Power Mac G5

The 64-bit professional dream machine.

Professionals need superior tools to produce designs, music, high-definition video or the next scientific breakthrough. The new Power Mac G5 line extends as far as you require. Two 64-bit G5 processors reaching top speeds of 2.7GHz, room for up to 8GB of main memory, pro performance graphics cards and ultrahigh-bandwidth system architecture will give you more results than systems costing twice as much. Dual processing starts at $1999.

Supersonic Speed

The Power Mac G5 offers 2.0GHz, 2.3GHz and 2.7GHz dual-processor models with a speed boost at the top of the line. The dual 2.7GHz system packs so much power into tight quarters that Apple designed a liquid cooling system for it, resulting in a cool tower that runs Photoshop nearly two times faster than a Pentium 4-based system. In fact, for most creative endeavors, the Power Mac G5 simply has no competition in its class.

A 64-bit OS for Your 64-Bit Machine

Every Power Mac G5 comes with Tiger, the latest release of Mac OS X. Search your entire Power Mac in a single click with Spotlight, access up-to-the-second information with Dashboard and run all of your software faster. With its 64-bit features, Tiger also provides access to as much physical memory as you can install in your Power Mac G5. And because the system can manipulate data in multiple applications entirely in RAM, even 32-bit applications benefit from these high-performance features.

DVD+R DL (Double-Layer) vs. DVD-R (Single Layer)(1)

Total Capacity	8.5GB	4.7GB
Songs (AAC)	2100	1200

Double Layer

Buy Now

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Test drive the Power Mac G5, attend free workshops and meet Mac specialists who can answer your questions.

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Does It Faster

The PowerPC G5 processor dramatically accelerates performance in real world applications. When compared head-to-head against PCs in a series of Photoshop tests, the dual 2.7GHz, 2.3GHz and 2.0GHz Power Mac G5 systems ran the 45 filters 98%, 78% and 59% faster, respectively, than the

	Photos (JPEG)	7000	3900
RAW	**Photos (RAW)**	650	350
	MPEG-2 Video	4 hours	2 hours

Double-Layer Drive
The 16x SuperDrive built into every dual-processor Power Mac G5 now supports double-layer (DVD+R DL) discs. While single-layer DVD discs hold up to 4.7GB of data, double-layer discs have two layers, allowing the SuperDrive laser to read from and write to both layers, almost doubling the storage capacity to 8.5GB. Use iDVD — included on every Power Mac G5 — to author discs with up to four hours of video content. Or use DVD Studio Pro 4, Apple's professional DVD authoring application, for your commercial-grade titles and high-definition DVD projects.

High-Performance Graphics
The Power Mac G5 comes with a graphics card installed in an AGP 8X Pro slot for a maximum bandwidth of 2.1GB per second. That's a good thing, because the Power Mac G5 uses its graphics card to accelerate the entire system. Powerful graphics give Quartz Extreme the power to display Mac OS X features — such as drop shadows and ripple effects — seamlessly. Your graphics card does the heavy lifting so the G5 processor can crunch numbers at the same time.

Standard dual-processor Power Mac configurations feature the ATI Radeon 9600 or the ATI Radeon 9650 graphics card for excellent all-around performance. The Radeon 9600 can handle up to two 23-inch Apple Cinema HD Displays, while the 9650 supports a 30-inch Apple Cinema HD Display right out of the box. For true over-the-top performance, configure your system with one of the fastest graphics cards available: the ATI Radeon X850 XT or the NVIDIA GeForce 6800 GT DDL. In fact, the NVIDIA GeForce 6800 GT even allows you to connect two 30-inch Apple Cinema HD Displays for a staggering 8 million pixels of screen real estate.

Exquisitely Advanced Technology
With 64-bit power and high-bandwidth architecture, the Power Mac G5 alleviates the limitations and bottlenecks of the traditional PC — opening up a wealth of possibilities for 2D and 3D designers, video and audio producers, scientists, researchers and game developers and players. A dual-independent frontside bus architecture, an advanced system controller and high-speed, high-capacity memory combine to make the Power Mac G5 one of the fastest PCs ever built.

Choose Wisely
The Power Mac G5 product line comes in dual 2.0GHz, dual 2.3GHz and dual 2.7GHz configurations to support your creative endeavors. They all feature a 16x SuperDrive (DVD +R DL/DVD±RW/CD-RW) as standard equipment across the line. And of course they come with one FireWire 800 port, two FireWire 400 ports, three PCI-X or PCI expansion slots, three USB 2.0 ports, analog audio in, analog audio out, optical S/PDIF in, optical S/PDIF out, front headphone and speaker jack and built-in Gigabit Ethernet — all as standard equipment. All models are AirPort Extreme-ready and feature an optional internal Bluetooth module.

1. 1GB = 1 billion bytes, actual formatted capacity less; song capacity is based on 4 minutes per song and 128-Kbps AAC encoding; JPEG photo capacity is based on 1.2MB

3.6GHz Pentium 4-based system, and 72%, 56% and 38% faster than the dual 3.6GHz Xeon-based system.(2)

Take the Power Mac G5 for a spin: See a QuickTime VR

Quiet Operation
The Power Mac G5's enclosure houses four discrete thermal zones to compartmentalize the primary heat-producing components. Fans in the zones spin at very low speeds, resulting in a system two times quieter than the Power Mac G4.

Bandwidth to Burn
The ultrahigh-bandwidth system architecture of the Power Mac G5 features dual-independent frontside busses running at up to 1.35GHz — one on each processor — for maximum throughput from the system to the G5 processors. And a point-to-point system controller lets data move directly between subsystems, without affecting processor function.

PCI-X Expansion
The dual 2.3GHz and dual 2.7GHZ Power Mac G5 models come with three PCI-X slots, giving you the benefit of fast PCI technology. The PCI-X protocol supports high-performance PCI devices, increasing speeds from 33MHz to 133MHz and throughput from 266 Mbps to 2 GBps. So you can customize your Power Mac G5 to your creative use, with video capture cards, pro audio tools, fibre channel networking and high-speed disk drives.

Plugged In
It's easy to plug printers, scanners and other devices into the Power Mac G5. In addition to sporting a full complement of ports on the back, the front panel of the Power Mac G5 offers FireWire 400 and USB 2.0 ports, as well as a headphone jack. Gigabit Ethernet, FireWire, USB 2.0 and optical digital and analog audio are integrated through an 800MHz bi-

(approx. 3 megapixels) per image; RAW photo capacity is based on 13MB per image; video capacity based on standard MPEG-2 format.

2. Testing conducted by Apple in April 2005 using preproduction dual 2.0GHz, 2.3GHz and 2.7GHz Power Mac G5 units; all other systems were shipping units. File size = 600MB. For PC systems, cache sizes were: Dell Dimension XPS Gen4 = 2048K L2; Dell Precision 670 = 2048K L2; Alienware Aurora 5500 = 1024K L2; Box Tech Series 7300 = 1024 L2.

directional HyperTransport bus.

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Power Mac G5

Supporting Every Grand Venture is a Solid Foundation
Start your next project on the ultimate creative platform. Each of the dual-processor Power Mac G5 models offers lightning-fast performance, built on G5 processors running at up to 2.7GHz. A 64-bit processor with two double-precision floating-point units, two integer units and support for symmetric multiprocessing, the G5 combines an optimized Velocity Engine with a superscalar, super-pipelined execution core that can execute more than 200 simultaneous in-flight instructions. This high-bandwidth core has over 12 discrete functional units that process massive amounts of instructions in parallel.

Power Mac G5 Info

Tech Papers
- Power Mac G5 Technology & Performance Overview
- PowerPC G5 White Paper

More Information
- Design for the Environment

Designed for Future Thought
The PowerPC G5 with Mac OS X Tiger offers a seamless transition to 64-bit performance: Current 32-bit code — such the Mac OS 9 Classic environment and existing applications — runs natively at processor speed. With no interruptions to your workflow. And no additional investment in software required to take advantage of 64-bit power, period. The PowerPC architecture was designed from the beginning to run both 32-bit and 64-bit application code. This enables the PowerPC G5 processor to run applications natively for an immediate performance boost.

Configurations	Single 1.8GHz	Dual 2.0GHz	Dual 2.3GHz	Dual 2.7GHz
Model	M9555LL/A	M9747LL/A	M9748LL/A	M9749LL/A
G5 Processor	Single 1.8GHz PowerPC G5	Dual 2.0GHz PowerPC G5	Dual 2.3GHz PowerPC G5	Dual 2.7GHz PowerPC G5
L2 Cache	512K per processor			
Frontside bus	600MHz	1GHz per processor	1.15GHz per processor	1.35GHz per processor
DDR SDRAM memory	256MB PC3200 (400MHz) Supports up to 4GB	512MB PC3200 (400MHz) Supports up to 4GB	512MB PC3200 (400MHz) Supports up to 8GB	
8X AGP Pro graphics	NVIDIA GeForce FX 5200 Ultra with 64MB DDR SDRAM, single-link DVI port and ADC port	ATI Radeon 9600 with 128MB DDR SDRAM, two single-link DVI ports		ATI Radeon 9650 with 256MB DDR SDRAM, one single-link and one dual-link DVI port
Hard drive(1)	80GB Serial ATA; 7200 rpm	160GB Serial ATA; 7200 rpm	250GB Serial ATA; 7200 rpm	

Optical drive	8x SuperDrive (DVD-R/CD-RW)	16x SuperDrive (DVD+R DL/DVD±RW/CD-RW)
PCI slots	Three open full-length 33MHz, 64-bit PCI slots	Three open full-length PCI-X slots: one 133MHz, 64-bit slot and two 100MHz, 64-bit slots
Expansion	One FireWire 800 port, two FireWire 400 ports (one on front); three USB 2.0 ports (one on front), two USB 1.1 ports (on keyboard); AGP 8X Pro slot with graphics card installed	
Bays	Two internal hard drive bays (1 occupied); one optical drive bay (occupied)	
Networking	10/100/1000BASE-T Ethernet and 56K V.92 modem (standard on single 1.8GHz system, available as a build-to-order option or Apple Authorized Service Provider upgrade kit on dual-processor systems)(3)	
Wireless	AirPort Extreme ready (based on 802.11g specification; IEEE 802.11b Wi-Fi certified) (2); Bluetooth option (build-to-order option; also available as an Apple Authorized Service Provider upgrade kit on dual-processor systems)	
Audio	Optical digital audio input, optical digital audio output, analog audio input, analog audio output, front headphone minijack and speaker	
System software	Mac OS X version 10.4 Tiger	
Software	Mac OS X, Dashboard, Mail, Safari, iChat AV, Address Book, QuickTime, iLife (includes iTunes, iPhoto, iMovie HD, iDVD and GarageBand), iCal, DVD Player, Classic environment, Art Directors Toolkit X, GraphicConverter, Microsoft Office 2004 for Mac Test Drive, OmniGraffle, OmniOutliner, QuickBooks New User Edition, Zinio Reader, Xcode Developer Tools	
Hardware accessories	Apple Keyboard, Apple Mouse, USB keyboard extension cable, DVI to VGA adapter, AirPort antenna, modem cable (single 1.8GHz system only)	
Limited warranty and service	Your Power Mac G5 comes with 90 days of free telephone support and a one-year limited warranty. Purchase the AppleCare Protection Plan to extend your service and support to three full years. Only the AppleCare Protection Plan provides you with direct telephone support from Apple technical experts and the assurance that repairs will be handled by Apple-certified technicians using genuine Apple parts. For more information, visit Apple support or call 800-823-2775.	

Build-to-Order Options	Order a custom-configured computer from the online Apple Store or an authorized Apple reseller.
Memory	(PC3200 DDR SDRAM; installed in pairs): 256MB (single 1.8GHz system only), 512MB, 1GB, 2GB, 4GB, 8GB (dual-processor 2.3GHz and 2.7GHz systems only)
Hard drives(1)	• 80GB Serial ATA (single 1.8GHz system only) • 160GB Serial ATA • 250GB Serial ATA • 2x 250GB Serial ATA (single 1.8GHz system only) • 1x or 2x 400GB Serial ATA (dual-processor systems only)
Optical drives	• Single 1.8GHz system: 8x SuperDrive (DVD-R/CD-RW), Combo drive (DVD-ROM/CD-RW) • Dual 2.0, dual 2.3 and dual 2.7GHz systems: 16x SuperDrive (DVD+R DL/DVD±RW/CD-RW)
Graphics	• ATI Radeon 9600 XT with 128MB of DDR SDRAM, ADC and DVI ports (single 1.8GHz system only) • ATI Radeon 9600 with 128MB of DDR SDRAM, two single-link DVI ports (dual-processor systems only) • ATI Radeon 9650 with 256MB of DDR SDRAM, one single-link DVI port and one dual-link DVI port (dual-processor systems only) • ATI Radeon X850 XT with 256MB of GDDR3 SDRAM, one dual-link DVI port and one ADC port (dual-processor systems only) • NVIDIA GeForce 6800 GT DDL with 256MB GDDR3 SDRAM, two dual-link DVI ports (occupies AGP slot and adjacent PCI slot)
Audio	• Apple iPod • Logitech Z-5500 5.1 Speakers T7156LL/A • Monster 1m Toslink Digital Fiber Optic Cable T7153LL/A • Monster 2m Toslink Digital Fiber Optic Cable T7154LL/A
External storage	• Xserve RAID with Apple Fibre Channel PCI-X Card

Wireless	• AirPort Extreme Card M8881LL/A • AirPort Extreme Base Station M8930LL/A • AirPort Express Featuring AirTunes M9470LL/A • AirPort Extreme Base Station (with modem and antenna port) M8799LL/A • Internal Bluetooth module with antenna • Apple Wireless Keyboard M9270LL/A • Apple Wireless Mouse M9269Z/A
Services	• AppleCare Protection Plan M8850LL/A • .Mac Subscription M8778LL/A

Technical Specifications

Processing

- Single 1.8GHz, dual 2.0GHz, dual 2.3GHz or dual 2.7GHz 64-bit PowerPC G5 microprocessors
- PowerPC processor architecture with 64-bit data paths and registers
- Native support for 32-bit application code
- 512K on-chip L2 cache running at processor speed
- Parallel data structure supporting up to 215 simultaneous in-flight instructions
- Simultaneous issue of up to 10 out-of-order operations
- Dual-pipeline Velocity Engine for 128-bit single-instruction, multiple-data (SIMD) processing
- Two independent double-precision floating-point units
- Advanced three-stage branch-prediction logic
- One 600MHz or two 1GHz, 1.15GHz or 1.35GHz 64-bit DDR frontside busses supporting up to 21.6 GBps data throughput
- Point-to-point system controller

Memory

- 128-bit data paths for up to 6.4-GBps memory throughput
- Single 1.8GHz system:
  - 256MB of PC3200 (400MHz) DDR SDRAM
  - Four DIMM slots supporting up to 4GB of main memory
- Dual 2.0GHz system:
  - 512MB of PC3200 (400MHz) DDR SDRAM
  - Four DIMM slots supporting up to 4GB of main memory
- Dual 2.3GHz and dual 2.7GHz systems:
  - 512MB of PC3200 (400MHz) DDR SDRAM
  - Eight DIMM slots supporting up to 8GB of main memory
- Support for the following DIMMs (in pairs):
  - 128MB DIMMs (64-bit-wide, 128- or 256-Mbit)

Graphics and displays

- AGP 8X Pro graphics slot supporting up to 2-GBps data throughput, with one of the following graphics cards installed:
  - NVIDIA GeForce FX 5200 Ultra with 64MB DDR SDRAM, one single-link DVI port and ADC port (single 1.8GHz system only)
  - ATI Radeon 9600 XT with 128MB of DDR SDRAM, two single-link DVI ports and ADC port (single 1.8GHz system only)
  - ATI Radeon 9600 with 128MB of DDR SDRAM, two single-link DVI ports (dual-processor systems only)
  - ATI Radeon 9650 with 256MB of DDR SDRAM, one DVI port and one dual-link DVI port (dual-processor systems only)
  - ATI Radeon X850 XT with 256MB of GDDR3 SDRAM, one dual-link DVI port and one ADC port (build-to-order option, dual-processor systems only)
  - NVIDIA GeForce 6800 GT DDL with 256MB GDDR3 SDRAM, two dual-link DVI ports (build-to-order option; occupies AGP slot and adjacent PCI slot)
- Built-in support for digital resolutions up to 1920 x 1200 pixels. An ATI Radeon 9650, ATI Radeon X850 XT, or NVIDIA GeForce 6800 GT DDL graphics card is required to power the 2560 x 1600-pixel resolution of the 30-inch Apple Cinema HD Display. An NVIDIA GeForce 6800 GT (or Ultra) DDL graphics card is required to power two 30-inch Apple Cinema HD Displays.
- Support for analog resolutions up to 1600 x 1200 pixels
- Dual display support for extended desktop and video mirroring modes
- Support for up to two Apple Cinema Displays(2)

Storage

- Two 3.5-inch hard drive bays, each with a 150MBps Serial ATA controller; with the following hard drive options:
  - 1 80GB 7200-rpm Serial ATA; 8MB memory buffer (1) (single 1.8GHz system only)
  - 1 160GB 7200-rpm Serial ATA; 8MB

PCI expansion

- Single 1.8GHz and dual 2.0GHz systems:
  - Three open full-length 33MHz, 64-bit PCI slots
- Dual 2.3GHz and dual 2.7GHz systems:
  - One open full-length 133MHz, 64-bit PCI-X slot and two open full-length 100MHz, 64-bit PCI-X slots

Communications

- 10/100/1000BASE-T Ethernet (RJ-45)
- Optional 56K V.92 modem (RJ-11) (3)
- Expansion slot for optional 54 Mbps AirPort Extreme Card (based on IEEE 802.11g specification; 802.11b Wi-Fi certified) (4)
- External AirPort Extreme antenna
- Optional internal Bluetooth module and antenna

Peripherals and audio

- One FireWire 800 port and two FireWire 400 ports (one on front panel, 15W total power)
- Three USB 2.0 ports (one on front panel), two USB 1.1 ports on keyboard
- Front headphone minijack and speaker
- Optical digital audio input and output Toslink connectors
- Analog audio input and output minijacks

Electrical and environmental requirements

- Meets ENERGY STAR requirements
- Line voltage: 100-125V AC or 200-240V AC
- Frequency: 50Hz to 60Hz, single phase
- Maximum current: 6.5A (low-voltage range) or 7.5A (high-voltage range) for 100-125V AC, 3.5A for 200-240V AC
- Operating temperature: 50° to 95° F (10° to 35° C)
- Storage temperature: -40° to 116° F (-40° to 47° C)
- Relative humidity: 5% to 95% noncondensing
- Maximum altitude: 10,000 feet

Size and weight

- Height: 20.1 inches (51.1 cm)

- 256MB DIMMs (64-bit-wide, 128- or 256-Mbit)
- 512MB DIMMs (64-bit-wide, 256-Mbit)
- 1GB DIMMs (64-bit-wide, 256-Mbit)

memory buffer(1)

- 1 250GB 7200-rpm Serial ATA; 8MB memory buffer(1)
- 2 250GB 7200-rpm Serial ATA; 8MB memory buffer (single 1.8GHz system only)
- 1 or 2 400GB 7200-rpm Serial ATA; 8MB memory buffer(1) (dual-processor systems only)

- Single 1.8GHz system:
  - Optical drive bay with 8x SuperDrive (DVD-R/CD-RW) installed; writes DVD-R discs at up to 8x speed, reads DVDs at up to 10x speed, writes CD-R discs at up to 24x speed, writes CD-RW discs at up to 10x speed, reads CDs at up to 32x speed

- Dual 2.0GHz, dual 2.3GHz and 2.7GHz systems:
  - Optical drive bay with 16x SuperDrive (DVD+R DL/DVD±RW/CD-RW) installed; writes DVD-R discs at 16x speed, writes DVD+R DL discs at up to 4x speed, reads DVDs at up to 16x speed, writes CD-R and CD-RW discs at up to 24x speed and reads CDs at up to 32x speed.

- Width: 8.1 inches (20.6 cm)
- Depth: 18.7 inches (47.5 cm)
- Weight: Single-processor configuration, 36 pounds (16.4 kg); dual-processor configuration, 44.4 pounds (20.2 kg) (5)

1. 1GB = 1 billion bytes; actual formatted capacity less.
2. Second Apple flat-panel display may require ADC to DVI Adapter, sold separately. Connecting two 30-inch Apple Cinema HD Displays requires NVIDIA GeForce 6800 GT or Ultra DDL graphics card.
3. Actual rates will vary. Modem standard on single 1.8GHz systems and optional on dual-processor systems.
4. Wireless Internet access requires AirPort Extreme Card, wireless access point and Internet access (fees may apply). Achieving data rates up to 54 Mbps requires that all users have an AirPort Extreme Card and connect to an AirPort Extreme or AirPort Express Base Station. Some ISPs are not compatible with AirPort. Range may vary with site conditions.
5. Weight varies by configuration and manufacturing process.

- Internet access requires a compatible Internet service provider; fees may apply. Product contains electronic documentation. Backup copy of software is included.

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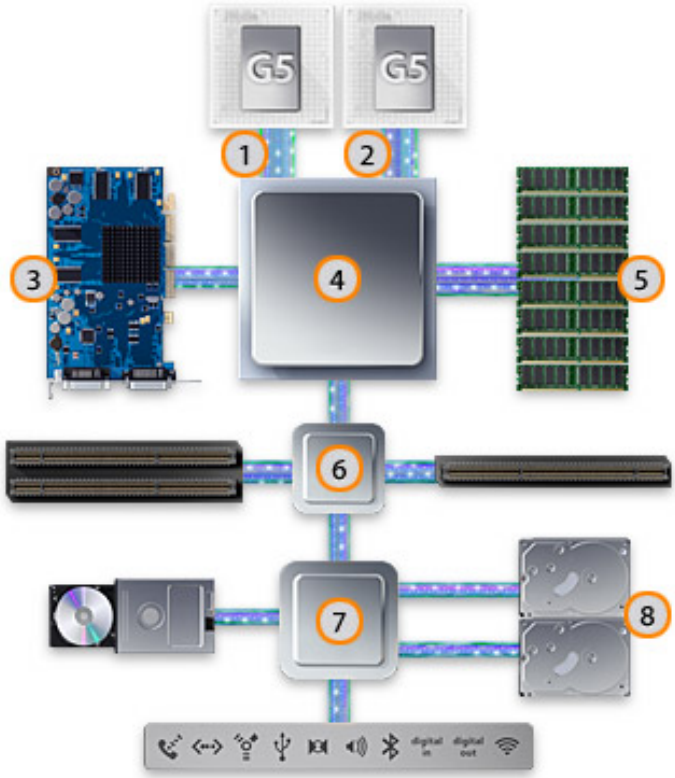
Power Mac G5

The radically designed, ultrahigh-bandwidth system architecture of the Power Mac G5 helps the PowerPC G5 processors perform to their full potential.

Bottlenecks in the system architecture are usually what hold back the fastest processors. That's why the Power Mac G5 system architecture has been engineered to eliminate traffic jams in your data path. The Power Mac G5 system architecture delivers phenomenal throughput for the most intensive image-editing, rendering and scientific computing tasks — without the stop-and-go traffic patterns that can choke even the fastest processors.

Consider the frontside bus, for instance: There's one for each processor for maximum throughput to and from each PowerPC G5 processor. And the point-to-point system controller allows data to move directly between all subsystems — without affecting the processor. Add to that the 400MHz, 128-bit memory bus, AGP 8X Pro graphics bus — as well as the HyperTransport interface that connects the PCI-X controller and the I/O subsystems to the system controller — and you're looking at some impressive architectural advances that speed up the data flow inside your computer.



The Power Mac G5 boosts the performance of the PowerPC G5 processor with a high-bandwidth system architecture.

1 **Frontside Bus up to 1.35GHz**
Designed to harness the power of the PowerPC G5 processor, a 1.35GHz, 64-bit bidirectional Double Data Rate (DDR) frontside bus maximizes throughput between the processor and the system controller. And unlike most processor interfaces, which can carry data in only one direction at a time and waste precious time changing directions, the PowerPC G5 features two high-speed unidirectional 32-bit data paths — one flowing continuously into the processor and one flowing from the processor. This lets data move in opposite directions simultaneously, with no other

demands on the data stream and no wait time while the processor and system controller compete for use of the bus. What's more, the data streams integrate clock signals along with the data, allowing the frontside bus to work at speeds of up to 1.35GHz for an astonishing 10.8GB per second of aggregate bandwidth.

