

Original PC Hardware Reference

SOME OF THE MAIN TOPICS IN THIS CHAPTER ARE

System-Unit Features by Model

An Introduction to the PC (5150)

An Introduction to the PC Convertible (5140)

An Introduction to the XT (5160)

An Introduction to the Portable PC

An Introduction to the AT

An Introduction to the XT Model 286

Although IBM no longer seems in a position to dictate the majority of PC standards (Intel and Microsoft seem to have taken on that role), all the original PC specifications and standards were determined by IBM and set forth in its original line of personal computers. From these original IBM PC, XT, and AT systems came many of the standards to which even new systems today must still conform. This includes motherboard form factors, case and power supply designs, ISA bus architecture, system resource usage, memory mapping and architecture, system interfaces, connectors, pinouts, and more. As such, nearly every PC-compatible system on the market today is based in some form on one or more of the original IBM products. The original lines of systems are often called Industry Standard Architecture (ISA) systems or Classic PCs. IBM calls them Family/1 systems.

This chapter serves as a technical reference for IBM's original family of personal computer systems. Much of the information in this chapter is a sort of history lesson; it is easy to see how far IBM-compatible computing has come when you look over the specifications of the original systems the PC standard is based on. I find this information valuable to teach others the origins of what we call a PC-compatible system.

Because PC compatibles are mostly based on the IBM XT and especially AT systems, you can see where things such as the motherboard, case, and power supply shapes came from, as well as the positions of slots, connectors, and other components on the boards. You can also get a glimpse of the levels of performance these systems originally offered.

Although these systems have long since been discontinued, I am amazed that I still find many of them in use. From individuals to large corporations, to the government and military, I still occasionally encounter these old systems in my training and consulting practice. Often the only part of the original system that remains is the case and power supply, because newer Baby-AT form factor motherboards easily fit in most of the original IBM machines. In fact, I still have several of the original IBM XT and AT cases around that now sport modern Pentium motherboards, large hard drives, and all-new components!

System-Unit Features by Model

The following sections discuss the makeup of all the various versions or models of the original IBM systems, and also include technical details and specifications of each system. Every system unit has a few standard parts. The primary component is the motherboard, which has the CPU (central processing unit, or microprocessor) and other primary computer circuitry. Each unit also includes a case with an internal power supply, a keyboard, certain standard adapters or plug-in cards, and usually some form of disk drive.

There is an explanation of each system's various submodels along with details about the differences between and features of each model. The changes from model to model and version to version of each system are also shown.

Included for your reference is part-number information for some of the systems and options. This information is for comparison and reference purposes only; all these systems have been discontinued and generally are no longer available. However, it is interesting to note that IBM still

stocks and sells component parts and assemblies for even these discontinued units—including the original PC, XT, and AT systems.

The original IBM systems can be identified not only by their name, but also by a number assigned to each system. IBM normally put the name of the computer on a small 1×1-inch-square brushed-metal plate on the front cover, and the system number on a similar metal plate on the rear of the chassis. The system names and numbers correspond as follows:

| System Number | System Name |
|---------------|------------------------------------|
| 4860 | PCjr |
| 5140 | PC Convertible (laptop) |
| 5150 | PC |
| 5155 | Portable PC (really a portable XT) |
| 5160 | XT |
| 5162 | XT-286 (really an AT) |
| 5170 | AT |

Note that because modern PC components are often designed to be physically compatible with the original IBM systems, you can (and usually should) replace any failed or obsolete components in the older IBM systems with non-IBM replacement parts. Invariably you will be able to obtain upgraded or improved components compared to the originals, and at a greatly reduced price. An example is one original 286 IBM AT that I have, which now sports a Pentium MMX motherboard, 64MB of RAM, 9GB SCSI drive, 12x CD-ROM, and a host of other options. Of course, the only original IBM parts left in the system are the case and power supply, which are both more than 14 years old!

An Introduction to the PC (5150)

IBM introduced the IBM Personal Computer on August 12, 1981, and officially withdrew the machine from the market on April 2, 1987. During the nearly six-year life of the PC, IBM made only a few basic changes to the system. The basic motherboard circuit design was changed in April 1983, to accommodate 64KB RAM chips. Three different ROM BIOS versions were used during the life of the system; most other specifications, however, remained unchanged. Because IBM no longer markets the PC system, and because of the PC's relatively limited expansion capability and power, the standard PC is obsolete by most standards.

The system unit supports only floppy disk drives unless the power supply is upgraded or an expansion chassis is used to house the hard disk externally. IBM never offered an internal hard disk for the PC, but many third-party companies stepped in to fill this void with upgrades. The system unit included many configurations with single or dual floppy disk drives. Early on, one version was even available with no disk drives, and others used single-sided floppy drives.

The PC motherboard was based on the 16-bit Intel 8088 microprocessor and included the Microsoft Cassette BASIC language built into ROM. For standard memory, the PC offered configurations with as little as 16KB of RAM (when the system was first announced) and as much as

256KB on the motherboard. Two motherboard designs were used. Systems sold before March 1983 had a motherboard that supported a maximum of only 64KB of RAM, and later systems supported a maximum of 256KB on the motherboard. In either case, you added more memory (as much as 640KB) by installing memory cards in the expansion slots.

The first bank of memory chips in every PC is soldered to the motherboard. Soldered memory is reliable but not conducive to easy servicing because it prevents you from easily exchanging failing memory chips located in the first bank. The chips must be unsoldered and the defective chip replaced with a socket so that a replacement can be plugged in. When IBM services the defective memory, IBM advises you to exchange the entire motherboard. Considering today's value of these systems, replacing the motherboard with one of the many compatible motherboards on the market might be a better idea. Repairing the same defective memory chip in the XT system is much easier because all memory in an XT is socketed.

The only disk drive available from IBM for the PC is a double-sided (320 or 360KB) floppy disk drive. You can install a maximum of two drives in the system unit by using IBM-supplied drives, or four drives using half-height third-party drives and mounting brackets.

The system unit has five slots that support expansion cards for additional devices, features, or memory. All these slots support full-length adapter cards. In most configurations, the PC included at least a floppy disk controller card. You need a second slot for a monitor adapter, which leaves three slots for adapter cards.

All models of the PC have a fan-cooled 63.5-watt power supply. This low-output power supply doesn't support much in the way of system expansion, especially for power-hungry items such as hard disks. Usually, this low-output supply must be replaced by a higher output unit, such as the one used in the XT. Figure 1 shows an interior view of a PC system unit.

An 83-key keyboard with an adjustable typing angle is standard equipment on the PC. The keyboard is attached to the rear of the system unit by a six-foot coiled cable. Figure 2 shows the back panel of the PC.

Most model configurations of the PC system unit included these major functional components:

- Intel 8088 microprocessor
- ROM-based diagnostics (POST)
- BASIC language interpreter in ROM
- 256K of Dynamic RAM
- Floppy disk controller
- One or two 360K floppy drives
- A 63.5-watt power supply
- Five I/O expansion slots
- Socket for the 8087 math coprocessor

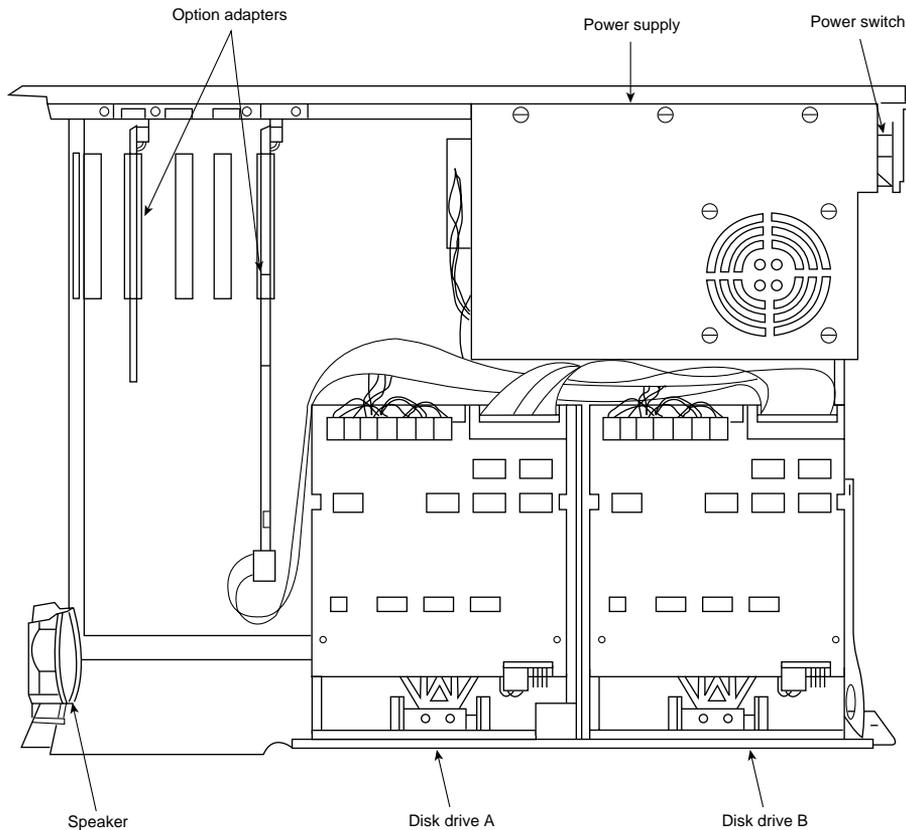


Figure 1 The IBM PC interior view.

PC Models and Features

Although several configurations of the IBM PC were available before March 1983, only two models were available after that time. The later models differ only in the number of floppy drives. IBM designated these models as follows:

- *IBM PC 5150 Model 166.* 256KB RAM, one 360KB drive
- *IBM PC 5150 Model 176.* 256KB RAM, two 360KB drives

The IBM PC was never available with a factory-installed hard disk (XT systems came with hard disks), primarily because the system unit had limited room for expansion and offered few resources with which to work. After IBM started selling XTs with only floppy disk drives (on April 2, 1985), the PC essentially became obsolete. The XT offered much more for virtually the same price, so investing in a PC after the XT introduction was questionable.

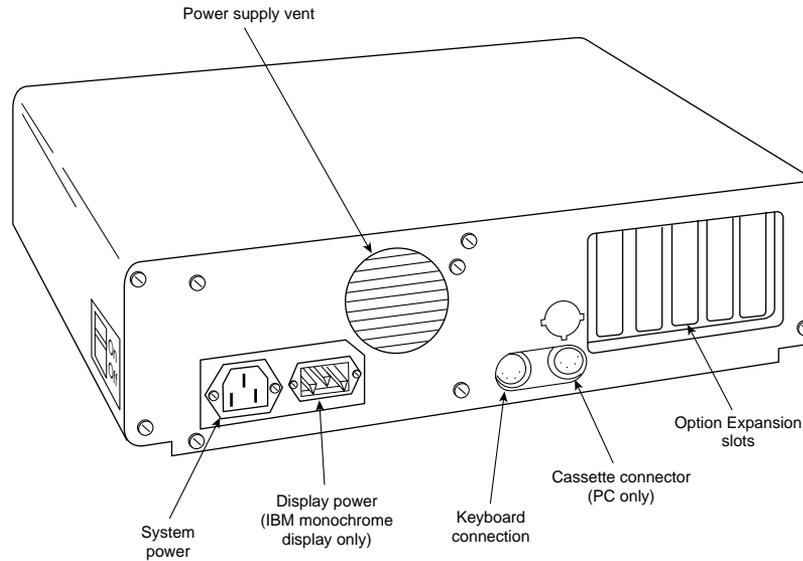


Figure 2 The IBM PC rear view.

IBM finally officially withdrew the PC from the market on April 2, 1987. IBM's plans for the system became obvious when the company didn't announce a new model with the enhanced keyboard, as it did with other IBM systems. In retrospect, it is amazing that the system was sold over a period of nearly six years with few changes!

Table 1 shows the part numbers for the IBM PC system units and options.

Table 1 IBM PC Models and Part Numbers

| Description | Number |
|---|---------------|
| PC system unit, 256KB, one double-sided drive | 5150166 |
| PC system unit, 256KB, two double-sided drives | 5150176 |
| Options | Number |
| PC expansion-unit Model 001 with 10MB hard disk | 5161001 |
| Double-sided disk drive | 1503810 |
| 8087 math coprocessor option | 1501002 |
| BIOS update kit (10/27/82 BIOS) | 1501005 |

With some creative purchasing, you could make a usable system of a base PC by adding the requisite components, such as a full 640KB of memory as well as hard disk and floppy drives. Only you can decide when your money is better invested in a new system.

Before you can think of expanding a PC beyond even a simple configuration, and to allow for compatibility and reliability, you must address the following two major areas:

- ROM BIOS level (version)
- 63.5-watt power supply

In most cases, the low-output power supply is the most critical issue, because all PCs sold after March 1983 already had the latest ROM BIOS. If you have an earlier PC system, you also must upgrade the ROM, because the early versions lack some required capabilities—in particular, the capability to scan the memory range C0000-DFFFF in the Upper Memory Area (UMA) for adapter card ROMs.

PC BIOS Versions

Three different BIOS versions have been used in the IBM PC. They can be identified by their date and summarized as follows:

- *April 24, 1981.* The first PC BIOS version would only support a maximum of 544KB of RAM. In addition, it would not scan the UMA for adapter card ROMs, such as those found on EGA/VGA video adapters, hard disk controllers, and SCSI adapters. This BIOS is very rare, and any such machine is almost a collector's item because it represents one of the first PCs ever made.
- *October 19, 1981.* The second PC BIOS has the same 544KB RAM and UMA scan limitations as the first BIOS, but it does fix a couple of minor display bugs. Even this BIOS is not very common.
- *October 27, 1982.* The third and final PC BIOS has support for a full 640KB of base RAM plus the necessary UMA scan to support adapter cards with ROMs on them. To be useful at all, a PC must have this BIOS revision. If your PC BIOS is one of the older two versions, note that IBM sells a BIOS update kit under part number 1501005.

Table 2 lists the different IBM Family/1 (PC, XT, and AT) BIOS versions. It also shows the ID, sub-model, and revision bytes that can be determined by a software function call.

Int 15h, C0 = Return System Configuration Parameters

Some of the systems, such as the PC and earlier XT and AT systems, only support the ID byte; the submodel and revision bytes had not been established when those systems were developed. The table also shows the number of drive types supported in the AT and XT-286 systems BIOS.

Table 2 IBM Family/1 (PC, XT, AT) System BIOS Dates

| System | CPU | Speed | BIOS Date | ID, Submodel, Revision | BIOS Drive Types |
|----------------|-------|---------|-----------|------------------------------|------------------------|
| PC | 8088 | 4.77MHz | 04/24/81 | FF — — | — |
| PC | 8088 | 4.77MHz | 10/19/81 | FF — — | — |
| PC | 8088 | 4.77MHz | 10/27/82 | FF — — | — |
| PCjr | 8088 | 4.77MHz | 06/01/83 | FD — — | — |
| PC-XT, PPC | 8088 | 4.77MHz | 11/08/82 | FE — — | — |
| PC-XT | 8088 | 4.77MHz | 01/10/86 | FB 00 01 | — |
| PC-XT | 8088 | 4.77MHz | 05/09/86 | FB 00 02 | — |
| PC Convertible | 80C88 | 4.77MHz | 09/13/85 | F9 00 00 | — |
| PC-AT | 286 | 6MHz | 01/10/84 | FC — — | 15 |
| PC-AT | 286 | 6MHz | 06/10/85 | FC 00 01 | 23 |
| PC-AT | 286 | 8MHz | 11/15/85 | FC 01 00 | 23 |
| PC-XT 286 | 286 | 6MHz | 04/21/86 | FC 02 00 | 24 |

The ID, submodel, and revision byte numbers are in hexadecimal.

— means this feature is not supported.

