CSC 211: DIGITAL ELECTRONICS II

- Lesson 7: **Introduction to microcomputers and microcomputer organization**

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Lesson Objectives

- At the end of the lesson, the learner should be able to:
  - Outline the components of microcomputer
  - Explain the working of a microcomputer
  - Explain the working of a microprocessor
  - Explain the programmer's model of a microprocessor
  - Outline the types of microprocessor
  - Explain the basic concepts of a microprocessor

Introduction

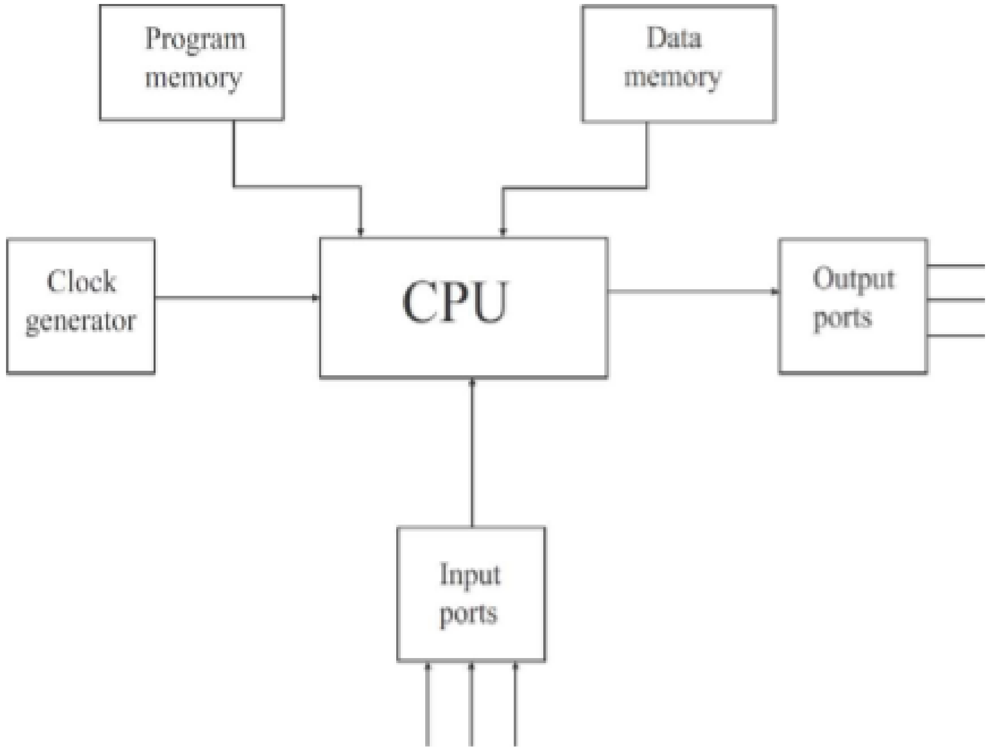
- What is a microcomputer?
- **Microcomputer**, an electronic device with a microprocessor as its central processing unit (CPU).
- *Microcomputer* was formerly a commonly used term for personal computers, particularly any of a class of small digital computers whose CPU is contained on a single integrated semiconductor chip.
- Thus, a microcomputer uses a single microprocessor for its CPU, which performs all logic and arithmetic operations.
- The system also contains a number of associated semiconductor chips that serve as the main memory for storing program instructions and data and as interfaces for exchanging data of this sort with peripheral devices (e.g., keyboard, video display, and printer) and auxiliary storage units.

Major components of the computer

- The basic components of a microcomputer are:
    1. CPU
    2. Program memory
    3. Data memory
    4. Output ports
    5. Input ports
    6. Clock generator.

Major components of the computer

- These components are shown in figure below:



Central Processing Unit

- The CPU consists of:
  - ALU (Arithmetic and Logic Unit),
  - Register unit and
  - control unit.
- The CPU retrieves stored instructions and data word from memory; it also deposits processed data in memory.

