Microcontroller & Embedded Systems-Module-3-2

ESTD : 2001
An Institute with a Difference

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Text book 2: Shibu K V, “Introduction to Embedded Systems”, Tata McGraw Hill Education, Private Limited, 2nd Edition.
Chapter 1(Sections 1.2 to 1.6) ,Chapter 2(Sections 2.1 to 2.6)

3.2.2 Memory

- The memory used in ES can be either **Program Storage Memory** (ROM) or
- **Data memory** (RAM)
- **On-chip memory--**Certain Embedded processors/controllers contain built in program memory and data memory and this memory is known as on-chip memory
- **Off-chip-Memory--**Others do not contain any memory inside the chip and requires external memory to be connected with the controller/processor to store the control algorithm. It is called off-chip memory.

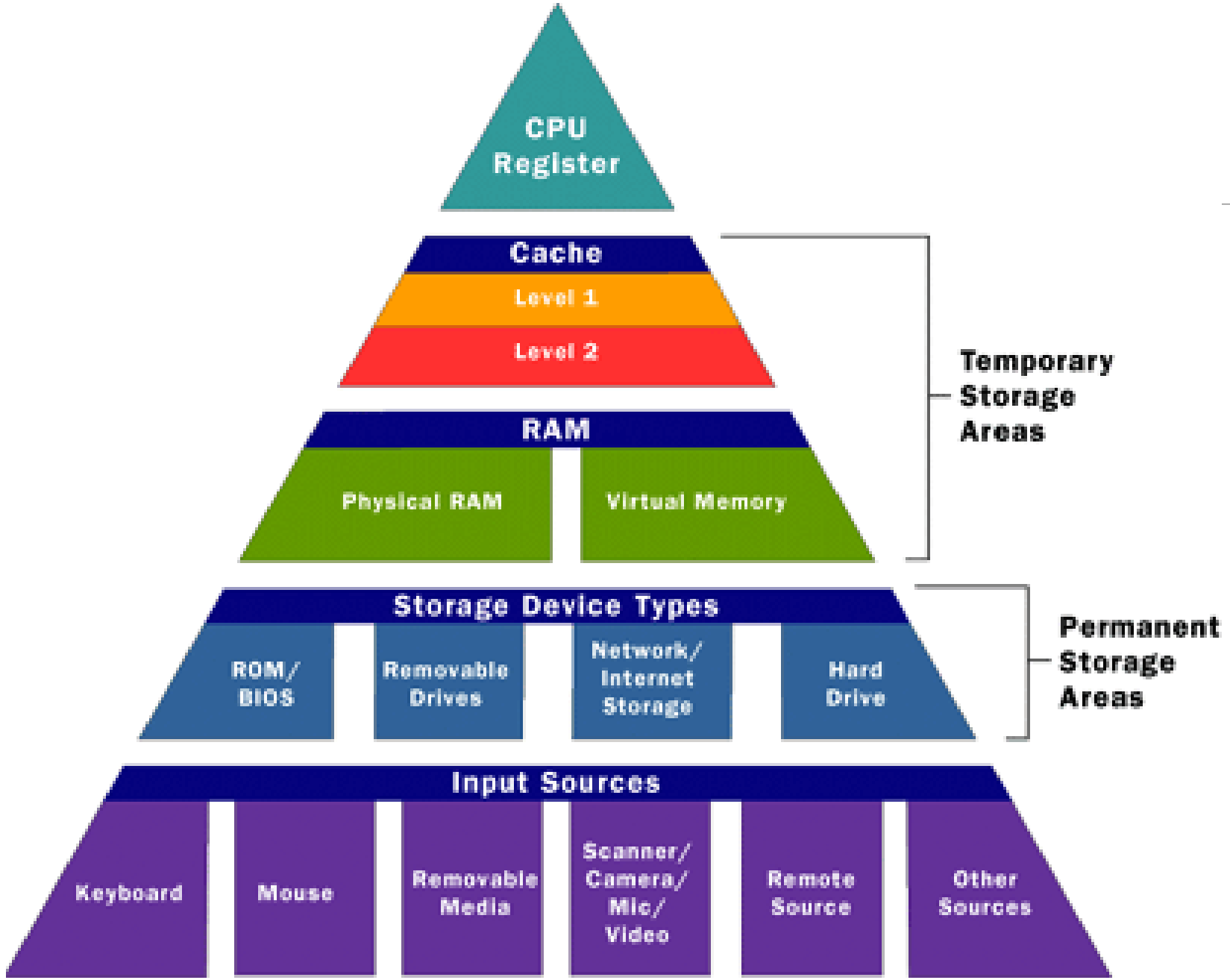
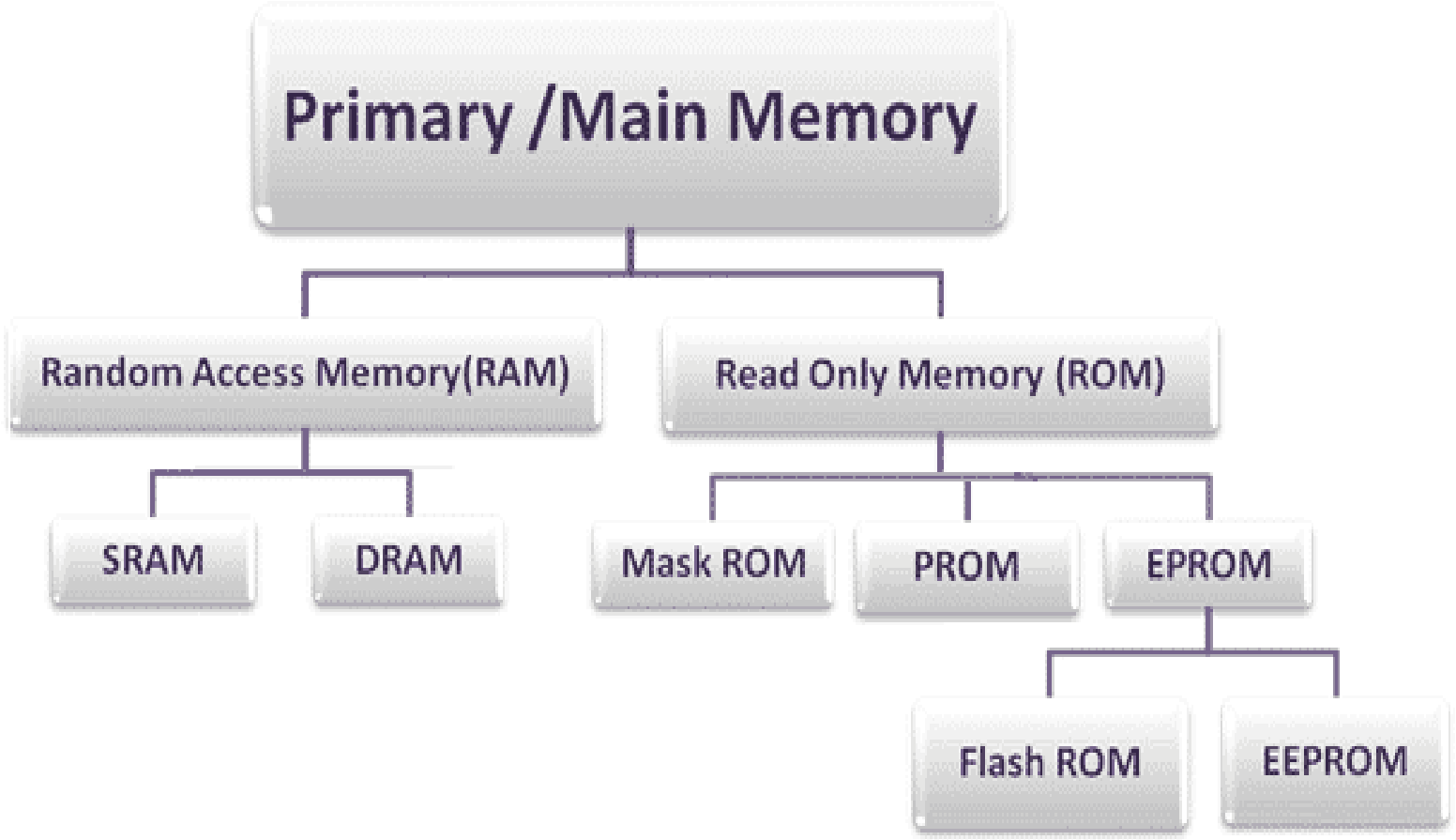


