Theory of Operation

Power Macintosh

Introduction

This section contains information about how the Power Macintosh operates. The Power Macintosh components work together to provide these general functions:

- Central processing and control
- Memory
- Input/output (I/O)
- Video and sound

As you read this section, refer to the Power Macintosh Block Diagram, which shows the relationship of the components in Power Macintosh computers.

Specific functions of Power Macintosh components are covered in sections about

- Power supply
- Apple SuperDrive
- SCSI hard drive
- Internal mass storage devices
- Main logic board
- Expansion cards
- System startup sequence

Central Processing and Control

Processing and control logic in all Power Macintosh models are handled by the central processing unit (CPU) with the built-in math coprocessor and digital signal processor (DSP). Additional control signals are generated by the high-speed memory controller (HMC), Apple Memory Mapped I/O Controller (AMIC), and other components. The Squidlet Chip provides the system clocks.

CPU

The main processor in the Power Macintosh computers is a PowerPC 601 microprocessor. Features of the PowerPC 601 microprocessor include

- Full reduced instruction set computing (RISC) processing architecture
- Parallel integer and floating-point processing units
- An internal memory management unit (MMU)
- 32 Kbits of on-chip cache memory

The PowerPC 601 is a 32-bit address bus and a 64-bit data bus microprocessor.

