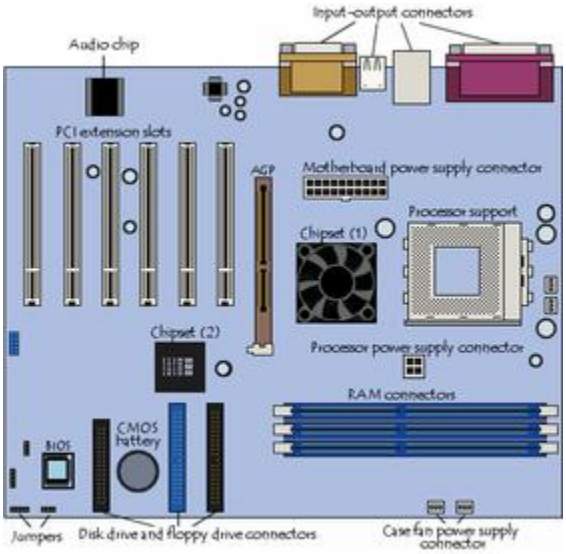
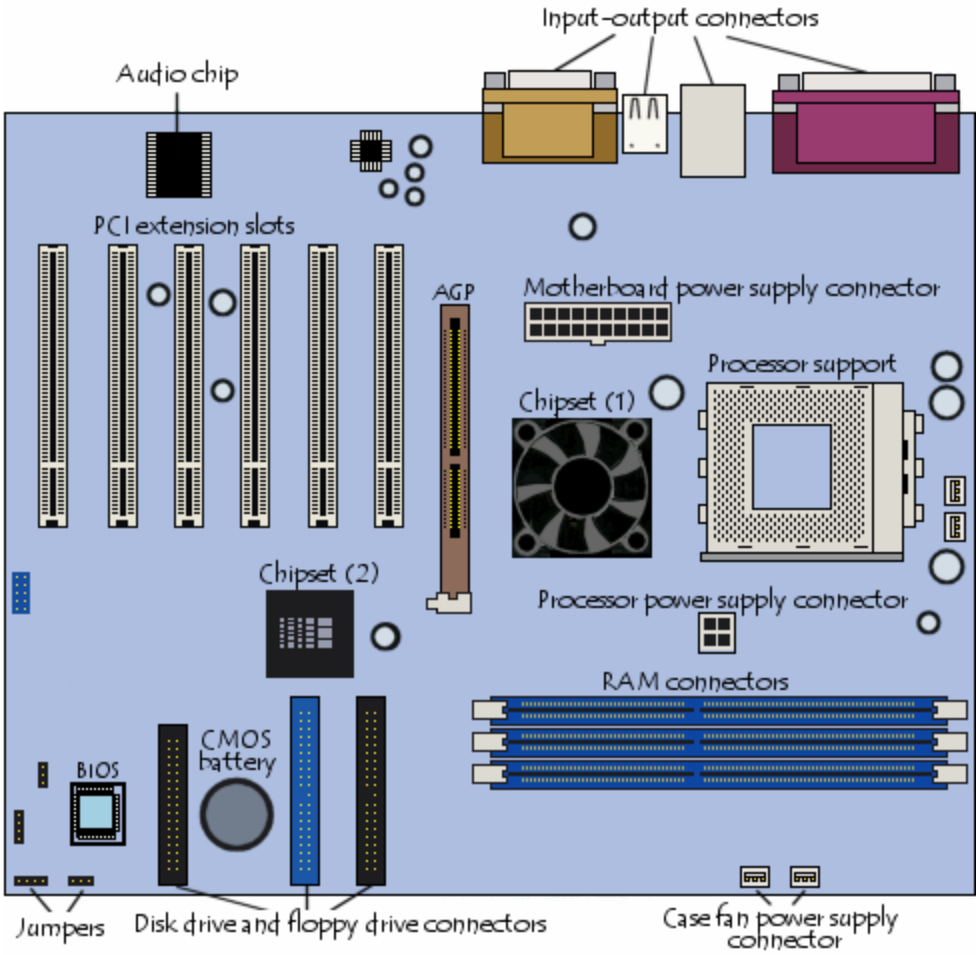
Motherboard



Introduction to motherboards

The primary component of a computer is the **motherboard** (sometimes called the "*mainboard*"). The motherboard is the hub which is used to connect all of the computer's essential components.