Fig: Different types of processor Memory

Classification Of Memory

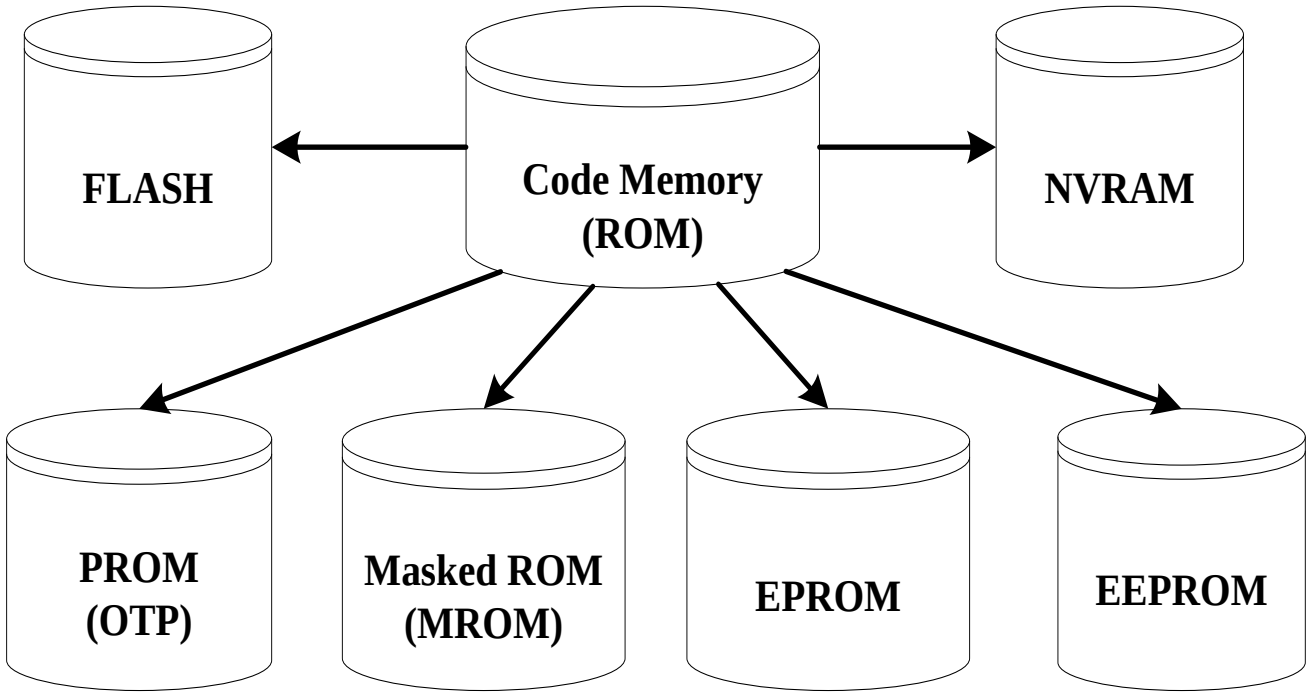


RAM	ROM
1. Temporary Storage.	1. Permanent storage.
2. Store data in MBs.	2. Store data in GBs.
3. Volatile.	3. Non-volatile.
4.Used in normal operations.	4. Used for startup process of computer.
5. Writing data is faster.	5. Writing data is slower.

Difference between RAM and ROM

Program Storage Memory (ROM)

- Stores the program instructions
- Retains its contents even after the power to it is turned off. It is generally known as Non-volatile storage memory
- Fig shows Classification



Mask ROM (MROM)

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- One-time programmable memory.
- Uses hardwired technology for storing data.
- The device is factory programmed by masking and metallization process according to the data provided by the end user.
- The primary advantage of MROM is low cost for high volume production. They are the least expensive type of solid state memory.
- The limitation with MROM based firmware storage is the inability to modify the device firmware against firmware upgrades.

Programmable Read Only Memory (PROM) / One-Time Programmable (OTP)

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- Unlike MROM it is not pre-programmed by the manufacturer
- PROM/OTP has nichrome or polysilicon wires arranged in a matrix, these wires can be functionally viewed as fuses
- It is programmed by a PROM programmer which selectively burns the fuses according to the bit pattern to be stored
- Fuses which are not blown/burned represents a logic “1” where as fuses which are blown/burned represents a logic “0”.The default state is logic “1”
- OTP is widely used for commercial production of embedded systems whose proto-typed versions are proven and the code is finalized
- It is a low cost solution for commercial production. OTPs cannot be reprogrammed

Erasable Programmable Read Only Memory (EPROM)

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- EPROM gives the flexibility to re-program the same chip
- EPROM stores the bit information by charging the floating gate of an FET
- Bit information is stored by using an EPROM Programmer, which applies high voltage to charge the floating gate
- EPROM contains a quartz crystal window for erasing the stored information.
- If the window is exposed to Ultra violet rays for a fixed duration, the entire memory will be erased
- Even though the EPROM chip is flexible in terms of re-programmability, it needs to be taken out of the circuit board and needs to be put in a UV eraser device for 20 to 30 minutes

Electrically Erasable Programmable Read Only Memory (EEPROM)

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- The information contained in the EEPROM memory can be altered by using electrical signals at the register/Byte level
- They can be erased and reprogrammed within the circuit
- These chips include a chip erase mode and in this mode they can be erased in a few milliseconds.
- It provides greater flexibility for system design.
- The only limitation is their capacity is limited when compared with the standard ROM (A few kilobytes).

