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Task#7

Embedded Systems Concepts

☐ Topics :

- **Types of Systems**
- **SBC - SOC**
- **Intro to Embedded Systems**
  (IC - MPU - MCU - DSP – ECU)
- **CPU**
  (Components - Fetch&Execute Cycle - Register Files)
- **RISC vs CISC**
- **Types of Memory**
  (Volatile - non Volatile - Hybrid)

1- Computer Systems

A Computer System is a complete setup of hardware and software components, including a CPU, memory, input/output devices, and storage devices, that work together to perform computing tasks. It's characterized by its speed, accuracy, diligence, versatility, and storage capacity. The term "system" signifies the interconnectedness of these components.

2- Embedded Systems

These are computer systems that are integrated into a larger system to perform a specific task. They contain both hardware and software components, such as microprocessors, microcontrollers, volatile and non-volatile memory, graphics processing units (GPUs), input/output communication interfaces and ports, power supplies, and system and application code. Embedded systems can range from simple systems like controlling the speed of a DC motor using a microcontroller, to complex systems like creating a smartphone with embedded processors.

- **Microcontrollers :**

  These are integrated circuits that combine a processor core, memory, and input/output peripherals into a single chip. They are commonly used in embedded systems due to their compactness and cost-effectiveness. Microcontrollers are designed for specific tasks with integrated peripherals, while microprocessors are more versatile and handle general-purpose computing.

- **Microprocessors :**

  A microprocessor is a small chip that resides in computers and other electronic devices. Its basic job is to receive input and provide the appropriate output. While this may seem like a simple task, modern processors can handle trillions of calculations per second. The central processor of a computer is also known as the CPU, or "central processing unit." This processor handles all the basic system instructions, such as processing mouse and keyboard input and running applications.

3- SBC - SOC

☐ **System on Chip (SoC) :**

SoC stands for System on Chip. It is an integrated circuit or silicon chip that has all the components fabricated on a silicon chip.
- SoC contains memory, oscillator, voltage regulator, ADC, DAC, processor, power management unit, USB, and UART.
- The processor is the heart of SoC, usually, SoC has multiple co-processors. It can be a microcontroller, microprocessor, or DSP.
- SoC is small in size and includes many features and functions. It consumes low power and is cost-effective.
- SoC is less adaptable as compared with SBC and is more expensive compared with SBC.
- SoC is used in smartphones, smartwatches, tablets, computers, and Internet of Things applications such as home automation.

☐ **Single Board Computer (SBC) :**

SBC stands for Single Board Computer. It is a whole computer constructed

on a single printed circuit board that contains memory, processor, I/O devices, and other slots.
- The Blocks of the SBC contain a Power supply, Memory, ethernet port, GPIO pins, processor, SD card slot, HDMI connectors, and USB port.
- Processor is the heart of SBC usually ARM processor is used in SBC.
- SBCs are easy to use, have verified hardware, low power consumption, and good performance at a low price.
- SBC is more adaptable as compared with SoC and is less expensive compared with SoC.
- SBCs are used in flexible IoT gateways, smart assets monitoring, and Artificial Intelligence.

4- Intro to Embedded Systems
(IC - MPU - MCU - DSP - ECU)

- **IC (Integrated Circuit) :**
  A small electronic device made up of multiple interconnected electronic components such as transistors, resistors, and capacitors.

- **MPU (Memory Protection Unit) :**
  A computer hardware unit that provides memory protection. It is usually implemented as part of the central processing unit (CPU).

- **MCU (Microcontroller Unit) :**
  An intelligent semiconductor integrated circuit that consists of a processor unit, memory modules, communication interfaces, and peripherals.

- **DSP (Digital Signal Processing) :**
  The process of analyzing and modifying a signal to optimize or improve its efficiency or performance.

- **ECU (Electronic Control Unit) :**
  A small device in a vehicle's body that is responsible for controlling a specific function.

5- CPU
(Components - Fetch&Execute Cycle - Register Files)

- **CPU (Central Processing Unit) :**
  The CPU is the primary component of a computer that performs most of the processing inside the computer. It's often referred to as the "brain" of the computer.

- **Components of CPU :**

  ### 1- Control Unit (CU) :
  The CU controls the way input and output devices, the ALU, and the computer's memory respond to the instructions sent to the CPU.

  ### 2- Arithmetic Logic Unit (ALU) :
  The ALU is responsible for performing arithmetic and logical calculations.

  ### 3- Registers :
  Registers are part of a computer's memory that is used to store the instructions temporarily to provide the processor with the instructions at times of need.

- **CPU Fetch and Execute Cycle :**

  - **Fetch** : Retrieve the next instruction from memory.
  - **Decode** : The Control Unit decodes the fetched instruction.
  - **Execute**: The decoded instruction is executed, and results are stored. This cycle repeats until the computer is shut down.

- **Register Files :**
  A register file is an array of processor registers in a CPU. The instruction set architecture of a CPU will almost always define a set of registers which are used to stage data between memory and the functional units on the chip.

Register files are part of the architecture and visible to the programmer, as opposed to the concept of transparent caches.

6- RISC vs CISC

- **RISC (Reduced Instruction Set Computer) :**
  RISC is a type of CPU architecture that uses a small, optimized set of instructions for high performance and efficiency. The main idea behind RISC is to simplify hardware by using an instruction set composed of a few basic steps for loading, evaluating, and storing operations. This results in simpler instruction decoding, faster execution, and lower power consumption. However, RISC processors require more instructions to perform complex tasks, which can lead to increased memory usage and higher costs.

- **CISC (Complex Instruction Set Computer)** :
  CISC is a computer architecture in which single instructions can execute several low-level operations or are capable of multi-step operations or addressing modes within single instructions. The main idea behind CISC is that a single instruction will do all loading, evaluating, and storing operations. This leads to reduced code size and more memory-efficient code. However, CISC processors take longer to execute instructions because they have more complex instructions and need more time to decode them. Also, CISC processors have more complex instruction sets, which makes them more difficult to design and manufacture.

7- Types of Memory
(Volatile - non Volatile - Hybrid)

- **Volatile Memory :**
  This type of memory requires power to maintain the stored information. When the power is interrupted, the stored data is lost. Types of volatile memory include:

1- Dynamic RAM (DRAM) :

Stores each bit of information in a different capacitor within the integrated circuit.

2- Static RAM (SRAM) :

Does not need continuous electrical refreshes, but it still requires constant current to sustain the difference in voltage.

- **Non-Volatile Memory :**
  This type of memory can retain stored information even after power is removed. Types of non-volatile memory include:

1- Mask ROM :

In this type of ROM, the data is written during the manufacturing process and cannot be electronically modified later.

2- Read-Only Memory (ROM) :

Can only read from its memory; it cannot write to and also cannot modify anything written to it.

3- Programmable ROM (PROM) :

Can be altered once after the memory device is manufactured.

4- Erasable Programmable Read-Only Memory (EPROM) :

This is a type of ROM that can be programmed and then erased by exposing it to UV light. The process of programming and erasing can be repeated several times

5- Electrically Erasable Programmable ROM (EEPROM) :

Can read, modify, and delete information if required.

6- Flash Memory :

A type of EEPROM that is erased and programmed in large blocks.

- **Hybrid Memory :**
  Combines the features of both volatile and non-volatile memory. It can be read and written as desired, like RAM, but maintain their contents without electrical power, just like ROM.