The BIOS date is stored in all PC-compatible systems at memory address FFFF5h. To display the date of your BIOS, a simple DEBUG command can be used to view this address. DEBUG is a command program supplied with MS-DOS. At the DOS prompt, execute the following commands to run DEBUG, display the date stored in your BIOS, and then exit back to DOS:

```
C:\>DEBUG
-D FFFF:5 L 8
FFFF:0000          30 31 2F-32 32 2F 39 37          01/22/97
-Q
```

In this example, the system queried shows a BIOS date of 01/22/97.

PC Technical Specifications

Technical information for the personal computer system and keyboard is described in this section. Here, you find information about the system architecture, memory configurations and capacities, standard system features, disk storage, expansion slots, keyboard specifications, and physical and environmental specifications. This kind of information might be useful in determining what parts you need when you are upgrading or repairing these systems. Figure 3 shows the layout and components on the PC motherboard.

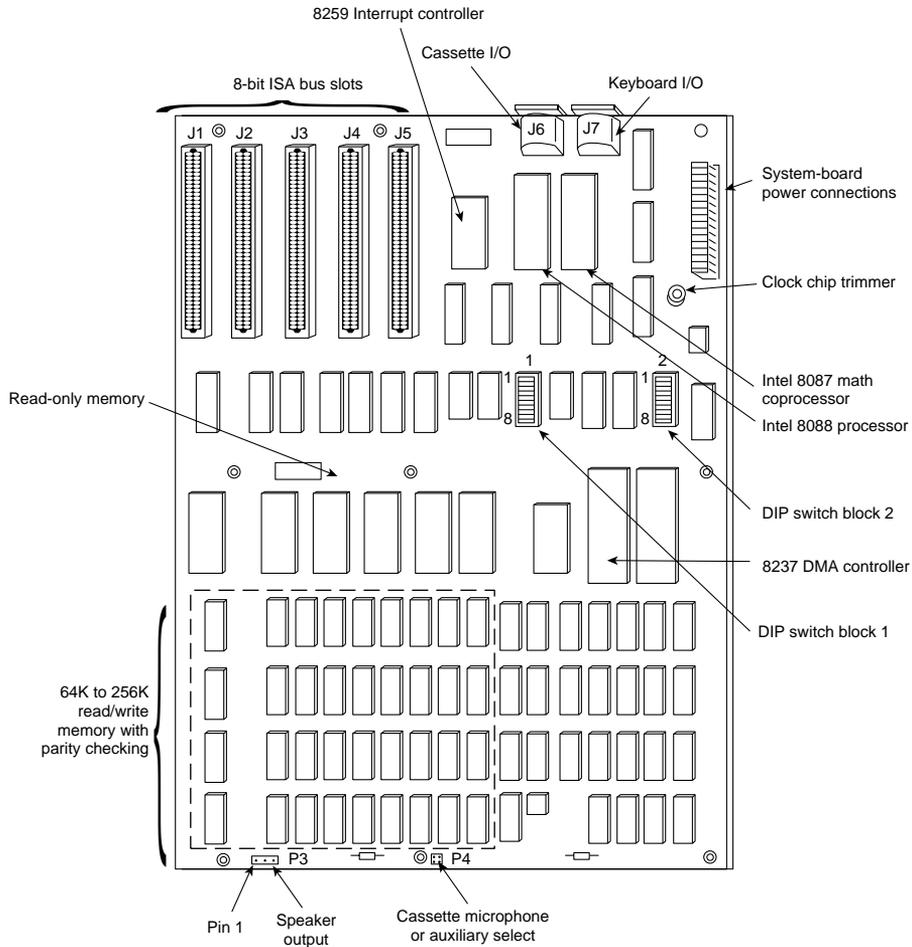


Figure 3 The IBM PC motherboard.

System Architecture

| | |
|------------------------------|--------------------------------------|
| Microprocessor | 8088 |
| Clock speed | 4.77MHz |
| Bus type | ISA (Industry Standard Architecture) |
| Bus width | 8-bit |
| Interrupt levels | 8 (6 usable) |
| Type | Edge-triggered |
| Shareable | No |
| DMA channels | 4 (3 usable) |
| Bus masters supported | No |
| Upgradable processor complex | No |

(continues)

(continued)

Memory

| | |
|---------------------------------|---|
| Standard on system board | 16KB, 64KB, or 256KB |
| Maximum on system board | 256KB |
| Maximum total memory | 640KB |
| Memory speed (ns) and type | 200ns Dynamic RAM chips |
| System board memory-socket type | 16-pin DIP |
| Number of memory-module sockets | 27 (3 banks of 9 chips) |
| Memory used on system board | 27 16KB×1-bit or 64KB×1-bit DRAM chips in 3 banks of 9, one soldered bank of 9 16KB×1-bit or 64KB×1-bit chips |
| Memory cache controller | No |
| Wait states: | |
| System board | 1 |
| Adapter | 1 |

Standard Features

| | |
|---------------------------------|---------------|
| ROM size | 40KB |
| ROM shadowing | No |
| Optional math coprocessor | 8087 |
| Coprocessor speed | 4.77MHz |
| Standard graphics | None standard |
| RS232C serial ports | None standard |
| UART chip used | NS8250B |
| Maximum speed (bits per second) | 9,600bps |
| Maximum number of ports | 2 supported |
| Pointing device (mouse) ports | None standard |
| Parallel printer ports | None standard |
| Bidirectional | No |
| Maximum number of ports | 3 supported |
| CMOS real-time clock (RTC) | No |
| CMOS RAM | None |

Disk Storage

| | |
|--|---------------|
| Internal disk and tape drive bays | 2 full-height |
| Number of 3 1/2-inch and 5 1/4-inch bays | 0/2 |
| Standard floppy drives | 1×360KB |
| Optional floppy drives: | |
| 5 1/4-inch 360K | Optional |
| 5 1/4-inch 1.2M | No |
| 3 1/2-inch 720K | Optional |
| 3 1/2-inch 1.44M | No |
| 3 1/2-inch 2.88M | No |
| Hard disk controller included | None |

Expansion Slots

| | |
|-------------------------------|-------|
| Total adapter slots | 5 |
| Number of long/short slots | 5/0 |
| Number of 8-/16-/32-bit slots | 5/0/0 |
| Available slots (with video) | 3 |

Keyboard Specifications

| | |
|-----------------------------|------------|
| 101-key enhanced keyboard | No, 83-key |
| Fast keyboard speed setting | No |
| Keyboard cable length | 6 feet |

Physical Specifications

| | |
|----------------|-------------|
| Footprint type | Desktop |
| Dimensions: | |
| Height | 5.5 inches |
| Width | 19.5 inches |
| Depth | 16.0 inches |
| Weight | 25 pounds |

Environmental Specifications

| | |
|-----------------------------------|-----------------|
| Power-supply output | 63.5 watts |
| Worldwide (110/60,220/50) | No |
| Auto-sensing/switching | No |
| Maximum current: | |
| 104-127 VAC | 2.5 amps |
| Operating range: | |
| Temperature | 60–90 degrees F |
| Relative humidity | 8–80 percent |
| Maximum operating altitude | 7,000 feet |
| Heat (BTUs/hour) | 505 |
| Noise (Average db, operating, 1m) | 43 |
| FCC classification | Class B |

Tables 3 and 4 show the switch settings for the PC (and XT) motherboard. The PC has two eight-position switch blocks (Switch Block 1 and Switch Block 2), whereas the XT has only a single Switch Block 1. The PC used the additional switch block to control the amount of memory the system would recognize, and the XT automatically counted up the memory amount.

Table 3 IBM PC/XT Motherboard Switch Settings

| Switch Block 1 (PC and XT) | | |
|-----------------------------------|-----------------|---|
| | Switch 1 | IBM PC Function (PC Only) |
| | Off | Boot from Floppy Drives |
| | On | Do Not Boot from Floppy Drives |
| | Switch 1 | IBM XT Function (XT Only) |
| | Off | Normal POST (power on self test) |
| | On | Continuous Looping POST |
| | Switch 2 | Math Coprocessor (PC/XT) |
| | Off | Installed |
| | On | Not Installed |
| Switch 3 | Switch 4 | Installed Motherboard Memory (PC/XT) |
| On | On | Bank 0 Only |
| Off | On | Banks 0 and 1 |
| On | Off | Banks 0, 1, and 2 |
| Off | Off | All 4 Banks |
| Switch 5 | Switch 6 | Video Adapter Type (PC/XT) |
| Off | Off | Monochrome (MDA) |
| Off | On | Color (CGA)—40x25 mode |
| On | Off | Color (CGA)—80x25 mode |
| On | On | Any Video Card with Onboard BIOS (EGA/VGA) |
| Switch 7 | Switch 8 | Number of Floppy Drives (PC/XT) |
| On | On | 1 floppy drive |
| Off | On | 2 floppy drives |
| On | Off | 3 floppy drives |
| Off | Off | 4 floppy drives |

Table 4 Switch Block 2 (PC Only) Memory Settings

| Memory | Switch Number (Switch Block 2, PC Only) | | | | | | | |
|---------------|--|----------|----------|----------|----------|----------|----------|----------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 16KB | On | On | On | On | On | Off | Off | Off |
| 32KB | On | On | On | On | On | Off | Off | Off |
| 48KB | On | On | On | On | On | Off | Off | Off |
| 64KB | On | On | On | On | On | Off | Off | Off |
| 96KB | Off | On | On | On | On | Off | Off | Off |
| 128KB | On | Off | On | On | On | Off | Off | Off |
| 160KB | Off | Off | On | On | On | Off | Off | Off |
| 192KB | On | On | Off | On | On | Off | Off | Off |
| 224KB | Off | On | Off | On | On | Off | Off | Off |
| 256KB | On | Off | Off | On | On | Off | Off | Off |

| Memory | Switch Number (Switch Block 2, PC Only) | | | | | | | |
|--------|---|-----|-----|-----|-----|-----|-----|-----|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 288KB | Off | Off | Off | On | On | Off | Off | Off |
| 320KB | On | On | On | Off | On | Off | Off | Off |
| 352KB | Off | On | On | Off | On | Off | Off | Off |
| 384KB | On | Off | On | Off | On | Off | Off | Off |
| 416KB | Off | Off | On | Off | On | Off | Off | Off |
| 448KB | On | On | Off | Off | On | Off | Off | Off |
| 480KB | Off | On | Off | Off | On | Off | Off | Off |
| 512KB | On | Off | Off | Off | On | Off | Off | Off |
| 544KB | Off | Off | Off | Off | On | Off | Off | Off |
| 576KB | On | On | On | On | Off | Off | Off | Off |
| 608KB | Off | On | On | On | Off | Off | Off | Off |
| 640KB | On | Off | On | On | Off | Off | Off | Off |

An Introduction to the PC Convertible (5140)

IBM marked its entry into the laptop computer market on April 2, 1986, by introducing the IBM 5140 PC Convertible. The system superseded the 5155 Portable PC (IBM's transportable system), which was discontinued. The IBM 5140 system wasn't a very successful laptop system. Other laptops offered more disk storage, higher processor speeds, more-readable screens, lower cost, and more-compact cases, which pressured IBM to improve the Convertible. Because the improvements were limited to the display, however, this system never gained respect in the marketplace. It is significant in two respects: It marked IBM's entry into the laptop and notebook portable system market—a market they have tremendous success in today with the ThinkPad systems. And, the Convertible was the first IBM PC system supplied with 3 1/2-inch floppy drives.

The PC Convertible was available in two models. The Model 2 had a CMOS 80C88 4.77MHz microprocessor, 64KB of ROM, 256KB of Static RAM, an 80-column×25-line detachable liquid crystal display (LCD), two 3 1/2-inch floppy disk drives, a 78-key keyboard, an AC adapter, and a battery pack. Also included were software programs called Application Selector, SystemApps, Tools, Exploring the IBM PC Convertible, and Diagnostics. The Model 22 is the same basic computer as the Model 2 but with the diagnostics software only. You can expand either system to 512KB of RAM by using 128K RAM memory cards, and you can include an internal 1,200bps modem in the system unit. With aftermarket memory expansion, the computers can reach 640KB.

Although the unit was painfully slow at 4.77MHz, one notable feature was the use of static memory chips for the system's RAM. Static RAM does not require the refresh signal that normal Dynamic RAM (DRAM) requires, which would normally be about 7 percent of the processor's time in a standard PC or XT system. This means that the Convertible is about 7 percent faster than an IBM PC or XT, even though they all operate at the same clock speed of 4.77MHz. Because of the increased reliability of the Static RAM (compared to DRAM) used in the Convertible, as

well as the desire to minimize power consumption, none of the RAM in the Convertible is parity checked.

At the back of each system unit is an extendable bus interface. This 72-pin connector enables you to attach the following options to the base unit: a printer, a serial or parallel adapter, and a CRT display adapter. Each feature is powered from the system unit. The CRT display adapter operates only when the system is powered from a standard AC adapter. A separate CRT display or a television set attached through the CRT display adapter requires a separate AC power source.

Each system unit includes a detachable LCD. When the computer is not mobile, the LCD screen can be replaced by an external monitor. When the LCD is latched in the closed position, it forms the cover for the keyboard and floppy disk drives. Because the LCD is attached with a quick-disconnect connector, you can remove it easily to place the 5140 system unit below an optional IBM 5144 PC Convertible monochrome or IBM 5145 PC Convertible color display. During the life of the Convertible, IBM offered three different LCD displays. The first display was a standard LCD, which suffered from problems with contrast and readability. Because of complaints, IBM changed the LCD to a super-twisted-type LCD display, which had much greater contrast. Finally, the third LCD display added a fluorescent backlight to the super-twisted LCD display, which not only offered greater contrast, but also made the unit usable in low-light situations.

The PC Convertible system unit has these standard features:

- Complementary Metal-Oxide Semiconductor (CMOS) 80C88 4.77 MHz microprocessor
- Two 32KB CMOS ROMs containing these items:
 - POST (Power-On Self Test) of system components
 - BIOS (basic input/output system) support
 - BASIC language interpreter
- 256KB CMOS Static RAM (expandable to 512KB)
- Two 3 1/2-inch, 720KB (formatted) floppy drives
- An 80-column×25-line detachable LCD panel (graphics modes: 640×200 resolution and 320×200 resolution)
- LCD controller
- 16K RAM display buffer
- 8KB LCD font RAM
- Adapter for optional printer (#4010)
- Professional keyboard (78 keys)
- AC adapter
- Battery pack

The system-unit options for the 5140 are shown in this list:

- 128KB Static RAM memory card (#4005)
- Printer (#4010)

- Serial/parallel adapter (#4015)
- CRT display adapter (#4020)
- Internal modem (#4025)
- Printer cable (#4055)
- Battery charger (#4060)
- Automobile power adapter (#4065)

The following two optional displays were available for the PC Convertible:

- IBM 5144 PC Convertible Monochrome Display Model 1
- IBM 5145 PC Convertible Color Display Model 1

PC Convertible Specifications and Highlights

This section lists some technical specifications for the IBM 5140 PC Convertible system. The weights of the unit and options are listed because weight is an important consideration when you carry a laptop system. Figure 4 shows the PC Convertible motherboard components and layout.

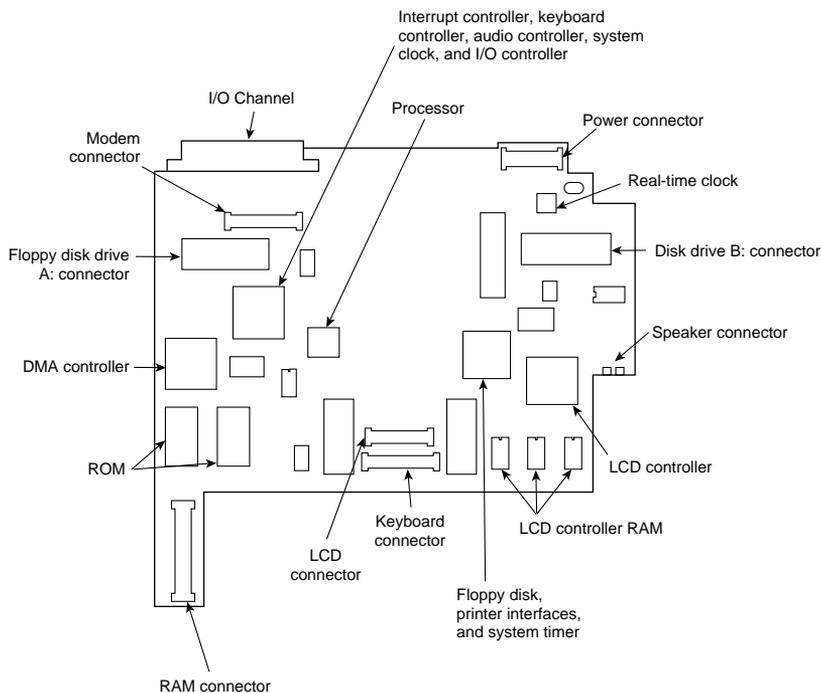


Figure 4 The PC Convertible motherboard.