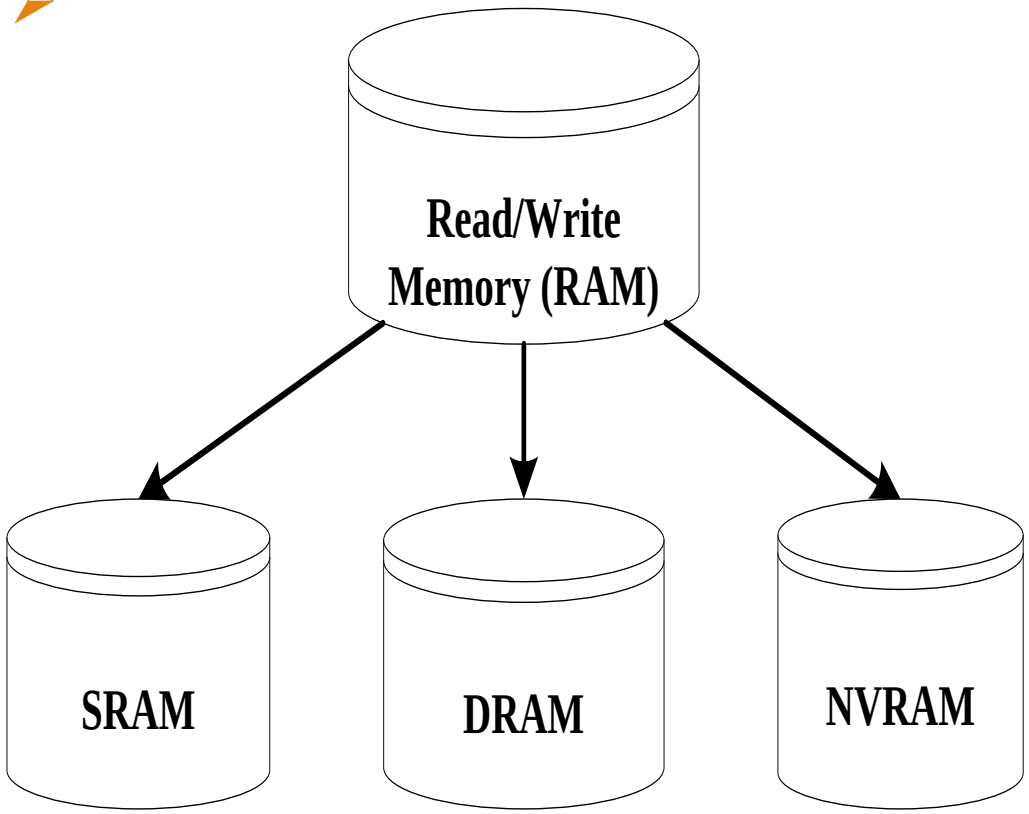
Flash

- FLASH memory is a variation of EEPROM technology
- It combines the re-programmability of EEPROM and the high capacity of standard ROMs
- FLASH memory is organized as sectors (blocks) or pages
- FLASH memory stores information in an array of floating gate MOSFET transistors
- The erasing of memory can be done at sector level or page level without affecting the other sectors or pages.
- Each sector/page should be erased before re-programming

NVRAM

- Non-volatile RAM is a type of RAM that retains data after the host device's is turned off.
- It contains static RAM based memory and a minute battery for providing supply to the memory in the absence of external power supply.
- The memory and battery are packed together in a single package.
- The life span of NVRAM is expected to be around 10 years"
- DS-1644 from Maxim/Dallas is an example of 32KB NVRAM.