2 **Dual-Independent Frontside Buses**
Each G5 processor has its own dedicated bidirectional interface to the system controller. That's a mind-boggling 21.6 GBps of total bandwidth on dual 2.7GHz systems — more than twice the 8.5-GBps maximum bandwidth of Pentium 4-based systems using the latest PC architecture. In addition to providing fast access to main memory, this high-performance frontside bus architecture enables each PowerPC G5 processor to discover and access data in the other processor's L1 and L2 caches for ultrafast performance.

3 **AGP 8X Pro Graphics Bus**
The Power Mac G5 sports AGP 8X Pro for high-performance 3D graphics. And "Pro" means you get additional power for industrial-strength graphics. This specification doubles the amount of data transferred in a single AGP bus cycle. The 66MHz AGP 8X Pro bus strobes eight times per clock cycle, resulting in a 533MHz data rate and bandwidth of 2.1 GBps.

4 **Advanced PowerPC G5 System Controller**
Central to the overall performance of the Power Mac G5 is the system controller. This revolutionary Application Specific Integrated Circuit (ASIC) is one of the industry's fastest. As an advanced engineering concept, it's beautiful in its simplicity: A point-to-point architecture provides each primary subsystem with dedicated throughput to main memory, neatly avoiding time-consuming contention for bandwidth (unlike subsystems that share a bus and are compelled to constantly negotiate for access and bandwidth across a common data path).

5 **128-Bit 400MHz DDR Memory Architecture**
The Power Mac G5 128-bit memory controller supports 400MHz, DDR SDRAM and enables main memory to address two banks of SDRAM at a time, reading and writing on both the rising and falling edge of each clock cycle. This effectively doubles the bandwidth, so the Power Mac G5 can achieve a maximum memory throughput of up to 6.4 GBps — an advance that's especially welcome when you're working with enormous files. In addition, direct memory access (DMA) works with the point-to-point system controller to give each subsystem — such as PCI cards and graphics processing units — its own 6.4-GBps interface to main memory, without siphoning power from your processors. Thanks to the 64-bit PowerPC G5 processor and 64-bit memory support built into Mac OS X Tiger, the Power Mac G5 can utilize all the installable memory — more memory than most other desktop PCs. The dual 2.3GHz and dual 2.7GHz systems have eight DIMM slots and can hold up to 8GB of memory — enough to process huge data sets and rich media files within system RAM, without the delay of having to access the disk drive. In fact, 64-bit memory support allows each individual application on your system to access all installable memory, shattering the 4GB barrier.

6 **133MHz PCI-X Expansion**
The Power Mac G5 features PCI-X, which increases the PCI bus speed from 33MHz to 133MHz, and the throughput from 266 MBps to a combined total of 2 GBps. PCI-X operates more efficiently, giving you more usable bandwidth at any clock frequency — ideal for HD video and other high-bandwidth applications.

7 **High-Performance I/O**
The HyperTransport protocol integrates the Power Mac G5 I/O subsystems and connects them to the system controller. Serial ATA, Gigabit Ethernet, FireWire, USB 2.0 and optical digital and analog audio are all integrated through a bi-directional 800MHz HyperTransport interconnect for a maximum throughput of 1.6GB per second.

8 **Serial ATA Storage**
The Power Mac G5 can hold two internal Serial ATA drives that support 1.5-GBps throughput per channel (equivalent to a 150-MBps data rate). Designed to meet the demands of digital video editing, 3D modeling and other data-intensive applications, Serial ATA is the industry-standard storage interface that replaces the typical (a.k.a. Parallel) ATA interface. Since each Serial ATA drive is on an independent bus, there's no competition for bandwidth as with Parallel ATA.

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Power Mac G5

The Power Mac G5 out-shoots its PC competition in a battery of tests. But it's in the rough-and-tumble of real-world performance that the Power Mac really shines — showing off its professional versatility in the process.

The Power Mac G5 puts tremendous creative firepower at your disposal. Your unfair advantages start with a powerful 64-bit processor, running at clock speeds of up to 2.7GHz. Combine that with 1.35GHz dual-independent frontside buses, an advanced system controller, a fast 128-bit 400MHz memory bus and state-of-the-art expansion, and you begin to understand why the Power Mac G5 is the kind of machine a PC wouldn't want to compete for a job against. (1)

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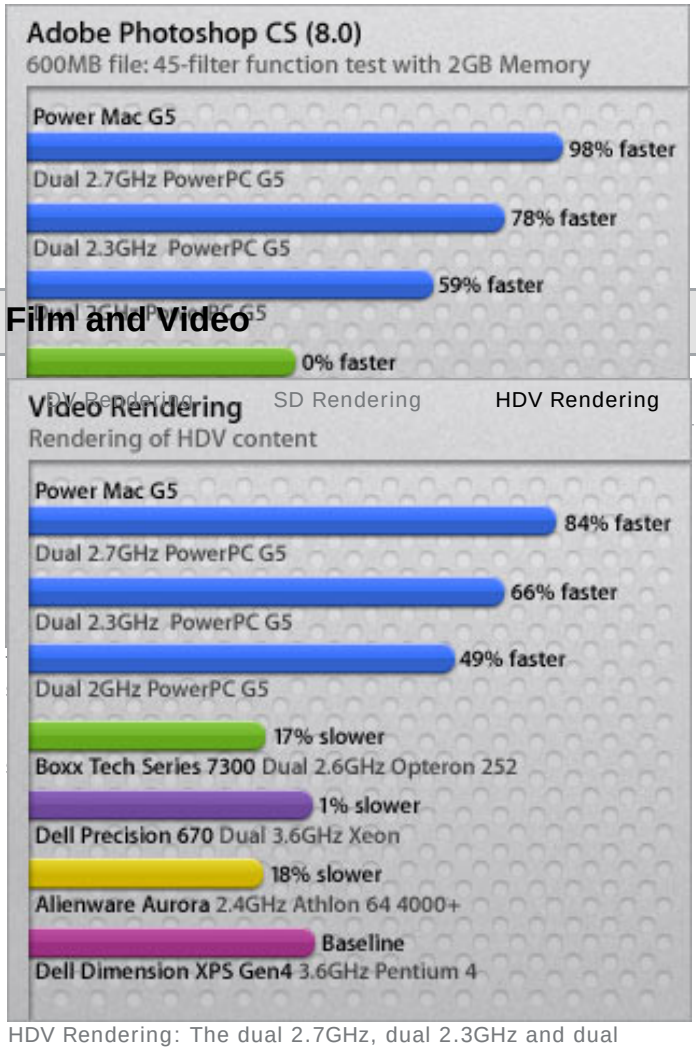
Design for the Environment

Design and Print

Design and Print Pro

For design and publishing professionals, the Power Mac G5 lets you realize your ideas as fast as you can imagine them, rendering huge images and layouts in no time, and — with up to 8GB of memory — giving you instant access to large files and assets. With the Serial ATA hard drive, built-in Gigabit Ethernet and high-speed integrated I/O support, you have high-bandwidth connections to printers, scanners, cameras, storage, networks and more. The Quartz graphics engine in Mac OS X guarantees breathtaking content onscreen, while ColorSync ensures perfect color from capture to edit to output. You can even automate regular tasks with AppleScript to speed your workflow. Publishing tools like Adobe Creative Suite and QuarkXPress are specially designed for Mac OS X and will bring your ideas to life in print or on the Web. And while the Power Mac G5 shines at specific tasks, you'll also find it speeds your entire day along as well. Use the productivity calculator to find out how much compared to your current system.

Nearly Two Times Faster Than Dell Dimension XPS



HDV Rendering: The dual 2.7GHz, dual 2.3GHz and dual 2.0GHz Power Mac G5 systems running Final Cut Pro 5 rendered a complex project 84%, 66% and 49% faster, respectively, than the 3.6GHz Pentium 4-based system. Performing the HDV test using Final Cut Express produces even faster results. While Final Cut Pro renders transitions and effects in their native format (long GOP MPEG-2) for the highest-possible quality, both Adobe Premiere Pro and Final Cut Express render HDV video in an intermediate format, allowing faster editing on systems with less processing power. Using Final Cut Express HD 3.0, the dual 2.7GHz, dual 2.3GHz and dual 2.0GHz Power Mac G5 systems rendered the same complex project 187%, 166% and 145% faster, respectively, than the 3.6GHz Pentium 4-based system.(1)(3)

To demonstrate the superiority of the Power Mac G5, Apple conducted tests using Adobe Photoshop CS 8.0, the most widely used application among creative professionals. Adobe Photoshop is a particularly effective cross-platform measure of system performance because it has been optimized for both Macintosh and Windows platforms. Apple ran the tests using a 600MB Photoshop file and a suite of 45 commonly used Photoshop actions, including file saving, image adjustments, mode changes and filters. Apple measured the time to execute each filter or function and compared the performance of all actions using an indexed score.

Film and Video

Film and Video Virtuoso

No matter what the format — DV, SD, HDV or film — the Power Mac G5 gives film and video professionals the freedom and power to create studio-quality projects. With support for more simultaneous streams, real-time effects and cutting-edge software like Apple's Final Cut Studio, Alias Maya, Adobe After Effects and NewTek LightWave, you can edit sequences, generate effects, composite scenes, render and process video, author DVDs and animate characters in record time. A Mac OS X- and QuickTime-based workflow provides the flexibility to author in any format and XML extensibility to share projects between applications. The Power Mac G5 also makes it easy to build a state-of-the-art studio, with support for high-speed Xserve RAID storage, a specialized PCI-X acquisition card and high-performance FireWire decks and devices.

HDV Rendering: 84% Faster Than Dell Dimension XPS

One of the final stages of any film or video project is the processor-intensive task of rendering. Apple measured the time to render a two-minute video project with various commonly used effects and filters, including color corrections, transitions, compositing and basic text treatments, on Power Mac G5 and PC systems. To demonstrate video rendering performance, Apple tested Final Cut Pro 5 on the Power Mac G5 and Adobe Premiere Pro on various PC systems using virtually identical projects in DV, SD and HDV formats.

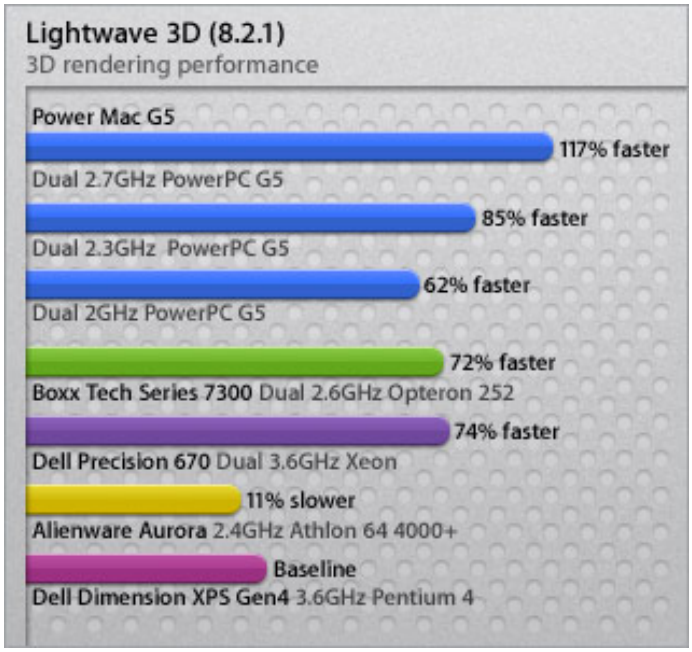
Video editors and producers add innovative motion graphics and effects to film, video, DVD and web projects using tools like Motion and Adobe After Effects. To demonstrate the performance of Power Mac G5 hardware when rendering effects for video, Apple tested After Effects on the Power Mac G5 and an array of PC systems. After Effects has been optimized for both the G5 and PC architectures.

3D Rendering: Over Two Times Faster Than Dell Dimension XPS

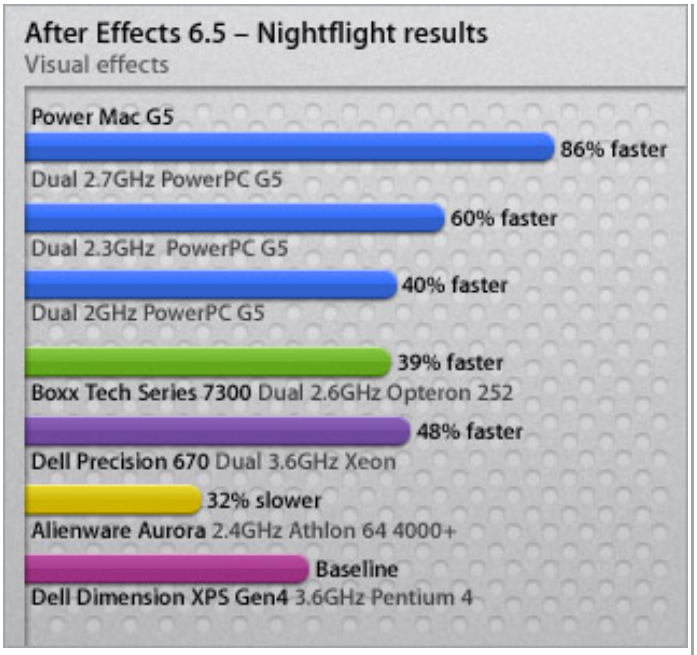
LightWave 3D is a popular digital content creation application that includes a fast rendering engine. Its capabilities are proven in film, television and gaming, and it is also used for creating graphics for print and the Web — anywhere 3D content is needed. To demonstrate the performance of the Power Mac G5, Apple rendered a scene using LightWave 3D and measured the time it took each system to complete the task.

Video Effects: Nearly Two Times Faster Than Dell Dimension XPS

Video editors and producers add innovative motion graphics and effects to film, video, DVD and web projects using tools like Motion and Adobe After Effects. To demonstrate the performance of Power Mac G5 hardware when rendering effects for video, Apple tested After Effects on the Power Mac G5 and an array of PC systems. After Effects has been optimized for both the G5 and PC architectures.

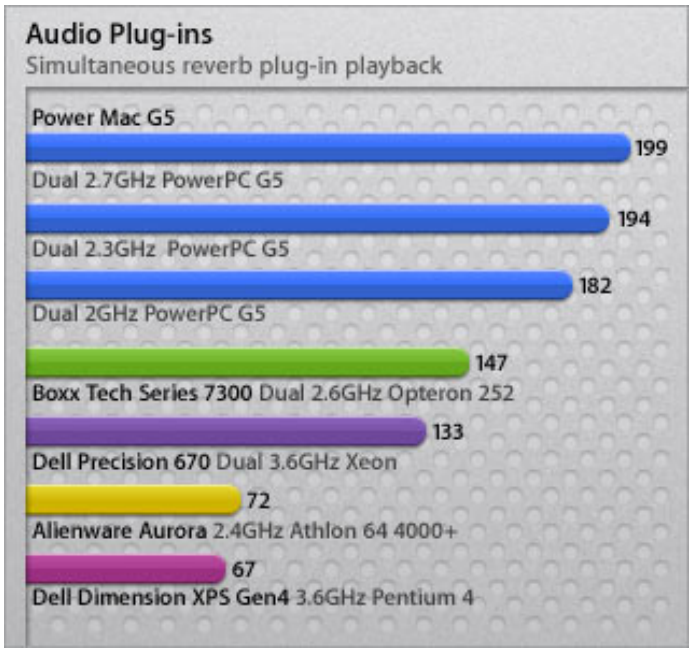


The dual 2.7GHz, dual 2.3GHz and dual 2.0GHz Power Mac G5 systems were 117%, 85% and 62% faster, respectively, than the 3.6GHz Pentium 4-based system; the dual 2.7GHz and dual 2.3GHz Power Mac G5 systems were 24% and 6% faster, respectively, than the dual 3.6GHz Xeon-based system.(1)(4)



The dual 2.7GHz, dual 2.3GHz and dual 2.0GHz Power Mac G5 performed the Nightflight render test 86%, 60% and 40% faster than the 3.6GHz Pentium 4-based system; the dual 2.7GHz and dual 2.3GHz Power Mac G5 systems outperformed the dual 3.6GHz Xeon-based system by 25% and 8%, respectively.(1)(5)

Music and Audio



The dual 2.7GHz, dual 2.3GHz and dual 2.0GHz Power Mac G5 systems played 132, 127 and 115 more reverb plug-ins, respectively, than the 3.6GHz Pentium 4-based system and 52, 47 and 35 more reverb plug-ins, respectively, than the dual 2.6GHz Opteron-based system. (1)(6)

Music and Audio Maestro

Music and audio pros now have even more power at their fingertips to compose, record, edit, mix and perform. The Power Mac G5 effortlessly synthesizes instruments and applies effects, and up to 8GB of memory provides ample room to compose using an unprecedented number of tracks. The built-in optical digital and analog audio ports support new and legacy hardware, and FireWire and USB support connections to virtually any audio, MIDI and storage device. Fast PCI-X provides expansion options for digital signal processing hardware and external storage. Mac OS X with Core Audio can run several applications simultaneously, while Audio Units provide a robust plug-in protocol designed to work seamlessly across Audio Units host applications. And with state-of-the-art applications such as Apple's Logic Pro and Soundtrack Pro, Digidesign Pro Tools, MOTU Digital Performer and Steinberg Cubase SX and Nuendo, you have a wealth of innovative software to capture your inspiration.

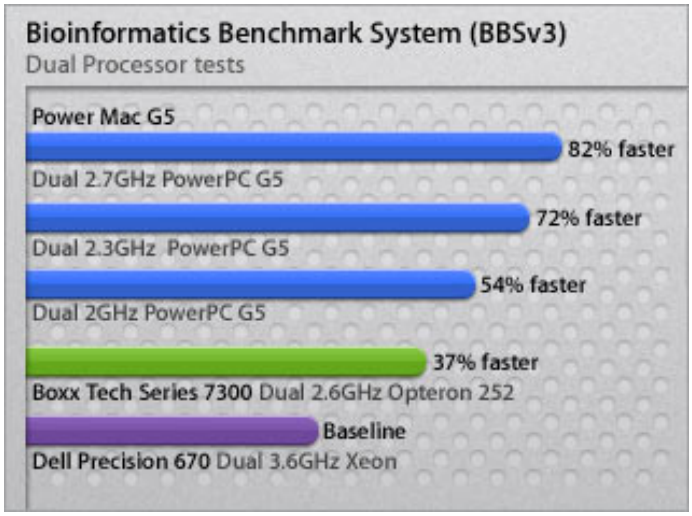
Nearly Three Times the Plug-ins as Dell Dimension XPS

To quantify the performance advantages of the Power Mac G5 for audio production, Apple tested Logic Pro 7. Apple created a processor-intensive workload containing multiple unique audio tracks, assigned five default reverb plug-ins to each audio track and tested each platform to see which application could play more plug-ins.

Science and Technology

Science and Technology Groundbreaker

The Power Mac G5 gives scientific researchers the ability to make discoveries in record time. Each 64-bit PowerPC G5 processor features two double-precision floating-point units and an optimized Velocity Engine that dramatically accelerate



The dual 2.7GHz, dual 2.3GHz and dual 2.0GHz Power Mac G5 performed the BBSv3 dual processor tests 82%, 72% and 54% faster, respectively, than the dual 3.6GHz Xeon-based system and 33%, 26% and 12% faster, respectively, than the dual 2.6GHz Opteron-based system.(1)(7)

the computational task at hand. Open source, UNIX-based Mac OS X provides unprecedented power, compatibility and stability to run complex scientific applications and command-line tools alongside essential productivity applications, such as Microsoft Excel and Adobe Photoshop. You can develop custom applications while doing everyday work, all on the same computer and in the same operating system. Dual displays expand your screen real estate, and powerful graphics processors enable advanced scientific visualization. So whether you're doing molecular modeling with PyMOL, searching for DNA alignments with BLAST, analyzing statistics with SPSS, modeling equations with Mathematica, or building your own programs with Apple's Xcode tools, the power to discover and publish is right in front of you.

Over 80% Faster Than Dell Precision 670 at Scientific Analysis

To demonstrate the performance advantages of the Power Mac G5 for processor-intensive scientific analysis, Apple used Bioinformatics Benchmark System version 3 (BBSv3). This benchmark is based on current, popular applications and data sets from the bioinformatics community and represents the day-to-day workload of a typical research scientist. The current benchmark uses bioinformatics application suites NCBI BLAST and HMMER as the workload. For this benchmark, Apple used FASTA databases dated January 1, 2005; NCBI BLAST version 2.2.10; and HMMER version 2.3.2.

1. Testing conducted by Apple in April 2005 using preproduction dual 2.0GHz, 2.3GHz and 2.7GHz Power Mac G5 units; all other systems were shipping units.
2. File size = 600MB. For PC systems, cache sizes were: Dell Dimension XPS Gen4 = 2048K L2; Dell Precision 670 = 2048K L2; Alienware Aurora 5500 = 1024K L2; Boxx Tech Series 7300 = 1024K L2.
3. The Power Mac G5 systems were testing with a prerelease version of Final Cut Pro 5. The PC systems were tested with Adobe Premier Pro version 1.5.1. For PC systems, cache sizes were: Dell Dimension XPS Gen4 = 2048KB L2; Dell Precision 670 = 2048KB L2; Alienware Aurora 5500 = 1024KB L2; Boxx Tech Series 7300 = 1024KB L2.
4. Benchmark scene = Skull_Head_Newest. For PC systems, cache sizes were: Dell Dimension XPS Gen4 = 2048K L2; Dell Precision 670 = 2048K L2; Alienware Aurora 5500 = 1024K L2; Boxx Tech Series 7300 = 1024K L2.
5. For PC systems, cache sizes were: Dell Dimension XPS Gen4 = 2048K L2; Dell Precision 670 = 2048K L2; Alienware Aurora 5500 = 1024K L2; Boxx Tech Series 7300 = 1024K L2.
6. All Power Mac systems were tested using Logic Pro 7.0. The Dell Dimension XPS Gen4, Dell Precision 670, Alienware Aurora 5500 and Boxx Tech Series 7300 were tested using Steinberg Cubase SX 3.01. For PC systems, cache sizes were: Dell Dimension XPS Gen4 = 2048K L2; Dell Precision 670 = 2048K L2; Alienware Aurora 5500 = 1024K L2; Boxx Tech Series 7300 = 1024K L2.
7. Test results based on the Bioinformatics Benchmark System (BBSv3), using January 1, 2005 FASTA databases; NCBI BLAST version 2.2.10; and HMMER version 2.3.2.

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Power Mac G5

A removable side door gives you access to the slots and bays of the Power Mac G5, so you can add more memory, a second hard drive or an AirPort Extreme Card quickly and easily — no tools required.

Up to 800GB of Internal Storage

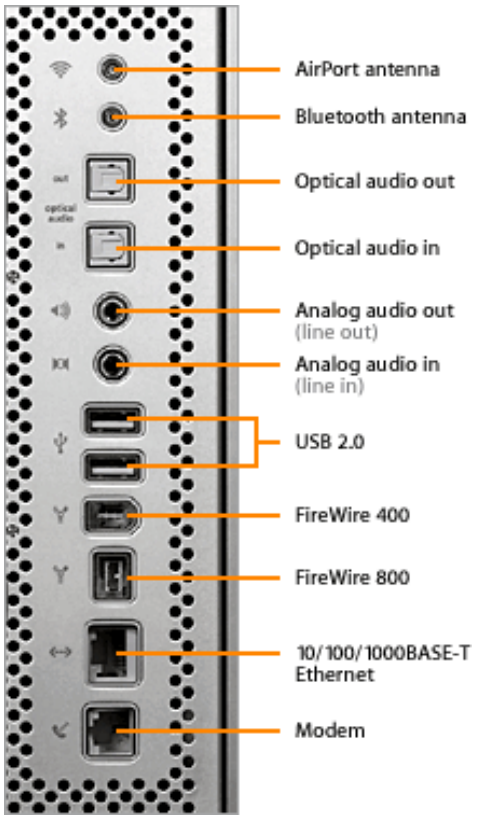
The Power Mac G5 has two Serial ATA hard drive bays for up to 800GB of fast internal mass storage — ideal for video, audio and high-resolution graphics. Built-in software RAID allows you to stripe the two drives for increased performance or mirror them for high reliability. And it's easy to add storage as your needs grow. Single-drive systems come with the cabling to connect a second hard drive, and the easy-to-open side panel lets you insert a new drive yourself. Want massive storage? Just use a Fibre Channel PCI card to connect to Xserve RAID, Apple's high-performance storage system.

Up to 8GB of Memory

The Power Mac G5 comes with four or eight DIMM slots that use fast PC3200 DDR SDRAM. Combine that with a 128-bit memory controller for up to 6.4-GBps throughput. Standard configurations come with 512MB of RAM. And since memory is scalable up to 8GB, you can add RAM as your application and workflow requirements increase.