Central Processing Unit

a) **ALU (Arithmetic and Logic Unit)**
   - This section performs computing functions on data.
   - These functions are arithmetic operations such as additions subtraction and logical operation such as AND, OR rotate etc.
   - Result are stored either in registers or in memory or sent to output devices.

b) **Register Unit:**

   It contains various register. The registers are used primarily to store data temporarily during the execution of a program. Some of the registers are accessible to the users through instructions.

c) **Control Unit:**

   It provides necessary timing and control signals necessary to all the operations in the microcomputer. It controls the flow of data between the µp and peripherals (input, output and memory). The control unit gets a clock which determines the speed of the µp.

Central Processing Unit

- The CPU has three basic functions

1. It fetches an instructions word stored in memory.
2. It determines what the instruction is telling it to do.(decodes the instruction)
3. It executes the instruction.

Central Processing Unit

- Executing the instruction may include some of the following major tasks.
  a) Transfer of data from register to register in the CPU itself.
  b) Transfer of data between a CPU register and specified memory location.
  c) Performing arithmetic and logical operations on data from a specific memory location or a designated CPU register.
  d) Directing the CPU to change a sequence of fetching instruction, if processing the data created a specific condition.
  e) Performing housekeeping function within the CPU itself in order to establish desired condition at certain registers.

Central Processing Unit

4. It looks for control signal such as interrupts and provides appropriate responses.
5. It provides states, control, and timing signals that the memory and input/output section can use.

Program Memory

- The basic task of a microcomputer system is to ensure that its CPU executes the desired instruction sequence is the program properly.
- The instruction sequence is stared in the program memory on initialization- usually a power up and manual reset the processor starts by executing the instruction in a predetermined location in program memory.

Program Memory

- The first instruction of the program should therefore be in this location in typical µp basic system, the program to be executed is a fixed one which does not change.
- Therefore microprocessor (µp) program are store on ROM, or PROM, EPROM, EEPROM. The user program is not stored in ROM because it needs not to be stored permanently.

Data Memory

- A microcomputer manipulates data according to the algorithm given by the instruction in the program memory.
- These instruction may require intermediate results to be stored, the functional block in Microcontroller (µc) have same internal register which can also be used if available for such storage external data memory is needed if the storage requirements is more.
- Apart from intermediate storage, the data memory may also be used to provide data needed by the program, to store some of the results of the program.

Data Memory

- Data memory is used for all storage purposes other than storage of program.
- Therefore, they must have head write capability RWM or RAM.
- It stores both the instructions to be executed (i.e. program) and the data involved. It usually contains ROM (Read memory).
- The ROM can only read and cannot be written into and is non volatile that is, it retains its contents when the power is turned off.
- A ROM is typically used to store instructions and data that do not change.

Data Memory

- For example, it stores the monitor program if a microcomputer. One can either read from or write into a RWM. The RWM is volatile, that is it does not retain its contents when the power is turned off.
- It is used to store user programmes and data which are temporary might change during the course of executing a program.
- During a memory read operation, the content of the addressed location is not destroyed.

Data Memory

- During a unit operation, the original content of the addressed location is destroyed.
- Both ROM and RWM are arranged into words, each of which has a unique address.
- The address of a word is memory location and it is placed in parentheses. Therefore, X is an address and (X) is the content of that address X.

Data Memory

- The address decodes taken an address and from the control unit and select the proper memory location and obtaining its content takes a certain amount of time, this times is the access time of the memory.
- The access time affects the speed of the computer, pins, and the computer must obtain the instruction and data from the memory.
- Memory sections is often subdivided into units called pages.

Data Memory

- The computer may access a memory location by first decreasing a particular page and then accessing a location on that page.
- The advantage of paging is that the computer can reach several locations on the same page with just the address in the page.
- The process is like describing street address by first specifying aspect and them listing the have numbers.

Data Memory

- The control section transfers data to or from memory as follows.
  1. The control section reads an address to the memory.
  2. The control section sends a read and write signal to the memory to indicate, the direction of the transform.
  3. The control section waits until transfer has been completed this delay precedes the actual data’s transfer in the input case and follows it in the output case.

Input/Output Ports

- The input and output ports provide the microcomputer the capability to communicate with the outside world.
- The input ports allow data to pass from the outside world to the µc data which will be used in the data manipulation being done by the microcomputer to send data to output devices.
- The user can enter instruction (i.e. program) and data in memory through input devices such as keyboard, or simple switches, disk devices or card readers.