Read-Write Memory/ Random Access Memory (RAM)

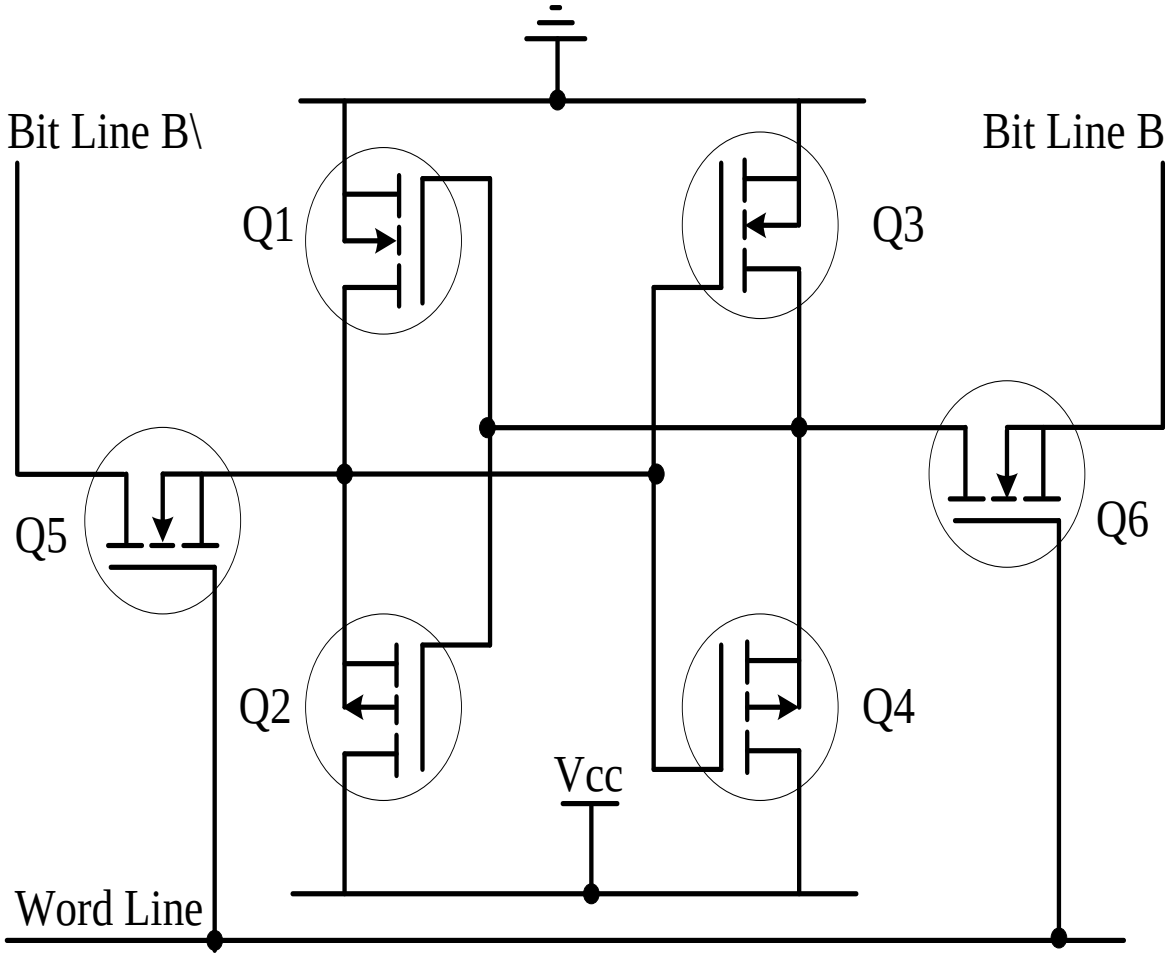


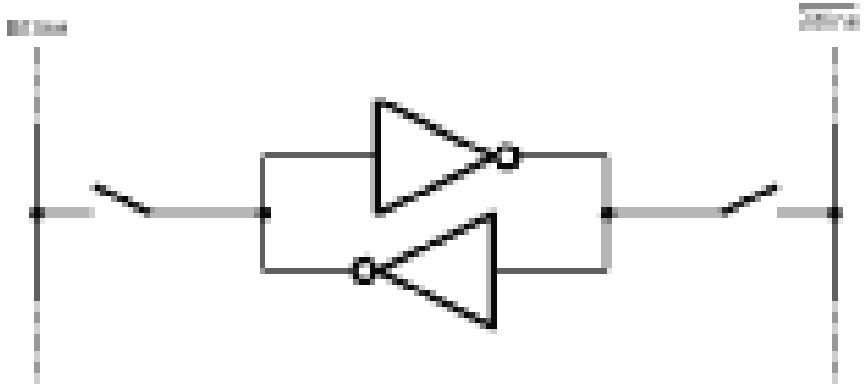
- RAM is the data memory or working memory of the controller/processor.
- Controller/processor can read from it and write to it.
- RAM is volatile, meaning when the power is turned off, all the contents are destroyed.
- RAM is a direct access memory
- RAM generally falls into three categories:
  - Static RAM (SRAM),
  - dynamic RAM (DRAM) and
  - non-volatile RAM (NVRAM).