PCI-X Expansion Slots

PCI and PCI-X cards enable the Power Mac G5 to perform specialized tasks, such as video capture and playback and audio digital signal processing (DSP). PCI-X supports 3.3V signaling and Universal 33MHz and 66MHz PCI cards. Choose a PCI or PCI-X Power Mac G5 system: Three 64-bit PCI-X slots let you add one card running at 133MHz and two cards running at 100MHz, and three 64-bit PCI slots allow you to add three 33MHz cards.



AirPort, Bluetooth and modem optional

Plugged In

It's easy to plug printers, scanners and other devices into the Power Mac G5. In addition to sporting a full complement of ports

Graphics Options

3D graphics and models, animation, visualization and the latest generation of games require the fastest graphics cards available. The Power Mac G5 features a powerful AGP 8X Pro graphics interface and the latest in high-performance cards from NVIDIA and ATI. For crystal-clear viewing, Apple's widescreen, all-digital displays are the perfect complement to the Power Mac G5. And support for dual 20-inch Cinema and 23-inch Cinema HD Displays is built into every system. The top-of-the-line NVIDIA GeForce 6800 GT DDL graphics card even supports two massive 30-inch Cinema HD Displays, expanding your desktop canvas to an amazing 8 million pixels.

FireWire and USB 2.0

All Power Mac G5 systems have one FireWire 400 port on the front and one on the back of the enclosure — as well as a next-generation FireWire 800 port on the back — for connecting to high-bandwidth devices such as DV cameras, hard drives and digital music players. You also get two USB 1.1 ports on the keyboard and three USB 2.0 ports — one on the front and two on the back — for connecting printers, scanners, graphics tablets, keyboards, microphones, speakers, joysticks and other industry-standard input and output devices.

Optical Digital Audio

The Power Mac G5 comes with audio capabilities that are not usually found on personal computers. The state-of-the-art optical digital audio in and out ports use the S/PDIF (Sony/Philips Digital Interface) protocol over Toslink cables for connecting to devices such as decks, receivers, digital instruments and even 5.1 surround-sound speaker systems. And since S/PDIF is an optical signal — a beam of light — you won't get any ground loop interference caused by copper wiring.

on the back, the front panel has FireWire 400 and USB 2.0 ports, as well as a minijack for headphones and desktop speakers.

Gigabit Ethernet

Gigabit (10/100/1000BASE-T) Ethernet is built into every Power Mac G5, and the autosensing port makes it simple to connect two systems without using a crossover cable.

Go Wireless

Wireless networking is equally simple using the optional 54 Mbps AirPort Extreme Card and either an AirPort Extreme Base Station or an AirPort Express Base Station. The optional Bluetooth module and antenna allow you to connect wirelessly to a range of digital devices like cell phones, PDAs, printers and Apple's wireless keyboard and mouse.

Analog Audio

The Power Mac G5 also features high-quality, analog stereo audio line in and line out ports. A handily-positioned minijack on the front panel makes it easy to plug in your headphones.

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Power Mac G5

The Power Mac G5 is the world's coolest personal computer in every sense of the term. Mind-boggling leaps in processing power require innovative design for dissipating heat. So the Power Mac G5 delivers a system that screams with power, not noisy fans.

Hip to be Cool

Take it up a notch without losing your cool. The top-of-the-line Power Mac G5 with dual 2.7GHz processors squeezes outrageous performance into tight quarters. To cool down those steaming circuits, Apple designed a sophisticated liquid cooling system that takes off the heat without bumping up the noise. Mac OS X dynamically adjusts the flow of the fluid and the speed of the fans based on temperature and power consumption.

Take the Power Mac G5 for a spin: See a QuickTime VR

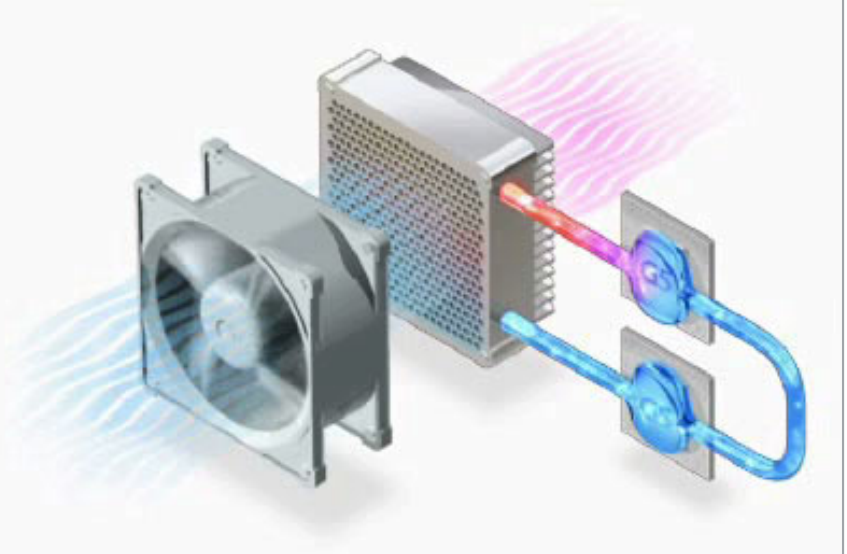
Take a closer look: browse through a gallery of high-resolution photos of the Power Mac G5.

Quiet Operation

It's no secret that computers generate heat. So Apple divided the inside of the Power Mac G5 into four discrete thermal zones, compartmentalizing the primary heat-producing components — processor, PCI, storage and power supply — so the system can decrease the temperature of a single zone without affecting the others.

Each thermal zone is equipped with its own dedicated fans spinning at

Click to see liquid cooling in action. (1.6MB)



The dual 2.7GHz Power Mac G5 features an innovative liquid cooling system that's more efficient than a traditional heat sink. This system provides a continuous flow of thermally conductive fluid that transfers heat from the processors as they work. The heated fluid then flows through a radiant grille, where air passing over cooling fins returns the fluid to its original temperature.

Truly Intelligent Design
An exceptional computer demands an exceptional enclosure. The Power Mac G5 has a stunning chassis forged of anodized aluminum. Apple engineers were also pretty obsessive about clutter. That's why there isn't any. Especially conspicuous by its absence is that tangle of unsightly wires and cables that turn the inside of a typical PC into a veritable rat's nest. "A place for everything and everything in its place" isn't just something your mom said: It's an important philosophical precept that Apple applies rigorously to hardware design.

This clutter-free design also allows for intelligently managed heat dissipation through four independently controlled thermal zones. To make the Power Mac G5 even easier to cool, a transparent internal air deflector channels airflow over the processor heat sinks and the expansion slots.

Thoughtful Considerations
If you try hard enough you might cram everything into the average PC case. The Power Mac G5 was designed from the inside out so that the case and internals fit together for maximum thermal efficiency.

very low speeds for minimum acoustic output. Using 21 different sensors, Mac OS X constantly monitors component temperatures and power consumption in each zone, dynamically adjusting individual fan speeds for the quietest possible operation. As a result, the Power Mac G5 runs two times quieter than the previous Power Mac G4.

Access is Everything

The Power Mac G5's easy-to-open side panel unlatches in a snap, giving you fast access to the slots and bays inside. For no-hassle expansion, the design lets you add things like memory or an AirPort Extreme card without tools. And drive guides let you mount high-capacity hard drives when your storage needs grow. Or lock it up to keep the inside of your computer safe from tampering.

Plugged In

It's easy to plug printers, scanners and other devices into the Power Mac G5. In addition to sporting a full complement of ports on the back, the front panel has FireWire 400 and USB 2.0 ports, as well as a headphone jack.

Power Mac G5

Today's graphics subsystems power more than just the latest games. They provide the driving force for advanced operating system and application features not found anywhere but Macintosh. The Power Mac G5 features the latest cards from top manufacturers for full-throttled visual spectacles.

Apple's integrated approach to systems engineering means complicated technologies work in concert. Mac OS X delivers the foundation for the marriage of the PowerPC G5 and graphics processors. Integrated into the system, OpenGL lets Apple and third party developers create complex visuals in an industry-standard format. QuickTime renders video and other media, while Quartz Extreme offloads these computations to the graphics processor for maximum efficiency.

This means your graphics card delivers much of the processing power for creating transitions in Keynote, real-time video effects in Final Cut Pro and particle acceleration in Motion. You'll even see this power in the Mac OS X interface itself, as your GPU animates the genie effect in the dock, rolls down save and print sheets, choreographs windows in Exposé and displays system controls for brightness, sound and application switching in a transparent overlay. Such elegant advances can be found only on a Mac, with its powerful combination of UNIX, OpenGL, intuitive interface and impressive hardware. And of course, the Power Mac G5 gives you the best opportunity to harness these capabilities.

Stunning Graphics out of the Box

Standard configurations of the Power Mac G5 include the ATI Radeon 9600 with 128MB DDR SDRAM or the ATI Radeon 9650 with 256MB DDR SDRAM, giving you the horsepower to work in 2D and 3D environments. These programmable cards allow next-generation games and digital content creation applications to offload computations from the CPU to the GPU. The Radeon 9600 has two DVI ports for connecting to two 20- or 23-inch Apple Cinema

8 Million Pixels

The dual-processor 2.7GHz Power Mac G5 and its ATI Radeon 9650 graphics card now support a massive 30-inch Apple Cinema HD Display right out of the box. Increase graphics performance with the optional ATI Radeon X850 XT — or add the NVIDIA GeForce 6800 GT DDL graphics card to connect two 30-inch Cinema HD Displays for the ultimate creative canvas of eight million pixels. These graphics cards, designed specifically to support the dual-link DVI connection, deliver 2560-by-1600 resolution.

Apple Flat-Panel LCD Displays

Feast your eyes on more than 4 million pixels in the first high-resolution 30-inch flat-panel display designed for the personal computer. The Apple Cinema Display line, which also includes 20-inch and 23-inch models, features an elegant anodized aluminum enclosure to complement the Power Mac G5 or PowerBook G4.

Displays, as well as to industry-standard VGA and DVI displays. The Radeon 9650 has one standard DVI port and one dual-link DVI port, allowing it to connect to a 30-inch Apple Cinema HD Display and a 20- or 23-inch Apple Cinema Display simultaneously.

The Next Generation from ATI
For blockbuster entertainment and design, Power Mac customers can now choose to upgrade to the ATI Radeon X850 XT with 256MB of fast GDDR3 video memory. Based on the next-generation graphics architecture from ATI, this card features 16 parallel pixel pipelines and memory bandwidth of up to 34.6 GBps. New technologies include the SmartShader HD shader engine and Smoothvision HD with 3Dc for advanced texture filtering and image enhancement. The Radeon X850 XT has one ADC port and one dual-link DVI port — enabling it to support both a 30-inch Apple Cinema HD Display and a 20- or 23-inch Apple Cinema Display.(1)

Over-the-Top Graphics from NVIDIA
Bring detailed worlds to life with movie-quality lighting, textures and effects. On the optional NVIDIA GeForce 6800 GT DDL card, the fastest and most visually advanced graphics processor, a 256-bit memory interface and 256MB of GDDR3 video memory combine to deliver production studio-caliber graphics — in real time. Perfect for intensive 3D modeling tasks and for equally intense next-generation games, the NVIDIA GeForce 6800 GT DDL features highly programmable shader engines and OpenGL feature sets. And best of all, it supports two massive 30-inch Apple Cinema HD Displays to give you the big, big picture.

Graphics Card Performance
In today's dual-processor Power Mac G5 systems, the Quartz Extreme feature of Mac OS X leverages the power of the graphics processors by offloading OpenGL and QuickTime duties to the graphics chip, thus freeing up the main processors for other tasks. To provide 3D performance for your varied needs, Apple offers a selection of graphics cards to choose from. We compared the NVIDIA GeForce 6800 GT DDL and the ATI Radeon X850 XT with the ATI Radeon 9650 on a dual 2.7GHz Power Mac G5 to illustrate the relative performance of each graphics card in design and gaming scenarios.

Over 40% Faster at Motion Graphics
Motion, Apple's real-time motion graphic design application, uses self-propelled behaviors, character-by-character title animation and natural simulations to enhance multimedia productions. Optimized for the Power Mac G5, Motion leverages the graphics processor to animate effects onscreen in real time, providing instant animations for a high-speed workflow. The test protocol measured the uncached playback, cached playback and export to QuickTime of a project, simultaneously applying lens flare, kaleidoscope, contrast, saturate, sphere and Gaussian blur filters to a 20-second NTSC video clip.

Dual 2.7GHz Power Mac G5 systems configured with the NVIDIA GeForce 6800 GT DDL completed the Motion filter test 42% faster than the dual 2.7GHz Power Mac G5 with the standard ATI Radeon 9650.(2)

Nearly Three Times Faster for 3D Gaming

Dual-Display Support
The Power Mac G5 comes with a DVI port for the Apple Display line — as well as support for both extended desktop and video mirroring modes.

Get the Perfect Picture

ATI Radeon 9600
Connect up to two 23" displays and enjoy excellent 2D/3D application performance.

ATI Radeon 9650
Connect one 23" and one 30" display, while experiencing more textures and even better performance.

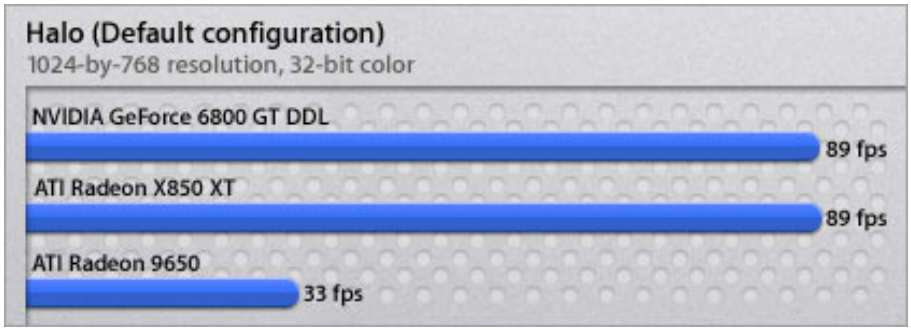
ATI Radeon X850 XT
Connect one 23" and one 30" display and benefit from next-generation graphics and jaw-dropping performance.(1)

NVIDIA GeForce 6800 GT DDL
Run the most demanding 2D/3D applications across two 30" displays for the ultimate in creative freedom.

The NVIDIA card occupies the AGP slot and adjacent PCI slot; all ATI cards occupy the AGP slot only.

Are You Game?
Enjoy outstanding 3D performance for immersive visual experience in the latest games. The 66MHz AGP 8X Pro bus strobes eight times per clock cycle, giving you a 533MHz data rate and a maximum

3D gaming involves complex visualizations and rapid movements that require maximum processor performance and top-of-the-line graphics capabilities. The Power Mac G5 provides a robust platform that not only supports the latest 3D technologies, but also delivers a great gaming experience. Superfast graphics performance and 64-bit G5 processors combine to deliver more frames per second at higher resolutions — all with more complexity and better texturing than ever before. Frame rates were measured using the game Halo, one of the most popular gaming titles on the market today, which leverages the programmability features of the graphics card. The Time Demo benchmark built into Halo was run at 1024-by-768 resolution using the advanced pixel shaders option (version 1.4).



Dual 2.7GHz Power Mac G5 systems configured with the NVIDIA GeForce 6800 GT DDL or the ATI Radeon X850 XT played 56 more frames per second than the dual 2.7GHz Power Mac G5 with the standard ATI Radeon 9650.(3)

1. A DVI to ADC Adapter is required to connect a second DVI display to the ADC port of the ATI Radeon X850 XT.
2. Testing conducted by Apple in June 2005 using dual 2.7GHz Power Mac G5 units and preproduction video cards.
3. Testing conducted by Apple in June 2005 using dual 2.7GHz Power Mac G5 units and preproduction video cards. Halo was tested using the Time Demo benchmark with advanced pixel shaders (1.4).

bandwidth of 2.1 GBps. This performance drives graphics-intensive applications to astonishing resolutions, with lifelike texturing.

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Power Mac G5

Now included on every Power Mac G5, Mac OS X Tiger turns your tower into a finely tuned instrument that lets you focus on the tasks at hand, whether you're creating a workout soundtrack for your iPod, publishing a paper on the human genome or perfecting special effects for the next blockbuster film.

Use *All* Your Memory
Tiger now delivers the power of 64-bit computing to your Power Mac G5. In a 32-bit world, an application can address 4GB of memory. For the applications you use every day, that's more than enough. But if you work with large datasets such as the human genome or geospatial data, that's limiting. Tiger's 64-bit support shatters the 4GB limit, providing a virtual address space in excess of 18 billion *billion* bytes.

Find Anything, Fast.
Tiger introduces Spotlight, the lightning-fast search technology that illuminates every corner of your Mac. Search everything on your system: Files, emails, contacts, images, movies, calendars and applications appear instantly. Spotlight results include all the metadata inside files — the "what, when and who" of everything on your Mac — including the kind of content, author, file size and many more details.

Get Info in a Dash
The new Dashboard hosts nifty widgets that appear instantly and keep you up to date with timely information from the Internet. View stocks, check weather forecasts, track

Time to try your newfound power in the real world. From Apple's collection of professional applications to industry-leading third-party applications, software truly shines on the Power Mac G5. Discover just a few of the applications your Power Mac G5 will access easier, run faster and take further.

Elevate Production Values

You know the benefits of keeping all your production under one roof. Why not keep all your production tools in one box? Edit virtually any format, from film to DV and native HDV to fully uncompressed HD — complete with simultaneous multicamera playback — in real time with Final Cut Pro 5. Create, manipulate and fix audio with Soundtrack Pro. Create eye-popping motion graphics with the GPU-accelerated, 32-bit float rendering of Motion 2. Then author your finished product to DVD, complete with highly interactive titles and fast, distributed encoding, thanks to DVD Studio Pro 4. Do it all with Final Cut Studio and its integrated, state-of-the-art applications. Make Final Cut Studio your affordable, all-in-one virtual studio and it's a wrap.

Unleash the Next Wave
Logic Pro 7 features new instruments

flights, convert currency and units of measure, even look up businesses in the phone book. Your favorite widgets appear with up-to-the-second information, then disappear just as easily, so you can get back to what you were doing.

Make a Connection
Tiger makes your Mac a communications hub. Safari for Tiger features built-in RSS feed detection and display. Mail and Address Book incorporate Spotlight technology to help you stay organized. And iChat AV lets you video and audio conference or send instant messages. Add a .Mac account for iDisk storage, a mac.com email address, your own home page and powerful syncing capability.

Do It All
From QuickTime 7 with the revolutionary H.264 video codec to the world-class performance architecture of Core Audio to the drag-and-drop Workflows of Automator, Mac OS X Tiger offers a feature for every reason you use the Power Mac G5, and then some.

Enjoy Your Digital Life
With iLife '05 — free on every Power Mac G5 — you can import, organize and edit photos, then add them to slideshows and keepsake albums using iPhoto 5. Edit high-definition video and create movies automatically with iMovie HD's new Magic iMovie feature. Drag and drop video clips, pictures and music into new iDVD 5 templates. Or create multi-track recordings in GarageBand 2. Of course, iTunes seamlessly integrates with every iLife application and syncs to every iPod.

and effects, state-of-the-art loop composition tools as well as optimizations for the PowerPC G5 processor and Mac OS X, forming a highly productive system that will change the way you compose, record, edit and mix music in any studio environment. The latest version provides near unlimited processing resources through the simple addition of Macintosh computers.

Shake Things Up

Shake 4 is the only compositing software with a complete toolset for both single artists and visual effects facilities. With 3D multi-plane compositing, 32-bit Keylight and Primatte keying, cutting edge Optical Flow image processing, Final Cut Pro 5 integration and an open, extensible scripting language, Shake 4 delivers all the tools required for sophisticated film and television visual effects. The choice of Oscar-winning effects artists seven years in a row, Shake now offers a host of new features that give you the highest quality output for film and HD.

Work and Play
The Power Mac G5 and Mac OS X support just about any application you need to succeed. Optimized for fast performance with industry-leading titles from Adobe Photoshop CS to NewTek Lightwave 3D, the Power Mac G5 also blazes through traditional productivity apps such as Microsoft Office 2004 for Mac. And with state-of-the-art Power Mac G5 graphics technology at your fingertips, the gaming world is your oyster, too.

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Power Mac G5

A revolutionary 64-bit desktop computer designed to meet the high-performance, no-compromise requirements of today's most demanding professional applications, the Power Mac G5 has stunned customers, critics and developers alike with unprecedented performance. With dual 64-bit processors and a high-bandwidth architecture, this groundbreaking system alleviates the limitations and bottlenecks of the traditional PC — opening up a wealth of possibilities for 2D and 3D designers, video and audio producers, scientists and researchers.

Design and Print

As Fast as Your Imagination
For every innovation that enters the mainstream, there are those who've had the foresight to embrace it earlier than others. In the prepress and printing world, a prime example is the experience of Blanks Printing & Imaging of Dallas, Texas, and one of their largest and most demanding clients, Mervyn's Department Stores of Hayward, California.

Blanks wanted to implement a virtual color proofing workflow with its largest customer, Mervyn's, to improve the quality and process of color proofing while saving time and money. Their traditional, paper-based workflow for color proofing took anywhere from 10 days to two weeks. For Blanks and Mervyn's, that meant about four days wasted in transit for an average press project.

Using Apple systems — Power Mac G5 computers running Mac OS X with built-in ColorSync and Apple Cinema Displays — in both locations, Blanks and Mervyn's designers now view, annotate and color-correct proofs onscreen instead of on paper, stream electronic proofs via the Internet and ensure accurate color on thousands of varied projects — from first view to final sign-off — without ever relying on paper. "And," says Blanks' Technical Director Jim Smiddy, "save time, money and trouble in the bargain."

Find out more about how to customize the Power Mac G5 for a creative studio.

Designed for Design

- Faster G5 processors rip through huge images and layouts
- Up to 8GB of memory for fast access to large files and assets
- Serial ATA hard drives and Gigabit Ethernet for fast data transfers
- High-speed integrated I/O supports printers, scanners, cameras, storage and other devices

Science and Technology

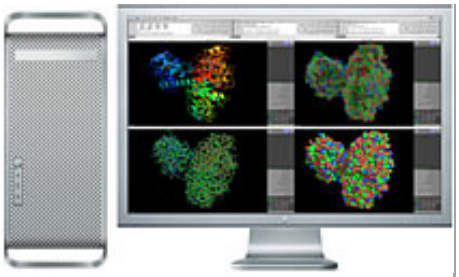
Accelerate Time to Discovery

Modern medical scanners (MRI, CT, and PET) produce gigabyte-sized images. Sets of these images combine to form 3D volumes which researchers can then analyze from any point of view or any angle. These medical volumes consist of hundreds or even thousands of images, and in the past, only doctors with access to expensive imaging workstations could make use of the huge data sets.

Dr. Osman Ratib of UCLA and Dr. Antoine Rosset of the University of Geneva have been working on a solution to bring advanced 3D medical volume rendering out of high-end research institutions and into the hands of doctors, caregivers and patients everywhere. Dr. Ratib, Dr. Rosset and their colleagues have developed the next-generation real-time 3D medical volume-rendering solution. The application is called OsiriX and it runs on a dual-processor Power Mac G5.

In order to allow more doctors and hospitals access to this advanced tool, the solution had to be based on a powerful desktop personal computer rather than an expensive dedicated workstation. And thanks to the 64-bit dual processor Power Mac G5, that's possible today. OsiriX is a multi-threaded application that takes full advantage of the dual 64-bit G5 processors in a Power Mac G5 and is optimized for the Velocity Engine. The Power Mac G5 was also ideal for their application because of its large memory support, reliable UNIX-based operating system, OpenGL support and powerful developer tools.

The Power Mac G5 delivers the performance, ease of use and interoperability you need to accelerate your research and make your next discovery.



64-Bit Breakthrough

Boasting 64-bit processors and the 64-bit memory support of Mac OS X Tiger, the Power Mac G5 shatters the 4GB barrier to support up to 8GB of 400MHz, 128-bit DDR SDRAM — enough to process huge data sets and rich media files within system RAM, without the delay of accessing the disk drive. In fact, 64-bit memory support allows each individual application access to all installable memory. And both 64-bit and 32-bit applications in Tiger can use hardware-accelerated math functions when running on a Power Mac G5.

With the Power Mac G5 and Mac OS X Tiger, a researcher can now run both productivity applications and high-performance UNIX applications on a single system. Mac OS X Tiger includes 64-bit optimized system math, vector and image libraries that take maximum advantage of the 64-bit G5 processor.