Dimensions

| | |
|--------|---|
| Depth | 360mm (14.17 inches) 374mm (14.72 inches) including handle |
| Width | 309.6mm (12.19 inches) 312mm (12.28 inches) including handle |
| Height | 67mm (2.64 inches) 68mm (2.68 inches) including footpads |

Weight

| | |
|--|-----------------------|
| Models 2 and 22 (including battery) | 5.5kg (12.17 pounds) |
| 128KB/256KB memory card | 40g (1.41 ounces) |
| Printer | 1.6kg (3.50 pounds) |
| Serial/parallel adapter | 470g (1.04 pounds) |
| CRT display adapter | 630g (1.40 pounds) |
| Internal modem | 170g (6 ounces) |
| Printer cable | 227g (8 ounces) |
| Battery charger | 340g (12 ounces) |
| Automobile power adapter | 113g (4 ounces) |
| 5144 PC Convertible monochrome display | 7.3kg (16 pounds) |
| 5145 PC Convertible color display | 16.9kg (37.04 pounds) |

To operate the IBM 5140 PC Convertible properly, you must have PC DOS version 3.2 or later. Previous DOS versions aren't supported because they don't support the 720KB floppy drive.

PC Convertible Models and Features

This section covers the options and special features available for the PC Convertible. Several kinds of options were available, from additional memory to external display adapters, serial/parallel ports, modems, and even printers.

Memory Cards

A 128KB or 256KB memory card expands the base memory in the system unit. You can add two of these cards, for a system-unit total of 640KB with one 256KB card and one 128KB card.

Optional Printer

A special printer is available that attaches to the back of the system unit or to an optional printer-attachment cable for adjacent printer operation. The printer's intelligent, microprocessor-based, 40cps, non-impact dot-matrix design makes it capable of low-power operation. The printer draws power from and is controlled by the system unit. Standard ASCII 96-character upper- and lowercase character sets were printed with a high-resolution 24-element print head. A mode for graphics capability is also provided. You can achieve near letter-quality printing by using either a thermal transfer ribbon on smooth paper or no ribbon on heat-sensitive thermal paper.

A special printer cable is available that is 22 inches (0.6 meters) long with a custom 72-pin connector attached to each end. With this cable, you can operate the Convertible printer when it is detached from the system unit and place the unit for ease of use and visibility.

Serial/Parallel Adapter

A serial/parallel adapter attaches to the back of the system unit, to a printer, or to another feature module attached to the back of the system unit. The adapter provides an RS-232C asynchronous communications interface and a parallel printer interface, which are both compatible with the IBM personal computer asynchronous communications adapter and the IBM personal computer parallel printer adapter.

CRT Display Adapter

A CRT display adapter attaches to the back of the system unit, printer, or other feature module attached to the back of the system unit. This adapter enables you to connect a separate CRT display, such as the PC Convertible monochrome display or PC Convertible color display to the system. By using optional connectors or cables, you can use the CRT display adapter to attach a standard Color Graphics Adapter (CGA) monitor. Because composite video output is available, you can use a standard television set.

Internal Modems

IBM offered two different internal modems for the Convertible. Both run Bell 212A (1,200bps) or Bell 103A (300bps) protocols. The modems came as a complete assembly, consisting of two cards connected by a cable. The entire assembly is installed inside the system unit. The original first design modem was made for IBM by Novation and did not follow the Hayes standard for commands and protocols. This rendered the modem largely incompatible with popular software designed to use the Hayes-command set. Later, IBM changed the modem to one that was fully Hayes compatible, and this resolved the problems with software. IBM never introduced a modem faster than 1,200bps for the Convertible. Fortunately, you can operate a standard external modem through the serial port, although you lose the convenience of having it built in.

Battery Charger/Auto Power Adapter

The battery charger is a 110-volt input device that charges the system's internal batteries. It does not provide sufficient power output for the system to operate while the batteries are being charged.

An available automobile power adapter plugs into the cigarette-lighter outlet in a vehicle with a 12-volt negative-ground electrical system. You can use the system while the adapter also charges the Convertible's battery.

Optional Displays

The 5144 PC Convertible monochrome display is a 9-inch (measured diagonally) composite video display attached to the system unit through the CRT display adapter. It comes with a display

stand, an AC power cord, and a signal cable that connects the 5144 to the CRT display adapter. This display does not resemble—and is not compatible with—the IBM monochrome display for larger PC systems. The CRT adapter emits the same signal as the one supplied by the Color Graphics Adapter for a regular PC. This display is functionally equivalent to the display on the IBM Portable PC.

The 5145 PC Convertible color display is a 13-inch color display attached to the system unit through the CRT display adapter. It comes with a display stand, an AC power cord, a signal cable that connects the 5145 to the CRT display adapter, and a speaker for external audio output. The monitor is a low-cost unit compatible with the standard IBM CGA display.

Table 5 shows the part numbers of the IBM Convertible system units.

Table 5 IBM Convertible Part Numbers

| 5140 PC Convertible System Units | Number |
|---|---------|
| Two drives, 256KB with system applications | 5140002 |
| Two drives, 256KB without system applications | 5140022 |

An Introduction to the XT (5160)

Introduced on March 8, 1983, the PC XT with a built-in 10MB hard disk (originally standard and later optional) caused a revolution in personal computer configurations. At the time, having even a 10MB hard disk was something very special. XT stands for eXTended. IBM chose this name because the IBM PC XT system includes many features not available in the standard PC. The XT has eight slots, allowing increased expansion capabilities, greater power-supply capacity, completely socketed memory, motherboards that support memory expansion to 640KB without using an expansion slot, and optional hard disk drives. To obtain these advantages, the XT uses a different motherboard circuit design than the PC.

The system unit was available in several models, with a variety of disk drive configurations: one 360KB floppy disk drive, two 360KB floppy disk drives, one floppy disk and one hard disk drive, or two floppy disk drives and one hard disk drive. The floppy disk drives were full-height drives in the earlier models and half-height drives in more recent models. With the four available drive bays, IBM had standard configurations with two floppy drives and a single hard disk, with room for a second hard disk provided all half-height units were used.

IBM offered only 10MB and 20MB full-height hard disks. In some cases, they also installed half-height hard disks, but they were always installed in a bracket-and-cradle assembly that took up the equivalent space of a full-height drive. If you wanted half-height hard disks (to install two of them stacked, for example), you had to use non-IBM-supplied drives or modify the mounting of the IBM-supplied half-height unit so that two could fit. Most aftermarket sources for hard disks had mounting kits that would work.

IBM also used double-sided (320/360KB) floppy disk drives in full- or half-height configurations. A 3 1/2-inch, 720KB floppy disk drive was available in more recent models. The 3 1/2-inch drives

were available in a normal internal configuration or as an external device. You could install a maximum of two floppy disk drives and one hard disk drive in the system unit, using IBM-supplied drives. With half-height hard disks, you could install two hard drives in the system unit.

The XT is based on the same 8- and 16-bit Intel 8088 microprocessor (the CPU has 16-bit registers but only an 8-bit data bus) as the PC and runs at the same clock speed. Operationally, the XT systems are identical to the PC systems except for the hard disk. All models have at least one 360K floppy disk drive and a keyboard. For standard memory, the XT offers 256K or 640K on the main board. The hard disk models also include a serial adapter.

The system unit has eight slots that support cards for additional devices, features, or memory. Two of the slots support only short option cards because of physical interference from the disk drives. The XT has at least a disk drive adapter card in the floppy-disk-only models, and a hard disk controller card and serial adapter in the hard disk models. Either five or seven expansion slots (depending on the model) are available. Figure 5 shows the interior of an XT.

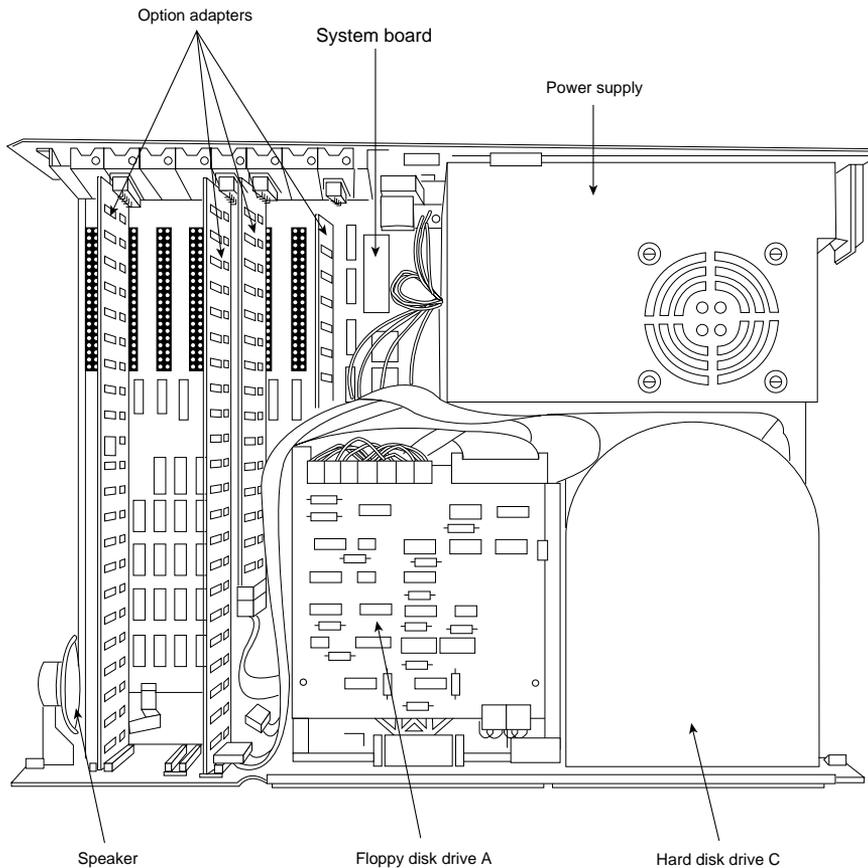


Figure 5 The IBM PC XT interior.

All XT models include a heavy-duty, fan-cooled, 130-watt power supply to support the greater expansion capabilities and disk drive options. The power supply has more than double the capacity of the PC's supply and can easily support hard disk drives and the full complement of expansion cards.

An 83-key keyboard was standard equipment with the early XT models but was changed to an enhanced 101-key unit in the more recent models. The keyboard is attached to the system unit by a six-foot coiled cable.

All models of the PC XT system unit contain these major functional components:

- Intel 8088 microprocessor
- ROM-based diagnostics (POST)
- BASIC language interpreter in ROM
- 256KB or 640KB of Dynamic RAM
- Floppy disk controller
- One 360KB floppy drive (full- or half-height)
- 10MB or 20MB hard disk drive with interface (enhanced models)
- Serial interface (enhanced models)
- Heavy-duty, 135-watt power supply
- Eight I/O expansion slots
- Socket for 8087 math coprocessor

XT Models and Features

The XT was available in many different model configurations, but originally only one model was available. This original model included a 10MB hard disk, marking the first time that a hard disk was standard equipment in a personal computer, and was properly supported by the operating system and peripherals. This computer helped change the industry standard for PCs from normally having only one or two floppy disk drives to now including one or more hard disks.

Today, most people wouldn't consider a PC to be even remotely usable without a hard disk. The original XT was expensive, however, and buyers couldn't unbundle, or delete, the hard disk from the system at purchase time for credit, and then add it later. This fact distinguished the XT from the PC and misled many people to believe that the only difference between the two computers was the hard disk. People who recognized and wanted the greater capabilities of the XT without the standard IBM hard disk, unfortunately, had to wait for IBM to sell versions of the XT without the hard disk drive.

The original Model 087 of the XT included a 10MB hard disk, 128KB of RAM, and a standard serial interface. IBM later increased the standard memory in all PC systems to 256KB. The XT reflected the change in Model 086, which was the same as the preceding 087 except for a standard 256KB of RAM.

On April 2, 1985, IBM finally introduced new models of the XT without the standard hard disk. Designed for expansion and configuration flexibility, the new models enabled you to buy the system initially at a lower cost and add your own hard disk later. The XT therefore could be considered in configurations that previously only the original PC could fill. The primary difference between the PC and the XT is the XT's expansion capability, provided by the larger power supply, eight slots, and better memory layout. These models cost only \$300 more than equivalent PCs, rendering the original PC no longer a viable option.

The extra expense of the XT can be justified with the first power-supply replacement you make with an overworked PC. The IBM PC XT is available in two floppy disk models:

- 5160068 XT with one full-height 360KB disk drive
- 5160078 XT with two full-height 360KB disk drives

Both these models have 256KB of memory and use the IBM PC XT motherboard, power supply, frame, and cover. The serial (asynchronous communications) port adapter isn't included as a standard feature with these models.

IBM introduced several more models of the PC XT on April 2, 1986. These models were significantly different from previous models. The most obvious difference, the 101-key Enhanced keyboard, was standard with these newer computers. A 20MB (rather than 10M) hard disk and one or two half-height floppy disk drives were included. The new half-height floppy disk drives allowed for two drives in the space that previously held only one floppy drive. With two drives, backing up floppy disks became easy. A new 3 1/2-inch floppy disk drive, storing 720KB for compatibility with the PC Convertible laptop computer, was released also. These newer XT system units were configured with a slightly different memory layout, allowing for 640KB of RAM on the motherboard without an expansion slot. This feature conserves power, improves reliability, and lowers the cost of the system.

One 5 1/4-inch, half-height, 360KB floppy disk drive and 256KB of system-board memory was standard with the XT Models 267 and 268. Models 277 and 278 have a second 5 1/4-inch floppy disk drive. Models 088 and 089 were expanded PC XTs with all the standard features of Models 267 and 268, a 20MB hard disk, a 20MB fixed disk drive adapter, a serial port adapter, and an additional 256KB of system-board memory—a total of 512KB.

The following list shows the highlights of these new models:

- Enhanced keyboard standard on Models 268, 278, and 089; 101 keys, and no status LEDs (XT interface cannot drive LEDs)
- Standard PC XT keyboard on Models 267, 277, and 088
- More disk capacity (20MB)
- Standard 5 1/4-inch, half-height, 360KB floppy drive
- Available 3 1/2-inch, half-height, 720KB floppy drive
- Capacity for four half-height storage devices within the system unit
- Capacity to expand to 640KB memory on system board without using expansion slots

These newest XT models has an extensively changed ROM BIOS. The new BIOS was 64KB and internally similar to the BIOS found in ATs. The ROM included support for the new keyboard and 3 1/2-inch floppy disk drives. The POST also was enhanced.

The new XTs were originally incompatible in some respects with some software programs. These problems centered on the new 101-key enhanced keyboard and the way the new ROM addressed the keys. However, because the problems weren't major, software companies quickly solved them.

Seeing how much IBM changed the computer without changing the basic motherboard design is interesting. The ROM was different, and the board now could hold 640KB of memory without a card in a slot. The memory trick was a simple one. IBM designed this feature into the board originally and chose to unleash it with these models of the XT.

During the past several years, I have modified many XTs to have 640KB on the motherboard, using a simple technique designed into the system by IBM. A jumper and chip added to the motherboard can alter the memory addressing in the board to enable the system to recognize 640KB. The new addressing is set up for 256KB chips installed in two of the four banks. The other two banks of memory contain 64KB chips—a total of 640KB.