Static RAM (SRAM)

- SRAM stores data in the form of Voltage. They are made up of flip-flops
- In typical implementation, an SRAM cell (bit) is realized using 6 transistors (or 6 MOSFETs). Four of the transistors are used for building the latch (flip-flop) part of the memory cell and 2 for controlling the access.
- SRAM is the fastest form of RAM available.
- SRAM is fast in operation due to its resistive networking and switching capabilities.
- The major limitations of SRAM are low capacity and high cost.
- Since a minimum of six transistors are required to build a single memory cell, imagine how many memory cells we can fabricate on a silicon wafer.
- In its simplest representation and SRAM cell can be visualized as shown in Fig:

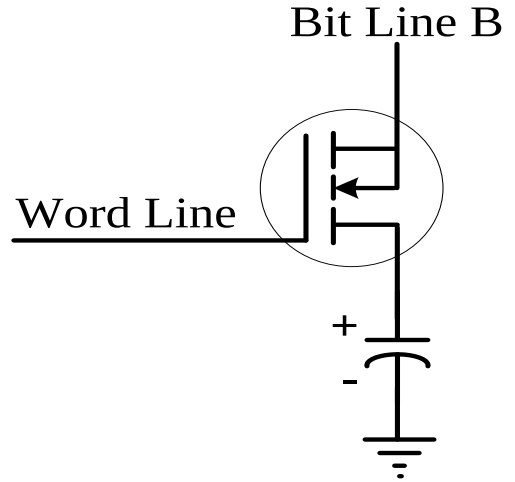
Static RAM (SRAM)





Dynamic RAM (DRAM)

- DRAM stores data in the form of charge. They are made up of MOS transistor gates
- The advantages of DRAM are its high density and low cost compared to SRAM
- The disadvantage is that since the information is stored as charge it gets leaked off with time and to prevent this they need to be refreshed periodically
- Figure illustrates the typical implementation of a DRAM cell.
- The MOSFET acts as the gate for the incoming and outgoing data whereas the capacitor acts as the bit storage unit.



SRAM Vs DRAM

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SRAM Cell	DRAM Cell
Made up of 6 CMOS transistors (MOSFET)	Made up of a MOSFET and a capacitor
Doesn't Require refreshing	Requires refreshing
Low capacity (Less dense)	High Capacity (Highly dense)
More expensive	Less Expensive
Fast in operation. Typical access time is 10ns	Slow in operation due to refresh requirements. Typical access time is 60ns. Write operation is faster than read operation.

Non-Volatile RAM (NVRAM)

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- Random access memory with battery backup
- It contains Static RAM based memory and a minute battery for providing supply to the memory in the absence of external power supply.
- The memory and battery are packed together in a single package.
- NVRAM is used for the non-volatile storage of results of operations or for setting up of flags etc.
- The life span of NVRAM is expected to be around 10 years.
- DS1744 from Maxim/Dallas is an example for 32KB NVRAM

Memory Selection for Embedded Systems

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- The ES requires:
  - Program memory-embedded OS ans applications
  - Data memory
  - Memory for holding non-volatile data-configuaration data,look-up table etc.
- lot of factors considered
  - Microcontroller selection
  - voltage range
  - Battery life
  - Read/write speeds
  - Memory size
  - Memory volatility
  - Erase/write endurance levels
  - Overall system costs

Sensors and Actuators

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- **Sensor:** A transducer device which converts energy from one form to another for any measurement or control purpose.
- Sensors acts as input device

Example: Hall Effect Sensor which measures the distance between the cushion and magnet in the Smart Running shoes from adidas.

- **Actuator**: A form of transducer device (mechanical or electrical) which converts signals to corresponding physical action (motion).
- Actuator acts as an output device

Example: Micro motor actuator which adjusts the position of the cushioning element in the Smart Running shoes from adidas.