Film and Video

Edit HD or Any Format in Real Time

An average reality program generates 100 hours of recorded material for every one hour of completed programming — an astonishing 4TB of data before a show even begins the editing process. Because the post-production process for reality TV is so labor-intensive, Bunim/Murray, producers of the hit show "The Real World," had to find a way to include more creative professionals in the editing process. In short, they had to make advanced editing equipment available to many more editors without accruing substantial capital expense.

The post-production challenge Bunim/Murray faced was in managing the media, storing it, digitizing it and then editing efficiently to find the story buried in hours of footage. Traditionally, high-end video editing and large shared storage solutions have been extremely cost-prohibitive. Bunim/Murray chose an Apple Power Mac G5, Final Cut Pro and Xsan solution and now provides three times as many editors with real-time access to its shared raw footage with no increase in equipment costs.

"The Apple solution pays for itself in about one season," says Mark Raudonis, Bunim/Murray director of post-production. "Then you can put the money you save to work in other ways."

Find out more about how to customize the Power Mac G5 for film and video.

Rendering New Vistas

The Power Mac G5 allows filmmakers and videographers to layer multiple video tracks, quickly render video with an almost unlimited number of real-time effects and transcode to final output.

- Faster G5 processors for more simultaneous streams and real-time effects
- High-bandwidth system architecture accommodates any video format, including HD
- Optimized floating point and Velocity Engine accelerates video processing and rendering
- Fast, integrated I/O supports high-performance storage, networking, PCI-X cards and more

Music and Audio

A Symphony of Capabilities

The Power Mac G5 supports more audio tracks and plug-ins than any previous Power Mac, giving audio professionals a wealth of creative options — all in a native environment. And the built-in optical S/PDIF connects professional as well as consumer audio hardware such as surround sound integrated amplifiers and speaker systems.

Pulse Music Productions in New York City has designed a collaborative, parallel music production workflow using a dual-processor Power Mac G5, Apple Cinema HD display, Logic Pro and ProTools in each of its seven recording studios. All of the rooms are connected to a shared file system, allowing engineers to pass files, session data and tracks instantaneously. This solution puts the same powerful collection of sophisticated instruments and tools into the hands of whomever is working in each room.

Pulse Music loses no time recreating a complicated recording session because it all lives in the Power Mac G5 — ready at a moment's notice — making the process more about the music and less about the gear and setup. This incredibly flexible solution promotes better collaboration because it enables several people to work on different elements of the same production at the same time, resulting in better creativity, better productivity and better music.

Find out more about using the Power Mac G5 for music and audio production.

Studio grade I/O

- Faster G5 processors and up to 8GB of memory for more audio tracks and plug-ins
- 133MHz PCI-X expansion supports the high-performance audio solutions
- Digital optical ports transmit pristine sound
- FireWire, USB and analog audio ports connect audio, MIDI and storage devices

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Power Mac G5

Technology and Performance Overview
June 2005

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The 64-Bit Professional Dream Machine

The Power Mac G5 opens up a wealth of computing opportunities:

- Graphic designers can manipulate Adobe Photoshop images for print, web, and animation almost two times faster than on the fastest Pentium 4–based PC.[1]
- Video producers can edit, add effects, and composite multiple streams of DV, SD, HD, and film content in real time.
- Musicians and audio producers can process an unprecedented number of audio tracks, all with complex filters and digital effects.
- Scientists can execute high-precision math on extremely large data sets and return results faster than ever.
- Artists, game developers, architects, and researchers can model and render complex 3D visualizations at remarkable speeds.

In June 2003, Apple introduced the Power Mac G5 to rave reviews. Designed to meet the high-performance, no-compromise requirements of demanding professionals, the Power Mac G5 made great strides in processing power, broke the 4GB memory barrier, introduced dual independent frontside buses, and came loaded with groundbreaking features. The Power Mac G5 has since established itself as the system of choice across multiple industries—from design and print, to film and video, to music and audio, to science and technology—ideal for designing stunning ad campaigns, mapping the human genome, and everything in between.

Apple now introduces three new dual processor Power Mac G5 systems running at up to 2.7GHz. The new line offers outstanding performance in demanding applications such as Adobe Photoshop, Final Cut Pro, Adobe After Effects, LightWave, Logic, BLAST, and HMMER. All configurations include a new 16x-speed SuperDrive, capable of burning double-layer DVDs with up to 8.5GB of content and perfect for authoring high definition DVDs in widescreen format with multiple languages and audio tracks. Faster standard graphics accelerate creative applications like Motion and popular games like Halo, as well as offering more choices for driving the 30-inch Apple Cinema HD Display. With this combination of industry-leading performance, stunning flat-panel displays, and groundbreaking applications, it's no wonder the Power Mac G5 is the system of choice for creative and scientific professionals.

At the center of this revolutionary system is the PowerPC G5, the ultrafast 64-bit processor developed in collaboration with IBM and produced using state-of-the-art IBM process technology. Combining this advanced processor with dual independent frontside buses, a high-bandwidth system architecture, and plenty of high-speed memory, the Power Mac G5 outperforms even the fastest Pentium 4–based desktop computers in an array of compute-intensive applications.[1]

The Power Mac G5 also features a host of leading-edge, industry-standard technologies. High-speed PCI-X slots allow you to install specialized cards to expand system capabilities and increase performance.[2] Serial ATA enables fast access to up to 800GB of internal storage[3] for huge databases and media assets, and an AGP 8X Pro graphics controller supports the latest generation of graphics cards for eye-popping 2D and 3D visuals. What's more, the Power Mac G5 features an efficient cooling system based on superquiet, low-speed fans and a revolutionary liquid cooling system,[2] all packed into an anodized aluminum chassis with easy access to internal components.

Whether you're a video editor, a musician, a graphic artist, or a scientist, the Power Mac G5 is your path to enhanced creativity and unparalleled productivity. Discover how you can accomplish things you never dreamed possible.

Key Features

The Power Mac G5 sets a new standard for desktop computing. Powerful 64-bit processing, dual independent frontside buses, up to 8GB of fast memory, and the latest I/O technologies are all packed into an amazingly quiet enclosure.

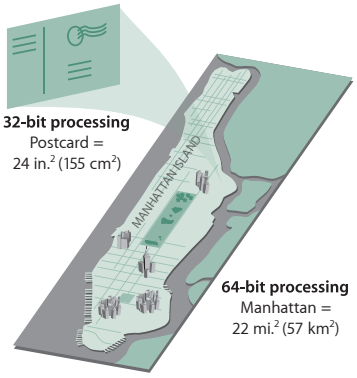
Inside the Power Mac G5

1. **64-bit PowerPC G5 processors.** The ultrafast 64-bit processor—with clock speeds up to 2.7GHz, an optimized Velocity Engine, and two double-precision floating-point units—accelerates all types of applications.
2. **Frontside bus up to 1.35GHz.** The ultrafast frontside bus maximizes processor performance by rapidly transferring instructions and data to and from the processor.
3. **Dual independent frontside buses.** An industry first, dual PowerPC G5 systems have two dedicated frontside buses for an extraordinary combined throughput of up to 21.6 GBps.
4. **400MHz DDR SDRAM.** A superefficient 128-bit memory bus speeds data in and out of main memory at up to 6.4 GBps.
5. **Up to 8GB of addressable memory.** The Power Mac G5 supports system memory up to 8GB,[2] ideal for manipulating high-resolution multimedia files and enormous data sets.
6. **AGP 8X Pro.** The 533MHz, 32-bit graphics interface supports high-performance graphics cards for stunning 2D and 3D visualization.
7. **133MHz PCI-X.** The industry's fastest PCI-X slots allow you to connect to high-performance devices using advanced expansion technology.[2]
8. **Serial ATA.** Serial ATA is the latest ATA mass storage technology. The Power Mac G5 has two independent channels of 150-MBps Serial ATA for fast access to high-capacity hard drives, providing up to 800GB of internal storage.[3]
9. **16x SuperDrive with double-layer support.** A versatile DVD+R DL/DVD±RW/CD-RW optical drive supports data archiving and media authoring with up to 8.5GB of content on new double-layer DVD media.
10. **Wireless connections.** Add an AirPort Extreme Card to network wirelessly[4]; add Bluetooth to connect to cell phones, PDAs, or Apple's wireless keyboard and mouse.
11. **High-performance I/O.** Fast ports make it easy to connect to the latest industry-standard solutions: Gigabit Ethernet networks, FireWire 800 and USB 2.0 peripherals, and optical digital audio equipment.
12. **Quiet enclosure.** The Power Mac G5 sports an innovative chassis designed to cool system components efficiently for the quietest possible operation.

Ultrafast 64-Bit PowerPC G5 Processor

The Power Mac G5 marked the arrival of a 64-bit architecture to the personal computer market. An all-new implementation of the PowerPC architecture, the G5 processor is based on the execution core of IBM's POWER Architecture. Apple has teamed with IBM to leverage this industry-leading design for the next generation of personal computing.

The result? The revolutionary PowerPC G5, with clock speeds of up to 2.7GHz, puts enormous, seemingly infeasible tasks within easy reach. In addition to a highly parallel execution core, it uses 64-bit data paths and registers to complete huge integer calculations and highly precise floating-point math in a single clock cycle—dramatically accelerating audio, video, graphics, and scientific workflows. In addition, 64-bit processing delivers a similarly dramatic leap in the amount of memory supported, enabling the Power Mac G5 to utilize up to 8GB of memory.



4.3 billion times bigger
To grasp the enormous leap from 32-bit to 64-bit processing, imagine equating the range of numbers a processor can express with a two-dimensional area. A 32-bit processor can express a range of integers equal to the size of a postcard, while a 64-bit processor can express a range of integers larger than the island of Manhattan.

An Exponential Leap in Computing Power

The labels "32-bit" and "64-bit" characterize the width of a microprocessor's data stream, which is a function of the sizes of its registers and the internal data paths that feed the registers. A 64-bit processor moves data and instructions along 64-bit-wide data paths—compared with the 32-bit-wide paths on 32-bit processors, such as Intel's Pentium 4 and Xeon. In addition, 64-bit processors have wide registers that can store extremely large or extremely precise 64-bit numbers.

The leap from 32-bit to 64-bit processing represents an exponential advance in computing power. With 32-bit registers, a processor has a dynamic range of 2^{32}, or 4.3 billion—which means it can express integers from 0 to 4.3 billion. With 64-bit registers, the dynamic range catapults to 2^{64}, or 18 billion billion—4.3 billion times larger than the range of a 32-bit processor. This means that computations involving very large integers or very precise numbers with extended decimals can be completed in one pass through the functional units, rather than several passes.

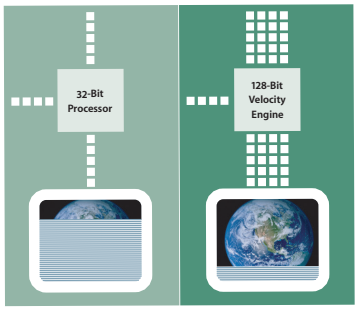
Vast Amounts of Addressable Memory

64-bit memory addressing
In Mac OS X v10.4 "Tiger," 64-bit memory addressing allows applications to break the 4GB memory barrier, enabling an individual process to address all of the available memory installed in the system (up to 8GB).

The move to 64-bit processing results in a similarly dramatic leap in the amount of memory supported. Computers keep track of data stored in memory using memory addresses. A memory address is a special kind of integer, which points to one byte in memory. Since memory addresses are computed in 64-bit registers capable of expressing integers up to 18 billion billion, the PowerPC G5 can theoretically address 16 exabytes (18 billion billion bytes) of virtual memory.

In practice, memory addressing is defined by the physical address space of the processor. The PowerPC G5, with 42 bits of physical address space, supports a colossal 2^{42} bytes, or 4 terabytes, of system memory. Although it's not currently feasible to purchase 4 terabytes of RAM, the advanced architecture of this processor allows for plenty of growth in the future.

More practical and still unprecedented for most personal computers, the Power Mac G5 can be configured with 8GB of addressable memory[2]—four times more than what is supported by a typical PC. Such large quantities of memory enable the system to contain a complex 3D model, massive digital images, a scientific simulation, or a sequence of video entirely in RAM. When data is stored in memory, the processor can access it 40 times faster than from the hard drive, drastically reducing the time to access, modify, and render the data and making it feasible to tackle gigantic projects on a desktop system.



The Velocity Engine can manipulate 128 bits of data per clock cycle, up to four times more than a 32-bit processor's general processing unit.

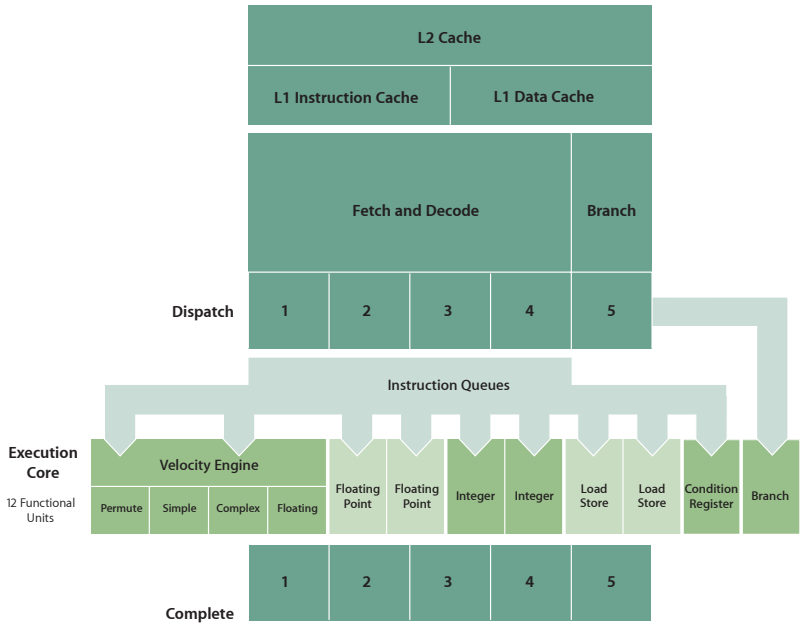
Next-Generation PowerPC Architecture

The PowerPC G5 is a highly parallel implementation of the PowerPC architecture, capable of handling large numbers of tasks at the same time. It's based on the execution core of the IBM POWER Architecture that drives IBM's top-of-the-line enterprise servers.

Apple and IBM leveraged this industry-leading design to introduce the 64-bit PowerPC G5 processor into the next generation of personal computers. The development of the PowerPC G5 builds on previous PowerPC designs, combining an optimized Velocity Engine and two double-precision floating-point units with a superscalar, superpipelined execution core that supports up to 215 simultaneous in-flight instructions. This high-bandwidth core has over 12 discrete functional units that can process instructions in parallel.

For more information about the PowerPC G5 architecture, see www.apple.com/g5processor.

PowerPC G5 Architecture



The execution core contains 12 discrete functional units:

- A dual-pipelined Velocity Engine uses two very large queues and dedicated 128-bit registers to perform single-instruction, multiple-data (SIMD) processing.
- Two 64-bit double-precision floating-point units provide the speed and accuracy required for highly complex mathematical computations.
- Two 64-bit integer units perform calculations for a broad range of simple and complex computing tasks.
- Two load/store units manage data as it is processed, keeping the processor's registers filled for faster operations.
- The condition register stores the results of branch predictions to improve the accuracy of future predictions.
- The branch prediction unit uses innovative three-component logic that increases the accuracy of speculative operation and maximizes processor efficiency.

Native Compatibility with 32-Bit Application Code

The PowerPC architecture was designed from the beginning to run both 32-bit and 64-bit application code. This means the transition to 64-bit performance is seamless: 32-bit code—such as Classic applications—runs natively at processor speed, with no interruptions to your workflow and no required additional investments in software.

IBM is a worldwide leader in semiconductor processor technologies, with a $3 billion, state-of-the-art facility in East Fishkill, New York.

State-of-the-Art Process Technology from IBM

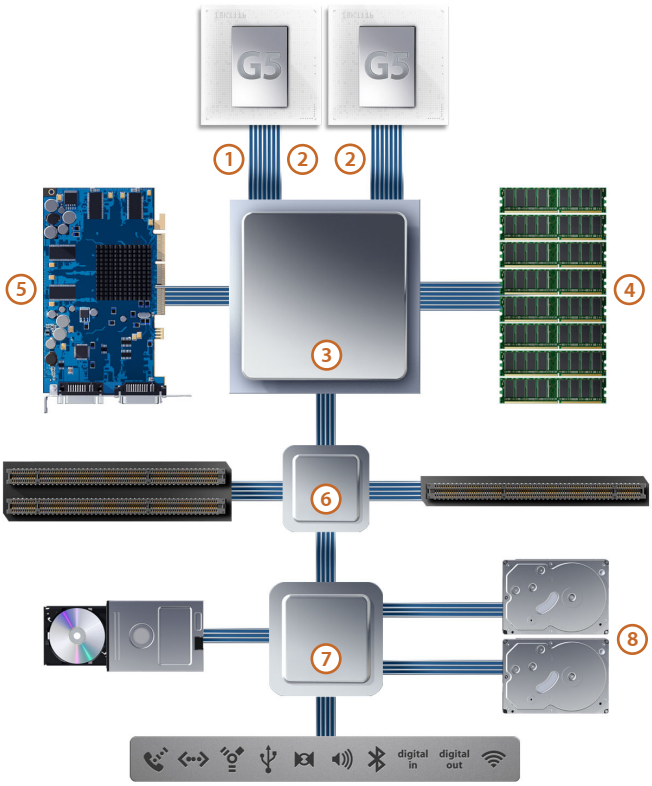
The PowerPC G5 is fabricated in one of IBM's world-class semiconductor manufacturing facilities. It uses 90-nanometer circuitry with more than 400 meters (1300 feet) of ultrathin copper wiring—less than 1/1000 the width of a human hair. With more than 58 million transistors, a high-performance silicon-on-insulator (SOI) process for faster operation, and copper interconnects for improved conductivity, this scalable design contributes to clock speeds of up to 2.7GHz.

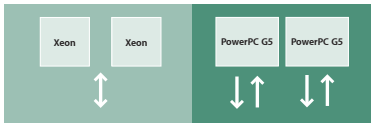
High-Bandwidth System Architecture

The Power Mac G5 matches the advanced technology of the PowerPC G5 with a high-bandwidth system architecture. It begins with a frontside bus running at up to 1.35GHz—one on each processor in dual processor systems—for maximum throughput to and from the PowerPC G5. A point-to-point system controller allows data to move directly between all subsystems, without impacting the processor. Bandwidth is further optimized by a 400MHz, 128-bit memory bus; an AGP 8X Pro graphics bus; and a HyperTransport interface that connects the PCI-X controller and the I/O subsystems to the system controller. The result is phenomenal throughput for tackling the most intensive image editing, media production, and scientific computing tasks—alleviating the limitations and bottlenecks of the traditional PC.

System Architecture

1. **Frontside bus up to 1.35GHz.** Provides up to 10.8-GBps bandwidth per processor.
2. **Dual independent frontside buses.** Provide up to 21.6-GBps aggregate bandwidth.[2]
3. **Advanced system controller.** Uses a point-to-point architecture to enable data to pass directly between subsystems.
4. **400MHz memory.** A 128-bit memory architecture supports high-speed PC3200 DDR SDRAM.
5. **AGP 8X Pro graphics bus.** At 533MHz, doubles the throughput of AGP 4X and provides added power for high-performance graphics cards.
6. **133MHz PCI-X expansion.** Supports advanced high-performance PCI devices, providing total throughput of up to 2 GBps.[2]
7. **High-performance I/O.** Integrates hard disk drives; SuperDrive; and FireWire 800, USB 2.0, networking, and optical digital audio ports.
8. **Serial ATA storage.** Supports 150-MBps Serial ATA drives for up to 800GB of fast internal storage.[3]





The dual-channel frontside bus allows data to travel to and from the PowerPC G5 processor at the same time. Each PowerPC G5 has its own dedicated interface to maximize throughput—compared with dual Xeon-based systems, in which the processors must share a single bus.

Up to 1.35GHz Frontside Bus

The performance advantages of the PowerPC G5 begin with an innovative Double Data Rate (DDR) frontside bus that speeds up communication between the processor and the memory controller. Unlike conventional processor interfaces, which carry data in only one direction at a time, this dual-channel frontside bus has two 32-bit point-to-point links (64 bits total): One link travels into the processor and another travels from the processor, which means no wait time while the processor and the system controller negotiate which will use the bus or while the bus switches direction. This enables data to move in opposite directions simultaneously and is a dramatic improvement over previous processor interfaces. The elastic interface self-tunes during startup for optimal signal quality.

Each G5 processor has its own bidirectional interface to the system controller, for total bandwidth of up to 21.6 GBps—over two times the 8.5-GBps maximum bandwidth of Pentium 4–based systems. In addition to providing fast throughput to main memory, this high-performance frontside bus architecture enables each PowerPC G5 to discover and access data in the other processor's caches—further increasing performance on dual processor systems.

Advanced System Controller

An advanced system controller is central to the overall performance of the Power Mac G5. This revolutionary application-specific integrated circuit (ASIC)—among the industry's fastest—is built using the same state-of-the-art IBM process technology as the PowerPC G5 processor. A superefficient point-to-point architecture provides each primary subsystem with dedicated throughput to main memory, so massive amounts of data can traverse the system without contention for bandwidth. In contrast, subsystems that share a bus, as on other personal computers, must deal with time-consuming arbitration while they negotiate for access and bandwidth across a common data path.

400MHz Memory

The Power Mac G5 features a 128-bit memory controller supporting 400MHz DDR SDRAM. DDR memory allows the system to read and write data on both the rising and falling edge of each clock cycle. By combining fast DDR memory with a wider 128-bit interface that can address two banks of SDRAM at a time, the Power Mac G5 can reach a memory throughput of up to 6.4 GBps—more than double the throughput of the Power Mac G4. For even greater performance, direct memory access (DMA) works with the point-to-point system controller to give each subsystem—such as PCI and graphics slots—its own 6.4-GBps interface to main memory, without needing to interact with the processor.

With the 64-bit G5 processor, the Power Mac G5 can address more memory than any previous Macintosh and many desktop PCs. Power Mac G5 systems can hold up to eight DIMMs for up to 8GB of memory.[2] This high-speed, high-capacity memory architecture enables graphics, video, audio, and scientific applications to run radically faster. Enormous files and data sets can be loaded into RAM for rapid access by the PowerPC G5—without having to access system storage. Data can be retrieved from memory 40 times faster than from the hard drive. In fact, accessing the first critical word of data from memory is 60,000 times faster than from a hard drive, so manipulation and analysis of data can be performed at remarkable speeds.

AGP 8X Pro Graphics Bus

The Power Mac G5 utilizes the AGP 8X Pro graphics interface for high-performance gaming and advanced graphics production. Compared with the AGP 4X interface in previous Power Mac systems, this specification doubles the maximum transfer rate and doubles the amount of data transferred in a single AGP bus cycle. The 32-bit, 66MHz AGP 8X Pro bus strobes eight times per clock cycle, resulting in a 533MHz data rate and a maximum bandwidth of 2.1 GBps. This increased performance enables graphics-intensive applications to achieve higher resolutions with improved complexity and texturing, for a more immersive visual experience. The "Pro" component of the AGP 8X Pro specification allows for additional electrical power for the latest graphics solutions.

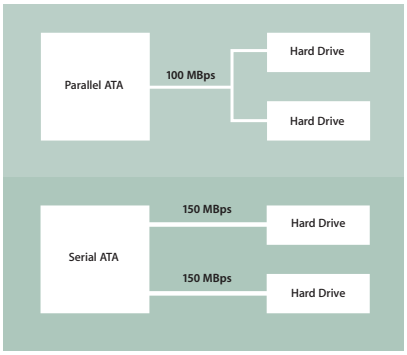
133MHz PCI-X Expansion

PCI-X is an advanced expansion protocol that addresses the need for higher-performance PCI devices, increasing the speed from 33MHz to 133MHz and throughput from 266 MBps to 2 GBps. PCI-X also operates more efficiently than PCI, resulting in more usable bandwidth at any clock frequency—ideal for high-bandwidth applications. The PCI-X specification uses 3.3V signaling and is designed for compatibility with legacy 3.3V and Universal cards.[5]

High-Performance I/O

The Power Mac G5 architecture uses the HyperTransport protocol to integrate the I/O subsystems and connect them to the system controller. Serial ATA, Gigabit Ethernet, FireWire, USB 2.0, optical digital audio, and analog audio are all integrated through two bidirectional 800MHz HyperTransport interconnects for a maximum throughput of 1.6 GBps.

