Study of Motherboard

Motherboards are complex. Let's break them down, component by component, and Understand how they work. Choosing a motherboard is a hugely important part of building a PC.

- **What does a motherboard do?**

It's the circuit board that connects all of your hardware to your processor, distributes electricity from your power supply, and defines the types of storage devices, memory modules, and graphics cards (among other expansion cards) that can connect to your PC. A modern motherboard is a printed circuit board (PCB) made of layers of fiberglass and copper, with other components mounted on it or socketed into it.

Modern PCBs usually have around 10 layers, making them much more densely interconnected than they appear on the surface.

A motherboard is a PC's primary circuit board. Though motherboard aesthetics change over time, their basic design makes it easy to connect new expansion cards, hard drives, and memory modules, as well as replace old ones.

- **Processor Socket**

Motherboards usually contain at least one processor socket, enabling your CPU (the PC's mechanical "brain") to communicate with other critical components. These include memory (RAM), storage, and other devices installed in expansion slots — both internal devices like GPUs and external devices like peripherals.

(Not all motherboards have a socket, though: in systems with less space, like Intel® NUC and most laptops, the CPU is soldered into the motherboard.)

Modern Intel motherboards connect CPUs directly to RAM, from which it fetches instructions from different programs, as well as to some expansion slots that can hold performance-critical components such as GPUs and storage drives. The memory controller lives on the CPU itself, but numerous other devices communicate with the CPU through the chipset, which controls many expansion slots, SATA connections, USB ports, and sound and network functions.

Some pins connect the CPU to memory via traces (lines of conductive metal) on your motherboard, while others are groups of power or ground pins. If your PC is having trouble booting up or recognizing installed memory, it could be caused by a bent pin that isn't making contact with your CPU, among other potential issues[2] like Cables , Power switches , Internal wiring or BIOS problems.

- **Chipset**

The *chipset* is a silicon backbone integrated into the motherboard that works with specific CPU generations. It enables communication between the CPU and the many connected storage and expansion devices like hard disk Printers.

While the CPU connects directly to RAM (via its built-in memory controller) and to a limited number of PCIe lanes [3] (expansion slots), the chipset acts as a hub that controls the other buses on the motherboard: additional PCIe lanes, storage devices, external ports like USB slots, and many peripherals.

Higher-end chipsets can feature more PCIe slots and USB ports than standard models, as well as newer hardware configurations and different allocations of PCIe slots (with more linked directly to the CPU).

The classic chipset design, common to chipsets for the Intel® Pentium®₅ processor family, was divided into a "northbridge" and "southbridge" that handled different functions of the motherboard. Together, the two chips formed the chip "set."

In this older design, the northbridge, or "memory controller hub," was linked directly to the CPU via a high-speed interface called the system bus or front-side bus (FSB). This controlled the system's performance-critical components: memory and the expansion bus that connected to a graphics card.

The southbridge, or "I/O Controller Hub," was connected to the northbridge with a slower internal bus, and controlled virtually everything else: other expansion slots, Ethernet and USB ports, onboard audio, and more. Intel has 3 main series for selection of chipset – z series, H-series and B series. [1]

1.1.3 Block Diagram

Figure 2 is a block diagram of the major functional areas of the board.