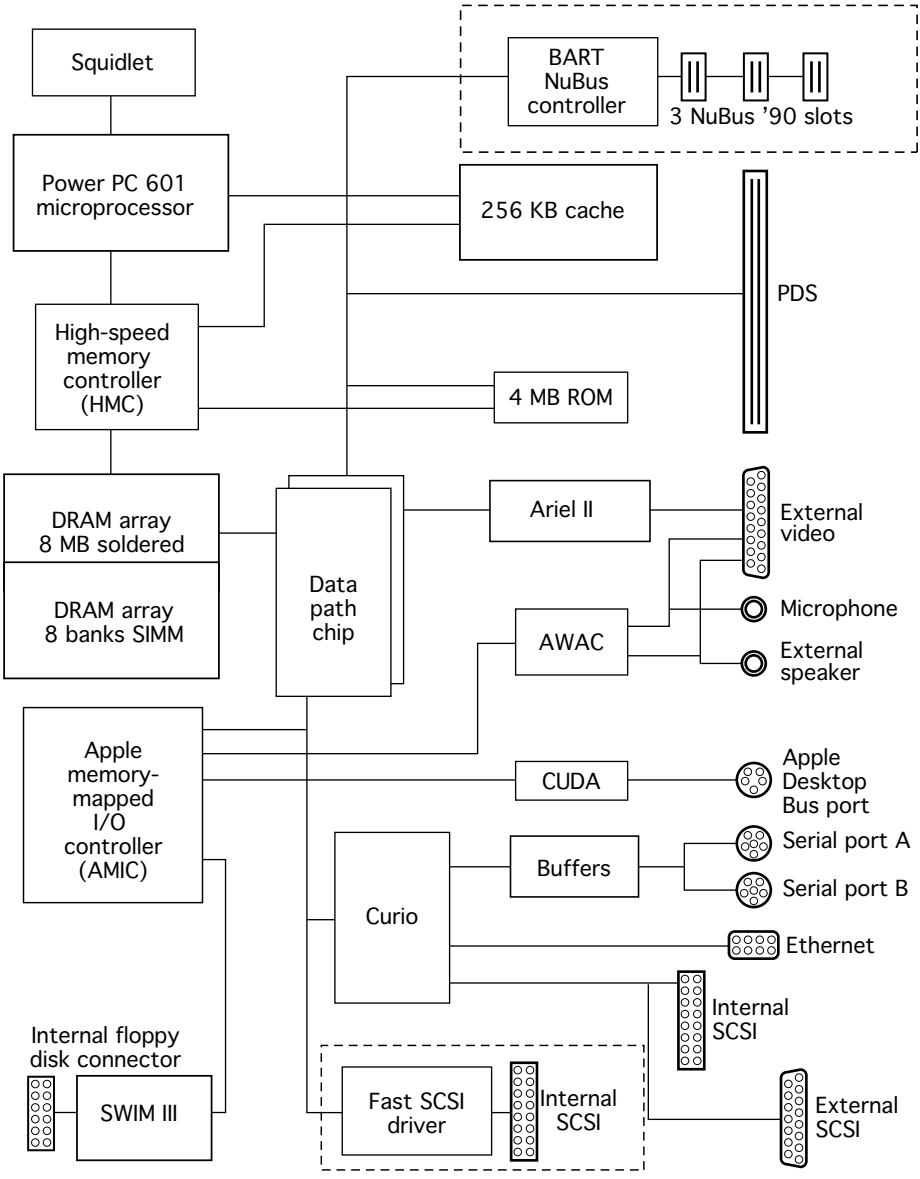
FPU

The PowerPC 601 includes a floating-point unit (FPU). The ability to execute three instructions in parallel, combined with the use of simple instructions with rapid execution times, yield high efficiency and throughput for PowerPC 601-based systems. This provides greater horsepower when running complex applications.

Power Macintosh Block Diagram

This diagram illustrates the chips responsible for controlling the processing and I/O. The components within the dotted lines are present only on the 8100.

Note: The physical layout of the ports does not correspond to the back panel of any of the Power Macintosh computers. For a back panel port illustration, see the “Ports and Pinouts” section under the Hardware tab.



Real-Time Clock (Squidlet Chip)

Squidlet is a 28-pin chip on the logic board that provides a set of synchronized system clocks for Power Macintosh computers. The Power Macintosh circuitry is driven by several clocks running at different frequencies that vary depending on the model. These clocks include the system clock (which is controlled by an oscillator and drives the PowerPC microprocessor) and the CPU bus clock (which is controlled by the system clock).

Memory

This section discusses Read Only Memory (ROM) and Random Access Memory (RAM), as well as changes from previous Macintosh computers.

ROM (Read Only Memory)

Power Macintosh computers contain 4 MB of ROM with 100 ns access time. Some of the system software that was stored on the hard disk in previous Macintosh computers is in ROM in Power Macintosh models. The high-speed memory controller (HMC) controls signals to the ROM.

RAM (Random Access Memory)

RAM for Power Macintosh computers is provided by dynamic random-access memory (DRAM) chips. While the computer is on, the operating system maintains a copy of parameter RAM (PRAM) plus the date and time in system RAM. Once each second, the operating system updates the time stored in RAM.

Input/Output

Any card in the BART NuBus slots, the Cuda chip, SWIM III chip, and Curio chip on the logic board control input and output (I/O). Power Macintosh computers have hardware interfaces for one internal floppy drive, one Apple Ethernet port, two RS-232/RS-422 serial ports, internal and external Small Computer System Interface (SCSI) parallel ports, and one Apple Desktop Bus (ADB) port.

Apple DeskTop Bus

The Apple DeskTop Bus (ADB) is the serial communication bus that connects keyboards, mouse devices, graphics tablets, and other input devices to Power Macintosh CPUs. The ADB network is now the Apple standard interface for input devices and is used on all Macintosh computers released after the Macintosh Plus.

ADB Devices

The ADB device driver (in system software) sends commands for an ADB device to the Cuda microcontroller chip on the Power Macintosh, which sends the commands over the bus to the appropriate device. In the other direction, an ADB device sends information through the bus to the Cuda chip. The ADB device drivers store all ADB data (such as key transitions and mouse motion information) in RAM on the logic board, where it can be accessed by software.

Two or more input devices (including the keyboard and mouse) can be connected to the same ADB. The devices can be connected in parallel or they can be daisy-chained.

All devices made for the ADB have a microprocessor that makes them intelligent devices. All devices except the mouse have ports for daisy-chaining other ADB devices. Because

the mouse has no port, it must be the last device in the chain.

SWIM III Chip

The SWIM III chip in the Power Macintosh replaces the SWIM II, SWIM, and IWM chips in earlier Macintosh computers. Like the IWM, the SWIM chip converts between the serial data used by Apple disk drives and the parallel data bus used by the CPU. It provides support for the internal Apple SuperDrive. When used with file-exchange software, it also allows the Apple SuperDrive to read and write to MS-DOS formatted disks. The Power Macintosh SWIM III chip supports direct access memory (DMA) data transfers, which minimizes use of the main microprocessor.

Curio Chip

The Curio I/O chip is a multipurpose I/O chip that contains a media-access controller for Ethernet, a SCSI controller for SCSI, and a serial communications controller (SCC) for serial I/O.