For more information about the many expansion and I/O options available on the Power Mac G5, see the section "State-of-the-Art Expansion."



Serial ATA versus Parallel ATA
The Power Mac G5 holds two internal Serial ATA drives, each on an independent bus—so there is no competition for drive performance, as with Parallel ATA.

Serial ATA Storage

Serial ATA is the next-generation industry-standard storage interface, replacing the Parallel ATA interface. Designed to keep pace with the demands of digital video creation and editing, audio storage and playback, and other data-intensive applications, Serial ATA supports 1.5-Gbps throughput per channel (equivalent to a data rate of 150 MBps).

The Power Mac G5 can hold two internal Serial ATA drives for a total capacity of up to 800GB of storage.[3] Each drive is on an independent bus, so there's no competition for drive performance, as with Parallel ATA. Performance is improved even further when drives are striped using software RAID in Mac OS X.

A Giant Leap over the Power Mac G4

The Power Mac G5 represents a huge leap over its predecessor. With the 64-bit G5 processor, high-bandwidth architecture, and state-of-the-art expansion options, Power Mac G5 users will realize performance gains in media authoring, video editing, real-time effects, audio synthesis, image processing, 3D rendering, numerical analysis, and physical modeling.

Compare the top-of-the-line dual 1.42GHz Power Mac G4 with the dual 2.7GHz Power Mac G5:

	Power Mac G4	**Power Mac G5**
Processor	32-bit PowerPC G4	64-bit PowerPC G5
Clock speed	1.42GHz	2.7GHz
Frontside bus	167MHz	1.35GHz per processor
Frontside bus bandwidth	1.3 GBps	10.8 GBps
Dual processor interface	One shared bus	Two independent buses
Dual processor bandwidth	1.3 GBps	21.6 GBps
Maximum memory	2GB	8GB
Memory	333MHz, 64-bit DDR SDRAM	400MHz, 128-bit DDR SDRAM
Memory bandwidth	2.7 GBps	6.4 GBps
Graphics	AGP 4X	AGP 8X Pro
PCI expansion	33MHz, 64-bit PCI	133MHz, 64-bit PCI-X
PCI throughput	266 MBps	2 GBps
ATA storage	100 MBps shared	Two 150-MBps channels

High-Performance Graphics and All-Digital Displays

Today 3D graphics produced on the Power Mac G5 are everywhere—from high-end animation in motion pictures, TV, and games to detailed modeling for architecture, engineering, and scientific visualization. In fact, Mac OS X uses visual effects and real-time performance pioneered in 3D gaming to create the stunning look and feel of the Aqua interface. Whether you create graphics or enjoy them onscreen, the Power Mac G5 is the ideal platform for an impressive 3D experience.

3D graphics and models, animation, visualization, and the latest generation of games require the fastest graphics cards available. The Power Mac G5 features a powerful AGP 8X Pro graphics interface and the latest in high-performance graphics cards from NVIDIA and ATI. For crystal-clear viewing, Apple's widescreen, all-digital displays are the perfect complement to the Power Mac G5. And support for dual displays—including two Apple Cinema Displays—is built into every system.[6]

AGP 8X Pro Graphics Options

Every Power Mac G5 system is built with a graphics card installed in the 533MHz AGP 8X Pro slot.

ATI Radeon 9600 and 9650
Standard Power Mac G5 configurations feature the ATI Radeon 9600 or the ATI Radeon 9650, which provide excellent all-around performance for users working in 2D and 3D environments. These programmable graphics cards are built on a quad-pipe architecture with SmartShader 2.0 technology and the HyperZ III+ memory architecture. Capable of delivering 1.3 billion and 1.6 billion textured pixels per second, respectively, both cards allow users to experience movie-quality effects for ultrarealism in next-generation 3D games and digital content creation applications. The Radeon 9600 features 128MB of video SDRAM and two DVI ports, allowing it to support up to two 20- or 23-inch Apple Cinema Displays, as well as industry-standard VGA and DVI displays. The Radeon 9650 speeds up performance with 256MB of video memory and has one standard DVI port and one dual-link DVI port. This allows the system to support a 30-inch Apple Cinema HD Display and a 20- or 23-inch Apple Cinema Display simultaneously.

Standard Graphics Cards

	ATI Radeon 9600	ATI Radeon 9650
Memory interface	128-bit	128-bit
Render pipelines	Four	Four
Frame buffer memory	128MB DDR SDRAM	256MB DDR SDRAM
Vertices per second	163 million	200 million
Fill rate (texels per second)	1.3 billion	1.6 billion
Memory bandwidth	6.4 GBps	8.6 GBps
Ports	Two DVI	DVI and dual-link DVI
Slots occupied	One	One

ATI Radeon X850 XT

For blockbuster entertainment and design, you can upgrade to the ATI Radeon X850 XT. This card is based on the next-generation graphics architecture from ATI, featuring 16 parallel pixel pipelines and memory bandwidth of up to 34.6 GBps. New technologies include the SmartShader HD shader engine and Smoothvision HD with 3Dc for advanced texture filtering and image enhancement. The Radeon X850 XT has 256MB of GDDR3 video memory, one ADC port and one dual-link DVI port, allowing it to support both a 30-inch Apple Cinema HD Display and a 20- or 23-inch Apple Cinema Display.

NVIDIA GeForce 6800 GT DDL

If over-the-top gaming performance, intensive 3D design work, or using two 30-inch Apple Cinema HD Displays heads your list, configure your Power Mac G5 with the NVIDIA GeForce 6800 GT DDL graphics card.[7] One of the fastest graphics cards available, it delivers up to 32 GBps of memory throughput. The GeForce 6800 GT DDL includes 256MB of ultrafast GDDR3 memory and two dual-link DVI ports. Each port is capable of supporting 2560-by-1600-pixel resolution, allowing you to connect two 30-inch Apple Cinema HD Displays for an amazing 8 million pixels of screen real estate.

Build-to-order Graphics Cards

	ATI Radeon X850 XT	NVIDIA GeForce 6800 GT DDL
Memory interface	256-bit	256-bit
Render pipelines	16	16
Frame buffer memory	256MB GDDR3	256MB GDDR3
Vertices per second	761 million	525 million
Fill rate (texels per second)	8.1 billion	5.6 billion
Memory bandwidth	34.6 GBps	32 GBps
Ports	One ADC, One dual-link DVI	Two dual-link DVI
Slots occupied	One	Two[7]

3D Graphics Performance

In today's dual processor Power Mac G5 systems, the Quartz Extreme feature of Mac OS X leverages the power of the graphics processors by offloading OpenGL and QuickTime tasks to the graphics chip, thus freeing up the main processors for other tasks. To provide 3D performance for the varied needs of Power Mac G5 users, Apple offers a selection of graphics cards to choose from. We compared the ATI Radeon 9650, ATI Radeon X850 XT and the NVIDIA GeForce 6800 GT DDL on a dual 2.7GHz Power Mac G5 to illustrate the relative performance of each graphics card in design and gaming scenarios.

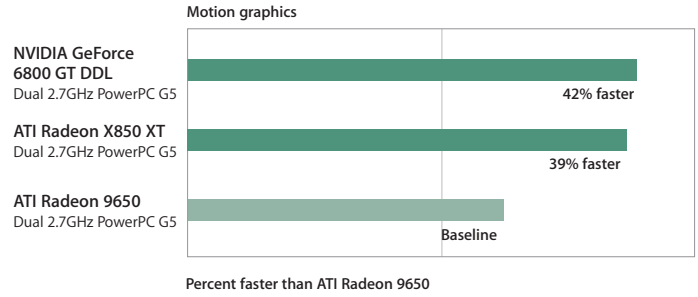
Motion 2
The world's first real-time motion graphics application with GPU-accelerated 32-bit float rendering. For more information, visit www.apple.com/finalcutstudio/motion.

Motion graphics

Motion, Apple's real-time motion graphic design application, uses self-propelled behaviors, character-by-character title animation, and natural simulations to enhance multimedia productions. Optimized for the Power Mac G5, Motion leverages the graphics processor to animate effects onscreen in real time, providing instant animations for a high-speed workflow. The test protocol measured the uncached playback, cached playback, and export to QuickTime of a project, simultaneously applying lens flare, kaleidoscope, contrast, saturate, sphere, and Gaussian blur filters to a 20-second NTSC video clip.

Motion 2.0 Filter Test Results

Over 40% faster than the standard ATI Radeon 9650



The dual 2.7GHz Power Mac G5 configured with the NVIDIA GeForce 6800 GT DDL completed the Motion filter test 42% faster than the dual 2.7GHz Power Mac G5 with the standard ATI Radeon 9650.

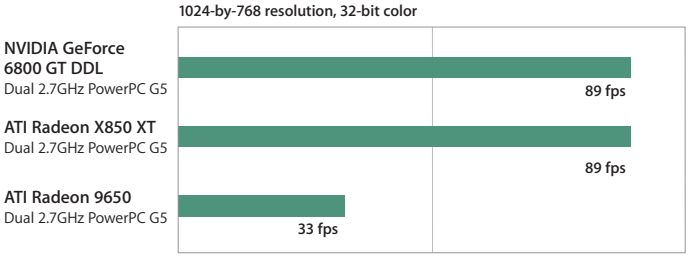
Testing conducted by Apple in June 2005 using dual 2.7GHz Power Mac G5 units and preproduction video cards.

3D gaming

3D gaming involves complex visualizations and rapid movements that require maximum processor performance and top-of-the-line graphics capabilities. The Power Mac G5 provides a robust platform that not only supports the latest 3D technologies, but also delivers a great gaming experience. Superfast graphics performance and 64-bit G5 processors combine to deliver more frames per second at higher resolutions—all with more complexity and better texturing than ever before. Frame rates were measured using the game Halo, one of the most popular gaming titles on the market today, which leverages the programmability features of the graphics card. The Time Demo benchmark built into Halo was run at 1024-by-768 resolution using the advanced pixel shaders option (version 1.4).

Halo Results

Almost 3 times the frames per second of the standard ATI Radeon 9650



The dual 2.7GHz Power Mac G5 configured with the NVIDIA GeForce 6800 GT DDL or ATI Radeon X850 XT played 56 more frames per second than the dual 2.7GHz Power Mac G5 with the standard ATI Radeon 9650.

Testing conducted by Apple in June 2005 using dual 2.7GHz Power Mac G5 units and preproduction video cards. Halo was tested using the Time Demo benchmark with advanced pixel shaders (1.4).

Choosing a Graphics Card

When selecting a graphics card for the Power Mac G5, you should consider performance features such as the amount of frame buffer memory; vertices and texels per second; memory bandwidth; support for the 30-inch Apple Cinema HD Display; and the card's general usage profile.

Card	ATI Radeon 9600	ATI Radeon 9650	ATI Radeon X850 XT	NVIDIA GeForce 6800 GT DDL
Memory interface	128MB	256MB	256MB	256MB
Vertices per second	163 million	200 million	761 million	525 million
Fill rate (texels per second)	1.3 billion	1.6 billion	8.1 billion	5.6 billion
Memory bandwidth	6.4GB	8.6GB	34.6GB	32GB
Support for 30-inch Apple Cinema HD Display	No	One	One	Two
Ideal for	All-purpose computing and basic 2D/3D applications	Additional, faster memory for large textures and a faster GPU for better 2D/3D application performance	Fastest memory and most advanced GPU for demanding 2D/3D applications	Fastest memory and most advanced GPU for demanding 2D/3D applications

Apple Cinema Displays

Apple offers a line of pure-digital flat-panel LCD displays that provide superior image quality, vivid color, and the industry's best wide-viewing technology. With a compact footprint to fit neatly in your work environment and an aluminum design to match the Power Mac G5, the Apple Cinema Displays deliver the benefits of thin and light LCD technology, with twice the brightness, twice the sharpness, and twice the contrast of a standard CRT display. All three Apple Cinema Displays can be calibrated for color-managed workflows and will maintain consistent color and quality without frequent recalibration.

Apple Cinema Displays

Choose from these flat-panel displays:

- 20-inch Apple Cinema Display (1680 by 1050 pixels)
- 23-inch Apple Cinema HD Display (1920 by 1200 pixels)
- 30-inch Apple Cinema HD Display (2560 by 1600 pixels)

Two Apple Cinema Displays in extended desktop mode provide an extrawide viewing area.[6]

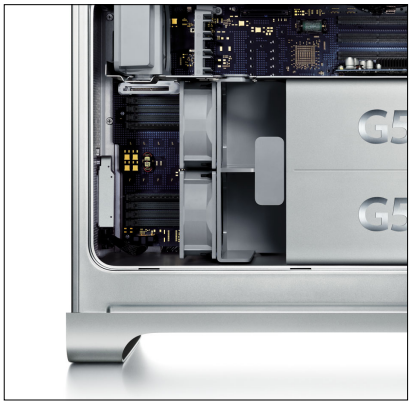
Support for Dual Displays

All Power Mac G5 systems support two Apple Cinema Displays,[6] which can be used in extended desktop or video mirroring mode. Extended desktop mode lets you distribute work across two displays, allowing more room for viewing rich content and complex applications that use floating palettes and long timelines. For example, Final Cut Pro users can view the application interface on the primary display while watching the final video output on the other. Video mirroring outputs identical information on both displays, enabling you to control a presentation on one display while the audience watches it on a second display or projected image.

A DVI to VGA Adapter is included with every Power Mac G5 for connecting to VGA displays, such as CRTs or projectors. For even more flexibility, you can order the Apple DVI to Video Adapter to connect to S-video and composite devices, such as TVs, VCRs, or overhead projectors with S-video or RCA (composite) connectors.

For more information about Apple Cinema Displays, visit www.apple.com/displays.

State-of-the-Art Expansion



With the removable side panel, DIMM slots are easy to access.

The Power Mac G5 is packed with state-of-the-art technologies, making it easy to expand the capabilities of your system as your projects grow and your workflow evolves. A removable side panel provides quick access to slots and bays, so you can add memory, a second hard drive, or an AirPort Extreme Card—all without tools. Ports on the front and back panels allow you to plug in a variety of industry-standard input and output devices, including optical digital audio components, high-bandwidth FireWire devices, and USB 2.0 peripherals.

Up to 8GB of Main Memory

Power Mac G5 systems have four or eight DIMM slots that use fast PC3200 DDR SDRAM. This high-performance memory operates at 400MHz for a throughput of up to 6.4 GBps. Standard configurations come with 512MB of RAM; memory is scalable up to 8GB,[2] so you can add RAM as your application and workflow requirements increase.

PCI-X Expansion Slots

The use of PCI cards or higher-performance PCI-X cards enables the Power Mac G5 to perform specialized tasks, such as video capture and playback or audio digital signal processing (DSP). For massive system storage, you can add a Fibre Channel PCI-X Card to connect to Xserve RAID, Apple's high-performance storage system.

Systems can be configured with PCI or PCI-X expansion technology: Three 64-bit PCI-X slots allow you to add one card running at 133MHz and two cards running at 100MHz; or three 64-bit PCI slots allow you to add three 33MHz cards. PCI-X is designed to support 3.3V signaling and Universal 33MHz and 66MHz PCI cards.[5]

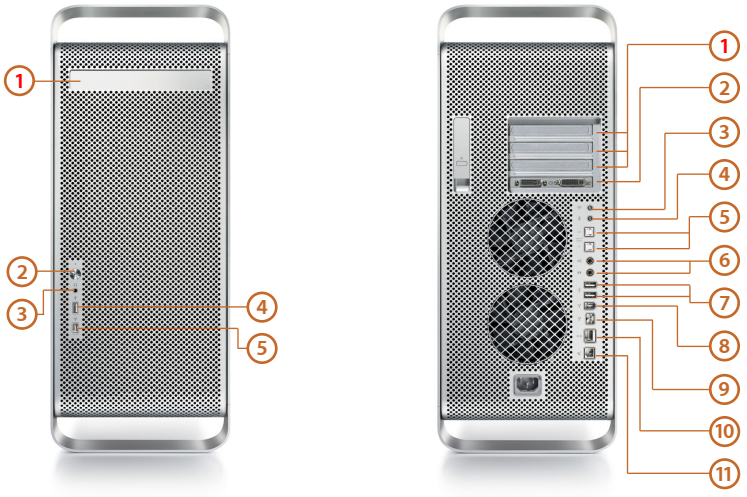
To install a new hard drive, just attach the drive guides and slide the drive onto the tracks until it clicks into place.

Up to 800GB of Internal Storage

The Power Mac G5 has two Serial ATA hard drive bays for up to 800GB of fast internal mass storage[3]—ideal for video, audio, and high-resolution graphics. Built-in software RAID allows you to stripe the two drives for increased performance or mirror them for high reliability.

It's easy to add storage as your needs grow. Single-drive systems come with the cabling to connect a second hard drive, and the easy-to-remove side panel allows you to insert a new drive yourself, without tools.

Connecting to the Power Mac G5



Front View

1. 16x SuperDrive
2. Power button
3. Headphone minijack
4. USB 2.0
5. FireWire 400

Rear View

1. PCI-X slots
2. DVI ports
3. AirPort antenna port
4. Bluetooth antenna port
5. Optical digital audio input/output
6. Analog audio input/output
7. USB 2.0
8. FireWire 400
9. FireWire 800
10. Gigabit Ethernet
11. Modem (build-to-order option)

Double-layer DVD
Double-layer DVD (DVD+R DL) discs have two layers, increasing their capacity up to 8.5GB on a single DVD. Similar to DVD-9 for commercially distributed DVD movies, a double-layer disc provides more space for high-bit-rate HD video.

Versatile SuperDrive

The SuperDrive built into every Power Mac G5 reads and writes a wide variety of DVD and CD media, and it now includes support for double-layer (DVD+R DL) discs capable of holding up to 8.5GB of data.

While traditional blank DVD-R discs have a single layer and hold up to 4.7GB of data, double-layer discs have two layers of data, one of them semitransparent. This allows the laser in the SuperDrive to read and write on either layer, almost doubling the storage space available. Using iDVD 5, included with every Power Mac G5, you can author discs with over 3.5 hours of video encoded in standard MPEG-2 format on one DVD+R DL disc. Compare that with 2 hours of video on a standard DVD-R disc.

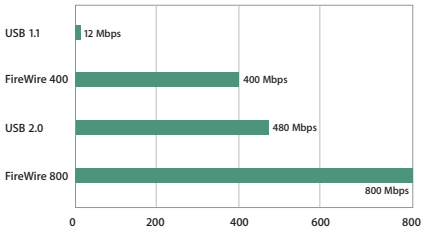
For DVD authors, the extra capacity of double-layer media is important for high-bit-rate video formats such as H.264, the latest format for professional DVD authoring.[8] Professional applications such as DVD Studio Pro offer the ability to author projects in widescreen format using high definition video. The additional disc capacity also allows for extra features such as additional languages, multiple soundtracks, and supplementary video angles.

DVD Studio Pro 4
The first commercially available DVD authoring software that burns high definition DVDs to the latest HD DVD specifications. For more information, visit www.apple.com/finalcutstudio/dvdstudiopro.

In the DVD authoring workflow, the ability to burn a commercial-quality project directly to a double-layer disc from the Power Mac G5 is a great benefit. Previously, DVD authors required a replication service to burn their project to a double-layer disc for review before duplication. Now you can burn multiple copies of your final DVD for quality assurance directly from the SuperDrive, simplifying your workflow and saving service bureau fees.

For professional photographers, double-layer DVDs make an excellent medium for storing high-quality digital images. A DVD+R DL disc provides enough space to archive an entire shoot—over 650 13MB RAW-format images can be burned on one double-layer disc, compared with approximately 350 images on a standard DVD-R.

Apple applications such as DVD Studio Pro, iDVD, and iTunes burn content right to disc, making it easy to author CDs and DVDs for use in most professional and consumer players. In Mac OS X you can archive to CD and DVD directly from the Finder. The industry-standard SuperDrive reads dozens of standard CD and DVD formats. It writes DVD-R discs at up to 16x speed, writes DVD+R DL discs at up to 4x speed, reads DVDs at up to 16x speed, writes CD-R and CD-RW discs at up to 24x speed, and reads CDs at up to 32x speed.



FireWire 800 versus USB 2.0
FireWire 800 has a maximum throughput of 800 Mbps, almost twice that of USB 2.0 at 480 Mbps.

FireWire and USB 2.0

FireWire is one of the fastest peripheral standards ever developed, making it easy to connect high-bandwidth devices such as DV cameras, hard drives, and digital music players. And since FireWire cables carry power, the Power Mac G5 can recharge your portable device's batteries, even while you're using the device.

All Power Mac G5 systems have one FireWire 400 port on the front and one on the back of the enclosure, as well as a next-generation FireWire 800 port on the back. FireWire 800 doubles the throughput of the original FireWire 400, from 400 to 800 Mbps.[9] The FireWire 800 port can also connect to FireWire 400 devices using the appropriate 9-pin-to-6-pin or 9-pin-to-4-pin cable. In addition, FireWire 800 works over distances of up to 100 meters, making it ideal for operation in larger facilities.

Three USB 2.0 ports, one on the front and two on the back—plus two USB 1.1 ports on the keyboard—connect to printers, scanners, graphics tablets, keyboards, microphones, speakers, joysticks, and other industry-standard input and output devices.

For more information, see www.apple.com/firewire and www.apple.com/usb.

Wired and Wireless Networking

Gigabit (10/100/1000BASE-T) Ethernet is built into every Power Mac G5, and the auto-sensing port even makes it possible to connect two systems directly, without the need for a crossover cable. Wireless networking is just as simple using the optional 54-Mbps AirPort Extreme Card and AirPort Express or AirPort Extreme Base Station.[4]

Bluetooth allows short-range wireless connections to a variety of digital devices, such as cell phones, personal digital assistants, printers, and Apple's wireless keyboard and mouse. The Power Mac G5 offers an optional Bluetooth 2.0 + EDR (Enhanced Data Rate) module and antenna. At a maximum data rate of 3 Mbps, it is up to three times faster than its predecessor (Bluetooth 1.0) and is completely backward compatible. An internal 56K V.92 modem is also available as a build-to-order option.[10]

For more information, see www.apple.com/airport and www.apple.com/bluetooth.

Optical Digital Audio

Soundtrack Pro
A revolutionary new audio editing and sound design application that makes video projects sound as good as they look. For more information, visit www.apple.com/finalcutstudio/soundtrackpro.

The Power Mac G5 features a comprehensive set of audio capabilities not commonly found in personal computers. State-of-the-art optical digital audio input and output ports use the S/PDIF (Sony/Philips Digital Interface) protocol over Toslink cables for connecting to devices such as decks, receivers, digital instruments, and even home theater systems. The optical digital audio ports on the Power Mac G5 support stereo and 5.1 surround sound speaker systems. Because optical digital audio transmits data as impulses of light rather than electrical signals, it enables true noise-free, pristine sound, eliminating troublesome ground loops.

Optical digital audio specifications

	Input	Output
Data format	S/PDIF (IEC60958-3)	S/PDIF (IEC60958-3)
Connector type	Toslink optical (IEC60874-17)	Toslink optical (IEC60874-17)
Sample rates		
– External clock mode	32kHz, 44.1kHz, or 48kHz	32kHz, 44.1kHz, or 48kHz
– Internal clock mode	16kHz to 96kHz	32kHz, 44.1kHz, or 48kHz
Bits per sample	16 or 24	16 or 24
Signal-to-noise ratio		
– External clock mode	Greater than 130 dB	Greater than 130 dB
– Internal clock mode	Greater than 110 dB	Greater than 130 dB
Total harmonic distortion		
– External clock mode	Less than 0.00003 percent	Less than 0.00003 percent
– Internal clock mode	Less than 0.0003 percent	Less than 0.00003 percent

Based on typical performance specifications.

Analog Audio

Completing the audio features of the Power Mac G5 are high-quality, analog stereo audio line input and line output ports; and a convenient minijack on the front panel that makes it easy to plug in headphones.

Analog input specifications

	Line input
Sample rates	32kHz, 44.1kHz, or 48kHz
Bits per sample	16 or 24
Jack type	3.5-mm stereo
Input impedance	Greater than 47K ohms
Maximum input voltage	$2V_{rms}$ (+8.2 dBu)
Frequency response	20Hz to 20kHz, +0.5 dB/–3 dB
Signal-to-noise ratio	Greater than 90 dB
Total harmonic distortion	Less than 0.006 percent

Based on typical performance specifications.