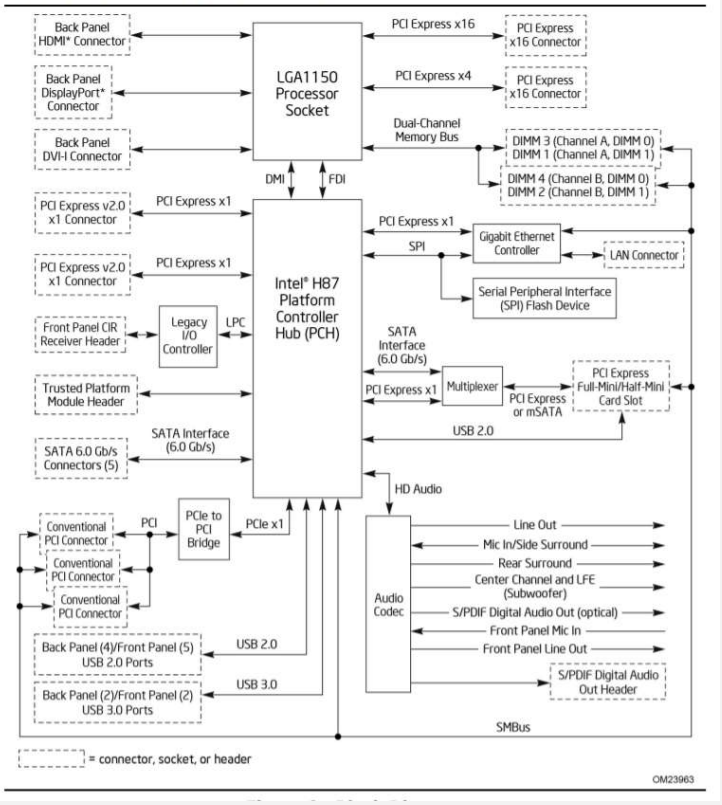

Figure1.1 Block Diagram

Figure 1.1. is a block diagram of the major functional areas of the board.

- **Expansion Slots -**

Peripheral Component Interconnect Express (PCIe) is a high-speed serial expansion bus integrated into either your CPU, motherboard's chipset, or both. This allows the installation of devices like graphics cards, solid-state drives, network adapters, RAID controller cards, capture cards, and many other expansion cards into the PCIe slots of a motherboard. The integrated peripherals featured on many motherboards also connect via PCIe.

Each PCIe link contains a specified number of data lanes, listed as ×1, ×4, ×8, or ×16 (often pronounced "by one," "by four," etc.). Each lane consists of two pairs of wires: one transmits data and the other receives data.

With current-generation PCIe implementations, a PCIe ×1 link has one data lane with a transfer rate of one bit per cycle. A PCIe×16 lane, typically the longest slot on your motherboard (and also the one used most often for a graphics card), has 16 data lanes capable of transferring up to 16 bits per cycle. However, future iterations of PCIe will allow doubling the data rate per clock cycle.

Each revision of PCIe has roughly doubled the bandwidth of the previous generation, and that means better performance for PCIe devices. A PCIe 2.0 ×16 link has a theoretical, bidirectional peak bandwidth of 16 GB/s; a PCIe 3.0 ×16 link has a peak of 32 GB/s. When comparing PCIe 3.0 lanes, the ×4 link commonly used by many solid-state drives has a peak theoretical bandwidth of 8 GB/s, whereas the ×16 link that GPUs leverage offers four times as much. (For more info refer [1]).

- **SATA**

SATA (Serial ATA) is an older computer bus less commonly used today to connect to 2.5" or 3.5" hard drives, solid-state drives, and optical drives that play DVDs and Blu-ray. Though slower than PCIe, the common SATA 3.0 interface supports data transfer speeds up to 6Gbit/s. The newer SATA Express (or SATAe) format uses two PCIe lanes to reach speeds up to 16Gbit/s. It's not to be confused

with External SATA (eSATA), an external port that allows easy connection of (compatible) portable hard drives.

- **RAM**

Motherboards also have slots for RAM modules: sticks of volatile memory that temporarily store data for fast retrieval. Multiple sticks of high-speed RAM can help PCs handle simultaneous programs without slowdown.

Full-size motherboards (like the ATX form factor) typically have four slots, while size-constrained boards like mITX usually use two. However, HEDT motherboards, like those for the Intel® Core™ X-series processor family (as well as server/workstation motherboards based on the Intel® Xeon®› platform) can have up to eight.

Recent Intel motherboards support dual-channel memory architecture, meaning there are two independent channels transferring data between the CPU's memory controller and a stick of DIMM (dual in-line memory modules) RAM. As long as sticks of RAM are installed in pairs with matching frequencies, this leads to speedier data transfer and better performance in some applications.

- **Form Factor**

Your motherboard's form factor determines the size of case you need, the number of expansion slots you'll have to work with, and many facets of the motherboard's layout and cooling. In general, larger form factors give builders more DIMM, full-size PCIe, and M.2 slots to work with. E.g. *ATX* (12" × 9.6"), *Extended ATX* or *eATX* (12" x 13"):

- **BIOS**

The first thing you see when your computer starts up is the BIOS, or Basic Input/Output System. This is the firmware that loads before your operating system boots up, and it's responsible for starting up and testing all connected hardware.

Though often referred to as the BIOS by users and motherboard labels alike, the firmware on modern motherboards is typically UEFI (Unified Extensible Firmware Interface). This more flexible environment boasts many user-friendly improvements, such as support for larger storage partitions, speedier boot-up, and a modern GUI (graphical user interface).