Complete instructions for how to install 640KB of memory on the XT motherboard can be found on the CD that accompanies this book.

XT BIOS Versions

Three different BIOS versions have been used in the IBM PC-XT. They can be identified by their date and summarized as follows:

- *November 8, 1982.* The original XT BIOS had all the features of the latest 10/27/82 PC BIOS, including 640KB base memory and UMA scan support. This BIOS version was also used in the XT motherboards found in the IBM Portable PC.
- *January 10, 1986.* The second revision XT BIOS added support for the 101-key Enhanced keyboard, plus full support for 3 1/2-inch 720KB floppy drives.
- *May 9, 1986.* This final revision contained some fixes for minor keyboard bugs related mainly to the enhanced keyboard.

Table 2 lists the different IBM Family/1 (PC, XT, and AT) BIOS versions. It also shows the ID, submodel, and revision bytes that can be determined by the software function call

```
Int 15h, C0 = Return System Configuration Parameters
```

Some of the systems such as the PC and earlier XT and AT systems only support the ID byte; the submodel and revision bytes had not been established when those systems were developed. Table 2 also shows the number of drive types supported in the AT and XT-286 systems BIOS.

The BIOS date is stored in all PC-compatible systems at memory address FFFF5h. To display the date of your BIOS, a DEBUG command can be used to view this address. DEBUG is a command program supplied with MS-DOS. At the DOS prompt, execute the following commands to run DEBUG, display the date stored in your BIOS, and then exit back to DOS:

```

C:\>DEBUG
-D FFFF:5 L 8
FFFF:0000
-Q

```

30 31 2F-32 32 2F 39 37

01/22/97

In this example, the system queried shows a BIOS date of 01/22/97.

XT Technical Specifications

Technical information for the XT system, described in this section, provides information about the system architecture, memory configurations and capacities, standard system features, disk storage, expansion slots, keyboard specifications, and also physical and environmental specifications. Figure 6 shows the layout and components on the XT motherboard.

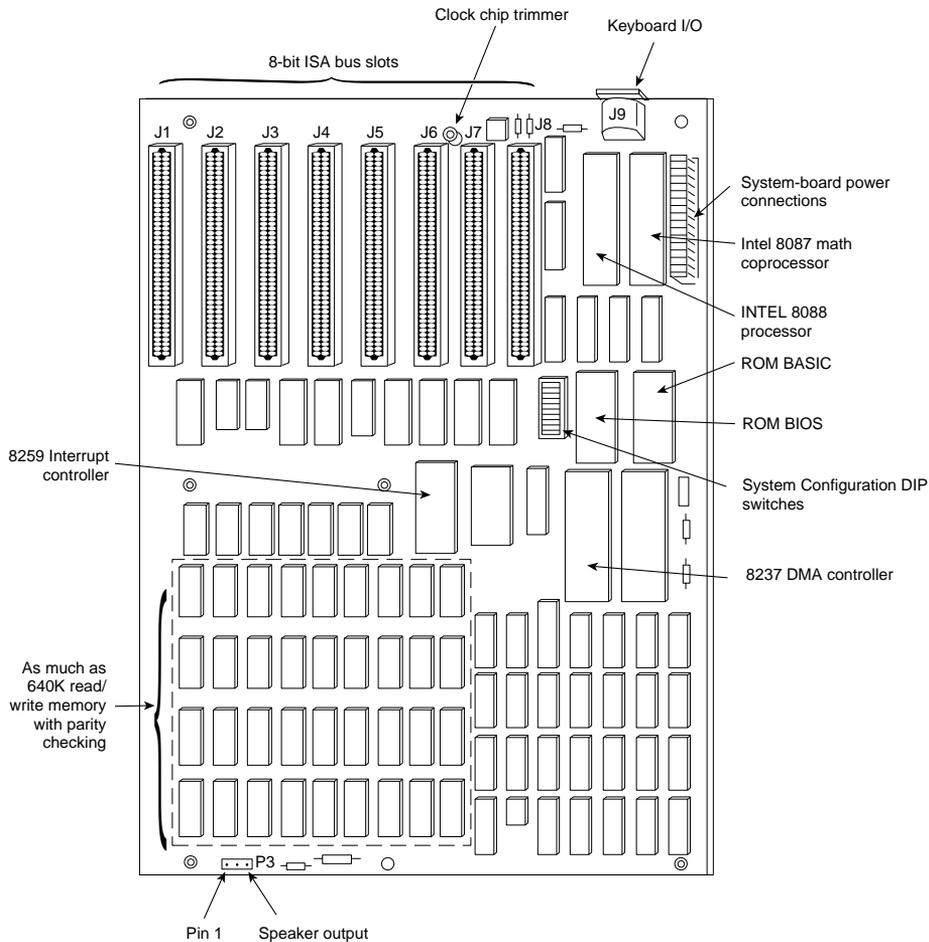


Figure 6 The XT motherboard.

System Architecture

| | |
|------------------------------|--------------------------------------|
| Microprocessor | 8088 |
| Clock speed | 4.77MHz |
| Bus type | ISA (Industry Standard Architecture) |
| Bus width | 8-bit |
| Interrupt levels | 8 (6 usable) |
| Type | Edge-triggered |
| Shareable | No |
| DMA channels | 4 (3 usable) |
| Bus masters supported | No |
| Upgradable processor complex | No |

Memory

| | |
|---------------------------------|--|
| Standard on system board | 256KB or 640KB |
| Maximum on system board | 256KB or 640KB |
| Maximum total memory | 640KB |
| Memory speed (ns) and type | 200ns Dynamic RAM chips |
| System board memory-socket type | 16-pin DIP |
| Number of memory-module sockets | 36 (4 banks of 9) |
| Memory used on system board | 36 64KB \times 1-bit DRAM chips in 4 banks of 9, or 2 banks of 9 256KB \times 1-bit and 2 banks of 9 64KB \times 1-bit chips |
| Memory cache controller | No |
| Wait states: | |
| System board | 1 |
| Adapter | 1 |

Standard Features

| | |
|-----------------------------------|-----------------|
| ROM size | 40KB or 64KB |
| ROM shadowing | No |
| Optional math coprocessor | 8087 |
| Coprocessor speed | 4.77MHz |
| Standard graphics | None standard |
| RS232C serial ports | 1 (some models) |
| UART chip used | NS8250B |
| Maximum speed (bits per second) | 9,600bps |
| Maximum number of ports supported | 2 |
| Pointing device (mouse) ports | None standard |
| Parallel printer ports | 1 (some models) |
| Bidirectional | No |
| Maximum number of ports supported | 3 |
| CMOS real-time clock (RTC) | No |
| CMOS RAM | None |

Disk Storage

| | | |
|---|--------------------------------|------|
| Internal disk and tape drive bays | 2 full-height or 4 half-height | |
| Number of 3 1/2-inch or 5 1/4-inch bays | 0/2 or 0/4 | |
| Standard floppy drives | 1x360KB | |
| Optional floppy drives: | | |
| 5 1/4-inch 360KB | Optional | |
| 5 1/4-inch 1.2MB | No | |
| 3 1/2-inch 720KB | Optional | |
| 3 1/2-inch 1.44MB | No | |
| 3 1/2-inch 2.88MB | No | |
| Hard disk controller included | ST-506/412 (Xebec Model 1210) | |
| ST-506/412 hard disks available | 10/20MB | |
| Drive form factor | 5 1/4-inch | |
| Drive interface | ST-506/412 | |
| Drive capacity | 10MB | 20MB |
| Average access rate (ms) | 85 | 65 |
| Encoding scheme | MFM | MFM |
| BIOS drive type number | 1 | 2 |
| Cylinders | 306 | 615 |
| Heads | 4 | 4 |
| Sectors per track | 17 | 17 |
| Rotational speed (RPMs) | 3600 | 3600 |
| Interleave factor | 6:1 | 6:1 |
| Data transfer rate (kilobytes/second) | 85 | 85 |
| Automatic head parking | No | No |

Expansion Slots

| | |
|-------------------------------|-------|
| Total adapter slots | 8 |
| Number of long/short slots | 6/2 |
| Number of 8-/16-/32-bit slots | 8/0/0 |
| Available slots (with video) | 4 |

Keyboard Specifications

| | |
|-----------------------------|--------|
| 101-key Enhanced keyboard | Yes |
| Fast keyboard speed setting | No |
| Keyboard cable length | 6 feet |

(continues)

(continued)

Physical Specifications

| | |
|----------------|-------------|
| Footprint type | Desktop |
| Dimensions: | |
| Height | 5.5 inches |
| Width | 19.5 inches |
| Depth | 16.0 inches |
| Weight | 32 pounds |

Environmental Specifications

| | |
|-----------------------------------|-----------------|
| Power-supply output | 130 watts |
| Worldwide (110v/60Hz, 220v/50Hz) | No |
| Auto-sensing/switching | No |
| Maximum current: | |
| 90–137 VAC | 4.2 amps |
| Operating range: | |
| Temperature | 60–90 degrees F |
| Relative humidity | 8–80 percent |
| Maximum operating altitude | 7,000 feet |
| Heat (BTUs/hour) | 717 |
| Noise (Average db, operating, 1m) | 56 |
| FCC classification | Class B |

Table 6 shows the XT motherboard switch settings. The XT motherboard uses a single eight-position switch block to control various functions, as detailed in the table.

Table 6 IBM PC/XT Motherboard Switch Settings**Switch Block 1 (PC and XT)**

| | Switch 1 | IBM PC Function (PC Only) |
|-----------------|-----------------|---|
| | Off | Boot from Floppy Drives |
| | On | Do Not Boot from Floppy Drives |
| | Switch 1 | IBM XT Function (XT Only) |
| | Off | Normal POST (power on self test) |
| | On | Continuous Looping POST |
| | Switch 2 | Math Coprocessor (PC/XT) |
| | Off | Installed |
| | On | Not Installed |
| Switch 3 | Switch 4 | Installed Motherboard Memory (PC/XT) |
| On | On | Bank 0 Only |
| Off | On | Banks 0 and 1 |
| On | Off | Banks 0, 1, and 2 |
| Off | Off | All 4 Banks |

Switch Block 1 (PC and XT)

| Switch 5 | Switch 6 | Video Adapter Type (PC/XT) |
|-----------------|-----------------|--|
| Off | Off | Monochrome (MDA) |
| Off | On | Color (CGA); 40x25 mode |
| On | Off | Color (CGA); 80x25 mode |
| On | On | Any Video Card with Onboard BIOS (EGA/VGA) |
| Switch 7 | Switch 8 | Number of Floppy Drives (PC/XT) |
| On | On | 1 floppy drive |
| Off | On | 2 floppy drives |
| On | Off | 3 floppy drives |
| Off | Off | 4 floppy drives |

Table 7 shows the part numbers of the XT system units.

Table 7 IBM XT Model Part Numbers

| Description | Number |
|--|---------------|
| XT system unit/83-key keyboard, 256KB: | |
| One full-height 360KB drive | 5160068 |
| One half-height 360KB drive | 5160267 |
| Two full-height 360KB drives | 5160078 |
| Two half-height 360KB drives | 5160277 |
| XT system unit/101-key keyboard, 256K: | |
| One half-height 360KB drive | 5160268 |
| Two half-height 360KB drives | 5160278 |
| XT system unit/83-key keyboard, 256KB, one serial, one full-height 360KB drive, 10MB hard disk | 5160086 |
| XT system unit/83-key keyboard, 640KB, one serial, one half-height 360KB drive, 20MB fixed disk | 5160088 |
| XT system unit/101-key keyboard, 640KB, one serial, one half-height 360KB drive, 20MB fixed disk | 5160089 |

Option Numbers

| | |
|---|---------|
| PC expansion-unit Model 002, 20MB fixed disk | 5161002 |
| 20MB fixed disk drive | 6450326 |
| 20MB fixed disk adapter | 6450327 |
| 10MB fixed disk drive | 1602500 |
| 10MB fixed disk adapter | 1602501 |
| 5 1/4-inch, half-height, 360KB drive | 6450325 |
| 5 1/4-inch, full-height, 360KB drive | 1503810 |
| 3 1/2-inch, half-height, 720KB internal drive | 6450258 |

(continues)

Table 7 Continued

| Description | Number |
|---|---------|
| Option Numbers | |
| 3 1/2-inch, half-height, 720KB external drive | 2683190 |
| 8087 math coprocessor option | 1501002 |
| Asynchronous serial adapter | 1502074 |
| Enhanced Keyboard Accessories | |
| Clear keycaps (60) with paper inserts | 6341707 |
| Blank light keycaps | 1351710 |
| Blank dark keycaps | 1351728 |
| Paper inserts (300) | 6341704 |
| Keycap-removal tools (6) | 1351717 |

An Introduction to the Portable PC

IBM introduced the Portable PC (PPC) on February 16, 1984. The IBM Portable PC, a “transportable” personal computer, is a small suitcase-sized system that has a built-in 9-inch amber composite video monitor, one 5 1/4-inch half-height floppy disk drive (with space for an optional second drive), an 83-key keyboard, two adapter cards, a floppy disk controller, and a CGA. The unit also has a universal-voltage power supply capable of overseas operation on 220-volt power. Figure 7 shows the Portable PC exterior.

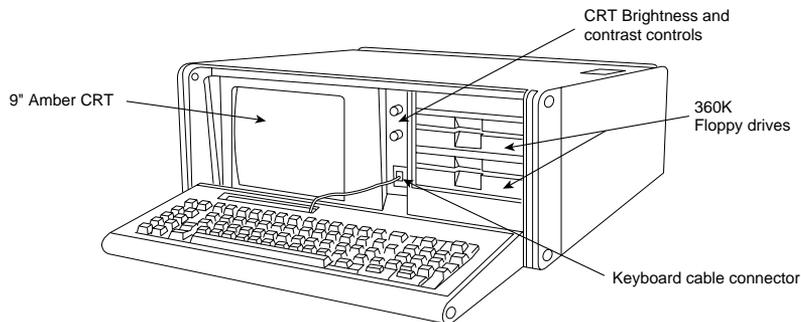


Figure 7 The IBM Portable PC.

The system board used in the IBM Portable PC is the same board used in the original IBM XT_s, with 256KB of memory. Because the XT motherboard was used, eight expansion slots are available for the connection of adapter boards, although only two slots can accept a full-length adapter card because of internal space restrictions. The power supply is basically the same as an XT's, with physical changes for portability and a small amount of power drawn to run the built-in monitor. In function and performance, the Portable PC system unit has identical characteristics to an equivalently configured IBM PC XT system unit. Figure 8 shows the Portable PC interior view.

IBM withdrew the Portable PC from the market on April 2, 1986, a date that coincides with the introduction of the IBM Convertible laptop PC. The Portable PC is rare because not many were sold, although it compared to, and in many ways was better than, the highly successful Compaq Portable that was available at the time. The Portable PC was largely misunderstood by the trade press and user community; most did not understand that the system was really a portable XT and had more to offer than the standard IBM PC. Maybe if IBM had called the system the Portable XT, it would have sold better!

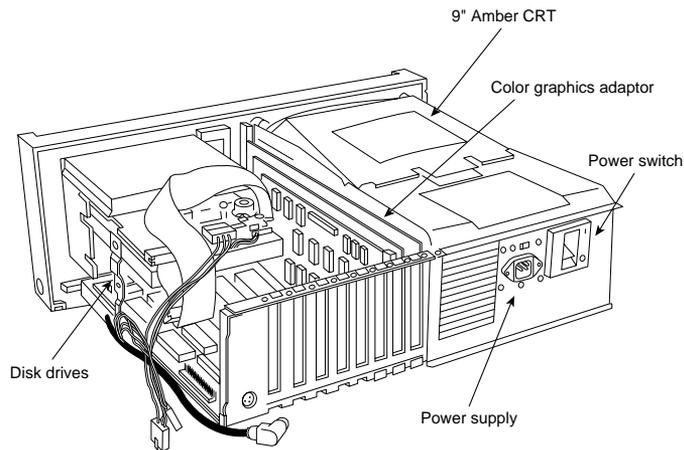


Figure 8 The IBM Portable PC interior.