As its name suggests, the motherboard acts as a "parent" board, which takes the form of a large printed circuit with connectors for expansion cards, memory modules, the processor, etc.

Characteristics

There are several ways in which a motherboard can be characterised, in particular the following:

- the form factor,
- the chipset,
- the type of processor socket used,
- the input-output connectors.

Motherboard form factor

The term "**form factor**" is normally used to refer to the motherboard's geometry, dimensions, arrangement, and electrical requirements. In order to build motherboards which can be used in different brands of cases, a few standards have been developed:

- **AT baby/AT full format** is a format used in the earliest 386 and 486 PCs. This format was replaced by the ATX format, which shape allowed for better air circulation and made it easier to access the components;
- **ATX**: The ATX format is an upgrade to Baby-AT. It was intended to improve ease of use. The connection device on an ATX motherboard is designed to make plugging in peripherals as easy as possible (for example, the IDEconnectors are located beside the disks.) What's more, motherboard components are arranged in parallel, so as to improve heat removal.
  - **ATX standard**: The ATX standard format is traditionally 305x244 mm. It includes an AGP connector and 6 PCI connectors.
  - **micro-ATX**: The microATX format is an upgrade to ATX, which has the same primary advantages in a smaller format (244x244 mm), with a lower cost. Micro-ATX includes an AGP connector and 3 PCIconnectors.
  - **Flex-ATX**: FlexATX is an expansion of microATX which offers manufacturers greater flexibility when designing their computers. It includes an AGP connector and 2 PCI connectors.
  - **mini-ATX**: miniATX is a compact alternative to the format microATX (284x208 mm), and includes an AGP connector and 4 PCI connectors instead of 3 that come with microATX. It is mainly intended for mini-PCs (barebone computers).
- **BTX**: The BTX format (*Balanced Technology eXtended*), supported by Intel, is a format designed to improve upon the arrangement of components, so as to optimize air circulation, acoustics, and heat dissipation. The various connectors (memory slots, expansion slots) are aligned in parallel, in the direction in which air circulates. Additionally, the microprocessor is located in the front end of the case, by the air intake, where the air is freshest. The BTX power cord is the same as with ATX power supplies. The BTX standard defines three formats:
  - **BTX standard**, with standard dimensions of 325x267 mm;
  - **micro-BTX**, with small dimensions (264x267 mm);
  - **pico-BTX**, with much smaller dimensions (203x267 mm).
- **ITX**: The ITX format (*Information Technology eXtended*), supported by Via, is an extremely compact format designed for miniature configurations such as mini-PC. There are two major ITX formats:
  - **mini-ITX**, with small dimensions (170x170 mm) and a PCI slot;

- **nano-ITX**, with extremely small dimensions (120x120 mm) and a miniPCI slot. For this reason, the choice of the motherboard (and its form factor) depends on which case is chosen. The table below summarises the characteristics of the various form factors.

Form factor	Dimensions	Slots
ATX	305 mm x 244 mm	AGP / 6 PCI
microATX	244 mm x 244 mm	AGP / 3 PCI
FlexATX	229 mm x 191 mm	AGP / 2 PCI
Mini ATX	284 mm x 208 mm	AGP / 4 PCI
Mini ITX	170 mm x 170 mm	1 PCI
Nano ITX	120 mm x 120 mm	1 MiniPCI
BTX	325 mm x 267 mm	7
microBTX	264 mm x 267 mm	4
picoBTX	203 mm x 267 mm	1

Integrated components

The motherboard includes some on-board components, meaning that they are integrated into its printed circuitry:

- The chipset, a circuit which controls the majority of resources (including the bus interface with the processor, cache memory and random-access memory, expansion cards, etc.)
- The CMOS clock and battery,
- The BIOS,
- The system bus and the expansion bus.

What's more, recent motherboards generally include a number of onboard multimedia and networking devices which can be disabled:

- integrated network card;

- integrated graphics card;
- integrated sound card;
- upgraded hard drive controllers.

