Read Only Memory (ROM)

Mask Programmable (Data "Written" During Device Fabrication")
Field Programmable (Data "Written" by Device Purchaser)

(i) PROM–Programmable Read Only Memory
(ii) EPROM–Erasable Programmable Read Only Memory
(iii) EEPROM–Electrically Erasable Programmable Read Only Memory.

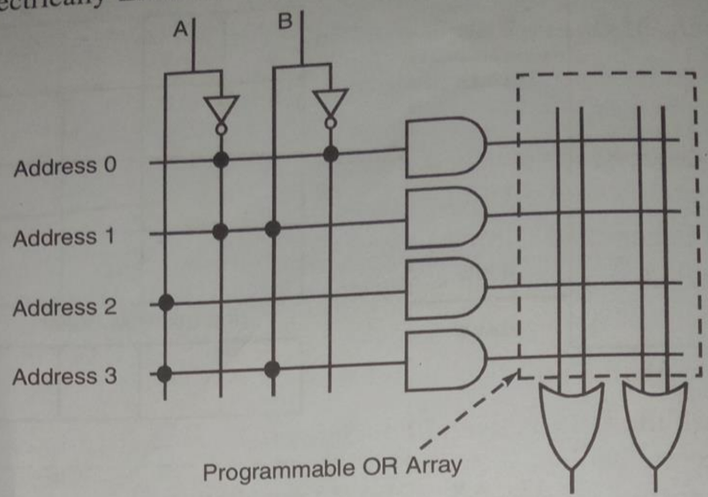

Fig. 6.10. PLD Architecture for PROM

PROM (Programmable Read-Only Memory)

It is a variation on ROM. PROM can be programmed by the user with the appropriate **Programming Device.** Whereas ROMs are hardwired, PROM has fuses that can be blown to program the chip. Once programmed, the data and instructions in PROM cannot be changed.

Flash Memory Applications and Limitations

The Flash memory was invented by Dr. Fujio Masuoka while working for Toshiba in 11084. According to Toshiba, the name 'Flash' was suggested by Dr. Masuoka's colleague, Mr. Shoji Ariizumi, because the erasure process of the memory contents reminded him of a flash of a camera.

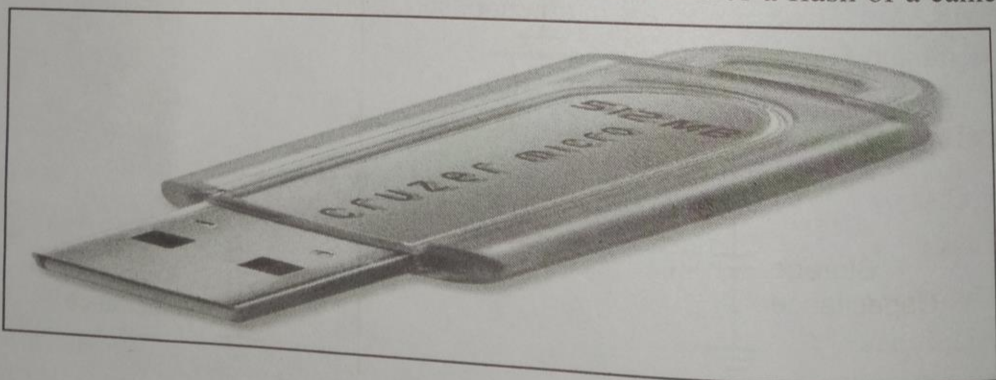

Fig. 6.11. Flash Memory Device

Flash memory is a form of EEPROM (Electrically Erasable Programmable Read-Only Memory) that allows multiple memory locations to be erased or written in one programming operation. In other terms, it is a form of rewritable memory chip that, unlike a RAM (Random Access Memory) chip, power supply is not required to hold the contents. It is commonly used in memory cards, USB flash drives, MP3 players, digital cameras and mobile phones.

(i) High Density

(ii) Read/Write
(iii) Non Volatile – Data stored indefinitely without power
(iv) Combine best characteristics of traditional RAM/ROM.

Applications of Flash Memory

The Flash Memory technology has evolved into the preferred storage media for a variety of consumer and industrial devices.

1. Notebook computers and Personal computers
2. Digital cameras and Personal Digital Assistants
3. Cell phones and pagers and Global Positioning Systems (GPS)
4. Electronic musical instruments and Solid-state music players such as Television set-top boxes and MP3 players.

