Embedded Systems Concepts

By : Tasnem Sabry

#Computing System:

A computing system is a collaborative setup of hardware (such as computers, servers, and devices) and software (including programs and operating systems) that work together to handle data, execute tasks, and facilitate various functions like calculations, communication, and data processing.

It has two types:

1- General purpose
2- Specific Purpose

It consists of:

1- Preprocessor
2- Memory
3- I/O Performance

#Embedded System:

An embedded system is a combination of computer hardware and software designed for a specific function, it is typically integrated into everyday objects and appliances to control and monitor various operations, it is often optimized for low power consumption, real-time operation, and size constraints, making them suitable for a wide range of applications.

#Difference between System board & System on chip:

ES - Challenge	SB	SOC
Size	larger in size compared to an SoC	much smaller in size compared to SB
Cost	more expensive to manufacture and purchase	Lower cost than SB
Power Consumption	Larger boards with separate components may consume more power.	Reduce power consumption
Performance	offer high performance	offer high performance
Configurability	configurable to some extent, allowing users to customize the system by adding or removing components	less configurable compared to system boards since all components are integrated onto a single chip

#Definitions:

IC

Integrated Circuit is a miniature electronic circuit consisting of semiconductor devices (such as transistors, diodes, and resistors) and other passive components (such as capacitors and inductors) fabricated on a single semiconductor substrate or chip.

VLSI

Very Large Scale Integration refers to the process of integrating a large number of electronic components onto a single semiconductor chip or die. VLSI enables the creation of complex and highly integrated electronic circuits with millions or even billions of components on a single chip.

MPU

Microprocessor Unit refers to a central processing unit (CPU) that contains the core processing components of a computer or electronic device on a single IC chip., it is responsible for executing instructions, performing calculations, and managing data within the device.

MCU

Microcontroller Unit is a compact integrated circuit (IC) that includes central processing unit, memory, I/O ports, it also designed to be embedded into electronic systems and are commonly used in various applications.

#Processor

It is a key component of a computing system responsible for executing instructions, performing calculations, and managing data. It is the "brain" of the computer and is responsible for carrying out various tasks required by software programs.
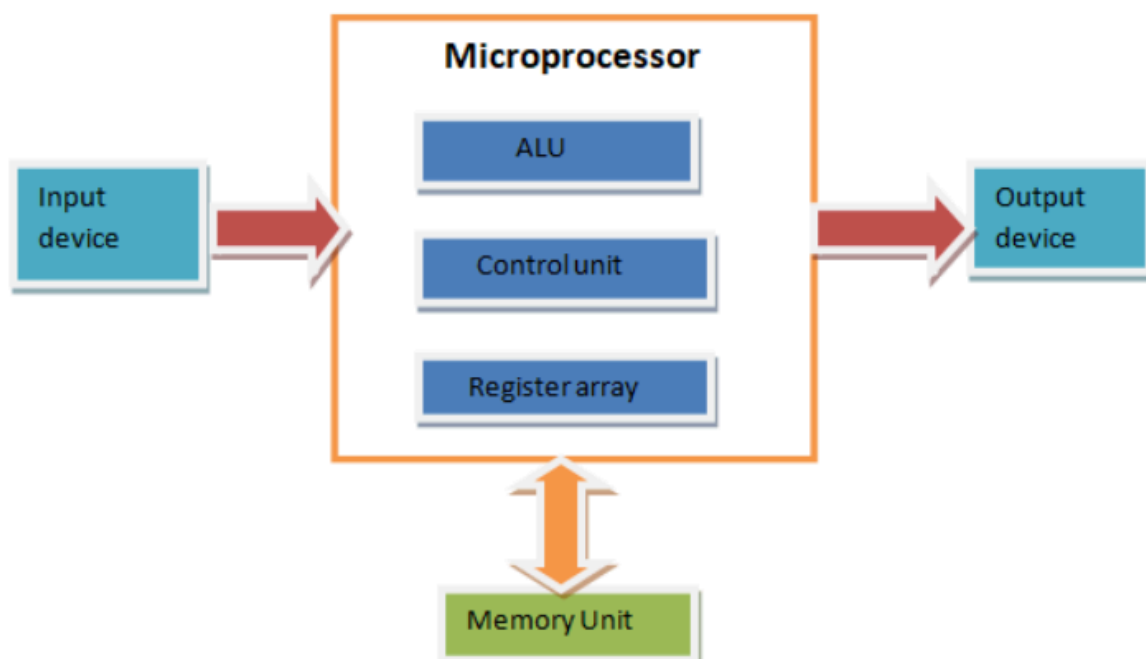
Processor consists of:
1- ALU
2- CU
3- Register Files