The I/O Subsystem

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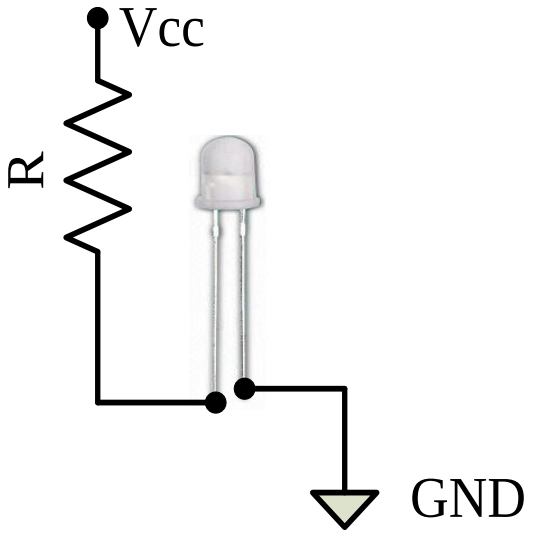
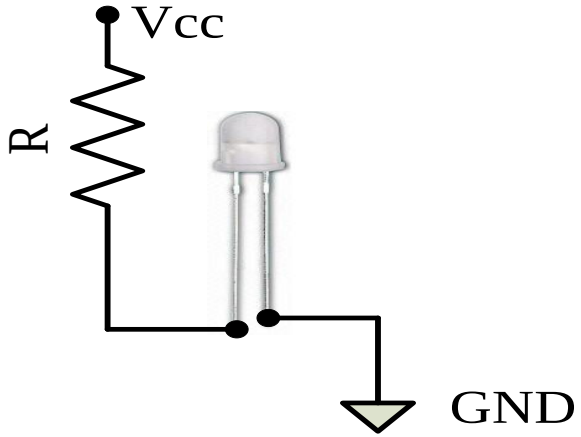
- The I/O subsystem of the embedded system facilitates the interaction of the embedded system with external world.
- The interaction happens through the sensors and actuators connected to the Input and output ports respectively of the embedded system.
- The sensors may not be directly interfaced to the Input ports, instead they may be interfaced through signal conditioning and translating systems like ADC etc.

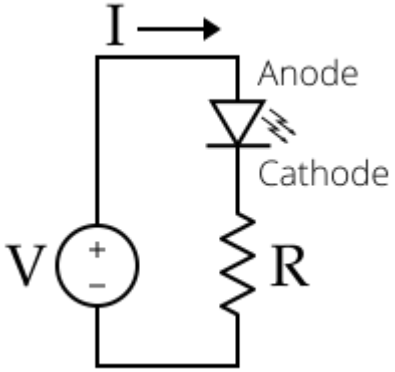
LED-Light Emitting Diode

- LED is an output device for visual indication in any embedded system.
- LED can be used as an indicator for the status of various signal or situations.
- Typical examples are indicating the presence of power conditions like “Device ON” Battery low or “Charging of battery” for a battery operated hand held embedded devices.
- LED is a pn junction diode and it contains an anode and a cathode.
- For proper functioning of the LED, the anode of it should be connected to +ve terminal of the supply voltage and cathode to the -ve terminal of supply voltage.



LED-Cont



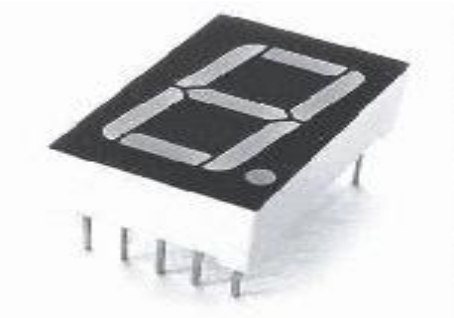


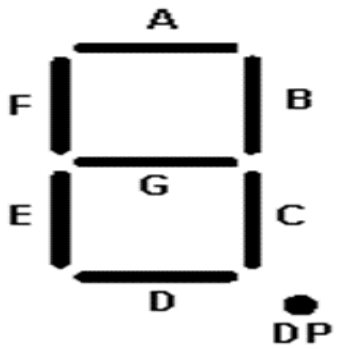
- LED's can be interfaced to the port pin of a processor/controller in two ways.

1.In the first method, the anode is directly connected to the port pin and the port pin drives the LED. In this approach the port pin 'sources' current to the LED when the port pin is at logic High (Logic '1').

2. In the second method, the cathode of the LED is connected to the port pin of the processor/controller and the anode to the supply voltage through a current limiting resistor. The LED is turned on when the port pin is at logic Low (Logic '0').