Limitations of Flash Memory

One limitation of flash memory is that although it can be read or programmed a byte or a word at a time in a random access fashion, it must be erased a "block" at a time. Starting with a freshly erased block, any byte within that block can be programmed. However, once a byte has been programmed, it cannot be changed again until the entire block is erased. In other words, flash memory (specifically NOR flash) offers random-access read and programming operations, but cannot offer random-access rewrite or erase operations.

(i) MRAM - MAGNETIC RAM
(ii) Infineon, IBM show prototype 16Mb magnetic RAM. Prototype MRAM chip brings power-saving technology one step closer
(iii) MRAM is expected to first be used in mobile applications as a replacement for flash.
(iv) At some point in the future, MRAM could also replace SRAM and DRAM, which is cheap to manufacture but is slower than MRAM and requires a constant power supply to retain stored data.
(v) Using MRAM instead of DRAM in notebooks PCs could help extend battery life, according to Infineon and IBM.

6.3.2. Auxiliary Memory Devices

(i) Floppy Disks
(ii) Hard Disks
(iii) Magnetic Disks
(iv) Magnetic Tapes
(v) CD-ROM Disks
(vi) Optical Disk
(vii) DVD-digital Video Disk

Floppy Disks

A soft magnetic disk is called *floppy* because it flops if you wave it (at least, the 5¼-inch variety does). Unlike most hard disks, floppy disks (often called *floppies* or *diskettes*) are portable, because you can remove them from a disk drive. Disk drives for floppy disks are called floppy drives. Floppy

disks are slower to access than hard disks and have less storage capacity, but they are much less expensive. And most importantly, they are portable.

Floppies come in three basic sizes :

1. **8-inch :** The first floppy disk design, invented by IBM in the late 11060s and used in the early 11070s as first a read-only format and then as a read-write format. The typical desktop/laptop computer does not use the 8-inch floppy disk.
2. **5¼-inch :** The common size for PCs made before 11087 and the predecessor to the 8-inch floppy disk. This type of floppy is generally capable of storing between 100 K and 1.2 MB of data. The most common sizes are 360 K and 1.2 MB.
3. **3½-inch :** *Floppy* is something of a misnomer for these disks, as they are encased in a rigid envelope. Despite their small size, microfloppies have a larger storage capacity than their cousins — from 400K to 1.4MB of data. The most common sizes for PCs are 720K (double-density) and 1.44MB high-density.

Hard Disks

Hard disk is a non-volatile storage device which stores digitally encoded data on rapidly rotating **platters** with **magnetic** surfaces. Strictly speaking, "drive" refers to an entire unit containing multiple platters, a read/write head assembly, driver electronics, and motor while "hard disk" (sometimes "platter") refers to the storage medium itself. It is connected to main memory through the bus and a disk controller.

> **DO YOU KNOW**
> **A hard disk (commonly known as a HDD (hard disk drive) or hard drive and formerly known as a fixed disk.**

The processor only occasionally interacts with secondary memory.

1. Secondary memory is where programs and data are kept on a long-term basis. Common secondary storage devices are the hard disk and floppy disks. The hard disk has enormous storage capacity compared to main memory.
2. The hard disk is usually contained in the systems unit of a computer. Data and programs on the hard disk are organized into files—named sections of the disk.
3. Hard disk might have a storage capacity of 40 gigabytes. This is about 300 times the amount of storage in main memory (assuming 128 megabytes of main memory). A hard disk is very slow compared to main memory.

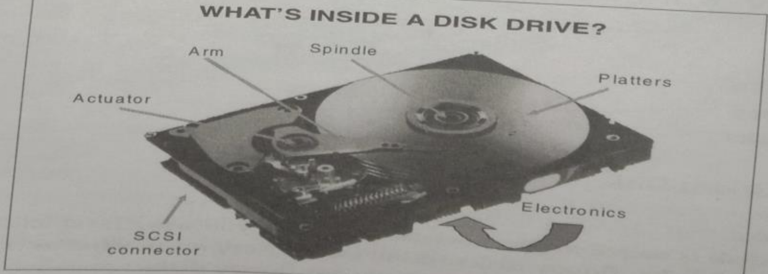

Fig. 6.12. Hard Disk-Components

Hard disks were originally developed for use with computers. In the 21st century, applications for hard disks have expanded beyond computers to include digital video recorders, digital audio players, personal digital assistants, and digital cameras. The need for large-scale, reliable storage, independent of a particular device, led to the introduction of configurations such as RAID, hardware such as network attached storage (NAS) devices, and systems such as storage area networks (SANs) for efficient access to large volumes of data.