Analog output specifications

	Line output	**Headphone jack**
Sample rates	32kHz, 44.1kHz, or 48kHz	32kHz, 44.1kHz, or 48kHz
Bits per sample	16 or 24	16 or 24
Jack type	3.5-mm stereo	3.5-mm stereo
Output impedance	24 ohms	24 ohms
Output voltage	$1.4V_{rms}$ (+4.1 dBu)	$1.4V_{rms}$ (+4.1 dBu)
Frequency response	20Hz to 20kHz, +0.5 dB/–3 dB	20Hz to 20kHz, +0.5 dB/–3 dB
Signal-to-noise ratio	Greater than 90 dB	Greater than 90 dB
Total harmonic distortion	Less than 0.01 percent	Less than 0.01 percent
Output power (into 32 ohms)	—	20 mW

Based on typical performance specifications.

Innovative Enclosure Design for Quiet Operation

An industry-leading system demands an exceptional enclosure design. The Power Mac G5 features a modern chassis constructed of anodized aluminum for a sleek, professional exterior. Inside, the efficient cooling system uses low-speed fans and a revolutionary liquid cooling system for superquiet operation—twice as quiet as a Power Mac G4.

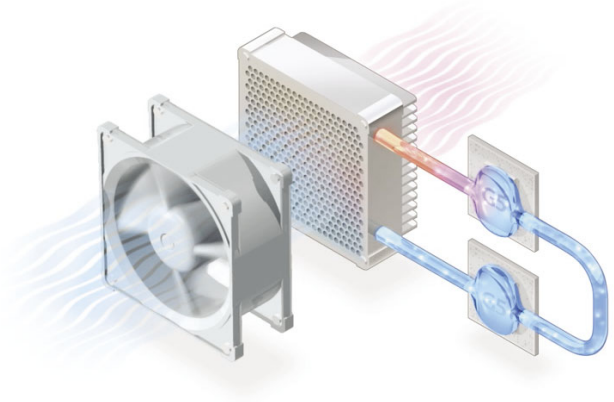
Intelligent Cooling System Using Low-Speed Fans

The Power Mac enclosure is divided into four discrete thermal zones that compartmentalize the primary heat-producing components: processor, PCI, storage, and power supply. This allows the system to increase or decrease the temperature of a single zone without affecting the others and without unnecessary cooling. The front panel is 35 percent perforated, so cooler outside air can enter, flow over the heat-producing components, and escape through the perforations in the rear panel. For added cooling efficiency, an internal air deflector channels airflow over the processor heat sinks and the PCI slots.

Each thermal zone is equipped with its own fans. Apple has engineered the nine fans to spin at very low speeds for minimum acoustic output. Using 21 different sensors, Mac OS X constantly monitors component temperatures in each zone and dynamically adjusts individual fan speeds to the appropriate levels, achieving the quietest possible operation.

State-of-the-Art Liquid Cooling System

In addition to the low-speed fans, the dual 2.7GHz Power Mac G5 features a liquid cooling system—the next generation in cooling technology. This system provides a continuous flow of thermally conductive fluid that transfers heat from the processors as they work harder. The heated fluid then flows through a radiant grille, where air passing over cooling fins returns the fluid to its original temperature. The liquid cooling system is controlled by Mac OS X, which dynamically adjusts the flow of the fluid and the speed of the fans based on the amount of heat being generated. The closed-loop liquid cooling system is completely maintenance free. In addition, because the liquid cooling system is more efficient than a standard heat sink, the Power Mac G5 continues to run quietly, even as system performance reaches new heights.



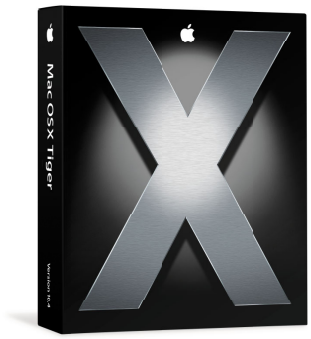
Easy Access and Usability

The Power Mac G5 has an easy-to-use removable side panel for fast access to expansion slots and bays. Designed for simple operation, the system allows you to add or remove the optical drive or an AirPort Extreme Card without tools. Intuitive drive guides let you add high-capacity hard drives in minutes when your storage needs increase. For peace of mind, an ingenious locking mechanism is integrated into the panel latch, giving you a convenient and elegant way to keep the components inside your computer safe from tampering.

The Power Mac G5 also comes equipped with a complete set of ports on the back panel, in addition to FireWire 400 and USB 2.0 ports and a headphone jack on the front panel. For added convenience, the integrated handles allow you to lift and move your Power Mac safely and easily.

Mac OS X: System Software for the Power Mac G5

Built on open standards
Mac OS X is built on open standards, integrating seamlessly with Windows, Linux, and other UNIX systems—thanks to support for common network platforms, standard file formats, and cross-platform UNIX and Java applications. For details on the latest version of Mac OS X, visit www.apple.com/macosx.



Mac OS X combines the power and stability of UNIX with Apple's legendary ease of use. The Power Mac G5 ships with Mac OS X version 10.4 "Tiger," the latest release of the Macintosh operating system. Built on a 64-bit kernel, Tiger supports 64-bit computation and 64-bit memory addressing that unleash the performance of the PowerPC G5 processor. At the same time, Mac OS X on the Power Mac G5 provides native compatibility with both 32-bit and 64-bit software, so you can migrate existing applications—even an entire workflow—to the latest G5 hardware, without interruption.

Optimized for G5

Mac OS X Tiger leverages the 64-bit capabilities of the PowerPC G5 processor with new 64-bit memory support, improved thread management, and optimized system libraries. With 64-bit memory addressing, individual application processes can break the 4GB memory barrier, addressing all of the available memory installed in the system. This is a major performance breakthrough for applications that analyze large data sets or edit large files.

Tiger enhances dual processor system performance with improved resource allocation for individual threads, known as fine-grained resource locking. This feature allocates resources to individual threads at a much more granular level, leaving additional system resources free and allowing more threads to execute at the same time. This will prove especially beneficial for dual processor systems, improving both multitasking and networking performance.

Mac OS X also includes system math, vector, and image libraries that are tuned for the 64-bit G5 processor. Applications can access these system-level libraries to take advantage of the optimized computational libraries for acceleration of a broad array of mathematical functions.

Core Technologies for Media

Mac OS X Tiger introduces a series of core technologies designed for the development of professional-quality media applications: Core Audio, Core Video, and Core Image. These components comprise entire libraries of high-performance imaging, audio, and video capabilities that can be built into any software application. Now software developers can add advanced features, such as high-bit-depth image transformation, high definition video functions, or even support for existing audio plug-ins in a new application, without having to author low-level code by hand. This capability is one of the reasons Mac OS X is the platform of choice for content creation software developers.

Enhanced Compiler

Apple supplies an enhanced compiler, GCC version 4.0, that generates optimal code for the Power Mac G5. The compiler produces code that executes efficiently on G5, G4, and G3 systems, so a single Mac OS X application runs optimally on each of Apple's supported processor architectures. Developers can now build and qualify a single version of their applications for 32-bit G3 and G4 systems as well as 64-bit G5 systems. Applications compiled with GCC 4.0 automatically receive the benefits of the optimizations listed above. In addition, GCC 4.0 automatically generates optimized code for the Velocity Engine, which previously had to be hand-coded. This advance makes it faster and easier to develop high-performance applications for Mac OS X.

Industry-Leading Performance

The Power Mac G5 is a revolutionary 64-bit desktop computer designed to meet the high-performance, no-compromise requirements of today's most demanding professional applications. With dual 64-bit processors and a high-bandwidth architecture, this groundbreaking system alleviates the limitations and bottlenecks of the traditional PC—opening up a wealth of possibilities for 2D and 3D designers, video and audio producers, scientists, and researchers. To test its prowess, Apple measured the Power Mac G5 against the top-of-the-line competing systems in key application categories.

Film and Video

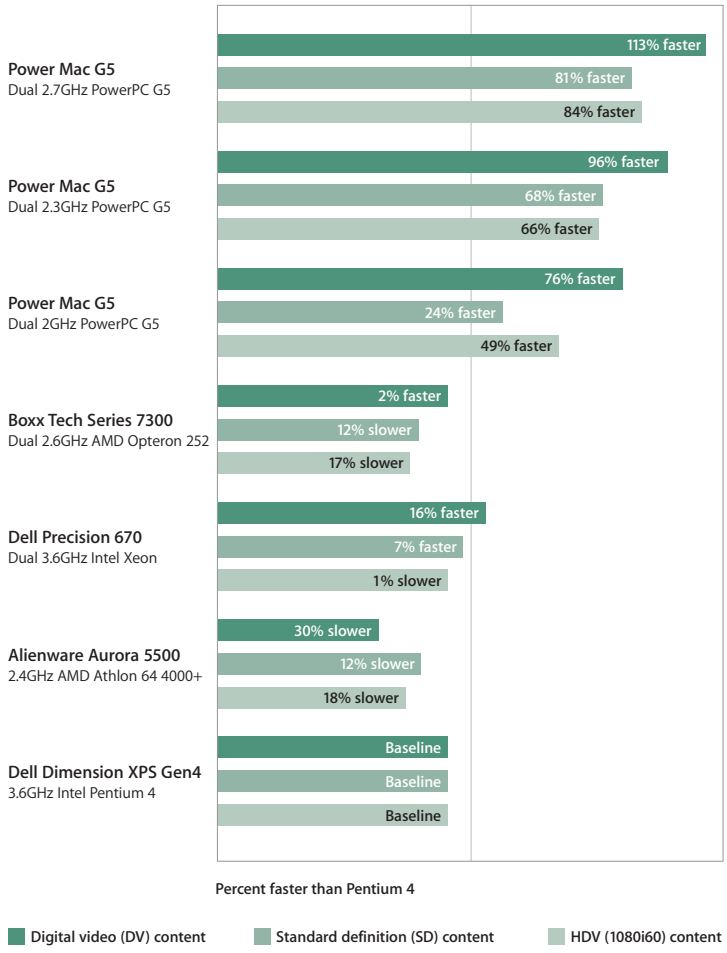
Triple the editorial creativity
Bunim/Murray Productions, creator of the hit show *The Real World*, launched a new genre of entertainment and has become a leader in reality TV production. To handle the huge volumes of raw footage that must be edited for each episode (a ratio of 100:1 versus the traditional scripted TV ratio of 5:1), Bunim/Murray has reengineered the production pipeline with the Power Mac G5, Final Cut Pro, and Apple's storage area network solution, Xsan. With its all-Apple solution, Bunim/Murray can now provide three times as many editors with real-time access to their shared footage with no increase in equipment costs. For more information, visit www.apple.com/itpro/profiles/bunim-murray and www.apple.com/finalcutstudio/finalcutpro.

No matter what the format—DV, SD, HD, or film—the Power Mac G5 gives film and video professionals the power to create studio-quality projects. The ultrafast G5 processor supports multiple simultaneous streams and real-time effects and accelerates video processing and rendering. With cutting-edge software like Apple's Final Cut Studio—the ultimate HD video production suite that features Final Cut Pro 5, Soundtrack Pro, Motion 2, and DVD Studio Pro 4—as well as Shake, Alias Maya, Adobe After Effects, and NewTek LightWave, you can edit sequences, generate effects, composite scenes, author DVDs, and animate characters in record time. The PowerPC G5 processor, driving a Mac OS X– and QuickTime-based workflow, provides the flexibility to author in any format with XML extensibility to share projects between applications. The Power Mac G5 also makes it easy to build a state-of-the-art studio, with support for high-speed Xserve RAID storage, specialized PCI-X acquisition cards, and high-performance FireWire decks and devices.

Video rendering
One of the final stages of any film or video project is the processor-intensive task of rendering. Apple measured the time to render a 2-minute video project with various commonly used effects and filters, including color corrections, transitions, compositing, and basic text treatments, on Power Mac G5 and PC systems. To demonstrate video rendering performance, Apple tested Final Cut Pro 5 on the Power Mac G5 and Adobe Premiere Pro on various PC systems using virtually identical projects in DV, SD, and HDV formats.

Final Cut Pro 5
Final Cut Pro 5—Apple's high-performance nonlinear editing suite for professional DV, SD, HD, and film editors—is optimized for the Power Mac G5 and Mac OS X. Taking full advantage of dual G5 processors and the Velocity Engine, Final Cut Pro 5 introduces multicam support and the ability to edit two streams of full-resolution uncompressed high definition video. For more information, visit www.apple.com/finalcutstudio/finalcutpro.

Video Rendering Results: G5 vs. PC



DV video rendering. When rendering a complex DV project containing multiple effects and filters, the dual 2.7GHz, dual 2.3GHz, and dual 2GHz Power Mac G5 systems running Final Cut Pro 5 were 113%, 96%, and 76% faster, respectively, than the 3.6GHz Pentium 4–based system and 83%, 68%, and 52% faster than the dual 3.6GHz Xeon-based system.

SD video rendering. When rendering a complex SD project containing multiple effects and filters, the dual 2.7GHz, dual 2.3GHz, and dual 2GHz Power Mac G5 systems running Final Cut Pro 5 were 81%, 68%, and 24% faster, respectively, than the 3.6GHz Pentium 4–based system and 69%, 58%, and 16% faster than the dual 3.6GHz Xeon-based system.

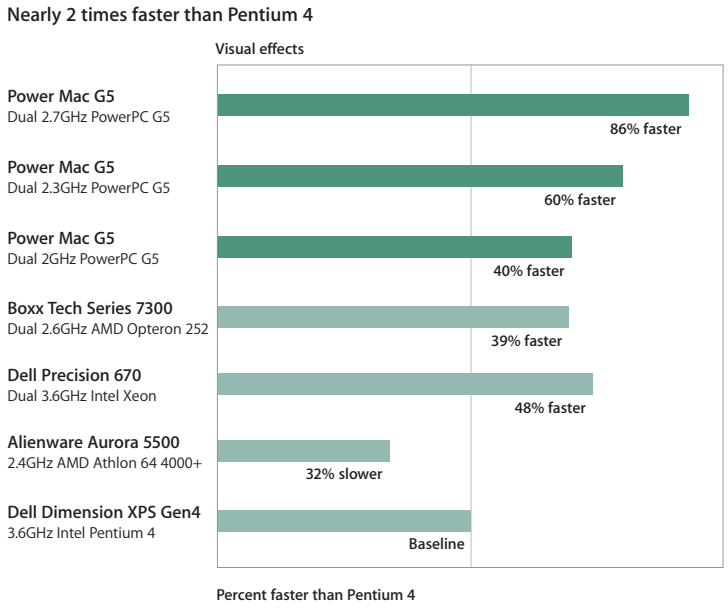
HDV video rendering. The dual 2.7GHz, dual 2.3GHz, and dual 2GHz Power Mac G5 systems running Final Cut Pro 5 rendered a complex project 84%, 66%, and 49% faster, respectively, than the 3.6GHz Pentium 4–based system. Performing the HDV test using Final Cut Express produces even faster results. While Final Cut Pro renders transitions and effects in their native format (long GOP MPEG-2) for the highest-possible quality, both Adobe Premiere Pro and Final Cut Express render HDV video in an intermediate format, allowing faster editing on systems with less processing power. Using Final Cut Express HD 3.0, the dual 2.7GHz, dual 2.3GHz, and dual 2GHz Power Mac G5 systems rendered the same complex project 187%, 166%, and 145% faster, respectively, than the 3.6GHz Pentium 4–based system.

Testing conducted by Apple in April 2005 using preproduction dual 2GHz, 2.3GHz, and 2.7GHz Power Mac G5 units; all other systems were shipping units. The Power Mac G5 systems were tested with a prerelease version of Final Cut Pro 5. The PC systems were tested with Adobe Premiere Pro version 1.5.1. For PC systems, cache sizes were: Dell Dimension XPS Gen4 = 2048K L2; Dell Precision 670 = 2048K L2; Alienware Aurora 5500 = 1024K L2; Boxx Tech Series 7300 = 1024K L2.

Video effects

Video editors and producers add innovative motion graphics and effects to film, video, DVD, and web projects using tools like Motion and Adobe After Effects. To demonstrate the performance of Power Mac G5 hardware when rendering effects for video, Apple tested After Effects on the Power Mac G5 and an array of PC systems. After Effects has been optimized for both the G5 and PC architectures.

After Effects 6.5 Nightflight Results: G5 vs. PC



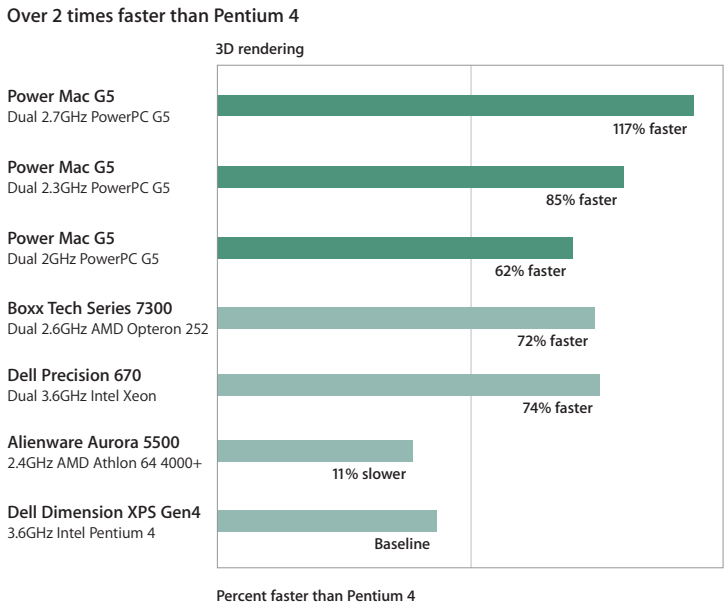
The dual 2.7GHz, dual 2.3GHz, and dual 2GHz Power Mac G5 systems performed the Nightflight render test 86%, 60%, and 40% faster, respectively, than the 3.6GHz Pentium 4–based system; the dual 2.7GHz and dual 2.3GHz Power Mac G5 systems outperformed the dual 3.6GHz Xeon-based system by 25% and 8%, respectively.

Testing conducted by Apple in April 2005 using preproduction dual 2GHz, 2.3GHz, and 2.7GHz Power Mac G5 units; all other systems were shipping units. For PC systems, cache sizes were: Dell Dimension XPS Gen4 = 2048K L2; Dell Precision 670 = 2048K L2; Alienware Aurora 5500 = 1024K L2; Boxx Tech Series 7300 = 1024K L2.

3D rendering

LightWave 3D is a popular digital content creation application that includes a fast rendering engine. Its capabilities are proven in film, television, and gaming, and it is also used for creating graphics for print and the web—anywhere 3D content is needed. To demonstrate the performance of the Power Mac G5, Apple rendered a scene using LightWave 3D and measured the time it took each system to complete the task.

LightWave 3D 8.2.1 Results: G5 vs. PC



The dual 2.7GHz, dual 2.3GHz, and dual 2GHz Power Mac G5 systems were 117%, 85%, and 62% faster, respectively, than the 3.6GHz Pentium 4–based system; the dual 2.7GHz and dual 2.3GHz Power Mac G5 systems were 24% and 6% faster, respectively, than the dual 3.6GHz Xeon-based system.

Testing conducted by Apple in April 2005 using preproduction dual 2GHz, 2.3GHz, and 2.7GHz Power Mac G5 units; all other systems were shipping units. Benchmark scene = Skull_Head_Newest. For PC systems, cache sizes were: Dell Dimension XPS Gen4 = 2048K L2; Dell Precision 670 = 2048K L2; Alienware Aurora 5500 = 1024K L2; Boxx Tech Series 7300 = 1024K L2.

Design and Print

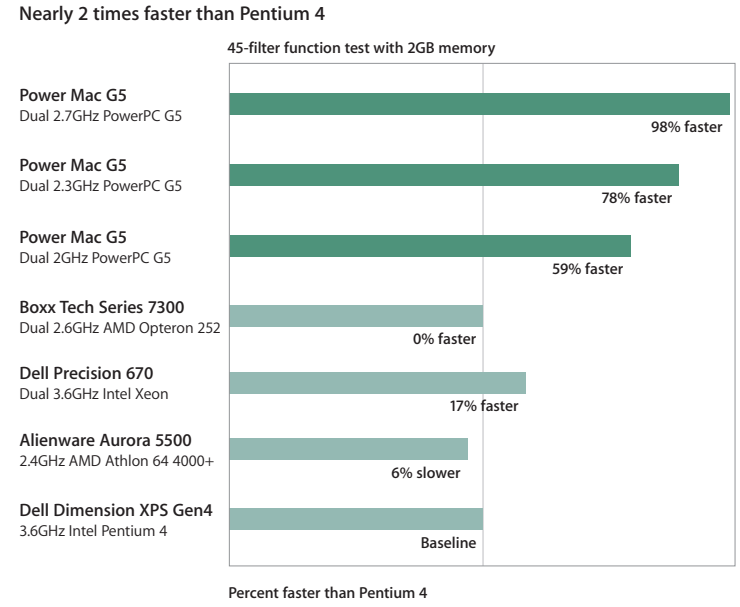
Visualizing accurate color for print
Blanks Printing and Imaging has pioneered virtual color proofing, a process designed to eliminate wasted transit days from the color proofing process to save time, money, and hassle for clients like Mervyn's, The Container Store, and Michaels. Using the Power Mac G5 running Mac OS X with built-in ColorSync and Apple Cinema HD Displays, Blanks has reduced its average color proofing cycle from 10–14 days to just one day. For more information, visit www.apple.com/pro/color.

With the Power Mac G5, design and publishing professionals can realize ideas as fast as they can imagine them. The blazing-fast G5 processor crunches through huge images and layouts, and up to 8GB of memory enables fast manipulation of large files and assets. Built-in Gigabit Ethernet and high-speed integrated I/O provide high-bandwidth connections to printers, scanners, cameras, storage, networks, and more. The Quartz graphics engine in Mac OS X renders breathtaking content across mediums, and ColorSync ensures perfect color from capture to edit to output. You can even automate repetitive and time-consuming tasks with Automator to streamline your workflow. Publishing tools like Adobe Creative Suite and QuarkXPress, designed for Mac OS X and accelerated by the PowerPC G5 processor, will bring ideas to life in print or on the web.

Image editing

To demonstrate the superiority of the Power Mac G5, Apple conducted tests using Adobe Photoshop CS (8.0), the most widely used application among creative professionals. Adobe Photoshop is a particularly effective cross-platform measure of system performance because it has been optimized for both Mac and Windows platforms. Apple ran the tests using a 600MB Photoshop file and a suite of 45 commonly used Photoshop actions, including file saving, image adjustments, mode changes, and filters. Apple measured the time to execute each filter or function and compared the performance of all actions using an indexed score.

Adobe Photoshop CS (8.0) Results: G5 vs. PC



The dual 2.7GHz, dual 2.3GHz, and dual 2GHz Power Mac G5 systems ran the 45 filters 98%, 78%, and 59% faster, respectively, than the 3.6GHz Pentium 4–based system and 72%, 56%, and 38% faster, respectively, than the dual 3.6GHz Xeon-based system.

Testing conducted by Apple in April 2005 using preproduction dual 2GHz, 2.3GHz, and 2.7GHz Power Mac G5 units; all other systems were shipping units. File size = 600MB. For PC systems, cache sizes were: Dell Dimension XPS Gen4 = 2048K L2; Dell Precision 670 = 2048K L2; Alienware Aurora 5500 = 1024K L2; Boxx Tech Series 7300 = 1024K L2.

Music and Audio

Modernizing music production
Pulse Music is delivering the next-generation music production studio based on a collaborative, parallel workflow to create better music, faster. The cornerstone of this workflow is a dual processor Power Mac G5, Apple Cinema Display, Logic, and Pro Tools in each of the seven recording studios in its new state-of-the-art Manhattan location. Not only does this production environment support better music production, but Pulse is also able to produce music up to 10 times faster. To learn more about how customers are using Apple audio solutions, visit www.apple.com/pro/musicaudio.