The chipset

The **chipset** is an electronic circuit whose job is to coordinate data transfers between the various components of the computer (including the processor and memory). As the chipset is integrated into the motherboard, it is important to choose a motherboard which includes a recent chipset, in order to maximise the computer's upgradeability.
Some chipsets may include a graphics or audio chip, which means that it is not necessary to install a graphics card or sound card. However, it is sometimes advised to disable them (whenever possible) in the BIOS setup and to install high-quality expansion cards in the appropriate slots.

The CMOS clock and battery

The **real time clock** (or **RTC** for short) is a circuit which synchronizes system signals. It is made from a crystal which, as it vibrates, gives off pulses (called *timer ticks*) in order to keep the system elements running on the same time. The *timer frequency* (expressed in *MHz*) the number of times the crystal vibrates each second, i.e. the number of *timer ticks* per second. The higher the frequency, the more information the system can process.
When the computer is turned off, the power supply stops providing electricity to the motherboard. When the computer is turned on again, the system is still on the right time. An electronic circuit, called the *CMOS* (*Complementary Metal-Oxyde Semiconductor*, sometimes called the *BIOS CMOS*), saves some system information, such as the time, the system date, and a few essential system settings.
The CMOS is kept powered by a battery (a *button battery*), or a battery located on the motherboard. Information on the hardware installed in the computer (such as the number of tracks or sectors on each hard drive) are stored in the CMOS. As the CMOS is a form of slow storage, certain systems sometimes recopy the CMOS's content into the RAM (fast storage); the term "*memory shadow*" is used to describe this process of copying the data into RAM.
The "*complementary metal-oxide semiconductor*" is a transistor manufacturing technology, the latest in a long line which includes the *TTL* ("*Transistor-transistor-logic*"), the *TTLS* (*TTL Schottky*) (faster), or the *NMOS* (negative channel) and *PMOS* (positive channel).

The CMOS allows many complementary channels to run on a single chip. Compared with TTL or TTLS, CMOS is much slower, but it consumes far less energy, which is why it is used in computer clocks, which run on batteries. The term CMOS is sometimes incorrectly used to refer to computer clocks.
When the system time keeps getting reset, or the clock runs late, all that is usually necessary is to change the battery.

The BIOS

The BIOS (*Basic Input/Output System*) is the basic program used as an interface between the operating system and the motherboard. The BIOS is stored in *ROM*(read-only memory, which can not be rewritten), so it uses data contained within the *CMOS* to find out what the system's hardware configuration is.
The BIOS can be configured using an interface (named the *BIOS setup*), which can be accessed when the computer is booting just be pressing a key (usually the *DEL* key. In reality, the BIOS setup is only used as an interface for configuration; the data is stored in the *CMOS*. For more information, check your motherboard's manual.)

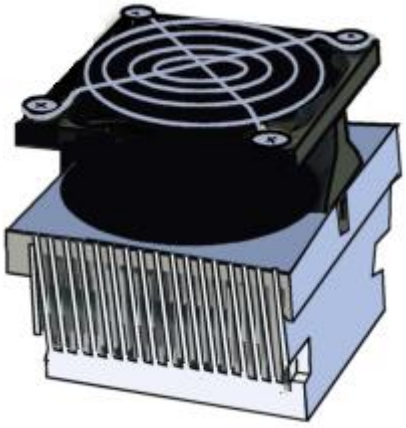
The processor socket

The processor (also called the *microprocessor*) is the computer's brain. It runs programs using a set of instructions. The processor is characterised by its frequency, the rate at which it executes instructions. This means that an 800 MHz processor can carry out 800 million operations per second.
The motherboard has a slot (sometimes several, for multi-processor motherboards) into which the processor is inserted, called the **processor socket**or **slot**.

- **Slot**: A rectangular connector into which the processor is mounted vertically.
- **Socket**: In addition to being the general term, it also refers more specifically to a square-shaped connector with many small connectors into which the processor is directly inserted.

Within these two large families, there are different versions used, depending on the type of processor. Whatever slot or socket is used, it is essential that the processor be inserted gently, so that none of its pins are bent (it has hundreds of them). To make inserting them easier, a concept called **ZIF** (*Zero Insertion Force*) has been created. ZIF sockets have a small lever, which, when lifted, allows the processor to be inserted without applying any pressure, and when lowered, it holds the processor in place.

