) mode.
2. The computer detects the shutdown signal.
3. The processor stops running.

4. The /CFW signal changes to low (active).
5. There is a time delay of 16 ms.
6. The system /RESET signal is asserted on the CPU and PCI busses.
7. The clocks stop operating.
8. The main power supplies (+5V, +3.3V, and +2.6V) switch off.
9. The computer is in the power-off mode.

User Installation of an Expansion Bay Module

The user can insert a module into the expansion bay while the computer is operating. This section describes the sequence of control events in the computer and gives guidelines for designing an expansion bay module so that such insertion does not cause damage to the module or the computer.

IMPORTANT

This section does not apply to expansion bay modules that use PCI devices. ▲

IMPORTANT

The user must not remove a module from the expansion bay while the computer is communicating with the module or, for a module with a disk drives, while the disk is spinning. ▲

Sequence of Control Signals

Specific signals to the Heathrow IC allow the computer to detect the insertion of a module into the expansion bay and take appropriate action. For example, when module with an ATA device is inserted, the computer performs the following sequence of events:

1. When a module is inserted, the /DEV_IN signal goes low, causing the Heathrow IC to generate an interrupt.
2. System software responds to the interrupt, determines the type of module inserted, and sets the /MB_PWR_EN signal low, which turns on the power to the expansion bay; see Figure 4-3 (page 72).

3. System software internally notifies the appropriate driver of the presence of a newly inserted module.

Essentially the reverse sequence occurs when a module is removed from the expansion bay:

1. When the module is removed, the /DEV_IN signal goes high causing the Heathrow IC to generate an interrupt.
2. System software responds to the interrupt and notifies the appropriate driver that the module has been removed.

Guidelines for Developers

Each expansion bay module must be designed to prevent damage to itself and to the computer when the user inserts or removes an expansion bay module with the computer running.

The expansion bay connector is designed so that when the module is inserted the ground and power pins make contact before the signal lines.

Even though you can design an expansion bay module that minimizes the possibility of damage when it is inserted hot—that is, while the computer is running—your instructions to the user should include warnings about the possibility of data corruption.

RAM Expansion Slots

The Macintosh PowerBook G3 Series computers have two RAM expansion slots that accommodate standard SO (small outline) DIMMs using SDRAM devices. One slot is on the bottom of the system module and is normally occupied by the factory-installed SO-DIMM. The other slot is on the top of the system module and is available for a user-installed SO-DIMM.

RAM expansion SO-DIMMs for the Macintosh PowerBook G3 Series computers must use SDRAM devices. If the user installs an SO-DIMM that uses EDO devices, the death chimes will sound when the user attempts to restart the computer.

An SO-DIMM for the Macintosh PowerBook G3 Series computers can contain either 16, 32, 64, or 128 MB of memory. Because of space limitations, a 128 MB SO-DIMM will fit only in the top slot.

Total RAM capacity using the highest-density devices available is 192 MB and is limited by the space available for the SO-DIMMs. The bottom slot can accommodate a 1.5-inch SO-DIMM with up to 64 MB of SDRAM. The top slot can accommodate a 2.0-inch SO-DIMM with up to 128 MB of SDRAM.

Note
Future devices with higher density may allow expansion beyond the current 192-MB limit.

Mechanical Design of RAM SO-DIMMs

The RAM expansion modules used in the Macintosh PowerBook G3 Series computers are standard 144-pin 8-byte DRAM SO-DIMMs, as defined in the JEDEC specifications.

The mechanical characteristics of the RAM expansion SO-DIMM are given in the JEDEC specification for the 144-pin 8-byte DRAM SO-DIMM. The specification number is JEDEC MO-190; it is available from the Electronics Industry Association's web site, at

http://www.eia.org/jedec/download/freestd/pub95/#MO

The specification defines SO-DIMMs with nominal heights of 1.0, 1.25, 1.5, or 2.0 inches. Macintosh PowerBook G3 Series computers can accommodate two SO-DIMMS, one with a height up to 1.5 inches and the other with a height up to 2.0 inches.