RS-232/RS-422 Serial Ports

The Power Macintosh uses two mini-DIN 9 connectors on the computer's back panel for attaching serial peripheral devices. Either port can be independently programmed for asynchronous or synchronous communication formats up to 9600 baud, including AppleTalk and the full range of Apple GeoPort protocols.

SCSI Bus

The Small Computer System Interface (SCSI) chip controls a high-speed parallel interface for up to seven internal and external SCSI devices that can be daisy-chained to the SCSI bus. To accomplish this, the one internal 50-pin ribbon connector for internal devices and one external DB-25 connector for external devices are connected in parallel. The Power Macintosh 8100 models contain a second internal SCSI cable that provides another SCSI interface to internal devices. Internal devices may be connected to either cable.

NuBus Expansion Interface

The NuBus interface in Power Macintosh computers provides access between RAM or ROM and plug-in expansion cards. It is not designed to allow plug-in cards to gain access to peripheral devices directly. However, NuBus cards for the Power Macintosh AV models can tap in to the raw audio and video signals of the Apple AV technologies.

The number of NuBus cards that can be used with a Power Macintosh depends upon the model. The Power Macintosh 7100 and 8100 models accept up to three NuBus cards. The Power Macintosh 6100 model accepts one NuBus card through an optional adapter card in the processor-direct slot (PDS). The Power Macintosh 6100AV model cannot accept a NuBus card because its PDS slot is already occupied by the AV card.

BART NuBus Controller

The BART NuBus controller chip on the Power Macintosh 8100 models provides the gateway between the NuBus and CPU bus. It supports all NuBus burst transactions and functions as a CPU bus master, transferring one-cycle or four-cycle transactions.

Video and Sound

All Power Macintosh models feature built-in, high-quality stereo sound input and output capabilities. These capabilities support speech recognition and synthesis, as well as broadcast-quality 16-bit sound.

AudioVision HDI-45 Monitor Socket

All Power Macintosh logic boards contain an HDI-45 monitor socket that supports Apple displays, and use main RAM for frame buffering. This supports monitors up to 13 inches at color depths up to 16 bits (or “thousands of colors”) and 16-inch monitors at color depths up to 8 bits (or 256 colors).

The HDI-45 monitor socket connector is not compatible with the DB-15 socket found on all other modular Macintosh models in the 68K series, unless a video adapter cable is used. The Power Macintosh 7100 and 8100 models come with the video expansion card already installed, and the card is compatible with the standard DB-15 connector. The Power Macintosh AV models come with an audio-visual (AV) card installed and a standard DB-15 connector. This enables users to have a second monitor. The video expansion card and

the AV card add a video port, and do not use the built-in port on the back of the Macintosh.

Power Macintosh AV Card

The Power Macintosh AV card enables users to connect to high-quality S-video devices to digitize video images from various video sources, as well as output video images to VCRs or television monitors. (VHS has 250 horizontal line resolution, whereas S-video has 400 horizontal line resolution, which produces the higher quality.) This card can support mixed video and graphics in full 24-bit color on small and medium-sized monitors, and 16-bit and 8-bit color on larger monitors.

This AV Card has its own standard DB-15 monitor connector, as well as S-video input and output connectors. This allows users to connect standard television equipment

with RCA-type connectors by using the adapter cables included with all Power Macintosh AV models.

The Power Macintosh AV card contains 2 MB of video RAM (VRAM) and provides advanced video I/O features, including compatibility with the NTSC, PAL, or SECAM television signal standards used by various countries. For example, North American countries use the NTSC standard.

Audio Waveform Amplifier and Converter (AWAC) Sound Chip

The AWAC chip controls the external stereo mini phone jacks for sound I/O. The sound system achieves simultaneous 16-bit broadcast-quality stereo sound input and output by using four 8K buffers. The system supports Apple Computer speech synthesis-and-recognition software. All Power Macintosh computers are supplied with a built-in speaker. Software controls the volume of sound to the built-in speaker and to the sound output connector independently.

Video Output

Video images, graphics images stored in video RAM (VRAM) may have different color depths. These images exit VRAM through its serial access memory port and pass to the color palette chip. This chip, also known as the Ariel chip, provides independent color lookup tables for video and graphics images, mixes them into a single digital RGB data stream, and then converts the result into analog RGB video.

Encoder Chip

The encoder chip either sends RGB signals directly to the monitor connector or encodes them into NTSC or PAL video signals in composite or S-video format. The chip then sends those signals to other connectors located on the card.