The processor generally includes some sort of foolproof device, in the form of a notched corner or colored markings, which must be aligned with the corresponding markings on the socket.



Since the processor releases heat, it is necessary to dissipate it, to keep the circuits from melting. This is why it is generally mounted atop a **heat sink**(sometimes called a *cooler* or *radiator*), which is made of a metal which conducts heat well (copper or aluminium) in order to increase the microprocessor's heat transfer surface. The heat sink includes a base in contact with the processor and fins in order to increase the heat transfer surface. A fan generally accompanies the cooler in order to improve air circulation around it and to improve the heat transfer. The unit also includes a fan which vents hot air from the case and let fresh air come in from outside.

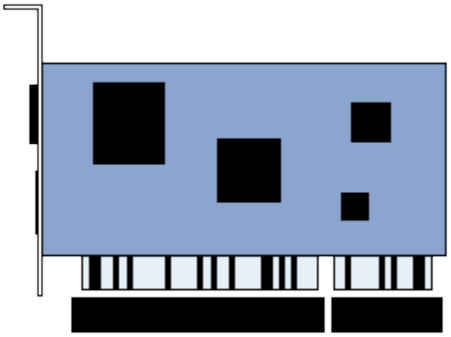
RAM connectors

RAM (*Random Access Memory*) is used to store data while the computer is running; however, its contents are wiped out as soon as the computer is switched off or restarted, as opposed to mass storage devices such as hard drives, which keep information safe even while turned off. This is why RAM is called "volatile."
Why, then, is RAM used at all, when hard drives cost less per byte stored? The answer is that RAM is extremely fast when compared to mass storage devices like hard drives. It has a response time on the order of a few dozen nanoseconds (about 70 for DRAM, 60 for EDO RAM, and 10 for SDRAM; as little as 6 ns for DDR SDRAM) as opposed to a few milliseconds for a hard drive.
RAM comes in the form of modules which plug into motherboard connectors.

Expansion slots

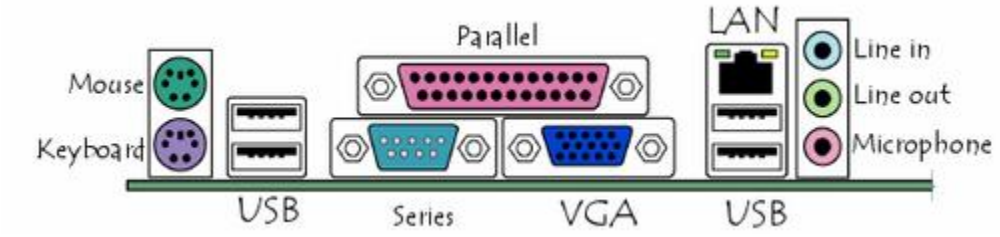
Expansion slots are compartments into which expansion cards can be inserted. These are cards which give the computer new features or increased performance. There are several types of slots:

- ISA slots (*Industry Standard Architecture*): For inserting ISA slots. The slowest ones are 16-bit.
- VLB slots (*Vesa Local Bus*): Bus formerly used for installing graphics cards.
- PCI slot (*Peripheral Component InterConnect*): used for connecting PCI cards, which are much faster than ISA cards and run on 32 bits
- AGP slot (*Accelerated Graphic Port*): A fast port for a graphics card.
- PCI Express slot (*Peripheral Component InterConnect Express*): Faster bus architecture than AGP and PCI buses.
- AMR slot (*Audio Modem Riser*): This type of slot is used for connecting mini-cards to PCs which are built for it.



the input-output connectors.

The motherboard has a certain number of input/output sockets found on the **rear panel**.



Most motherboards have the following connectors:

- A serial port, for connecting old peripherals;
- A parallel port, mainly for connecting old printers;
- USB ports (1.1, low-speed, or 2.0, high-speed), for connecting more recent peripherals;
- **RJ45 connector** (called *LAN* or *ethernet port*) used for connecting the computer to a network. It corresponds to a network card integrated into the motherboard;
- **VGA connector** (called *SUB-D15*), for connecting a monitor. This connector interfaces with the built-in graphics card;
- **Audio plugs** (*Line-In*, *Line-Out* and *microphone*), for connecting sound speakers or a hi-fi system, as well as a microphone. This connector interfaces with the built-in sound card;

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