The Portable PC system unit has these major functional components:

- Intel 8088 4.77MHz microprocessor
- ROM-based diagnostics (POST)
- BASIC language interpreter in ROM
- 256KB of Dynamic RAM
- Eight expansion slots (two long slots, one 3/4-length slot, and five short slots)
- Socket for 8087 math coprocessor
- Color/Graphics monitor adapter
- 9-inch amber composite video monitor
- Floppy disk interface
- One or two half-height 360KB floppy drives
- 114-watt universal power supply (115–230v, 50–60Hz)
- Lightweight 83-key keyboard
- Enclosure with carrying handle
- Carrying bag for the system unit

Figure 6 shows the XT motherboard, which is also used in the Portable PC. The following is the technical data for the Portable PC system:

System Architecture

| | |
|------------------------------|--------------------------------------|
| Microprocessor | 8088 |
| Clock speed | 4.77MHz |
| Bus type | ISA (Industry Standard Architecture) |
| Bus width | 8-bit |
| Interrupt levels | 8 (6 usable) |
| Type | Edge-triggered |
| Shareable | No |
| DMA channels | 4 (3 usable) |
| Bus masters supported | No |
| Upgradable processor complex | No |

Memory

| | |
|---------------------------------|---|
| Standard on system board | 256KB |
| Maximum on system board | 256KB |
| Maximum total memory | 640KB |
| Memory speed (ns) and type | 200ns Dynamic RAM chips |
| System board memory-socket type | 16-pin DIP |
| Number of memory-module sockets | 36 (4 banks of 9) |
| Memory used on system board | 36 64KB \times 1-bit DRAM chips in 4 banks of 9 chips |
| Memory cache controller | No |
| Wait states: | |
| System board | 1 |
| Adapter | 1 |

Standard Features

| | |
|-----------------------------------|--|
| ROM size | 40KB |
| ROM shadowing | No |
| Optional math coprocessor | 8087 |
| Coprocessor speed | 4.77MHz |
| Standard graphics | CGA adapter with built-in 9-inch amber CRT |
| RS232C serial ports | None standard |
| UART chip used | NS8250B |
| Maximum speed (bits per second) | 9,600bps |
| Maximum number of ports supported | 2 |
| Pointing device (mouse) ports | None standard |
| Parallel printer ports | None standard |
| Bidirectional | No |
| Maximum number of ports supported | 3 |
| CMOS real-time clock (RTC) | No |
| CMOS RAM | None |

Disk Storage

| | |
|--------------------------------------|---------------|
| Internal disk and tape drive bays | 2 half-height |
| Number of 3 1/2-inch/5 1/4-inch bays | 0/2 |
| Standard floppy drives | 1 or 2x360KB |
| Optional floppy drives: | |
| 5 1/4-inch 360KB | Optional |
| 5 1/4-inch 1.2MB | No |
| 3 1/2-inch 720KB | Optional |
| 3 1/2-inch 1.44MB | No |
| 3 1/2-inch 2.88MB | No |
| Hard disk controller included | None |

Expansion Slots

| | |
|-------------------------------|-------|
| Total adapter slots | 8 |
| Number of long/short slots | 2/6 |
| Number of 8-/16-/32-bit slots | 8/0/0 |
| Available slots (with video) | 6 |

Keyboard Specifications

| | |
|-----------------------------|--------|
| 101-key Enhanced keyboard | No |
| Fast keyboard speed setting | No |
| Keyboard cable length | 6 feet |

Physical Specifications

| | |
|----------------|-------------|
| Footprint type | Desktop |
| Dimensions: | |
| Height | 8.0 inches |
| Width | 28.0 inches |
| Depth | 17.0 inches |
| Weight | 31 pounds |

Environmental Specifications

| | |
|-----------------------------------|-----------------|
| Power-supply output | 114 watts |
| Worldwide (110/60,220/50) | Yes |
| Auto-sensing/switching | No |
| Maximum current: | |
| 90–137 VAC | 4.0 amps |
| Operating range: | |
| Temperature | 60–90 degrees F |
| Relative humidity | 8–80 percent |
| Maximum operating altitude | 7,000 feet |
| Heat (BTUs/hour) | 650 |
| Noise (Average db, operating, 1m) | 42 |
| FCC classification | Class B |

Table 8 shows the part numbers for the Portable PC.

Table 8 IBM Portable PC Model Part Numbers

| Description | Number |
|-------------------------------------|---------|
| 256KB, one 360KB half-height drive | 5155068 |
| 256KB, two 360KB half-height drives | 5155076 |
| Half-height 360KB floppy disk drive | 6450300 |

The disk drive used in the Portable PC was a half-height drive, the same unit specified for use in the PCjr. When the Portable PC was introduced, PCjr was the only other IBM sold with the same half-height drive.

An Introduction to the AT

IBM introduced the Personal Computer AT (Advanced Technology) on August 14, 1984. The IBM AT system included many features previously unavailable in IBM's PC systems, such as increased performance, an advanced 16-bit microprocessor, high-density floppy disk and hard disk drives, larger memory space, and an advanced coprocessor. Despite its new design, the IBM AT incredibly retained compatibility with most existing hardware and software products for earlier systems.

In most cases, IBM AT system performance was from three to five times faster than the IBM XT for single applications running DOS on both computers. The performance increase was due to the combination of a reduced cycle count for most instructions by the 80286 processor, an increased system clock rate, 16-bit memory, and a faster hard disk and controller.

The AT system unit has been available in several models: a floppy-disk-equipped base model (068) and several hard-disk-enhanced models. Based on a high-performance 16-bit Intel 80286 microprocessor, each computer includes Cassette BASIC language in ROM and a CMOS (Complementary Metal Oxide Semiconductor) clock and calendar with battery backup. All models are equipped with a high-density (1.2MB floppy disk drive, a keyboard, and a lock. For standard memory, the base model offers 256KB, and the enhanced models offer 512KB. In addition, the enhanced models have a 20MB or 30MB hard disk drive and a serial/parallel adapter. Each system can be expanded through customer-installable options. You can add memory (up to 512KB) for the base model by adding chips to the system board. You can expand all models to 16MB by installing memory cards.

Besides the standard drives included with the system, IBM only offered two different hard disks as upgrades for the AT:

- 30MB hard disk drive
- 20MB hard disk drive

IBM also offered only three different types of floppy drives for the AT:

- A second, high-density (1.2MB) floppy disk drive
- A double-density (320/360KB) floppy disk drive
- A new 3 1/2-inch 720KB drive

The original 068 and 099 models of the AT did not support the 720KB drive in the BIOS; you had to add a special driver (DRIVER.SYS—supplied with DOS) for the drive to work properly. The later model ATs supported the 720KB drive directly in the BIOS, and also added support for the 1.44MB high-density 3 1/2-inch floppy drive, although IBM never sold or officially supported such a drive in the AT.

You can install as many as two floppy disk drives and one hard disk drive or one floppy disk drive and two hard disk drives in the system unit. To use the high-density 5 1/4-inch floppy disk drives properly, you must have special floppy disks—5 1/4-inch, high-coercivity, double-sided, soft-sectored disks. Due to track width problems between the high-density (1.2MB) drives and the double-density (360KB) drives, a double-density floppy disk drive (320/360KB) was available for compatibility with the standard PC or XT systems. You can exchange disks reliably between the 1.2MB and the standard 360KB drives if you use the proper method and understand the recording process. For transferring data between a system with a 1.2MB drive to a system with a 360KB drive, you must start with a blank (never previously formatted) 360KB disk, which must be formatted and written only by the 1.2MB drive. No special precautions are needed to transfer the data the other way. This information is covered in Chapter 13, “Optical Storage.” For complete interchange reliability and to simplify the process, however, IBM recommends that you purchase the 360KB drive.

The AT motherboard has eight slots that support cards for additional devices, features, or memory. Six slots support the advanced 16-bit or 8-bit cards. Two slots support only 8-bit cards. All system-unit models use one 16-bit slot for the fixed disk and floppy disk drive adapter. The enhanced models use an additional 8-bit slot for the serial/parallel adapter. The result is seven available expansion slots for the base model and six available expansion slots for enhanced models. Figure 9 shows the interior of an AT system unit.

All AT models include a 192-watt universal power supply; a temperature-controlled, variable-speed cooling fan; and a security lock with key. The user selects the power supply for a country's voltage range. The cooling fan significantly reduces the noise in most environments; the fan runs slower when the system unit is cool and faster when the system unit is hot. When the system is locked, no one can remove the system-unit cover, boot the system, or enter commands or data from the keyboard, thereby enhancing the system's security.

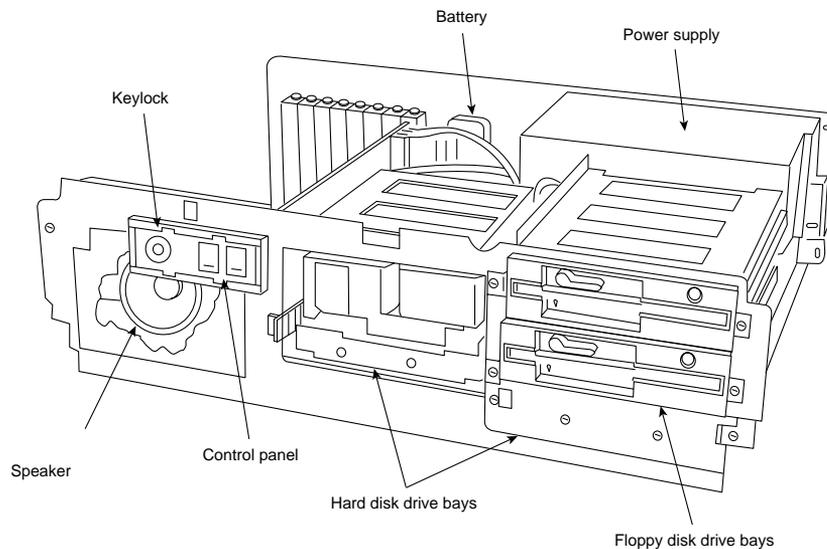


Figure 9 The IBM AT unit interior.

The keyboard is attached to the system unit by a 9-foot coiled cable that enables the AT to adapt to a variety of workspace configurations. The keyboard includes key-location enhancements and mode indicators for improved keyboard usability. Figure 10 shows the rear panel of an AT.

Every system unit for AT models has these major functional components:

- Intel 80286 (6MHz or 8MHz) microprocessor
- Socket for 80287 math coprocessor
- Eight I/O expansion slots (six 16-bit, two 8-bit)
- 256KB of Dynamic RAM (base model)
- 512KB of Dynamic RAM (enhanced models)
- ROM-based diagnostics (POST)
- BASIC language interpreter in ROM
- Hard/floppy disk controller
- 1.2MB hard disk floppy drive
- 20MB or 30MB hard disk drive (enhanced models)
- Serial/parallel interface (enhanced models)
- CMOS clock-calendar and configuration with battery backup
- Keylock
- 84-key keyboard or 101-key Enhanced keyboard (standard on newer models)
- Switchable worldwide power supply

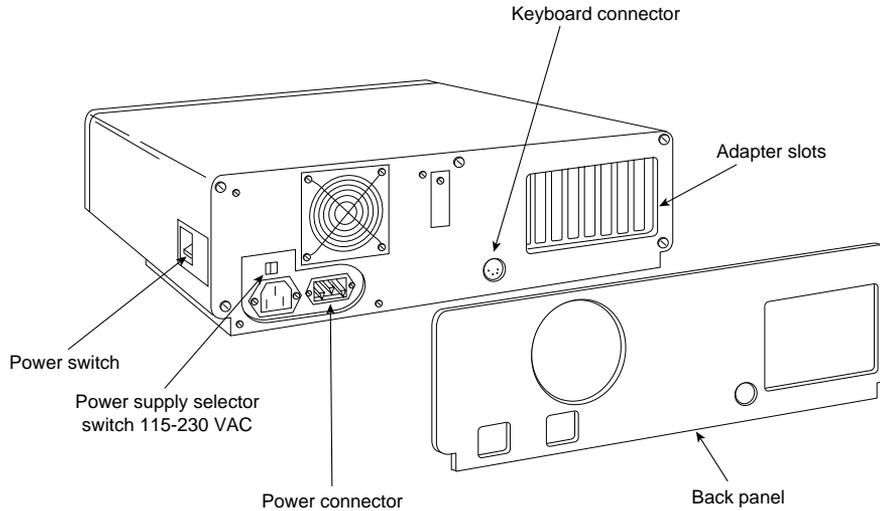


Figure 10 The IBM AT rear panel.

AT Models and Features

Since the introduction of the AT, several models have become available. First, IBM announced two systems: a base model (068) and an enhanced model (099). The primary difference between the two systems is the standard hard disk that came with the enhanced model. IBM has introduced two other AT systems since the first systems, each offering new features.

The first generation of AT systems has a 6MHz system clock that dictates the processor cycle time. The cycle time, the system's smallest interval of time, represents the speed at which operations occur. Every operation in a computer takes at least one or (usually) several cycles to complete. Therefore, if two computers are the same in every way except for the clock speed, the system with the faster clock rate executes the same operations in a shorter time proportional to the difference in clock speed. Cycle time and clock speed are two different ways of describing the same thing. Discussions of clock speed are significant when you're considering buying the AT, because not all models have the same clock speed.

All models of the AT include a combination hard/floppy disk controller, which is really two separate controllers on the same circuit board. The board was designed by IBM and Western Digital (WD) and manufactured for IBM by WD. This controller has no onboard ROM BIOS like the Xebec hard disk controller used in the XT. In the AT, IBM built full support for the hard disk controller directly into the motherboard ROM BIOS. To support different types of hard disks, IBM encoded a table into the motherboard ROM that listed the parameters of various drives that could be installed. In the first version of the AT, with a ROM BIOS dated 01/10/84, only the first

14 types in the table were filled in. Type 15 was reserved for internal reasons, and was not usable. Other table entries from 16 through 47 were left unused and were actually filled with zeros. Later versions of the AT added new drive types to the tables, starting from Type 16 and up.

The first two AT models were the 068 (base) model, which had 256KB on the motherboard and a single 1.2MB floppy disk drive, and the model 099 (enhanced), which had a 20MB hard disk drive, a serial/parallel adapter, and 512KB on the motherboard. IBM designated the motherboard on these computers as Type 1, which is larger than the later Type 2 board and uses an unusual memory layout. The memory is configured as four banks of 128KB chips—a total of 512KB on the board. This configuration sounds reasonable until you realize that a 128KB chip does not really exist in the physical form factor that IBM used. IBM actually created this type of memory device by stacking a 64KB chip on top of another one and soldering the two together. My guess is that IBM had many 64KB chips to use, and the AT was available to take them.

On October 2, 1985, IBM announced a new model of the AT, the Personal Computer AT Model 239. The system has all the standard features of the AT Model 099, but also has a 30MB hard disk rather than a 20MB hard disk. A second, optional 30MB hard disk drive expands the Model 239's hard disk storage to 60MB. This unit's motherboard, a second-generation design IBM calls Type 2, is about 25 percent smaller than the Type 1, but uses the same mounting locations for physical compatibility. All important items, such as the slots and connectors, remain in the same locations. Other major improvements in this board are in the memory. The 128KB memory chips have been replaced by 256KB devices. Now only two banks of chips were needed to get the same 512K on the board.

The AT Model 239 includes these items:

- 512KB of RAM (standard)
- 6MHz Type 2 motherboard with 256KB memory chips
- Serial/parallel adapter (standard)
- 30MB hard disk (standard)
- New ROM BIOS (dated 06/10/85). ROM supports 3 1/2-inch 720KB floppy drives without using external driver programs, and 22 usable hard disk types (up to Type 23), including the supplied 30MB disk. POST “fixes” clock rate to 6MHz.

The Type 2 motherboard's design is much improved over Type 1's; the Type 2 motherboard improved internal-circuit timing and layout. Improvements in the motherboard indicated that the system would be pushed to higher speeds—exactly what happened with the next round of introductions.