Video Input

Video input signals may be analog composite or S-video in NTSC, PAL, or SECAM format. A set of S-video-to-RCA adapter cables are included with Power Macintosh AV models to connect external video devices that have RCA connectors (such as camcorders, VCRs, and video monitors).

Power Supply

The power supply operates on standard line voltage and converts AC voltage to DC voltage for use by the logic board, the internal devices, and any expansion card in the Power Macintosh. The power supply also includes a fan that maintains the proper operating temperature. The power supply is removed and replaced as one unit.

Apple SuperDrive

All Power Macintosh computers include the Apple SuperDrive floppy drive. This version of the SuperDrive is called a *manual insert floppy* and does not include the automatic disk injection feature of previous versions of the Apple SuperDrive. It reads and writes on 400K (single-sided), 800K (double-sided), and 1.44 MB (high-density) 3.5-inch disks. With the help of utility software, it can also read from and write to MS-DOS disks.

SCSI Hard Drive

The hard disk drive connects to the logic board by way of the internal SCSI connector and the power connector. Replace the internal hard drive as one unit.

Internal Mass Storage Devices

Power Macintosh models may include the CD 300iplus CD-ROM drive. Any third-party SCSI device (such as a tape-backup, magneto-optical drive, or other removable mass media device) can be installed in place of the CD-ROM drive. However, any SCSI device must conform to the 5.25-inch, half-height size limit. In addition, the third-party vendor must supply the front faceplate to accommodate the specific mass storage device.

Main Logic Board

The main logic board contains the microprocessor, memory (RAM and ROM), control circuitry, NuBus slots, and ports. You can remove and replace the logic board as a module. If, however, you isolate a problem to either of the following components, you can remove and replace them individually:

- **DRAM SIMMs:** Single In-Line Memory Modules (SIMMs) are small printed circuit cards that contain dynamic RAM (DRAM) chips for expansion of random access memory.
- **Lithium battery:** This battery powers the real-time clock and the parameter RAM (which preserves Control Panel settings while the computer is turned off).

The logic board contains a SIMM socket for new ROM SIMMs. This provides a simple method for upgrading the ROM without removing the existing soldered ROM. This ROM contains some of the system software that was on disk in previous Macintosh computers.

Expansion Cards

Replaceable expansion cards plug into the PDS (processor-direct slot) connector on the logic board of Power Macintosh computers.

The 6100 series models don't require a video card, but can accommodate the optional Power Macintosh 6100 NuBus adapter card. You can install a DOS-compatibility card in the 6100 PDS with an adapter card to make the system DOS- and Windows-compatible.

The 7100 series models can use the 2 MB video card or the Apple Audio-Visual (AV) Technologies card in the PDS. The 7100 models can also use the Level 2 cache card in the Level 2 cache slot on the logic board to boost speed.

The 8100 series models can use the 4 MB video card or the Level 2 cache card. All Power Macintosh computers support the Power Macintosh AV card.

System Startup Sequence

The following sequence of events takes place when power is first applied to the Power Macintosh computers. Understanding this sequence will help you identify and troubleshoot any problems that occur during startup.

1 Pressing the Power-on key discharges voltage from the battery, which initiates the startup sequence. A normal startup chord is emitted as power from the power supply reaches the main logic board. If the battery voltage is too low, the system startup sequence will not begin.

2 The microprocessor is held in a wait state while the system tests (including a RAM test) are performed. Firmware routines contained in the ROM execute a RAM test to determine how much RAM is present in the machine and to verify the proper operation of that RAM.

3 System RAM is mapped for normal operation as soon as the system is fully tested and initialized.

4 When the tests are completed successfully, the Macintosh attempts to boot from a startup drive. If errors are identified during testing, error tones sound. The system searches for a System Folder on a readable disk in the following sequence:
- Internal floppy drive.
- The startup device as set in the control panel. (If the battery is removed or the parameter RAM is destroyed, the startup device defaults to the SCSI device with ID=0.)
- SCSI devices in descending order of SCSI ID (from 6 to 0).

When a disk with a System Folder has been found, the smiling Macintosh icon is displayed. Otherwise, the sad Macintosh icon appears.

5 The startup application is launched (normally the Finder) and the desktop appears on the screen. If this is not successful and a disk with a ”?” or “X” appears, try booting from another disk or CD.