- **Internal Connectors**

Power and Data Connectors

- 24-pin power connector , 8- or 4-pin 12V CPU power connector, PCIe power connector
- SATA Express/SATA 3 connectors, M.2 connectors

Headers

Front-panel header: a group of individual pins for the power button, reset button, hard drive LED, power LED, internal speaker, and case features

- Front panel audio header: powers headphone and speaker ports
- Fan and pump headers: for CPU, system, and water cooling
- USB 2.0, 3.0, and 3.1 headers, S/PDIF (digital audio) header, RGB strip headers

- **External Ports**

Your motherboard is the hub that external devices connect to, and its I/O controller manages these devices. Consumer motherboards provide ports that connect a CPU's integrated graphics to your monitor. Peripherals like a keyboard and mouse, audio devices, Ethernet cables, and more. Motherboards group external ports on their back panel, which is covered with a removable or integrated "I/O shield" that is grounded due to its contact with an often metal case. This is sometimes attached to the motherboard, or comes separately to be installed when putting together the system.

- **Peripherals and Data TransferUSB port:** A ubiquitous port used to connect to mice, keyboards, headphones, smartphones, cameras, and other peripherals. It provides both power and data (at speeds up to 20 GBit/s using USB 3.2).
- **Thunderbolt™ 3**[10] **port:** A high-speed port that uses a USB-C connector. Thunderbolt™ 3 technology transfers data at speeds up to 40 GB/s and also supports the DisplayPort 1.2 and USB 3.1 standards.
- **PS/2 port:** A legacy port, this color-coded six-pin connection connects to a keyboard or mouse.

- **Display**

These display ports connect to your motherboard's onboard graphics solution; a graphics card installed in one of your expansion slots will provide its own display port options.

- **HDMI (High-Definition Multimedia Interface):** This ubiquitous digital connection supports resolutions up to 8K at 30Hz as of the HDMI 2.1 revision.
- **DisplayPort:** This display standard supports resolutions up to 8K at 60Hz as of DisplayPort 1.4. Though more common on graphics cards than motherboards, many boards feature DisplayPort support through their Thunderbolt™ 3 port.
- **DVI (Digital Video Interface):** A legacy port dating back to 1999, this digital 29-pin connection can be either single-link or higher-bandwidth dual-link DVI. Dual-link supports resolutions up to 2560 × 1600 at 60Hz. It easily connects to VGA with an adapter.
- **VGA (Video Graphics Array):** An analog 15-pin connection with support for resolutions up to 2048 × 1536 at an 85Hz refresh rate. This legacy port is still sometimes seen on motherboards. Often suffers signal degradation with higher resolutions or shorter cables.

- **Audio**

The front of a PC case often features two analog 3.5mm audio ports labeled for headphones (headphone out) and a microphone (mic in).
The motherboard's rear panel usually has a bank of six color-coded and labeled 3.5mm analog audio ports for connecting to multichannel speaker systems.

- **Networking**

Most consumer motherboards include an RJ45 LAN port, which can connect to your router or modem via Ethernet cable. Some boards feature dual ports for use with a Wi-Fi antenna, as well as advanced connectivity features, such as dual 10-Gigabit Ethernet ports.

- **Overclocking**

High-end motherboards often provide automated testing and tuning to overclock your CPU, GPU, and memory, providing an easy-to-use alternative to manual adjustment of frequency and voltage numbers in the UEFI environment. They may also feature an onboard clock generator for fine control of CPU speed, an enhanced VRM (Voltage Regulator Module), extra thermal sensors near overclocked components, and even physical buttons on the motherboard to start and stop overclocking. You can learn more about **overclocking** . [3]

- **Cooling**

Motherboard components such as the PCH and VRM generate significant heat. To keep them at safe operating temperatures and prevent performance throttling, motherboard manufacturers install a variety of cooling solutions. These range from the passive cooling provided by heatsinks to active solutions, such as small fans or integrated water cooling.

For specific Motherboards and further studies Refer [4]

1.https://www.intel.in/content/www/in/en/gaming/resources/how-to-choose-a-motherboard.html
2.https://www.intel.in/content/www/in/en/gaming/resources/why-wont-my-computer-turn-on.html
3. https://www.intel.in/content/www/in/en/gaming/resources/how-to-overclock.html?
4.https://www.intel.in/content/www/in/en/support/articles/000006014/boards-and-kits/desktop-boards.html

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