Disks consist of platters, each with two surfaces. Each surface consists of concentric rings called tracks. Each track consists of sectors separated by gaps.

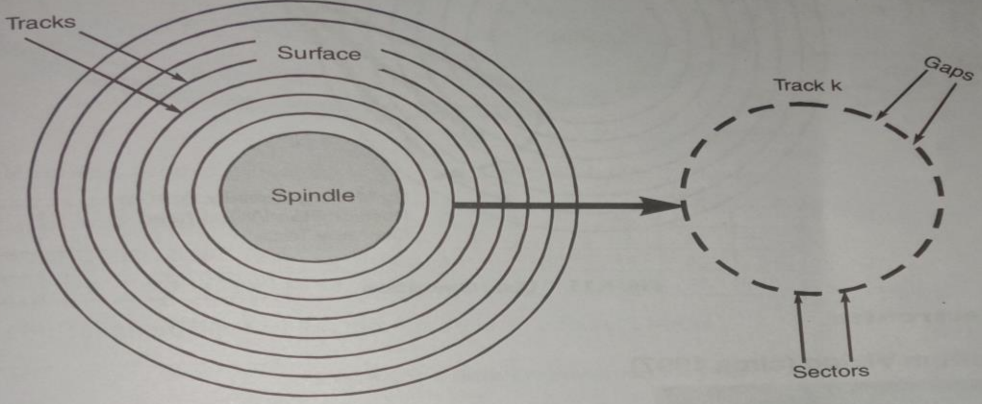

Fig. 6.13. Disck Configuration

Disk Operation (Multiplotter View)

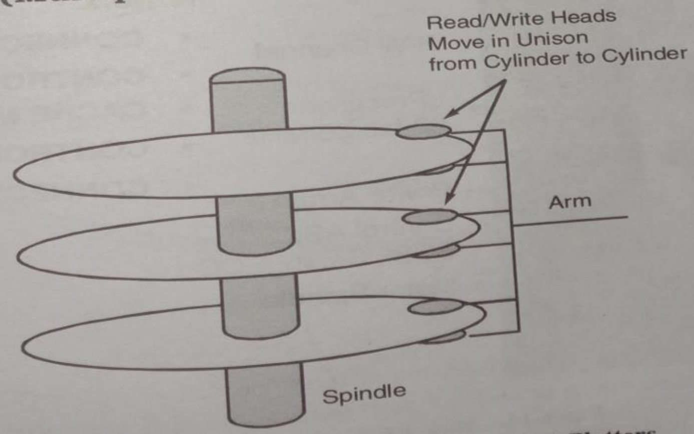

Fig. 6.14. Disk Configuration-Multi-Platters

Disk Access Time

Average time to access a specific sector approximated by:

Taccess = Tavg seek + Tavg rotation + Tavg transfer Seek time (Tavg seek)

(*i*) Time to position heads over cylinder containing target sector

(*ii*) Typical Tavg seek = 3-5 ms

Rotational Latency (Tavg Rotation)

(*i*) Time waiting for first bit of target sector to pass under r/w head.

(*ii*) Tavg rotation = 1/2 × 1/RPMs × 60 sec/1 min. For example, 3 ms for 10,000 RPM disk.

Transfer Time (Tavg transfer)

Time to read the bits in the target sector

Tavg transfer = 1/RPM x 1/(avg # sectors/track) × 60 secs/1 min

For example, 0.006ms for 10,000 RPM disk with 1,000 sectors/track given 512-byte sectors, ~85 MB/s data transfer rate.

Disk Access Time Example

Given :

(*i*) Rotational rate = 7,200 RPM

(*ii*) Average seek time = 5 ms

(*iii*) Avg # sectors/track = 1000

Derived average time to access random sector :

(*i*) Tavg rotation = 1/2 x (60 secs/7200 RPM) × 1000 ms/sec = 4 ms.

(*ii*) Tavg transfer = 60/7200 RPM × 1/400 secs/track × 1000 ms/sec = 0.008 ms.

- Taccess = 5 ms + 4 ms + 0.008 ms = 9.008 ms.
- Time to second sector: 0.008 ms.

TIPS

Access time dominated by seek time and rotational latency. First bit in a sector is the most expensive, the rest are free. SRAM access time is about 4 ns/doubleword, DRAM about 60 ns.