Input/Output Ports

- Computers are also used to measure and control physical quantities like temperature, pressure, speed etc.
- For these purposes, transducers are used to convert physical quantities into proportional electrical signals; A/D in computers are used to convert electrical signals into digital signals which are sent to the computer.
- The computer sends the results of the computation to the output devices e.g. LED, CRT, D/A converters, printers etc..
- These I/O devices allow the computer to communicate with the outside world I/O devices are called peripherals.

Clock Generator

- Operations inside the µp as well as in other parts of the µc, are usually synchronous by nature.
- The clock generator generates the appropriate clock periods during which instruction executions are carried out by the microprocessor.
- This condition ensures that events in different path of the systems can proceed in a systematic fashion.
- Some of the microprocessors have an internal clock generator circuit to generate a clock signal.

Clock Generator

- These microprocessors require an external crystal or RC network to be connected at the appropriate pins for deciding the operating frequency (e.g. 8085).
- Some microprocessors require an external clock generator (e.g. 8086).
- These microprocessors also provides an output clock signal which can be used by other devices in the microcomputer system for their own timing and synchronizing.

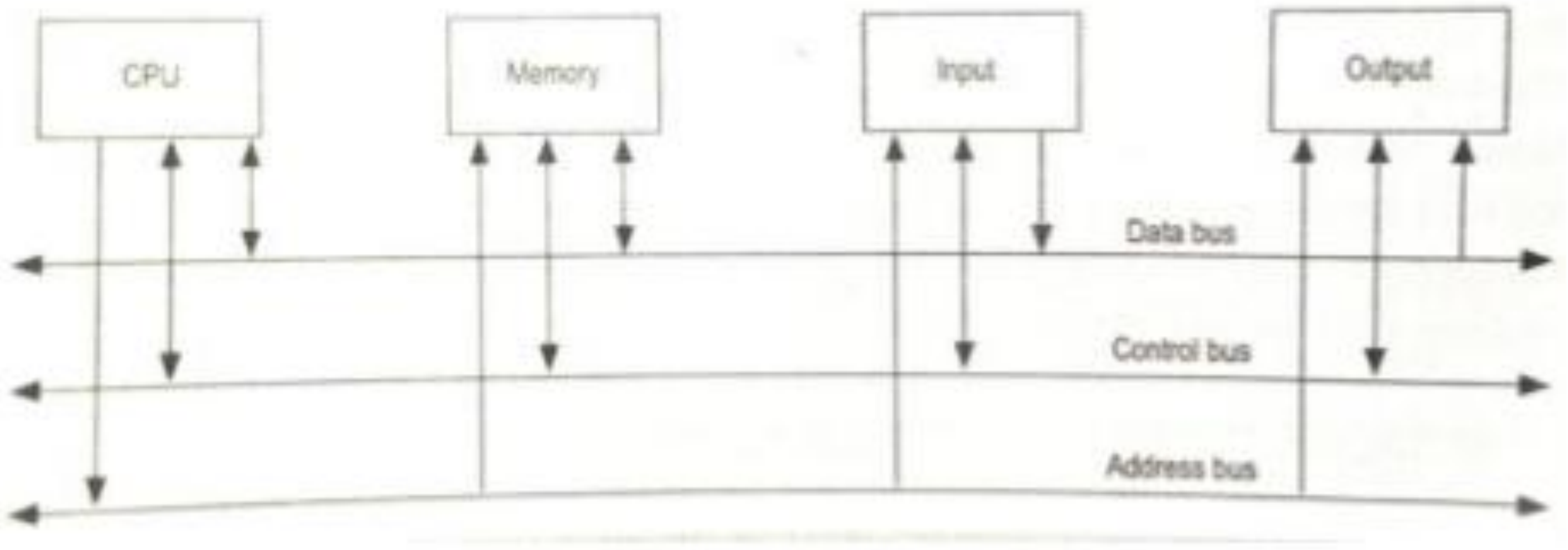
Microprocessor

- A microprocessor is a programmable electronics chip that has computing and decision making capabilities.
- Any microprocessor-based systems having limited number of resources are called microcomputers.
- Nowadays, microprocessor can be seen in almost all types of electronics devices like mobile phones, printers, washing machines etc.

Microprocessor

- Microprocessors are also used in advanced applications like radars, satellites and flights.
- Due to the rapid advancements in electronic industry and large scale integration of devices results in a significant cost reduction and increase application of microprocessors and their derivatives.