In addition to obvious physical differences, the Model 239 includes significantly different ROM software from the previous models. The new ROM supports more types of hard and floppy disks, and its new POST prevents alteration of the clock rate from the standard 6MHz models. Because support for the 30MB hard disk is built into the new ROM, IBM sold a 30MB hard disk upgrade kit that included the new ROM for the original AT systems. This \$1,795 kit represented the only legal way to obtain the newer ROM.

The 30MB hard disk drive upgrade kit for the Personal Computer AT Models 068 and 099 included all the features in the 30MB hard disk drive announced for the AT Model 239. The upgrade kit also had a new BIOS, essential to AT operation. The new ROM BIOS supports 22 drive types (compared to the original 14 in earlier ATs), including the new 30MB drive. To support the 30M hard disk drive, a new diagnostics floppy disk and an updated guide-to-operations manual were shipped with this kit.

The 30MB update kit included these items:

- 30MB hard disk drive
- Two new ROM BIOS modules
- Channel keeper bar (a bracket for the fixed disk)
- Data cable for the hard disk
- Diagnostics and Setup disk
- An insert to the AT guide-to-operations manual

Some people were upset initially that IBM had “fixed” the microprocessor clock to 6MHz in the new model, thereby disallowing any possible “hot rod” or overclocking modifications. Many people realized that the clock crystal on the AT models was socketed so that the crystal could be replaced easily by a faster one. More importantly, because the AT circuit design is modular, changing the clock crystal does not have repercussions throughout the rest of the system, as is the case in the PC and PC XT. For the price of a new crystal (from \$1–\$30) and the time needed to plug it in, someone easily could increase an AT’s speed by 30 percent, and sometimes more. Unfortunately, because of the POST in the newer model’s BIOS, you no longer can implement a simple speed-up alteration without also changing the ROM BIOS as well.

Many people believed that this change was made to prevent the AT from being “too fast” and therefore competing with IBM’s minicomputers. In reality, the earlier motherboard was intentionally run at 6MHz because IBM did not believe that the ROM BIOS software and critical system timing was fully operational at a higher speed. Also, IBM used some components that were rated only for 6MHz operation, starting, of course, with the CPU. Users who increased the speed of their early computers often received DOS error messages from timing problems, and in some cases, total system lockups due to components not functioning properly at the higher speeds.

Many companies selling speed-up kits sold software to help smooth over some of these problems, but IBM’s official solution was to improve the ROM BIOS software and motherboard circuitry, and to introduce a complete new system running at the faster speed. If you want increased speed no matter what model you have, several companies used to sell clock-crystal replacements that are frequency synthesizers rather than a fixed type of crystal. The units can wait until the POST is finished and change midstream to an increased operating speed. Unfortunately, I don’t know of anyone who is still making or selling these upgrades.

If you really want to speed up your AT by installing a faster clock crystal, instructions can be found on the CD accompanying this book on how to burn your own set of BIOS without the check. However, it requires the use of a specialized PROM or EPROM burner, or access to one.

On April 2, 1986, IBM introduced the Personal Computer AT Models 319 and 339. These were the last and best AT models, and were an enhancement of the earlier Model 239. The primary difference from the Model 239 is a faster clock crystal that provides 8MHz operation. The Model 339 has a new keyboard—the Enhanced keyboard—with 101 keys rather than the usual 84. Model 319 is the same as Model 339, but includes the original keyboard.

Highlights of the Models 319 and 339 are shown in this list:

- Faster processor speed (8MHz)
- Type 2 motherboard, with 256KB chips
- 512KB of RAM (standard)
- Serial/parallel adapter (standard)
- 30MB hard disk (standard)
- New ROM BIOS (dated 11/15/85). ROM support for 22 usable types (up to type 23) of hard disks, and 3 1/2-inch drives, at both 720KB and 1.44B capacities. POST “fixes” clock rate to 8MHz.
- 101-key Enhanced keyboard (standard on Model 339)

The most significant physical difference in these new systems is the Enhanced keyboard on the Model 339. This keyboard, similar to a 3270 keyboard, has 101 keys. It could be called the IBM “corporate” keyboard because it is standard on all new desktop systems. The 84-key PC keyboard still was available, with a new 8MHz model, as the Model 319.

These new 8MHz systems were available only in an enhanced configuration with a standard 30MB hard drive. If you wanted a hard disk larger than IBM’s 30MB, you could either add a second drive or replace the 30MB unit with something larger.

ROM support for 3 1/2-inch disk drives at both 720KB and 1.44MB exists only in Models 339 and 319. In particular, the 1.44MB drive, although definitely supported by the ROM BIOS and controller, was never offered as an option by IBM. This means that the IBM Setup program found on the Diagnostics and Setup disk did not offer the 1.44MB floppy drive as a choice when configuring the system. Anybody adding such a drive had to use one of the many Setup replacement programs available in the public domain, or “borrow” one from an IBM-compatible system that used a floppy disk-based setup program. Adding the 1.44MB drive became one of the most popular upgrades for the AT systems because many newer systems came with that type of drive as standard equipment. Earlier AT systems still can use the 720KB and 1.44MB drives, but they need to either upgrade the ROM to support them (recommended) or possibly use software drivers to make them work.

AT BIOS Versions

Three different BIOS versions have been used in the IBM AT. They can be identified by their date and summarized as follows:

- *January 1, 1984.* The first AT BIOS version supported only 1.2MB and 360B floppy drives directly. Only 14 hard disk types were supported. It came on the Model 068 and 099 systems with the Type 1 motherboard.
- *June 10, 1985.* The second AT BIOS added support for 720KB 3 1/2-inch drives directly (no drivers were required). Also, more hard disk drive types were added, for a total of 22 usable types. A new test was added to the POST that caused the POST to fail if the clock speed was altered from 6MHz. This BIOS was used on the Model 239 with a Type 2 motherboard.
- *November 15, 1985.* The third and final AT BIOS added support for 1.44M 3 1/2-inch drives (no drivers required). Enhanced 101-key keyboard support was added. The POST test checked for 8MHz operation, and failed if the system was running at any other speed. This BIOS was used on Model 319 and 339 systems, and came on a Type 2 motherboard.

Refer to Table 2 for a list of the different IBM Family/1 (PC, XT, and AT) BIOS versions. This table also shows the ID, submodel, and revision bytes that can be determined by a software function call.

```
Int 15h, C0 = Return System Configuration Parameters
```

Some of the systems such as the PC and earlier XT and AT systems only support the ID byte; the submodel and revision bytes had not been established when those systems were developed. The table also shows the number of drive types supported in the AT and XT-286 systems BIOS.

The BIOS date is stored in all PC-compatible systems at memory address FFFF5h. To display the date of your BIOS, a DEBUG command can be used to view this address. DEBUG is a command program supplied with MS-DOS. At the DOS prompt, execute the following commands to run DEBUG, display the date stored in your BIOS, and then exit back to DOS:

```
C:\>DEBUG
-D FFFF:5 L 8
FFFF:0000          30 31 2F-32 32 2F 39 37          01/22/97
-Q
```

In this example, the system queried shows a BIOS date of 01/22/97.

AT Motherboard BIOS Hard Drive Tables

The AT BIOS contains a special table that is used by the hard disk controller driver to determine the hard drive parameters. When a hard disk is installed into this type of system, the “type” of drive is entered into the CMOS RAM by whoever has installed the drive. Then, every time the system boots, it looks up the parameters by consulting the CMOS RAM for the particular type that has been selected.

Older systems were therefore limited to what different drives they could support or recognize by the entries burned into their BIOS table. The table used in IBM AT and PS/2 systems is shown in this section.

The various IBM AT and PS/2 systems that use a BIOS drive table do not necessarily have all the entries shown here. The number of table entries contained in a particular system BIOS can vary from one version to the next. For example, the original AT BIOS (01/10/84) only had Types 1–14 usable, while the later AT BIOS versions (06/10/85 and 11/15/85) had 1–14 and 16–23 usable. The XT-286 had 1–14 and 16–24 as usable types. Some of the PS/1 and PS/2 systems had the table filled in as far as Type 44.

Non-IBM systems quickly adopted special “User Definable” or even “Auto-Detect” types where you could either manually enter the complete table entry (rather than selecting a predetermined “type”), or the system would automatically read the type information directly from the drive.

Note

If you have a non-IBM PC-compatible system, note that the IBM table may be inaccurate for many of the entries past Type 15. Instead, you should consult your CMOS Setup program; most will show the available types as you scroll through them. Another option is to consult your system, motherboard, or BIOS documentation to see if it shows the correct table entries. A final alternative is a program such as the Seagate FINDTYPE program that will scan your BIOS, locate the table, and display or print it for viewing. This program can be downloaded from the Seagate Web site or BBS. Most compatibles follow the IBM table for at least the first 15 entries.

Most PS/2 systems have the drive’s defect map written as data on the drive one cylinder beyond the highest reported cylinder. This special data is read by the IBM PS/2 Advanced Diagnostics low-level format program. This process automates the entry of the defect list and eliminates the chance of human error, as long as you use only the IBM PS/2 Advanced Diagnostics for hard disk low-level formatting on those systems.

This type of table does not apply to IBM Enhanced Small Device Interface (ESDI) or SCSI hard disk controllers, host adapters, and drives. Because the ESDI and SCSI controllers or host adapters query the drive directly for the required parameters, no table-entry selection is necessary. Note, however, that the table for the ST-506/412 drives can still be found currently in the ROM BIOS of most of the PS/2 systems, even if the model came standard with an ESDI or SCSI disk subsystem.

Table 9 shows the IBM motherboard ROM BIOS hard disk parameters for AT or PS/2 systems using ST-506/412 (standard or IDE) controllers.

Table 9 IBM AT and PS/2 BIOS Hard Disk Table

| Type | Cylinders | Heads | WPC | Ctrl | LZ | S/T | M | Bytes |
|------|-----------|-------|-----|------|-----|-----|-------|-------|
| 1 | 306 | 4 | 128 | 00h | 305 | 17 | 10.16 | 10.65 |
| 2 | 615 | 4 | 300 | 00h | 615 | 17 | 28.42 | 21.41 |
| 3 | 615 | 6 | 300 | 00h | 615 | 17 | 30.63 | 32.12 |
| 4 | 940 | 8 | 512 | 00h | 940 | 17 | 62.42 | 65.45 |
| 5 | 940 | 6 | 512 | 00h | 940 | 17 | 46.82 | 49.09 |

| Type | Cylinders | Heads | WPC | Ctrl | LZ | S/T | M | Bytes |
|------|-----------|-------|-------|------|------|-----|--------|--------|
| 6 | 615 | 4 | 65535 | 00h | 615 | 17 | 28.42 | 21.41 |
| 7 | 462 | 8 | 256 | 00h | 511 | 17 | 30.68 | 32.17 |
| 8 | 733 | 5 | 65535 | 00h | 733 | 17 | 30.42 | 31.90 |
| 9 | 900 | 15 | 65535 | 08h | 901 | 17 | 112.06 | 117.50 |
| 10 | 820 | 3 | 65535 | 00h | 820 | 17 | 28.42 | 21.41 |
| 11 | 855 | 5 | 65535 | 00h | 855 | 17 | 35.49 | 37.21 |
| 12 | 855 | 7 | 65535 | 00h | 855 | 17 | 49.68 | 52.09 |
| 13 | 306 | 8 | 128 | 00h | 319 | 17 | 28.32 | 21.31 |
| 14 | 733 | 7 | 65535 | 00h | 733 | 17 | 42.59 | 44.66 |
| 15* | 0 | 0 | 0 | 00h | 0 | 0 | 0 | 0 |
| 16 | 612 | 4 | 0 | 00h | 663 | 17 | 28.32 | 21.31 |
| 17 | 977 | 5 | 300 | 00h | 977 | 17 | 40.55 | 42.52 |
| 18 | 977 | 7 | 65535 | 00h | 977 | 17 | 56.77 | 59.53 |
| 19 | 1024 | 7 | 512 | 00h | 1023 | 17 | 59.50 | 62.39 |
| 20 | 733 | 5 | 300 | 00h | 732 | 17 | 30.42 | 31.90 |
| 21 | 733 | 7 | 300 | 00h | 732 | 17 | 42.59 | 44.66 |
| 22 | 733 | 5 | 300 | 00h | 733 | 17 | 30.42 | 31.90 |
| 23 | 306 | 4 | 0 | 00h | 336 | 17 | 10.16 | 10.65 |
| 24 | 612 | 4 | 305 | 00h | 663 | 17 | 28.32 | 21.31 |
| 25 | 306 | 4 | 65535 | 00h | 340 | 17 | 10.16 | 10.65 |
| 26 | 612 | 4 | 65535 | 00h | 670 | 17 | 28.32 | 21.31 |
| 27 | 698 | 7 | 300 | 20h | 732 | 17 | 40.56 | 42.53 |
| 28 | 976 | 5 | 488 | 20h | 977 | 17 | 40.51 | 42.48 |
| 29 | 306 | 4 | 0 | 00h | 340 | 17 | 10.16 | 10.65 |
| 30 | 611 | 4 | 306 | 20h | 663 | 17 | 28.29 | 21.27 |
| 31 | 732 | 7 | 300 | 20h | 732 | 17 | 42.53 | 44.60 |
| 32 | 1023 | 5 | 65535 | 20h | 1023 | 17 | 42.46 | 44.52 |
| 33 | 614 | 4 | 65535 | 20h | 663 | 25 | 29.98 | 31.44 |
| 34 | 775 | 2 | 65535 | 20h | 900 | 27 | 28.43 | 21.43 |
| 35 | 921 | 2 | 65535 | 20h | 1000 | 33 | 29.68 | 31.12 |
| 36 | 402 | 4 | 65535 | 20h | 460 | 26 | 28.41 | 21.41 |
| 37 | 580 | 6 | 65535 | 20h | 640 | 26 | 44.18 | 46.33 |
| 38 | 845 | 2 | 65535 | 20h | 1023 | 36 | 29.71 | 31.15 |
| 39 | 769 | 3 | 65535 | 20h | 1023 | 36 | 40.55 | 42.52 |
| 40 | 531 | 4 | 65535 | 20h | 532 | 39 | 40.45 | 42.41 |
| 41 | 577 | 2 | 65535 | 20h | 1023 | 36 | 28.29 | 21.27 |

(continues)

Table 9 Continued

| Type | Cylinders | Heads | WPC | Ctrl | LZ | S/T | M | Bytes |
|------|-----------|-------|-------|------|------|-----|-------|-------|
| 42 | 654 | 2 | 65535 | 20h | 674 | 32 | 28.44 | 21.43 |
| 43 | 923 | 5 | 65535 | 20h | 1023 | 36 | 81.12 | 85.06 |
| 44 | 531 | 8 | 65535 | 20h | 532 | 39 | 80.89 | 84.82 |
| 45 | 0 | 0 | 0 | 00h | 0 | 0 | 0.00 | 0.00 |
| 46 | 0 | 0 | 0 | 00h | 0 | 0 | 0.00 | 0.00 |
| 47 | 0 | 0 | 0 | 00h | 0 | 0 | 0.00 | 0.00 |

**Table entry 15 is reserved to act as a pointer to indicate that the type is greater than 15.*

Type = Table entry number

Cylinders = Total number of cylinders

Heads = Total number of heads

WPC = Write Pre-Compensation starting cylinder

65535 = No Write Pre-Compensation (also shown as -1)

0 = Write Pre-Compensation on all cylinders

Ctrl = Control byte with values according to the following table

| Bit Number | Hex | Meaning |
|------------|-----|--------------------------------------|
| Bit 0 | 01h | Not used (XT = drive step rate) |
| Bit 1 | 02h | Not used (XT = drive step rate) |
| Bit 2 | 04h | Not used (XT = drive step rate) |
| Bit 3 | 08h | More than eight heads |
| Bit 4 | 10h | Not used (XT = imbedded servo drive) |
| Bit 5 | 20h | OEM defect map at (cylinders + 1) |
| Bit 6 | 40h | Disable ECC retries |
| Bit 7 | 80h | Disable disk access retries |

LZ = Landing-zone cylinder used for head parking

S/T = Number of sectors per track

M = Drive capacity in megabytes

Bytes = in millions

Modifying ROM BIOS Hard Disk Drive Parameter Tables

Because the IBM tables in the AT and XT-286 systems (as well as many of the compatibles of the day) were fixed, technicians back then often found it necessary to modify the BIOS in those systems to add drive types for new drives they wanted to install. For example, I added two new drive types to one of my old AT systems. Those types—25 and 26—have these parameters (see Table 10).