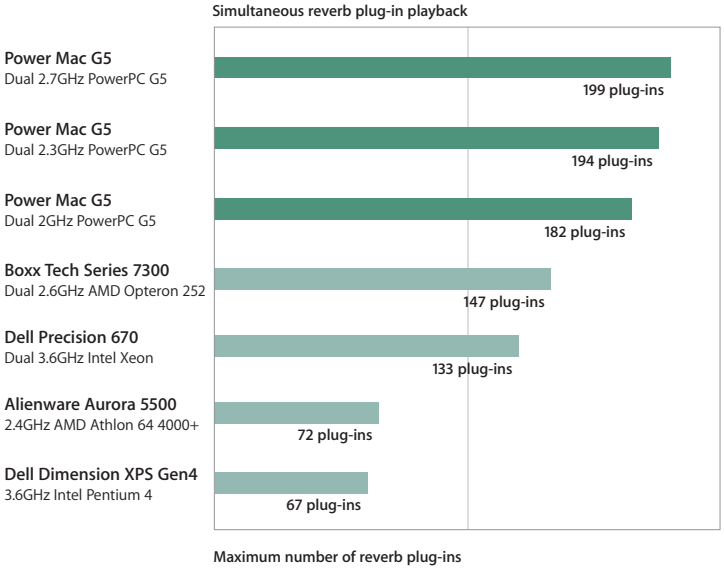
With the new Power Mac G5, music and audio professionals have even more power at their fingertips to compose, record, edit, mix, and perform. Dual PowerPC G5 processors effortlessly synthesize instruments and apply effects, and up to 8GB of memory provides ample freedom to compose using an unprecedented number of tracks. The built-in optical digital and analog audio ports support new and legacy hardware, and FireWire and USB ports let you connect to virtually any audio, MIDI, and storage device. Fast PCI-X allows the addition of specialized input/output and digital signal processing hardware solutions. Mac OS X with Core Audio allows you to run several applications simultaneously, while Audio Units provide a robust plug-in protocol designed to work seamlessly across Audio Units host applications. With state-of-the-art applications such as Apple's Logic Pro and Soundtrack, Digidesign Pro Tools, MOTU Digital Performer, and Steinberg Cubase SX and Nuendo, you have a wealth of innovative software to capture your inspiration.

Audio processing

To quantify the performance advantages of the Power Mac G5 for audio production, Apple tested Logic Pro 7. Apple created a processor-intensive workload containing multiple unique audio tracks, assigned five default reverb plug-ins to each audio track, and tested each platform to see which application could play more plug-ins.

Audio Application Results: G5 vs. PC

Nearly 3 times the plug-ins of the Pentium 4



The dual 2.7GHz, dual 2.3GHz, and dual 2GHz Power Mac G5 systems played 132, 127, and 115 more reverb plug-ins, respectively, than the 3.6GHz Pentium 4–based system and 52, 47, and 35 more reverb plug-ins, respectively, than the dual 2.6GHz Opteron-based system.

Testing conducted by Apple in April 2005 using preproduction dual 2GHz, 2.3GHz, and 2.7GHz Power Mac G5 units; all other systems were shipping units. All Power Mac systems were tested using Logic Pro 7.0. The Dell Dimension XPS Gen4, Dell Precision 670, Alienware Aurora 5500, and Boxx Tech Series 7300 were tested using Steinberg Cubase SX 3.01. For PC systems, cache sizes were: Dell Dimension XPS Gen4 = 2048K L2; Dell Precision 670 = 2048K L2; Alienware Aurora 5500 = 1024K L2; Boxx Tech Series 7300 = 1024K L2.

Scientific and Technical Computing

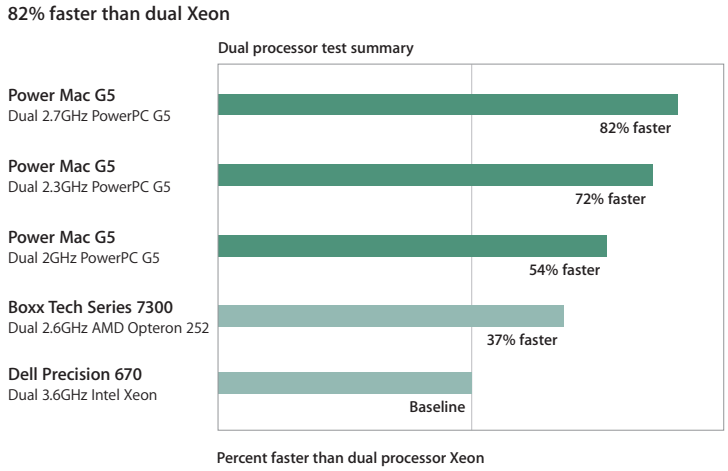
Affordable 3D medical visualization
Dr. Osman Ratib, professor and vice chair of information systems at the UCLA Department of Radiological Sciences, and colleague Dr. Antoine Rosset, from the University of Geneva, developed a high-performance 3D medical visualization solution built on the 64-bit processing power and affordability of today's Power Mac G5. At 10% of the cost of high-end scientific workstations, this solution allows doctors and hospitals everywhere to access advanced 3D medical visualization at the point of care, delivering better diagnoses and better medicine. For more information, visit developer.apple.com/business/macmarket/osirix.html.

The Power Mac G5 gives scientific researchers the ability to make discoveries in record time. Each 64-bit PowerPC G5 processor features two double-precision floating-point units and an optimized Velocity Engine that dramatically accelerate the computational task at hand. Open source, UNIX-based Mac OS X provides unprecedented power, compatibility, and stability to run complex scientific applications and command-line tools alongside essential productivity applications, such as Microsoft Excel and Adobe Photoshop. You can develop custom applications while doing everyday work, all on the same computer and in the same operating system. Dual displays expand your screen real estate, and powerful graphics processors enable advanced scientific visualization. So whether you're doing molecular modeling with PyMOL, searching for DNA alignments with BLAST, analyzing statistics with SPSS, modeling equations with Mathematica, or building your own programs with Apple's Xcode tools, the power to discover and publish is right in front of you.

Scientific analysis

To demonstrate the performance advantages of the Power Mac G5 for processor-intensive scientific analysis, Apple used Bioinformatics Benchmark System version 3, or BBSv3. This benchmark is based on current, popular applications and data sets from the bioinformatics community and thus represents common tasks of a typical research scientist. The current benchmark uses bioinformatics application suites NCBI BLAST and HMMER. For this benchmark, Apple used FASTA databases dated January 1, 2005; NCBI BLAST version 2.2.10; and HMMER version 2.3.2.

Bioinformatics Benchmark System (BBSv3) Results: G5 vs. PC



The dual 2.7GHz, dual 2.3GHz, and dual 2GHz Power Mac G5 systems performed the BBSv3 dual processor tests 82%, 72%, and 54% faster, respectively, than the dual 3.6GHz Xeon-based system and 33%, 26%, and 12% faster, respectively, than the dual 2.6GHz Opteron-based system. For detailed results, go to www.apple.com/science.

Testing conducted by Apple in April 2005 using preproduction dual 2GHz, 2.3GHz, and 2.7GHz Power Mac G5 units; all other systems were shipping units. Test results based on the Bioinformatics Benchmark System (BBSv3), available at www.scalableinformatics.com/metadot/index.pl?iid=2190, using January 1, 2005 FASTA databases; NCBI BLAST version 2.2.10, available at ftp://ftp.ncbi.nlm.nih.gov/blast/executables; and HMMER version 2.3.2, available at hmmer.wustl.edu. For PC systems, cache sizes were: Dell Dimension XPS Gen4 = 2048K L2; Dell Precision 670 = 2048K L2; Alienware Aurora 5500 = 1024K L2; Boxx Tech Series 7300 = 1024K L2.

For details about these and other performance tests, see www.apple.com/powermac/performance.

Product Configurations and Options

Why buy a Power Mac G5?

- The 64-bit PowerPC G5 accelerates all types of applications, thanks to clock speeds of up to 2.7GHz, an optimized Velocity Engine, and two double-precision floating-point units.
- With dual independent frontside buses and high-speed, high-capacity memory, applications rip through work faster than ever before.
- Whether at work or at play, you'll enjoy eye-popping graphics, especially on stunning Apple Cinema Displays.
- Apple's most expandable Mac provides high-bandwidth connections for a full range of industry-standard, high-performance peripherals.
- An innovative enclosure design uses a superefficient thermal zone scheme and low-speed fans to stay cool and quiet.
- Mac OS X runs state-of-the-art professional applications, provides full 64-bit memory support, and protects existing software investments for a seamless transition to 64-bit computing.

Standard Configurations

Apple offers Power Mac G5 systems to meet the needs of professionals, media producers, educators, and researchers. The following standard configurations are available through the Apple Store and Apple Authorized Resellers.

Order number	**M9747LL/A**	**M9748LL/A**	**M9749LL/A**
Processor	Dual 2GHz PowerPC G5	Dual 2.3GHz PowerPC G5	Dual 2.7GHz PowerPC G5
L2 cache	512K per processor	512K per processor	512K per processor
Frontside bus	1GHz per processor	1.15GHz per processor	1.35GHz per processor
Main memory	512MB of PC3200 (400MHz) DDR SDRAM; supports up to 4GB	512MB of PC3200 (400MHz) DDR SDRAM; supports up to 8GB	512MB of PC3200 (400MHz) DDR SDRAM; supports up to 8GB
Graphics	ATI Radeon 9600 with 128MB of DDR SDRAM and two DVI ports	ATI Radeon 9600 with 128MB of DDR SDRAM and two DVI ports	ATI Radeon 9650 with 256MB of DDR SDRAM, one DVI port, and one dual-link DVI port
Hard drive	160GB Serial ATA[3]	250GB Serial ATA[3]	250GB Serial ATA[3]
Optical drive	16x SuperDrive with double-layer support (DVD+R DL/DVD±RW/CD-RW)		
PCI slots	Three open full-length 33MHz, 64-bit PCI slots	Three open full-length PCI-X slots: one 133MHz, 64-bit slot and two 100MHz, 64-bit slots	Three open full-length PCI-X slots: one 133MHz, 64-bit slot and two 100MHz, 64-bit slots
Expansion	One FireWire 800 port, two FireWire 400 ports (one on front); three USB 2.0 ports (one on front), two USB 1.1 ports (on keyboard); AGP 8X Pro slot with graphics card installed; two internal hard drive bays (one occupied)		
Audio	Optical digital audio input, optical digital audio output, analog audio input, analog audio output, front headphone minijack and speaker		
Networking	10/100/1000BASE-T Ethernet, AirPort Extreme ready,[4] optional Bluetooth 2.0 + EDR (Enhanced Data Rate), optional 56K V.92 modem[10]		
Software	Mac OS X, Dashboard, Mail, Safari, iChat AV, Address Book, QuickTime, iLife (includes iTunes, iPhoto, iMovie HD, iDVD, and GarageBand), iCal, DVD Player, Classic environment, Art Directors Toolkit X, GraphicConverter, Microsoft Office 2004 for Mac Test Drive, OmniGraffle, OmniOutliner, QuickBooks New User Edition, Zinio Reader, Xcode Developer Tools		
Service and support	90 days of toll-free telephone support and one-year limited warranty		
Also included	Apple Keyboard, Apple Mouse, USB keyboard extension cable, DVI to VGA Adapter, AirPort antenna		

Build-to-Order Options

Order a custom-configured computer from the Apple Store or an Apple Authorized Reseller. Build-to-order options can include the following:

- Memory (PC3200 DDR SDRAM; installed in pairs): 512MB, 1GB, 2GB, 4GB, 8GB[2]
- Hard drives (Serial ATA): 160GB, 250GB, 400GB, two 400GB[3]
- Optical drive: 16x SuperDrive with double-layer support (DVD+R DL/DVD±RW/CD-RW), Combo drive (DVD-ROM/CD-RW)
- Graphics: ATI Radeon 9600 with 128MB of DDR SDRAM, ATI Radeon 9650 with 256MB of DDR SDRAM, ATI Radeon X850 XT with 256MB of GDDR3 SDRAM, NVIDIA GeForce 6800 GT DDL with 256MB of GDDR3 SDRAM (GeForce 6800 GT DDL occupies AGP slot and adjacent PCI slot)
- Wireless: AirPort Extreme Card, AirPort Express Base Station, AirPort Extreme Base Station,[4] Bluetooth 2.0 + EDR module with antenna, Apple Wireless Keyboard and Mouse
- External storage: Xserve RAID and Apple Fibre Channel PCI-X Card
- Networking: Gigabit Ethernet PCI-X Card, internal 56K V.92 modem[10]

Apple Displays and Adapters

To complete your Power Mac G5 system, you can choose from Apple's family of all-digital, flat-panel displays.

- Apple Cinema Display (20-inch flat panel), order number M9177LL/A
- Apple Cinema HD Display (23-inch flat panel), order number M9178LL/A
- Apple Cinema HD Display (30-inch flat panel), order number M9179LL/A
- ADC to DVI Adapter, order number T2774G/A
- DVI to Video Adapter (for connecting S-video or composite devices), order number M9267G/A

Other Products

These products are available to enhance your Power Mac G5 system.

- Audio: Apple iPod, iPod mini, iPod shuffle, Logitech Z-5500 5.1 speakers, Toslink optical digital cables
- Mac OS X Server

Extended Service and Support

Purchase the AppleCare Protection Plan to extend your service and support to up to three full years. The plan provides support for your Mac, the Mac OS, and many Apple consumer applications, so just one phone call can help resolve most issues. You can also enroll one Apple display for coverage, provided that your Power Mac G5 and display are purchased together. For more information, visit www.apple.com/support/products.

Technical Specifications

Processing

- Dual 2GHz, dual 2.3GHz, or dual 2.7GHz 64-bit PowerPC G5 microprocessors
- PowerPC processor architecture with 64-bit data paths and registers
- Native support for 32-bit application code
- 512K on-chip L2 cache running at processor speed
- Parallel data structure supporting up to 215 simultaneous in-flight instructions
- Simultaneous issue of up to 10 out-of-order operations
- Dual-pipeline Velocity Engine for 128-bit single-instruction, multiple-data (SIMD) processing
- Two independent double-precision floating-point units
- Advanced three-component branch prediction logic
- Dual independent 1GHz, 1.15GHz, or 1.35GHz 64-bit DDR frontside buses supporting up to 21.6-GBps data throughput
- Point-to-point system controller

Memory

- 128-bit data paths for up to 6.4-GBps memory throughput
- Dual 2GHz systems:
  - 512MB of PC3200 (400MHz) DDR SDRAM
  - Four DIMM slots supporting up to 4GB of main memory
- Dual 2.3GHz and dual 2.7GHz systems:
  - 512MB of PC3200 (400MHz) DDR SDRAM
  - Eight DIMM slots supporting up to 8GB of main memory
- Support for the following DIMMs (in pairs):
  - 256MB DIMMs (64-bit-wide, 128- or 256-Mbit)
  - 512MB DIMMs (64-bit-wide, 256-Mbit)
  - 1GB DIMMs (64-bit-wide, 256-Mbit)

Graphics and displays

- AGP 8X Pro graphics slot supporting up to 2-GBps data throughput, with one of the following graphics cards installed:
  - ATI Radeon 9600 with 128MB of DDR SDRAM and two DVI ports
  - ATI Radeon 9650 with 256MB of DDR SDRAM, one DVI port, and one dual-link DVI port
  - ATI Radeon X850 XT with 256MB of DDR SDRAM, one ADC port, and one dual-link DVI port
  - NVIDIA GeForce 6800 GT DDL with 256MB of GDDR3 SDRAM and two dual-link DVI ports (build-to-order option; occupies AGP slot and adjacent PCI slot)
- Support for digital resolutions up to 1920 by 1200 pixels; dual-link DVI ports support up to 2560 by 1600 pixels
- Support for analog resolutions up to 1600 by 1200 pixels
- DVI to VGA Adapter included
- Dual display support for extended desktop and video mirroring modes
- Support for up to two Apple flat-panel displays[6]

Storage

- Two 3.5-inch hard drive bays, each with a 150-MBps Serial ATA controller; one of the following is installed:
  - One 160GB 7200-rpm Serial ATA[3]; 8MB memory buffers
  - One 250GB 7200-rpm Serial ATA[3]; 8MB memory buffers
  - One or two 400GB 7200-rpm Serial ATA[3]; 8MB memory buffers (build-to-order option)
- Optical drive bay with one of the following installed:
  - 16x SuperDrive with double-layer support (DVD+R DL/DVD±RW/CD-RW); writes DVD-R discs at up to 16x speed, writes DVD+R DL discs at up to 4x speed, reads DVDs at up to 16x speed, writes CD-R and CD-RW discs at up to 24x speed, reads CDs at up to 32x speed
  - Combo drive (DVD-ROM/CD-RW); reads DVDs at up to 12x speed, writes CD-R discs at up to 32x speed, writes CD-RW discs at up to 10x speed, reads CDs at up to 32x speed

PCI expansion

- Dual 2GHz systems:
  - Three open full-length 33MHz, 64-bit PCI slots
- Dual 2.3GHz and dual 2.7GHz systems:
  - One open full-length 133MHz, 64-bit PCI-X slot and two open full-length 100MHz, 64-bit PCI-X slots

Communications

- 10/100/1000BASE-T Ethernet (RJ-45)
- Expansion slot for optional 54-Mbps AirPort Extreme Card (based on IEEE 802.11g standard; Wi-Fi Certified for 802.11g and 802.11b interoperability)[4]
- External AirPort Extreme antenna
- Optional internal Bluetooth 2.0 + EDR (Enhanced Data Rate) module and antenna
- Optional internal 56K V.92 modem (RJ-11)[10]

Peripherals and audio

- One FireWire 800 port; two FireWire 400 ports (one on front panel; 15W total power)
- Three USB 2.0 ports (one on front panel); two USB 1.1 ports on keyboard
- Front headphone minijack and speaker
- Optical digital audio input and output Toslink connectors
- Stereo audio input and output minijacks

Electrical and environmental requirements

- Meets ENERGY STAR requirements
- Line voltage: 100–125V AC or 200–240V AC
- Frequency: 50Hz to 60Hz, single phase
- Maximum current: 6.5A (low-voltage range) or 7.5A (high-voltage range)
- Operating temperature: 50° to 95° F (10° to 35° C)
- Storage temperature: –40° to 116° F (–40° to 47° C)
- Relative humidity: 5% to 95% noncondensing
- Maximum altitude: 10,000 feet

Size and weight

- Height: 20.1 inches (51.1 cm)
- Width: 8.1 inches (20.6 cm)
- Depth: 18.7 inches (47.5 cm)
- Weight: 44.4 pounds (20.2 kg)[11]

For More Information

For more information about the Power Mac G5, visit www.apple.com/powermac.

Internet access requires a compatible Internet service provider; fees may apply. Product contains electronic documentation. Backup copy of software is included. [1]Testing conducted by Apple in April 2005 using preproduction dual 2GHz, 2.3GHz, and 2.7GHz Power Mac G5 units; all other systems tested were shipping units. [2]Selected models. [3]1GB = 1 billion bytes; actual formatted capacity less. [4]Wireless Internet access requires AirPort Extreme Card, base station or other wireless access point, and Internet access (fees may apply). Achieving data rates up to 54 Mbps requires that all users have an AirPort Extreme Card and connect to an AirPort Express or AirPort Extreme Base Station. Some ISPs are not compatible with AirPort. Range may vary with site conditions. [5]Check with manufacturer for compatibility. [6]Second Apple flat-panel display may require ADC to DVI Adapter, sold separately. Connecting two 30-inch Apple Cinema HD Displays requires NVIDIA GeForce 6800 GT or Ultra DDL card. [7]NVIDIA GeForce 6800 GT and Ultra DDL cards occupy the AGP slot and adjacent PCI slot. [8]Playback of high definition 1920-by-1080 H.264 video requires a compatible player or a dual processor Power Mac G5. [9]Actual rates will vary. [10]Compatible ISP and telephone services required. Your ISP may not support all V.92 features. Modem will function according to V.90 standards if V.92 services are not available. Actual modem speeds lower. [11]Weight varies by configuration and manufacturing process.

PowerPC G5

White Paper
April 2005

Contents

Introduction

Key Features

- 64-bit architecture, capable of addressing vast amounts of memory
- Native support for 32-bit applications
- Frontside bus up to 1.35GHz, allowing a constant flow of data in and out of the processor
- Dual independent frontside buses in dual processor systems
- Superscalar execution core supporting up to 215 in-flight instructions
- Velocity Engine for accelerated single-instruction, multiple-data (SIMD) processing
- Two floating-point units for high-speed double-precision calculations
- Advanced three-component branch prediction logic to increase processing efficiency

In June 2003, Apple introduced the PowerPC G5, marking the arrival of a 64-bit processor architecture to the personal computer market. This revolutionary processor made its debut in the Power Mac G5, enabling computer users to tackle projects never before possible on a desktop system—and blaze through their work faster than ever. Now used in the Power Mac G5, Xserve G5, and iMac G5, the PowerPC G5 accelerates a wide range of intensive consumer, professional creative, server, and High Performance Computing (HPC) applications.

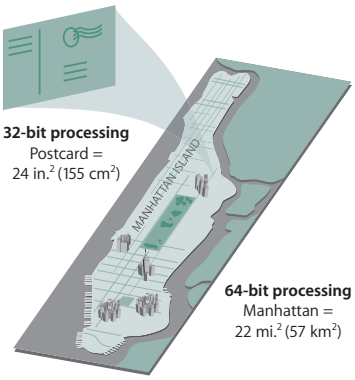
The PowerPC G5 is the product of a long-standing partnership between Apple and IBM, two companies committed to innovation and customer-driven solutions. In 1991, they co-created a PowerPC architecture that could support both 32-bit and 64-bit instructions. Leveraging this design, Apple went on to bring 32-bit RISC processing to desktop and portable computers, while IBM focused on developing 64-bit processors for enterprise servers. The PowerPC G5 represents a convergence of these efforts: Its design is based on the PowerPC instruction set, as well as the award-winning IBM POWER Architecture.

The PowerPC G5 boasts a next-generation architecture built for speed and massively parallel operations:

- The ability to address vast amounts of memory provides fast data access, boosting performance for 2D and 3D imaging, video rendering tasks, and transaction-intensive workgroup and Internet services.
- A dual-channel frontside bus at up to 1.35 gigahertz provides high bandwidth to and from the rest of the system, allowing large numbers of tasks to run concurrently.
- Fast L1 and L2 caches, group instruction dispatching, deep queues, and three-stage branch prediction logic increase processing efficiencies.
- A superscalar execution core with 12 functional units improves performance by executing multiple instructions per cycle in parallel.
- An optimized 128-bit Velocity Engine cranks through image editing tasks, high definition video transitions, media encoding, and complex scientific analysis.
- Two double-precision floating-point units accelerate 64-bit calculations for 3D visualization, research simulations, and multitrack audio creation.

The results are phenomenal. The PowerPC G5 boasts across-the-board performance enhancements that enable media applications and server transactions to run up to twice as fast. Best of all, existing 32-bit applications run natively on the PowerPC G5, so the transition to 64-bit processing is absolutely seamless. This enormous computing power is available on Apple systems today.

64-Bit Processor Technology



4.3 billion times bigger
To grasp the enormous leap from 32-bit to 64-bit processing, imagine equating the range of numbers a processor can express with a two-dimensional area. A 32-bit processor can express a range of integers equal to the size of a postcard, while a 64-bit processor can express a range of integers larger than the island of Manhattan.

The 64-bit PowerPC G5 is all about performance. With 64-bit-wide data paths and registers, it represents an exponential leap in processing power over traditional 32-bit processors. The groundbreaking PowerPC G5 can address vast amounts of main memory, while completing multiple 64-bit integer and double-precision floating-point calculations in every clock cycle.

An Exponential Leap in Computing Power

The labels "32-bit" and "64-bit" characterize the width of a microprocessor's data stream, which is a function of the sizes of its registers and the internal data paths that feed the registers. A 64-bit processor moves data and instructions along 64-bit-wide data paths—compared with the 32-bit-wide paths on 32-bit processors. In addition, 64-bit processors have wide registers that can store extremely large or extremely precise 64-bit numbers.

The leap from 32-bit to 64-bit processing represents an exponential advance in computing power. With 32-bit registers, a processor has a dynamic range of 2^{32}, or 4.3 billion—which means it can express integers from 0 to 4.3 billion. With 64-bit registers, the dynamic range catapults to 2^{64}, or 18 billion billion—4.3 billion times larger than the range of a 32-bit processor. This means that computations involving very large integers or very precise numbers with extended decimals can be completed in one pass through the functional units, rather than several passes.

Vast Amounts of Addressable Memory

The move to 64-bit processing results in a similarly dramatic leap in the amount of memory supported. Computers keep track of data stored in memory using memory addresses. A memory address is a special kind of integer, which points to one byte in memory. Since memory addresses are computed in 64-bit registers capable of expressing integers up to 18 billion billion, the PowerPC G5 can theoretically address 16 exabytes (18 billion billion bytes) of virtual memory.

In practice, memory addressing is defined by the physical address space of the processor. The PowerPC G5, with 42 bits of physical address space, supports a colossal 2^{42} bytes, or 4 terabytes, of system memory. Although it's not currently feasible to purchase 4 terabytes of RAM, the advanced architecture of this processor allows for plenty of growth in the future.