Microprocessor



Microprocessor-based system

Definition of terms

- **Bit:** A bit is a single binary digit.
- **Word:** A word refers to the basic data size or bit size that can be processed by the arithmetic and logic unit of the processor. A 16-bit binary number is called a word in a 16-bit processor.
- **Bus:** A bus is a group of wires/lines that carry similar information.
- **System Bus:** The system bus is a group of wires/lines used for communication between the microprocessor and peripherals.

Definition of terms

- **Memory Word:** The number of bits that can be stored in a register or memory element is called a memory word.
- **Address Bus:** It carries the address, which is a unique binary pattern used to identify a memory location or an I/O port. For example, an eight bit address bus has eight lines and thus it can address $2^8 = 256$ different locations. The locations in hexadecimal format can be written as 00H – FFH.

Definition of terms

- **Data Bus:** The data bus is used to transfer data between memory and processor or between I/O device and processor. For example, an 8-bit processor will generally have an 8-bit data bus and a 16-bit processor will have 16-bit data bus.
- **Control Bus:** The control bus carry control signals, which consists of signals for selection of memory or I/O device from the given address, direction of data transfer and synchronization of data transfer in case of slow devices.

Microprocessor

- A typical microprocessor consists of arithmetic and logic unit (ALU) in association with control unit to process the instruction execution.
- Almost all the microprocessors are based on the principle of store-program concept.
- In store-program concept, programs or instructions are sequentially stored in the memory locations that are to be executed.

Microprocessor

- To do any task using a microprocessor, it is to be programmed by the user.
- So the programmer must have idea about its internal resources, features and supported instructions.
- Each microprocessor has a set of instructions, a list which is provided by the microprocessor manufacturer.
- The instruction set of a microprocessor is provided in two forms: binary machine code and mnemonics.

Microprocessor

- Microprocessor communicates and operates in binary numbers 0 and 1.
- The set of instructions in the form of binary patterns is called a machine language and it is difficult for us to understand.
- Therefore, the binary patterns are given abbreviated names, called mnemonics, which forms the assembly language.
- The conversion of assembly-level language into binary machine-level language is done by using an application called assembler.

Technology Used

- The semiconductor manufacturing technologies used for chips are:
    1. Transistor-Transistor Logic (TTL)
    2. Emitter Coupled Logic (ECL)
    3. Complementary Metal-Oxide Semiconductor (CMOS)

Classification of Microprocessors

- Based on their specification, application and architecture microprocessors are classified.
- Based on size of data bus:
    1. 4-bit microprocessor
    2. 8-bit microprocessor
    3. 16-bit microprocessor
    4. 32-bit microprocessor

Classification of Microprocessors

- Based on application:
  1. General-purpose microprocessor- used in general computer system and can be used by programmer for any application. Examples, 8085 to Intel Pentium.
  2. Microcontroller- microprocessor with built-in memory and ports and can be programmed for any generic control application. Example, 8051.
  3. Special-purpose processors- designed to handle special functions required for an application. Examples, digital signal processors and application-specific integrated circuit (ASIC) chips.
  4. Reduced Instruction Set Computer (RISC) processors
  5. Complex Instruction Set Computer (CISC) processors

Classification of Microprocessors

- Classification based on length:

1. One-byte instructions: Instruction having one byte in machine code. Examples are depicted in Table 2.
2. Two-byte instructions: Instruction having two byte in machine code. Examples are depicted in Table 3
3. Three-byte instructions: Instruction having three byte in machine code. Examples are depicted in Table 4.

Classification of Microprocessors

- Table 2 Examples of one byte instructions

Opcode	Operand	Machine code/Hex code
MOV	A, B	78
ADD	M	86

Classification of Microprocessors

- Table 3 Examples of two byte instructions

Opcode	Operand	Machine code/Hex code	Byte description
MVI	A, 7FH	3E	First byte
		7F	Second byte
ADI	0FH	C6	First byte
		0F	Second byte

Classification of Microprocessors

- Table 4 Examples of three byte instructions

Opcode	Operand	Machine code/Hex code	Byte description
JMP	9050H	C3	First byte
		50	Second byte
		90	Third byte
LDA	8850H	3A	First byte
		50	Second byte
		88	Third byte