Table 10—Drive Types

| Type | Cylinders | Heads | WPC | Ctrl | LZ | S/T | M | Bytes |
|------|-----------|-------|-------|------|-----|-----|--------|--------|
| 25 | 918 | 15 | 65535 | 08h | 918 | 17 | 114.30 | 119.85 |
| 26 | 918 | 15 | 65535 | 08h | 918 | 26 | 174.81 | 183.31 |

WPC = Write Pre-Compensation start cylinder

Ctrl = Control byte, 08h = More than 8 heads, else 00h

LZ = Landing zone or head-parking cylinder

S/T = Sectors per track

M = Megabytes

Bytes = in millions

In my old AT system, these table entries originally were unused (zeros), as are the remainder of types from 27–47. By burning a new set of ROMs with these two new completed entries, I was able to use a Maxtor XT-1140 drive to maximum capacity with an MFM 17-sector-per-track controller (as Type 25) or an RLL 26-sector-per-track controller (as Type 26). This method precluded the need for a controller with its own separate onboard BIOS to override the motherboard table values. It also saved memory in the C000 or D000 UMA segments, where such a hard disk controller ROM normally would reside.

Tip

If you are interested in performing this modification, get the IBM AT Technical Reference Manual (sold by IBM or Annabooks), which documents the position and format of the drive tables in the BIOS.

Changing the Hard Disk Controller Head Step Rate

Another more complicated modification that you can perform to the AT BIOS is to increase the stepping rate of the hard disk controller. The first edition of this book briefly mentioned this modification, and a reader wrote to me to express interest in it. Details of the modification can be found on the CD. However, the performance increase is relatively slight.

AT Technical Specifications

Technical information for the AT system is described in this section. You will find information about the system architecture, memory configurations and capacities, standard system features, disk storage, expansion slots, and keyboard specifications, as well as physical and environmental specifications. This type of information can be useful in determining what types of parts are needed when you are upgrading or repairing these systems. Figures 11 and 12 show the layout and components on the two different AT motherboards.

System Architecture

| | |
|----------------|--------------------------------------|
| Microprocessor | 80286 |
| Clock speed | 6MHz or 8MHz |
| Bus type | ISA (Industry Standard Architecture) |
| Bus width | 16-bit |

(continues)

(continued)

System Architecture

| | |
|------------------------------|----------------|
| Interrupt levels | 16 (11 usable) |
| Type | Edge-triggered |
| Shareable | No |
| DMA channels | 8 (7 usable) |
| Bus masters supported | Yes |
| Upgradable processor complex | No |

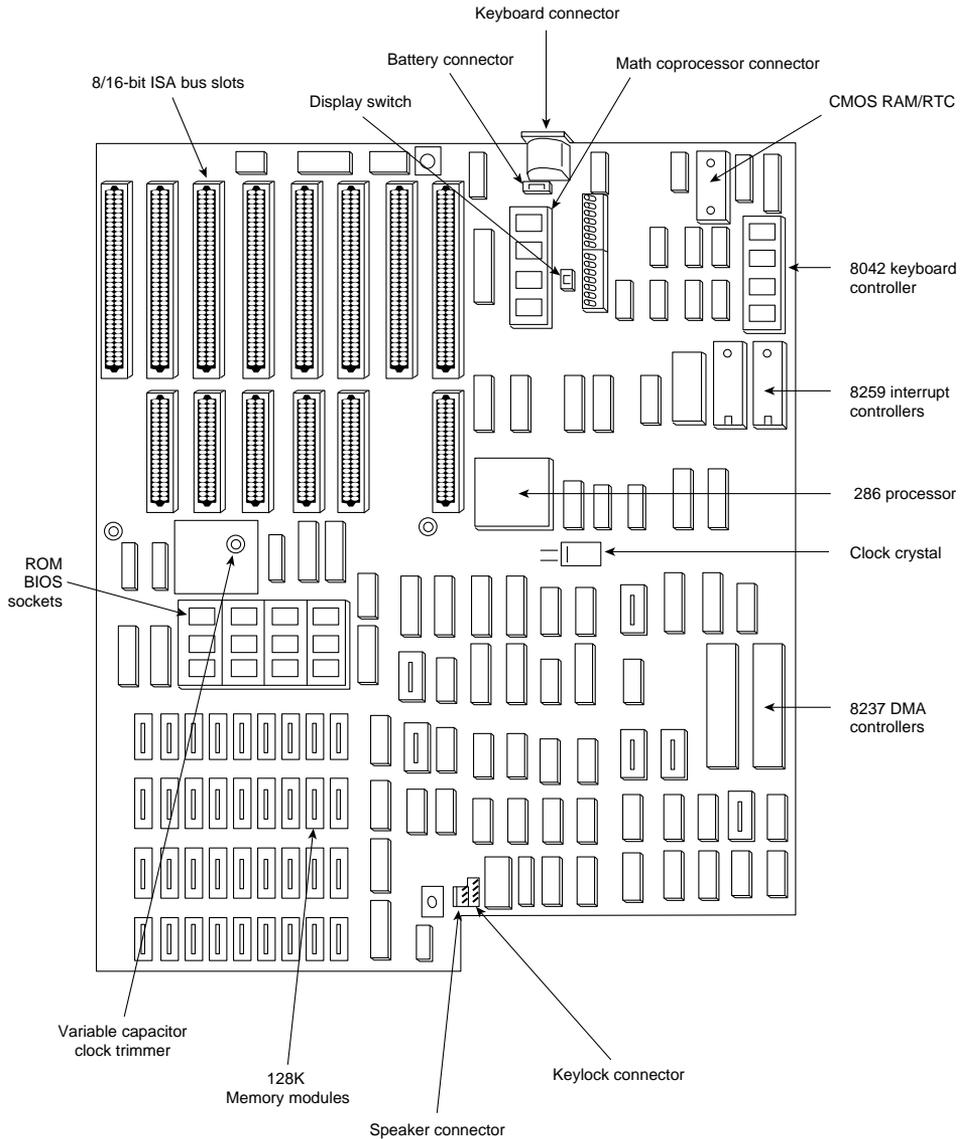


Figure 11 The IBM AT Type 1 motherboard.

Memory

| | |
|---------------------------------|---|
| Standard on system board | 512KB |
| Maximum on system board | 512KB |
| Maximum total memory | 16MB |
| Memory speed (ns) and type | 150ns Dynamic RAM chips |
| System board memory-socket type | 16-pin DIP |
| Number of memory-module sockets | 18 or 36 (2 or 4 banks of 18) |
| Memory used on system board | 36 128KB ×1-bit DRAM chips in 2 banks of 18, or 18 256KB ×1-bit chips in one bank |
| Memory cache controller | No |
| Wait states: | |
| System board | 1 |
| Adapter | 1 |

Standard Features

| | |
|-----------------------------------|-----------------|
| ROM size | 64KB |
| ROM shadowing | No |
| Optional math coprocessor | 80287 |
| Coprocessor speed | 4 or 5.33MHz |
| Standard graphics | None standard |
| RS232C serial ports | 1 (some models) |
| UART chip used | NS16450 |
| Maximum speed (bits per second) | 9,600bps |
| Maximum number of ports supported | 2 |
| Pointing device (mouse) ports | None standard |
| Parallel printer ports | 1 (some models) |
| Bidirectional | Yes |
| Maximum number of ports supported | 3 |
| CMOS real-time clock (RTC) | Yes |
| CMOS RAM | 64 bytes |
| Battery life | 5 years |

Disk Storage

| | |
|--|---------------------------------|
| Internal disk and tape drive bays | 1 full-height and 2 half-height |
| Number of 3 1/2-inch and 5 1/4-inch bays | 0/3 |
| Standard floppy drives | 1×1.2MB |
| Optional floppy drives: | |
| 5 1/4-inch 360KB | Optional |
| 5 1/4-inch 1.2MB | Standard |
| 3 1/2-inch 720KB | Optional |
| 3 1/2-inch 1.44MB | Optional (8MHz models) |
| 3 1/2-inch 2.88MB | No |

(continues)

(continued)

Disk Storage

| | | |
|---------------------------------------|---|------|
| Hard disk controller included | ST-506/412 (Western Digital WD1002-WA2 or WD1003-WA2) | |
| ST-506/412 hard disks available | 20/30MB | |
| Drive form factor | 5 1/4-inch | |
| Drive interface | ST-506/412 | |
| Drive capacity | 20MB | 30MB |
| Average access rate (ms) | 40 | 40 |
| Encoding scheme | MFM | MFM |
| BIOS drive type number | 2 | 20 |
| Cylinders | 615 | 733 |
| Heads | 4 | 5 |
| Sectors per track | 17 | 17 |
| Rotational speed (RPMs) | 3600 | 3600 |
| Interleave factor | 3:1 | 3:1 |
| Data transfer rate (kilobytes/second) | 170 | 170 |
| Automatic head parking | Yes | Yes |

Expansion Slots

| | |
|--------------------------------|-------|
| Total adapter slots | 8 |
| Number of long and short slots | 8/0 |
| Number of 8-/16-/32-bit slots | 2/6/0 |
| Available slots (with video) | 5 |

Keyboard Specifications

| | |
|-----------------------------|-------------------|
| 101-key Enhanced keyboard | Yes (8MHz models) |
| Fast keyboard speed setting | Yes |
| Keyboard cable length | 6 feet |

Physical Specifications

| | |
|----------------|-------------|
| Footprint type | Desktop |
| Dimensions: | |
| Height | 6.4 inches |
| Width | 21.3 inches |
| Depth | 17.3 inches |
| Weight | 43 pounds |

Environmental Specifications

| | |
|---------------------------|-----------|
| Power-supply output | 192 watts |
| Worldwide (110/60,220/50) | Yes |
| Auto-sensing/switching | No |
| Maximum current: | |
| 90-137 VAC | 5.0 amps |

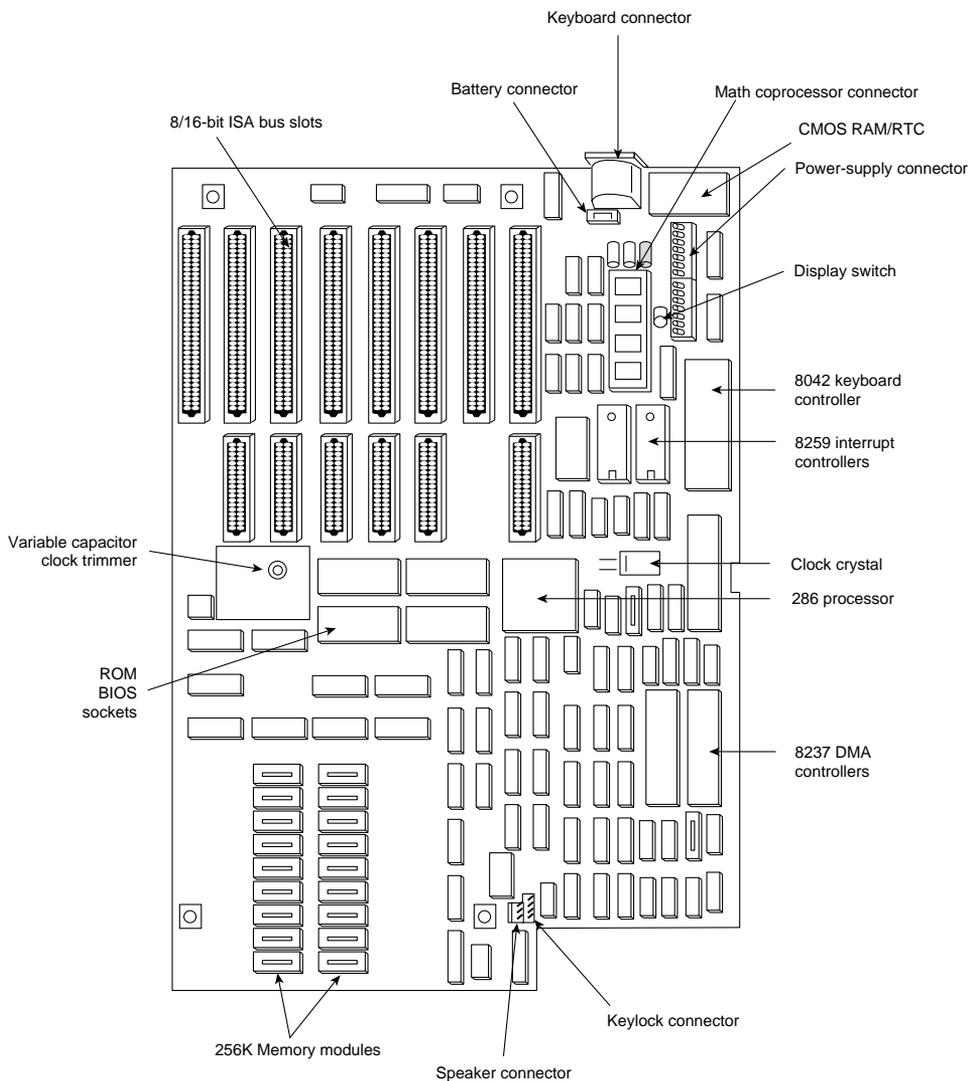


Figure 12 The IBM AT Type 2 motherboard.

Environmental Specifications

| | |
|-----------------------------------|-----------------|
| Operating range: | |
| Temperature | 60–90 degrees F |
| Relative humidity | 8–80 percent |
| Maximum operating altitude | 7,000 feet |
| Heat (BTUs/hour) | 1229 |
| Noise (Average db, operating, 1m) | 42 |
| FCC classification | Class B |

Table 10 shows the AT system-unit part number information.

Table 10 IBM AT Model Part Numbers

| Description | Number |
|--|---------|
| AT 6MHz/84-key keyboard, 256KB | |
| One 1.2MB floppy drive | 5170068 |
| AT 6MHz/84-key keyboard, 512KB, serial/parallel | |
| One 1.2MB floppy drive, 20MB hard disk | 5170099 |
| One 1.2MB floppy drive, 30MB hard disk | 5170239 |
| AT 8MHz/84-key keyboard, 512KB, serial/parallel | |
| One 1.2MB floppy drive, 30MB hard disk | 5170319 |
| AT 8MHz/101-key, 512KB, serial/parallel | |
| One 1.2MB floppy drive, 30MB hard disk | 5170339 |
| System Options | |
| 20MB fixed disk drive | 6450205 |
| 30MB fixed disk | 6450210 |
| 30MB fixed disk drive upgrade kit | 6450468 |
| 360KB half-height floppy disk drive (AT) | 6450207 |
| 1.2MB high-density drive | 6450206 |
| 3 1/2-inch, half-height, 720KB external drive (AT) | 2683191 |
| Serial/parallel adapter | 6450215 |
| 80287 math coprocessor option | 6450211 |
| Floor-standing enclosure | 6450218 |
| Enhanced Keyboard Accessories | |
| Clear keycaps (60) with paper inserts | 6341707 |
| Blank light keycaps | 1351710 |
| Blank dark keycaps | 1351728 |
| Paper keycap inserts (300) | 6341704 |
| Keycap-removal tools (6) | 1351717 |

An Introduction to the XT Model 286

On September 9, 1986, IBM introduced a new AT-type system disguised inside the chassis and case of an XT. This XT Model 286 system featured increased memory, an Intel 80286 microprocessor, and as many as three internal drives standard. The computer combined an XT's cost-effectiveness, flexibility, and appearance with the high-speed, high-performance technology of the Intel 80286 microprocessor. This model looked like an XT, but underneath the cover, it was all AT.