IMPORTANT
The JEDEC specifications for the heights of the SO-DIMMs gives a plus-or-minus 0.15 mm tolerance. In the Macintosh PowerBook G3 Series computers, the specified heights for the SO-DIMMs are maximum heights.

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 RAM SO-DIMMs

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

http://www.eia.org/jedec/download/freestd/pub21/

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 Macintosh PowerBook G3 Series computers are required to have the SPD feature. Information about the required values to be stored in the presence detect EEPROM is in section 4.1.2.5 and Figure 4.5.6–C (144 Pin SDRAM SO–DIMM, PD INFORMATION) of the JEDEC standard 21-C specification, release 7.

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 100 MHz or greater.

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

When the computer is in sleep mode, the maximum power-supply current available for each bank of SDRAM is 6 mA (see the section “RAM SO-DIMM Electrical Limits”). Developers should specify SDRAM devices with low power specifications so as to stay within that limit.

Configuration of RAM SO-DIMMs

Table 4-10 (page 79) shows the sizes of the RAM expansion modules that can be used in the Macintosh PowerBook G3 Series computers and the different sizes of SDRAM devices that make up those modules.

Table 4-10 Sizes of RAM expansion modules and devices

Device size	Device configuration	Number of devices per bank	Size of each bank
16 Mbits	2M x 4 x 2	16	32 MB
16 Mbits	1M x 8 x 2	8	16 MB
16 Mbits	512K x 16 x 2	4	8 MB
64 Mbits	8M x 4 x 2	16	128 MB
64 Mbits	4M x 4 x 4	16	128 MB
64 Mbits	4M x 8 x 2	8	64 MB
64 Mbits	2M x 8 x 4	8	64 MB
64 Mbits	2M x 16 x 2	4	32 MB
64 Mbits	1M x 16 x 4	4	32 MB
64 Mbits	1M x 32 x 2	2	16 MB
64 Mbits	512K x 32 x 4	2	16 MB

Macintosh PowerBook G3 Series computers accept either one or two SO-DIMMs. Any of the supported SO-DIMM sizes may be installed in either slot. The memory controller configures the combined memory of the SO-DIMMs into a contiguous array of memory addresses.

Note
The Macintosh PowerBook G3 Series computers do not support memory interleaving, so installing two SO-DIMMs of the same size does not result in any performance gain.

Address Multiplexing

Signals A[0] – A[13] on each RAM SO-DIMM make up a 14-bit multiplexed address bus that can support several different types of SDRAM devices. Table 4-11 (page 80) lists the types of devices that can be used in the Macintosh PowerBook G3 Series computers by size, configuration, and sizes of row and column addresses.

IMPORTANT

The Macintosh PowerBook G3 Series computers support only the types of SDRAM devices specified in Table 4-11. Other types of DRAM devices should not be used with these computers. ▲

Table 4-11 Types of DRAM devices

Device size	Device configuration	Size of row address	Size of column address
16 Mbits	2M x 4 x 2	11	10
16 Mbits	1M x 8 x 2	11	9
16 Mbits	512K x 16 x 2	11	8
64 Mbits	8M x 4 x 2	13	10
64 Mbits	4M x 4 x 4	12	10
64 Mbits	4M x 8 x 2	13	9
64 Mbits	2M x 8 x 4	12	9
64 Mbits	2M x 16 x 2	13	8
64 Mbits	1M x 16 x 4	12	8
64 Mbits	1M x 32 x 2	13	7
64 Mbits	512K x 32 x 4	12	7

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 card. Such a card 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 cards should use only 8-bit or 16-bit SDRAM devices.

The restriction on sleep current is required not only to maximize the battery life but to meet the limitations of the backup battery during hot swapping of the main battery.

CardBus Slot

The CardBus slot accepts either one Type III card or two Type II cards. The slot supports both 16-bit PC Cards and 32-bit CardBus Cards. The cards can be removed and replaced while the computer is operating. The slot supports Zoomed Video on the lower card connector.

For information about the latest version of the PC Card Manager, developers should refer to the PC Card Manager v3.0 SDK. The SDK is available on the March 1997 Reference Library edition of the Developer CD and on the Apple Developer World web page at:

ftp://ftp.apple.com/devworld/Development_Kits/PC_Card_Manager/

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