Very large quantities of RAM enable a desktop system to contain a gigantic 3D model, a complex scientific simulation, or an entire database in main memory. When data is stored in memory, the processor can access it 40 times faster than from the hard drive, drastically reducing the time to access and manipulate data. For server tasks that treat each user connection as a separate process, such as web hosting or database publishing, each process can access its own large memory space, allowing the system to cache relevant data for each user—for virtually instant response.

Multiple High-Precision Calculations

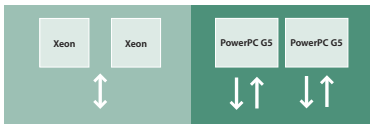
With 64-bit-wide data paths and registers, the PowerPC G5 can execute multiple instructions on 64 bits of data—including huge integer calculations and double-precision floating-point mathematics—in every clock cycle. In contrast, a 32-bit processor has to split up any data larger than 32 bits and process it in multiple passes. This leap in performance, from 32-bit to 64-bit processing, brings previously unmanageable tasks into the realm of practicality, facilitating highly accurate calculations required for scientific analysis, 3D effects, and video encoding. For example, a 3D model that would take all day and night to render on a 32-bit system can be finished by noon of the same day on a PowerPC G5–based system.

Next-Generation PowerPC Architecture

The PowerPC G5 is a highly parallel implementation of the PowerPC architecture, capable of handling large numbers of tasks at the same time. It's based on the execution core of the industry-leading IBM POWER Architecture that drives IBM's top-of-the-line enterprise servers. Apple collaborated with IBM to leverage this superscalar, superpipelined design for the next generation of personal computers and entry-level servers. The development of the PowerPC G5 builds on previous PowerPC designs, combining an optimized Velocity Engine unit, two double-precision floating-point units, advanced branch prediction logic, and a high-bandwidth frontside bus to support up to 215 simultaneous in-flight instructions.

Because the PowerPC instruction set was designed from the beginning to handle both 32-bit and 64-bit code, existing 32-bit applications run natively on PowerPC G5–based computers and servers. No software modification or optimization is required, and there's no need for emulation or translation software. In fact, most 32-bit applications run dramatically faster on the PowerPC G5.

Up to 1.35GHz Frontside Bus



Dual independent frontside buses
The dual-channel frontside bus allows data to travel to and from the PowerPC G5 processor at the same time. And in dual processor systems, each PowerPC G5 has its own dedicated interface to maximize throughput—compared with dual Xeon-based systems, in which the processors must share a single bus.

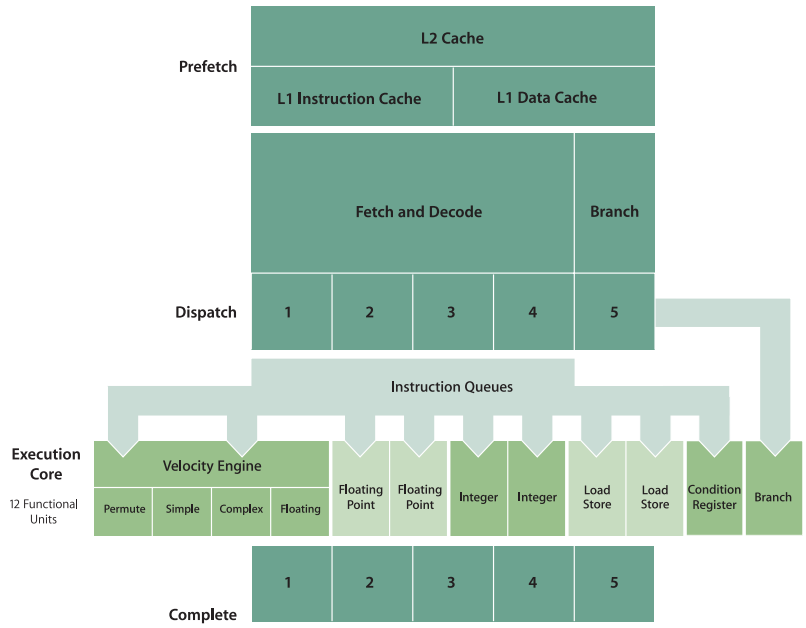
The performance advantages of the PowerPC G5 begin with an innovative Double Data Rate (DDR) frontside bus that speeds up communication between the processor and the memory controller. Unlike conventional processor interfaces, which carry data in only one direction at a time, this dual-channel frontside bus has two 32-bit point-to-point links (64 bits total): One link travels into the processor and another travels from the processor, which means no wait time while the processor and the system controller negotiate which will use the bus or while the bus switches direction. This elastic interface self-tunes during startup for optimal signal quality.

On a 2.7GHz PowerPC G5, the frontside bus operates at 1.35GHz for a total theoretical bandwidth of up to 10.8GB per second per processor. Dual PowerPC G5 systems get twice the bandwidth (21.6GB per second), because each processor has a dedicated frontside bus.

Fast Access to Data and Instructions

The PowerPC G5 features processing innovations that optimize the flow of data and instructions—making it ideal for streaming media, editing HD video, rendering 3D effects, serving databases, and hosting web applications, as well as for compute-intensive simulations and scientific analysis. Large caches and instruction preparation in the processor maximize performance as instructions are dispatched into the execution core and data is loaded into the registers.

PowerPC G5 Architecture



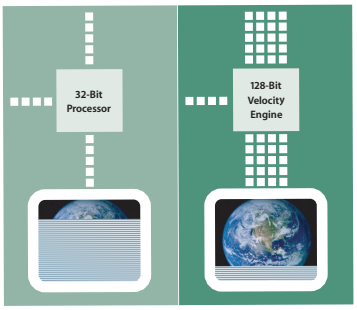
Prefetch
Prefetching improves processor performance by retrieving and caching data and instructions before they're demanded by the processor, ensuring optimal utilization of each processor cycle. The PowerPC G5 anticipates the need for data and instructions and prefetches them into its large L1 and L2 caches. To protect the integrity of data and instructions, L1 cache is parity-protected and L2 cache is protected using Error Correction Code (ECC) logic.

Fetch and decode
A low-latency 512K L2 cache provides fast access to data and instructions—at rates up to 64GB per second. Instructions are fetched from the L2 cache into a direct-mapped 64K L1 instruction cache. At the same time, 32K of write-through, two-way associative L1 data cache can fetch up to eight active data streams simultaneously.

Up to eight instructions per clock cycle are fetched from the L1 instruction cache for decoding. Decoding divides each instruction into smaller suboperations, giving the processor more freedom to schedule execution of code in parallel.

Group formation and dispatch
Before instructions are dispatched into the functional units, they are arranged, in program order, into groups of up to five. The PowerPC G5 dispatches these packaged groups to the queues in the execution core, where they are broken into individual instructions for out-of-order processing. When operations on the data are complete, the PowerPC G5 recombines the instructions into the original groups of five.

This grouping scheme enables the PowerPC G5 to track—and keep organized—an unusually large number of instructions with greater efficiency. By tracking groups rather than individual instructions, it can manage up to 100 instructions within the core simultaneously, in addition to 100-plus instructions in the various fetch, decode, and queue stages, for a total of 215 in-flight instructions.



The Velocity Engine can manipulate 128 bits of data per clock cycle, up to four times more than a 32-bit processor's general processing unit.

Fused multiply-add
The floating-point units in the PowerPC G5 are able to complete both a multiply operation and an add operation as part of the same machine instruction, thereby accelerating matrix multiplication, vector dot products, and other scientific computations. This instruction is referred to as fused multiply-add, or "fmadd," and is considered a basic building block for data-intensive floating-point computation.

The following computation can be completed by a fused multiply-add instruction in one pass through either of the two floating-point units in the G5:

T = (a * b) + c

On other processors, two instructions are required. The first is a multiply instruction:

U = (a * b)

The product "U" would be used later by a second instruction, an addition, to complete the computation:

V = U + c

Thus, in processors with comparable clock speeds, the computation of "(a * b) + c" can be completed twice as fast using fused multiply-add.

What's more, on the G5, round-off occurs just once in the computation of "T," while on other processors, round-off occurs twice, both in the computation of "U" and in the computation of "V," so fused multiply-add can deliver a more accurate result.

Issue queues
The PowerPC G5 includes eight deep issue queues that maximize the utilization of each functional unit. Individual instructions are issued to the appropriate functional unit at up to ten instructions per clock cycle. Each functional unit has a dedicated issue queue, where multiple instructions are sequenced for processing.

Superscalar Execution Core

At the heart of the PowerPC G5 is a superscalar execution core, composed of 12 functional units that execute different types of instructions concurrently for massive data throughput.

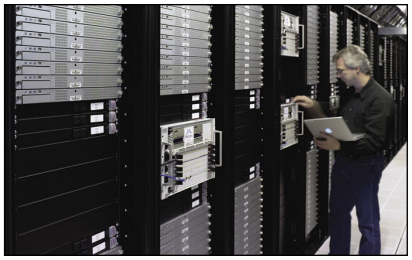
128-bit Velocity Engine
This powerful 128-bit vector processing unit accelerates data manipulation by applying a single instruction to multiple data at the same time, known as SIMD processing. Vector processing is useful for transforming large sets of data and other computationally intensive tasks, such as manipulating 3D images, rendering a video effect, encoding live media, or encrypting data. For example, when a designer uses a filter to apply a motion blur to an image, each pixel of the image must be changed according to the same set of instructions—a highly repetitive processing task.

The Velocity Engine on the PowerPC G5 has been optimized with two independent queues. It uses the same set of 162 instructions implemented in the PowerPC G4, enabling it to accelerate existing Mac OS X applications that have been optimized for the Velocity Engine. While operating concurrently with the integer and floating-point units, the Velocity Engine also supports highly parallel internal operations—for simultaneous processing of up to 128 bits of data in four 32-bit integers, eight 16-bit integers, sixteen 8-bit integers, or four 32-bit single-precision floating-point values.

Double-precision floating-point units
Today's powerful applications demand both precision and performance. That's why the PowerPC G5 has twice the double-precision floating-point hardware of the PowerPC G4, enabling it to complete at least two 64-bit mathematical calculations per clock cycle. In fact, each of its two floating-point units can perform both an add and a multiply with a single instruction, as well as full-precision square root calculations, for dramatic acceleration of complex computations.

Double-precision floating-point math is critical in research simulations and in many of the applications used to manipulate or render 3D graphics and video content. Weather prediction is one example of a highly iterative computing task that requires floating-point math. Large-scale models simulate weather patterns over time by measuring multiple influences, such as atmospheric pressure and airflow, at various instants and recalculating the model every minute. The floating-point capabilities of the PowerPC G5 provide the precision and performance to deliver accurate results within a useful timeframe.

Integer units
Integer units perform basic arithmetic and logic operations—such as add, subtract, multiply, and compare—which are used in virtually all computer functions, as well as in imaging, video, and audio applications. The PowerPC G5 has two integer units capable of both simple and complex instructions involving 32-bit or 64-bit data. What's more, they take full advantage of the processor's 64-bit registers and data paths to complete simple 64-bit integer calculations in a single clock cycle.



Machined for math
Virginia Tech gained international honors for building the fastest supercomputer at any academic institution in the world—using a cluster of original Power Mac G5 computers.* System X, a new cluster using 1100 64-bit dual processor Xserve G5 servers, operates at 12.25 teraflops.

Dedicated register files
To provide fast access to data, the PowerPC G5 is equipped with three sets of high-performance, low-latency register files: one containing 64-bit registers for integer calculations, one with 64-bit registers for floating-point calculations, and one with 128-bit registers for vector calculations. Each register file holds 32 registers for architected values, as well as 48 rename, or proxy, registers.

Load/store units
Load/store units perform memory-access operations, loading data into the registers of each functional unit and, after processing, storing the new data in L1 cache, L2 cache, or main memory as appropriate. With two load/store units, the PowerPC G5 is able to keep its wide instruction window filled with data for maximum processing efficiency.

Since the PowerPC G5 is capable of handling more than 200 in-flight operations, it needs a robust storage mechanism for the data associated with those instructions. While the instructions are being scheduled in the core, the load/store units load the associated data from L1 cache into the data registers behind the units that will be processing the data. To improve processing efficiency, the PowerPC G5 features a large number of rename registers that act as proxies, or placeholders, until the appropriate data arrives for execution. The instruction is held in queue, allowing other operations to take place until the actual data is loaded into the registers.

Condition register unit
When instructions have finished executing, they have the option to store information about their outcome in the processor's 32-bit condition register for future reference. The condition register can hold up to eight condition codes, which describe the outcome of eight different instructions. To improve the flow of data throughout the execution core, subsequent operations—such as branch instructions—can consult the condition register for the results of earlier operations.

The condition register unit performs logical operations related to the condition register. Programmers can manipulate and compare condition codes using a collection of PowerPC instructions, which are executed in this special functional unit. These comparisons are normally handled by an integer unit in other processors. With a dedicated functional unit for condition code comparisons, the PowerPC G5 effectively reduces the workload of its two integer units.

Branch prediction unit
Advanced processors use branch prediction and speculative instruction execution to keep processing resources constantly in use. A branch is a question in the processing queue: Which instruction should go next? Branch prediction anticipates the answer; and speculative execution schedules that instruction. If the prediction is correct, the processor works more efficiently, because the instruction has executed before it is required. If the prediction is incorrect, the processor must clear the unneeded branch, as well as any related data and instructions, resulting in an empty space called a pipeline bubble. Pipeline bubbles reduce performance as the processor marks time waiting for the next instruction.

The branch prediction unit on the PowerPC G5 uses innovative three-component logic to reduce pipeline bubbles and maximize processor efficiency. The success or failure of each prediction is captured in three large 16K branch history tables—local, global, and selector—that are used to improve the accuracy of future branch predictions.

Local branch prediction takes place as individual instructions are fetched into the processor and the types of branches are recorded in the local branch history table. Global branch prediction occurs at the same time: Branches are identified in their processing context, relating to preceding and subsequent operations; and the results are recorded in the global branch history table. The third, "selector" history table identifies which prediction type, local or global, was more accurate in predicting the outcome of each branch. This dynamic local/global/selector branch history scheme can predict branch processes with a high degree of accuracy, allowing the PowerPC G5 to efficiently use every processing cycle.

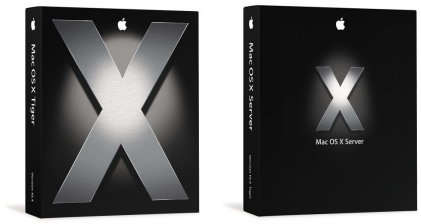
Designed for Symmetric Multiprocessing

Dual processors provide the high-density power and scalability required by applications in audio and video production; rendering, encoding, and compression farms; and research and computational clustering environments. Traditional server tasks also benefit from the increased bandwidth provided by multiprocessing, as many assorted transactions that use network file services, serve web pages, access databases, and authenticate users can be processed concurrently.

The PowerPC G5 is designed for symmetric multiprocessing. Dual independent frontside buses allow each processor to handle its own tasks at maximum speed with minimal interruption. At the same time, this high-performance bus interface enables each processor to discover and access data in the other processor's caches, a technique called intervention, or snooping. Cache intervention guarantees cache coherency, which ensures that the processor always fetches the correct data, even if it has been modified and is stored in the cache of the other processor.

For maximum efficiency, dual PowerPC G5 systems work with the operating system to schedule priorities. With sophisticated multiprocessing capabilities built in, Mac OS X and Mac OS X Server dynamically manage multiple processing tasks across the two processors. This allows dual PowerPC G5 systems to accomplish up to twice as much as a single-processor system in the same amount of time, without requiring any special optimization of the application.

64-Bit Capabilities in Mac OS X



Mac OS X v10.4 "Tiger"
With a robust and open UNIX-based foundation, Mac OS X and Mac OS X Server offer breakthroughs in innovation, ease of use, and reliability.

Mac OS X is a robust UNIX-based operating system that includes full support for preemptive multitasking with protected memory and symmetric multiprocessing. Apple has written Mac OS X version 10.4 and Mac OS X Server version 10.4 to leverage the 64-bit features of the PowerPC G5 architecture, providing advanced computation power and more main memory for industry-leading application performance.

While Mac OS X and the PowerPC G5 are the perfect platform for next-generation creative, scientific, and networking applications, they also run today's 32-bit applications natively. There's no need for emulation software or additional investment in applications, allowing users to upgrade their workflows to G5 hardware without interruption. What's more, unmodified application code takes immediate advantage of faster processor clock speeds. Applications optimized for the Velocity Engine on the PowerPC G4 use the same instruction set on the more efficient G5 processor, resulting in faster vector operations.

Performance gains are most dramatic when applications—particularly compute-intensive applications—are recompiled for the PowerPC G5. Developers can use Apple's Xcode tools to optimize their software for maximum performance on Apple's G5–based systems.

Updated Kernel and Numerical Libraries

PowerPC G5–optimized libraries
To optimize application performance on the PowerPC G5, Mac OS X includes math, vector, and image processing routines:

- Double-precision transcendental functions (libm)
- Vectorized transcendental functions (vMathLib)
- 128-bit integer math (vBigNum)
- Basic Linear Algebra Subprograms (BLAS)
- Linear Algebra Package (LAPACK)
- Vectorized digital signal processing (vDSP)
- Vector image processing (vImage)

On all Apple systems, Mac OS X and Mac OS X Server feature a high-performance 64-bit file system that supports HFS+ (and HFS+ journaled) file systems up to 16TB, so users can create very large, single file systems for massive databases, image archives, and digital video storage.

Apple has optimized Mac OS X for the PowerPC G5 architecture, enabling current 32-bit applications to benefit immediately from the key advances of 64-bit processing. On PowerPC G5–based systems, Mac OS X can utilize the processor's 64-bit instructions and registers. Mac OS X can also address the 4TB of physical memory supported by the PowerPC G5. For improved performance, Mac OS X v10.4 now supports 64-bit memory addressing, allowing data-intensive applications requiring more than 4GB of memory to address as much memory as is installed in the system.

Mac OS X includes a collection of highly optimized libraries that take advantage of new and faster math functions supported by the 64-bit PowerPC G5. These advanced math and vector libraries use the best-possible functionality for a specific PowerPC processor. Existing applications that use the built-in math libraries will benefit—without modification—from these enhancements. For example, applications use the Apple library routine for the square root function rather than calculating

it themselves. On G4 and G3 systems, the math library computes the square root using a software algorithm, while on G5 systems, it uses the much more efficient hardware instruction.

Integrated development for Mac OS X and Mac OS X Server
Apple's robust Xcode tools make it easy to build high-performance applications for the PowerPC G5 processor.

Software Development for the PowerPC G5

Xcode, Apple's development toolset, makes it easy to optimize applications for the massively parallel execution core of the PowerPC G5. An enhanced version of GCC (GNU Compiler Collection) incorporates the machine model for the PowerPC G5, taking full advantage of the PowerPC instruction grouping and supporting the enhanced math hardware functions. By recompiling with Xcode and the GCC 4.0 compiler, developers can get improved code generation that keeps the processor's integer and floating-point units constantly fed with instructions.

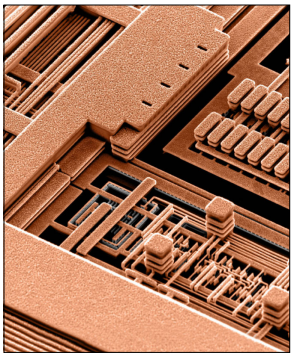
GCC 4.0 generates PowerPC G5–optimized code that also executes efficiently on G4 and G3 systems. This allows developers to build and qualify a single version of their applications for both 32-bit and 64-bit PowerPC-based systems. In addition, GCC 4.0 includes autovectorization capabilities. Previously, developers had to create code for the Velocity Engine vector processing unit by hand. Now the compiler can generate vector-based code automatically, delivering superior application performance while requiring less work for the developer.

For advanced performance optimization, Xcode includes Computer Hardware Understanding Development (CHUD) tools. These powerful tools measure and evaluate performance, identifying specific areas of an application that can benefit significantly from the capabilities of the PowerPC G5. For example, the MONster tool provides direct access to integrated performance counters on the G5, which test the efficiency of application code by measuring its impact on the processor.

For more information about development resources for the PowerPC G5 processor, see developer.apple.com.

State-of-the-Art IBM Process Technology

Industry-leading process technology
IBM is a worldwide leader in semiconductor process technologies. The PowerPC G5 is fabricated in its $3 billion, state-of-the-art facility in East Fishkill, New York.



Copper interconnects improve conductivity and boost processor performance.

The PowerPC G5 is fabricated in IBM's state-of-the-art facility in East Fishkill, New York. With industry-leading build, assembly, and test technology, IBM uses a 90-nanometer process with more than 58 million transistors and ten layers of copper interconnects.

To get electronics so small requires miniaturization breakthroughs, and IBM's long-standing dedication to scientific research has made these advances possible. For instance, the company began researching copper as an interconnect method over 25 years ago, but the technique didn't become practical until recently. IBM's cutting-edge process results in a small chip that can run at high clock speeds, while drawing less power and producing less heat.

Anatomy of a Processor

A microprocessor makes logic decisions based on whether its transistors are holding a charge—that is, whether they are "on" or "off." Each transistor on the PowerPC G5 is just .00000009 meter (90 nanometers) wide, built on a layer of silicon on insulator (SOI). SOI refers to the placement of a thin layer of insulator between transistors and bulk silicon. When transistors are built on this SOI layer, their capacitance, or the tendency to store a residual electrical charge, is reduced—which results in faster operation.

The smaller the transistors, the more difficult it is to wire them together. For over 30 years, the semiconductor industry relied on aluminum wiring to connect transistors. But as semiconductors get smaller, requiring thinner and narrower connections, aluminum increasingly resists the flow of electricity and becomes harder to use. And at such small sizes, resisting electrons may even jump wires, which can turn nearby transistors on and off at random.

The PowerPC G5 uses copper interconnects to transmit electrical signals faster and more reliably than aluminum can. Its 58 million transistors are connected by over 400 meters of copper wire that is less than 1/1000 the width of a strand of human hair. These ultrathin paths allow the electrons to complete a sequence in less time, because they don't need to travel as far.

To improve conductivity further, IBM developed an additive-copper, dual-damascene wiring process as a replacement for the conventional subtractive-aluminum process. The damascene method isn't new; swords made in Damascus, Syria, over 2500 years ago were forged with this process. Ages later, the semiconductor industry began using a much evolved damascene process for copper circuit boards, but IBM was the first company to discover a method for using copper in chip wiring. The result is a 40 percent gain in conductivity and faster processor operation.

Technical Specifications

64-bit PowerPC processor architecture

- Virtual address range: 64 bits, or 16 exabytes
- Physical address range: 42 bits, or 4 terabytes
- 64-bit data paths and registers
- Native support for 32-bit application code
- 64K L1 instruction cache; 32K L1 data cache, parity-protected
- 512K internal L2 cache, ECC-protected
- Microcoded instructions for up to four internal operations per instruction
- Support for fetching up to eight instructions per cycle
- Hardware-initiated instruction prefetching from L2 cache
- Hardware- or software-initiated data stream prefetching; support for up to eight active streams

Frontside bus

- Frequency: Double Data Rate (DDR) running at up to 1.35GHz
- Width: 64-bit dual-channel

Wide execution core

- Support for up to 215 in-flight instructions
- In-order dispatch of up to five operations into distributed issue queue structure
- Simultaneous issue of up to ten out-of-order operations:
  - One Velocity Engine permute operation
  - One Velocity Engine arithmetic logic operation
  - Two floating-point operations
  - Two fixed-point register-to-register operations
  - Two load or store operations
  - One condition register operation
  - One branch operation
- Out-of-order and speculative issue of load operations
- Dual-pipeline 128-bit Velocity Engine for single-instruction, multiple-data (SIMD) processing
- Two independent floating-point units for double-precision calculations
- Three register files, each holding 32 architected values and 48 rename registers:
  - One general-purpose register file to contain 64-bit registers for integer calculations
  - One floating-point register file to contain 64-bit registers for floating-point calculations
  - One vector register file to contain 128-bit registers for vector calculations
- One 32-bit condition register containing up to eight condition codes

Three-component branch prediction logic

- Speculative superscalar inner core organization
- Fast, selective flush of incorrect speculative instructions and results
- Prediction of up to two branches per cycle
- Support for up to 16 predicted branches in flight
- Prediction hints added to branch instructions
- Prediction support for branch direction and branch addresses

Physical specifications

- 58 million transistors
- 90-nanometer, silicon-on-insulator (SOI) process
- Die size: 66 square millimeters

For More Information

For more information about the PowerPC G5 processor, visit www.apple.com/g5processor.

* Based on TOP500 List of Supercomputer Sites, November 2003.