The IBM XT Model 286 can operate as much as three times faster than earlier models of the XT in most applications. It has a standard 640KB of memory. Various memory-expansion options enable users to increase its memory to 16MB.

Standard features in this system include a half-height, 1.2MB, 5 1/4-inch, high-density floppy disk drive; a 20MB hard disk drive; a serial/parallel adapter card; and the IBM Enhanced keyboard. You can select an optional, internal, second floppy disk drive from the following list:

- Half-height, 3 1/2-inch, 720KB floppy drive
- Half-height, 3 1/2-inch, 1.44MB floppy drive
- Half-height, 5 1/4-inch, 1.2MB floppy drive
- Half-height, 5 1/4-inch, 360KB floppy drive

The IBM XT Model 286's performance stems primarily from the AT motherboard design, with 16-bit I/O slots and an Intel 80286 processor running at 6MHz. In addition to the type of processor used, clock speed and memory architecture are the primary factors in determining system performance. Depending on the model, the IBM AT's clock speed is 6MHz or 8MHz, with one wait state; the XT Model 286 processes data at 6MHz, with zero wait states. The elimination of a wait state improves performance by increasing processing speed for system memory access. The zero-wait-state design makes the XT Model 286 definitely faster than the original AT models that ran at 6MHz and about equal in speed to the 8MHz AT systems. Based on tests, the XT Model 286 also is about three times faster than an actual XT.

Because the XT Model 286 is an AT-class system, the processor supports both real and protected modes. Operating in real address mode, the 80286 is 8088-compatible; therefore, you can use most software that runs on the standard PC systems. In real address mode, the system can address as much as 1MB of RAM. Protected mode provides a number of advanced features to facilitate multitasking operations. Protected mode provides separation and protection of programs and data in multitasking environments. In protected mode, the 80286 can address as much as 16MB of real memory and 1GB of virtual memory. In this mode, the XT Model 286 can run advanced operating systems such as OS/2 and UNIX. When the XT Model 286 was introduced, it was the least-expensive IBM system capable of running a true multitasking operating system.

The IBM XT Model 286 has a standard 640KB of RAM. Memory options enable the system to grow to 15 1/2MB, much higher than the 640KB limit in other PC XTs. If you add an operating system such as OS/2 or Windows, you can take advantage of the larger memory capacities that the XT Model 286 provides.

A 20MB hard disk drive is a standard feature in the XT Model 286, as is a 5 1/4-inch, 1.2MB, high-density floppy disk drive. A similar floppy disk drive is standard on all models of the AT. Floppy disks formatted on a 1.2MB floppy disk drive can therefore be read by an AT or an XT Model 286. The 1.2MB floppy disk drive also can read floppy disks formatted with PC-family members that use a 360KB floppy disk drive. Figure 13 shows the interior of an XT-286 system unit.

The XT Model 286 features the IBM Enhanced keyboard with indicator lights. Many IBM personal computers use the Enhanced keyboard, but the XT Model 286 was the first PC XT to feature keyboard indicator lights.

Five slots support the advanced 16-bit cards or 8-bit cards; three support only 8-bit cards. Two of the three 8-bit slots support only short cards.

A hard disk and floppy drive adapter card are standard features in the XT Model 286. This multi-function card takes only one 16-bit slot and supports as many as four disk drives (two floppy disk drives and two hard disk drives).

The serial/parallel adapter, another standard feature, is a combination card that requires only one slot (either type) and provides a serial and a parallel port. The parallel portion of the adapter has the capacity to attach devices, such as a parallel printer, that accept eight bits of parallel data. The fully programmable serial portion supports asynchronous communications from 50bps to 9,600bps, although even higher speeds are possible with the right software. The serial portion requires an optional serial-adaptor cable or a serial-adaptor connector. When one of these options is connected to the adapter, all the signals in a standard EIA RS-232C interface are available. You can use the serial port for interfacing a modem, a remote display terminal, a mouse, or other serial device. The XT Model 286 supports up to two serial/parallel adapters.

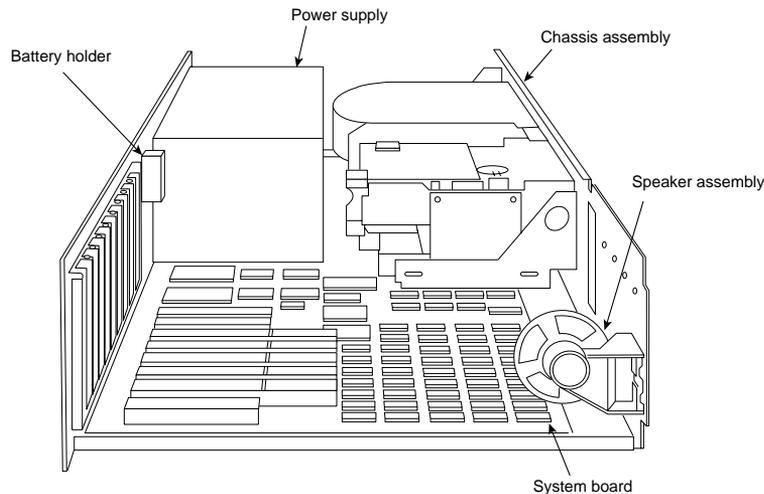


Figure 13 The IBM XT-286 interior.

A standard IBM XT Model 286 offers these features:

- 80286 processor at 6MHz with zero wait states
- 640KB of motherboard memory

- 1.2MB floppy drive
- 20MB hard disk
- Five 16-bit and three 8-bit expansion slots
- Fixed disk/floppy disk drive adapter (occupies one 16-bit expansion slot)
- Serial/parallel adapter (occupies one 16-bit expansion slot)
- Enhanced 101-key keyboard with indicator lights
- CMOS time and date clock with battery backup

XT Model 286 Models and Features

The XT Model 286 processor is as much as three times faster internally than the preceding XT family and as much as 25 percent faster than the AT Model 239, depending on specific applications. A 20MB fixed disk and a 1.2MB 5 1/4-inch floppy disk drive were standard on the XT Model 286. One additional floppy disk drive can be installed internally as drive B. You can add as a second half-height floppy drive any type of floppy drive, including both the double- and high-density versions of the 5 1/4- and 3 1/2-inch drives.

If you want to be able to read standard 5 1/4-inch data or program floppy disks created by the XT Model 286 on other PC systems, you might want to add a 5 1/4-inch 360KB floppy disk drive to provide full read/write compatibility with those systems. This is due to the fact that the 1.2M drives write a narrower track than the 360KB drives and are incapable of properly overwriting a floppy disk written on first by a 360KB drive. If full read/write compatibility with 360KB drives is not important, you can add a second 1.2MB high-density floppy disk drive.

You can add any 3 1/2-inch drive, including the 720KB and 1.44MB versions. Because the 1.44MB does not have any read/write compatibility problems with the 720KB drives, however, and the 1.44MB drives always can operate in 720KB mode, I suggest adding only the 1.44MB 3 1/2-inch drives rather than the 720KB versions. The higher density drive is only a small extra expense compared to the double-density version. Most people do not know that full ROM BIOS support for these 1.44MB drives is provided in the XT Model 286. Unfortunately, because IBM never offered the 1.44MB drive as an option, the supplied Setup program does not offer the 1.44MB drive as a choice in the Setup routine. Instead, you have to use one of the many available public domain AT type setup programs, or “borrow” such a program from an AT-compatible system.

XT Model 286 Technical Specifications

The technical information for the XT-286 system described in this section covers the system architecture, memory configurations and capacities, standard system features, disk storage, expansion slots, keyboard specifications, and also physical and environmental specifications. You can use this information to determine the parts you need when you are upgrading or repairing these systems. Figure 14 shows the layout and components on the XT-286 motherboard.

System Architecture

| | |
|------------------------------|--------------------------------------|
| Microprocessor | 80286 |
| Clock speed | 6MHz |
| Bus type | ISA (Industry Standard Architecture) |
| Bus width | 16-bit |
| Interrupt levels | 16 (11 usable) |
| Type | Edge-triggered |
| Shareable | No |
| DMA channels | 8 (7 usable) |
| Bus masters supported | Yes |
| Upgradable processor complex | No |

Memory

| | |
|---------------------------------|---|
| Standard on system board | 640KB |
| Maximum on system board | 640KB |
| Maximum total memory | 16MB |
| Memory speed (ns) and type | 150ns Dynamic RAM chips/SIMMs |
| System board memory-socket type | 30-pin (9-bit) SIMM |
| Number of memory-module sockets | 2 |
| Memory used on system board | One bank of 4 64KB × 4-bit and 2 64KB ×1-bit DRAM parity chips, and one bank of 2 9-bit SIMMs |
| Memory cache controller | No |
| Wait states: | |
| System board | 0 |
| Adapter | 1 |

Standard Features

| | |
|-----------------------------------|---------------|
| ROM size | 64KB |
| ROM shadowing | No |
| Optional math coprocessor | 80287 |
| Coprocessor speed | 4.77MHz |
| Standard graphics | None standard |
| RS232C serial ports | 1 |
| UART chip used | NS16450 |
| Maximum speed (bits per second) | 9,600bps |
| Maximum number of ports supported | 2 |
| Pointing device (mouse) ports | None standard |
| Parallel printer ports | 1 |
| Bidirectional | Yes |
| Maximum number of ports supported | 3 |
| CMOS real-time clock (RTC) | Yes |
| CMOS RAM | 64 bytes |
| Battery life | 5 years |

Disk Storage

| | |
|--|---|
| Internal disk and tape drive bays | 1 full-height and 2 half-height |
| Number of 3 1/2-inch and 5 1/4-inch bays | 0/3 |
| Standard floppy drives | 1×1.2MB |
| Optional floppy drives: | |
| 5 1/4-inch 360KB | Optional |
| 5 1/4-inch 1.2MB | Standard |
| 3 1/2-inch 720KB | Optional |
| 3 1/2-inch 1.44MB | Optional |
| 3 1/2-inch 2.88MB | No |
| Hard disk controller included | ST-506/412 (Western Digital WD1003-WA2) |
| ST-506/412 hard disks available | 20MB |
| Drive form factor | 5 1/4-inch |
| Drive interface | ST-506/412 |
| Drive capacity | 20MB |
| Average access rate (ms) | 65 |
| Encoding scheme | MFM |
| BIOS drive type number | 2 |
| Cylinders | 615 |
| Heads | 4 |
| Sectors per track | 17 |
| Rotational speed (RPMs) | 3,600 |
| Interleave factor | 3:1 |
| Data transfer rate (kilobytes/second) | 170 |
| Automatic head parking | No |

Expansion Slots

| | |
|--------------------------------|-------|
| Total adapter slots | 8 |
| Number of long and short slots | 6/2 |
| Number of 8-/16-/32-bit slots | 3/5/0 |
| Available slots (with video) | 5 |

Keyboard Specifications

| | |
|-----------------------------|--------|
| 101-key Enhanced keyboard | Yes |
| Fast keyboard speed setting | Yes |
| Keyboard cable length | 6 feet |

Physical Specifications

| | |
|----------------|-------------|
| Footprint type | Desktop |
| Dimensions: | |
| Height | 5.5 inches |
| Width | 19.5 inches |
| Depth | 16.0 inches |
| Weight | 28 pounds |

(continues)

(continued)

Environmental Specifications

| | |
|-----------------------------------|-----------------|
| Power-supply output | 157 watts |
| Worldwide (110v/60Hz, 220v/50Hz) | Yes |
| Auto-sensing/switching | Yes |
| Maximum current: | |
| 90–137 VAC | 4.5 amps |
| Operating range: | |
| Temperature | 60–90 degrees F |
| Relative humidity | 8–80 percent |
| Maximum operating altitude | 7,000 feet |
| Heat (BTUs/hour) | 824 |
| Noise (Average db, operating, 1m) | 42 |
| FCC classification | Class B |

Table 13 lists the XT Model 286 system-unit part numbers.

Table 13 IBM XT-286 Model Part Numbers

| Description | Number |
|---|---------|
| XT Model 286 system unit, 6MHz 0 wait state, 640KB, serial/parallel, 1.2MB floppy drive, one 20MB hard disk | 5162286 |
| Optional Accessories | |
| 5 1/4-inch, half-height 360KB drive | 6450325 |
| 3 1/2-inch, half-height 720KB internal drive | 6450258 |
| 3 1/2-inch, half-height 720KB external drive | 2683190 |
| 80287 math coprocessor option | 6450211 |
| Enhanced Keyboard Accessories | |
| Clear keycaps (60) with paper inserts | 6341707 |
| Blank light keycaps | 1351710 |
| Blank dark keycaps | 1351728 |
| Paper keycap inserts (300) | 6341704 |
| Keycap removal tools (6) | 1351717 |

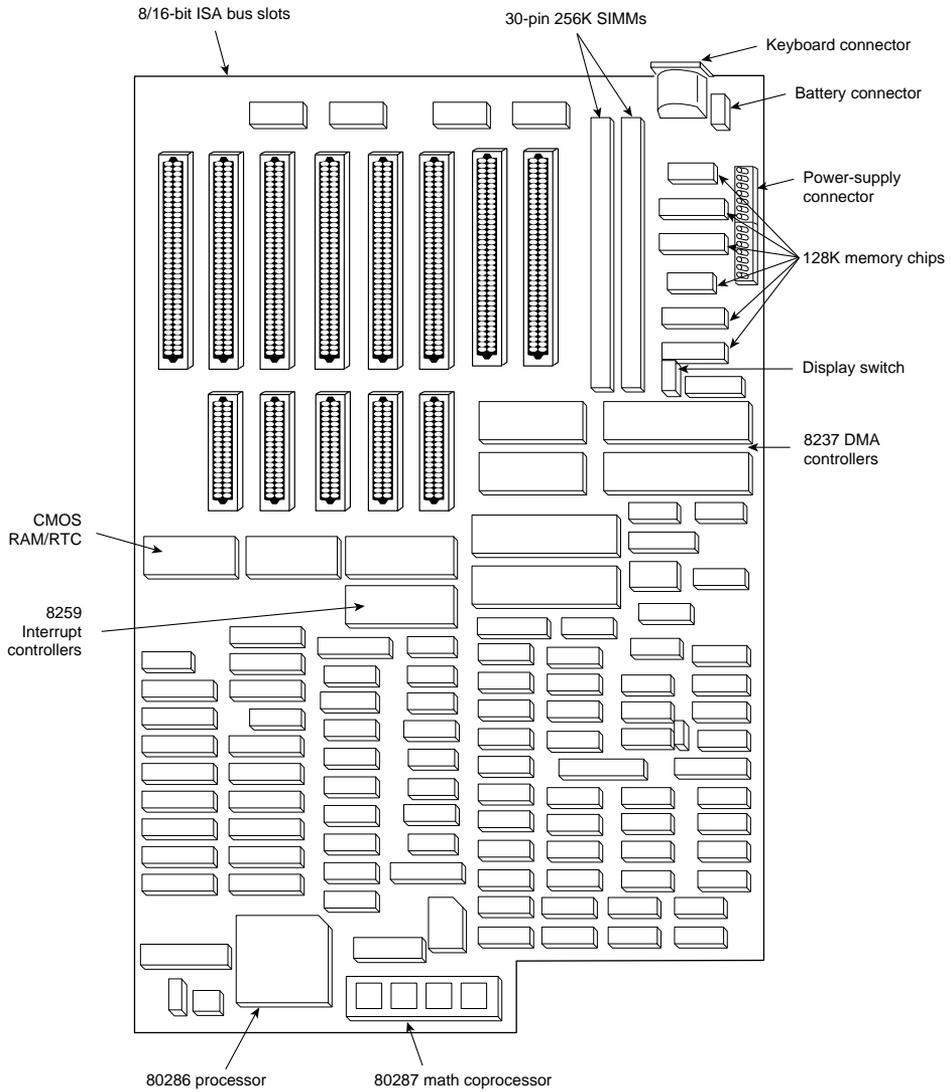


Figure 14 The IBM XT-286 motherboard.