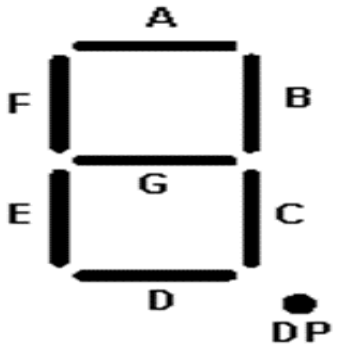
7 segment LED display





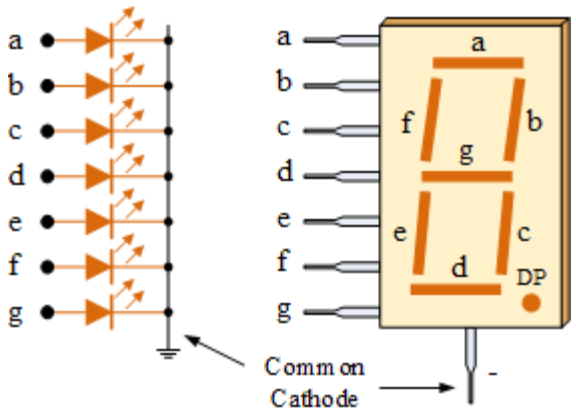
- The 7 – segment LED display is an output device for displaying alpha numeric characters.
- It contains 8 light-emitting diode (LED) segments arranged in a special form. Out of the 8 LED segments, 7 are used for displaying alpha numeric characters and 1 is used for representing decimal point.
- • The LED segments are named A to G and the decimal point LED segment is named as DP.

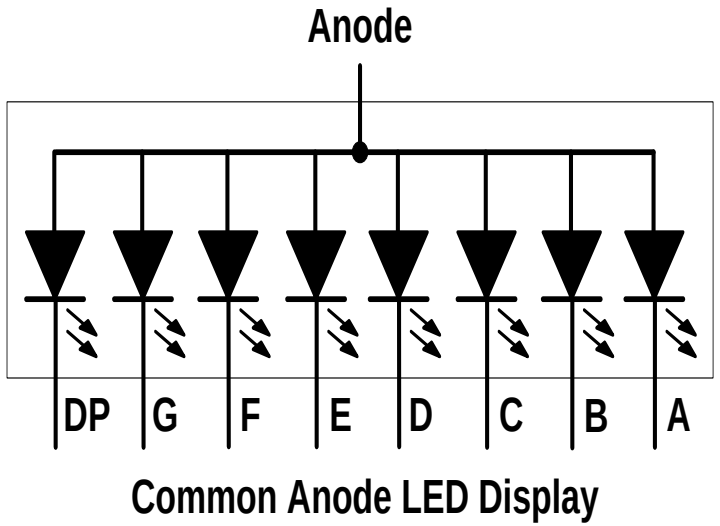
7 segment LED display

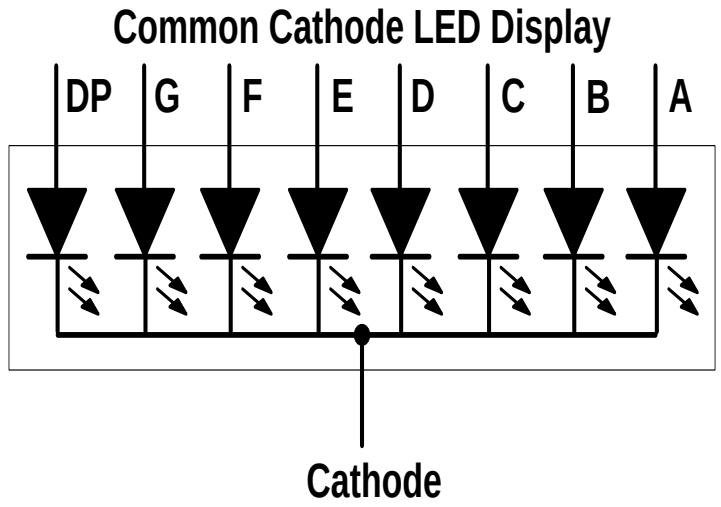


digit	h (.dot)	g	f	e	d	c	b	a	Value
0	0	0	1	1	1	1	1	1	3F
1	0	0	0	0	0	1	1	0	06
2	0	1	0	1	1	0	1	1	5B
3	0	1	0	0	1	1	1	1	4F
4	0	1	1	0	0	1	1	0	66
5	0	1	1	0	1	1	0	1	6D
6									7D
7									07
8									7F
9									6F
A									77
B									7C
C									39
D									5E
E	0	1	1	1	1	0	0	1	79
F	0	1	1	1	0	0	0	1	71

7 segment LED display







Thank You