1- ALU
Arithmetic Logic Unit is a fundamental component of a computer's central processing unit responsible for performing arithmetic and logical operations on binary data. It receives input data from registers or memory, performs the specified operation, and produces output data that may be stored back into registers or memory.

2- CU
Control Unit is a component within a CPU that manages the execution of instructions and coordinates the activities of other hardware components, It is responsible for fetching instructions from memory, decoding them, and controlling the operation of the ALU, registers, and other functional units within the CPU.

3- Register Files:
Register file are collections of registers that are used for storing data temporarily during the execution of instructions.

It has two types:
1- General purpose
2- Specific Purpose

For Specific Purpose:

PC
Program Counter is a special-purpose register that stores the memory address of the next instruction to be fetched and executed.

SP
The Stack Pointer stores the address of the top of the stack in the system's memory.

ACC
Accumulator is used for storing the results of arithmetic and logic operations performed by the CPU.

IR
Instruction Register holds the currently fetched instruction from memory during the instruction execution cycle.

PSW
Processor Status Word contains various status flags and control bits related to the execution of instructions and the state of the CPU.

Instruction Life Cycle:

1- Fetch

2- Decode

3- Execute

#Memory:

It providing the storage space needed to hold program instructions, data, and intermediate results during processing.

Volatile Memory

It requires power to maintain stored data and loses its contents when power is turned off, this type of memory is typically used for temporary storage and includes -- RAM

Non-Volatile Memory

It retains stored data even when power is turned off, this type of memory is used for permanent or long-term storage and includes -- ROM

Hybrid Memory

It refers to a memory architecture that combines elements of both volatile and non-volatile memory technologies to achieve a balance between performance, capacity, and data persistence.

Types Of RAM

SRAM

- **Cell Structure:** Composed of multiple transistors arranged in a flip-flop configuration.
- **Access Time:** Faster access times (5-20 ns).
- **Capacity:** Less dense and more expensive compared to DRAM.
- **Power Consumption:** Consumes more power due to its complex cell structure.
- **Stability:** More stable and does not require periodic refreshing to maintain data integrity.

DRAM

- **Cell Structure:** Composed of a single transistor and a capacitor for each cell.
- **Access Time:** Slower access times (50-100 ns).
- **Capacity:** More dense and less expensive compared to SRAM.
- **Power Consumption:** Consumes less power compared to SRAM.
- **Stability:** Requires periodic refreshing to maintain data integrity. loss in case of power loss or interruptions.

Types Of ROM

MROM

- Type of ROM where the data or instructions are permanently encoded during the manufacturing process.
- It is cost-effective for large production runs but requires the creation of custom masks.

PROM

- It allows users to program data or instructions into the memory after manufacturing.
- The data is fixed and cannot be changed, PROM is suitable for small-scale production or custom applications

EPROM

- It allows users to erase and reprogram the memory multiple times using ultraviolet light exposure to clear the memory cells.
- It is useful for development and testing purposes but require special handling

Types Of Hybrid

EEPROM

- It can be electrically erased and reprogrammed repeatedly, it retains data even when the power is turned off.
- EEPROM cells consist of floating-gate transistors that trap electrons to store data.

FLASH MEMORY

- It can be electrically erased and reprogrammed in blocks or sectors, it retains data even when the power is turned off.
- Flash memory cells consist of floating-gate transistors similar to EEPROM but are organized into larger blocks for efficient erase and program operations.

NVRAM

- It is a type of memory that retains data even when power is removed similar to EEPROM and Flash memory, it refers to memory devices that use a different technology than traditional EEPROM or Flash.