# **Microprocessors/Microcontrollers**

A central processing unit (CPU) fabricated on one or more chips, containing the basic arithmetic, logic, and control elements of a computer that are required for processing data

### Introductory Example: Traffic Control

- Consider a simple control system: sequencing of the red, yellow, and green lights at a traffic crossing.
- Is it possible to solve by an electronic control system involving combinational and sequential logic integrated circuits?
- With a more complex situation, there might be many more variables to control in a more complex control sequence.
- The question here is how to simplify the system based on hardwired connection of combinational and sequential logic integrated circuits by using a microprocessor and using software to make the connections.

## Microprocessor System

- The microprocessor we are concerned in mechatronics is for use as a control system and is termed embedded microprocessor. Such microprocessor is dedicated to controlling a specific function and is self-starting requiring no human intervention and completely selfcontained with its own operating program.
- Examples include the system in a washing machine. The operator has to select the type of wash required by pressing the appropriate button or rotating a switch.
- A microprocessor system has three main parts:
  - Central processing unit (CPU)
  - Input and output interfaces
  - Memory to hold the program instructions and data.



#### Buses

- Digital signals move from one section to another along paths called busses. A bus in the physical sense, is just a number of conductors along which electrical signals can be carried. It may be tracks on a printed circuit or wires in a ribbon cable. There are three types of buses in a microprocessor:
  - Data bus: Carry the data associated with the processing function of the CPU.
  - Address bus: Carries signal which indicate whether data is to be found and so the selection of certain memory locations at input or output ports.
  - Control bus: Carries signals relating to control actions. For example the microprocessor informs the memory whether to read data from an input or write data to an output device.

#### The Microprocessor

- The microprocessor is generally referred to as the central processing unit. It is that part of the processor system which processes the data, fetching instructions from memory, decoding them and executing them. The following are the main parts of the processor:
  - Arithmetic and logic unit (ALU) for data manipulation.
  - Registers for memory. There are many types of registers including:
    - Accumulator register where data for an input to the ALU is temporarily stored in order for the CPU to be able to read.
    - Status registers that contains information concerning the result of the latest process carried out by the ALU.
    - Program counter register that allows the CPU to keep track of its position in a program.
    - Memory address register containing the address of data.
    - Instruction register to store the instructions.
    - General purpose register that acts as temporary storage for data.
    - Stock pointer register that form an address which defines the top of the stack in RAM.
  - Control unit for timing and sequences of operation.

Data bus



### Memory

- The memory unit in a microprocessor system stores binary data and takes the form of one or more integrated circuits. There are a number of forms of memory unit.
  - ROM for data to be stored permanently (read-only-memory). ROMs are programmed with the required contents during the manufacture of the integrated circuit.
  - PROM or programmable ROM is used for ROM chips that can be programmed by the user.
  - EPROM or erasable and programmable ROM that can be programmed and their content altered.
  - EEPROM or electrically erasable PROM
  - RAM or random-access memory. This memory can be read or written to.

### Input/Output

- Input/output is defined as the transfer of data between the microprocessor and the external world.
- The term **peripheral devices** is used for pieces of equipment that exchange data with a microprocessor system.
- Because of speed and characteristics of peripheral devices can differ from those of the microprocessor, they are connected via interface chips in order to synchronize data transfer between the peripheral devices and the microprocessor.
- In input operations the input device places the data in the data register of the interface chip; this holds the data until it is read by the microprocessor.
- In output operations the microprocessor places the data in the register until it is read by the peripheral.
- Students should give an example of microprocessor system.

#### Microcontrollers

- For a microprocessor to give a system which can be used for control, additional chips are necessary such as memory devices for program and data storage and input/output ports to allow it to communicate with the external world and receive signals from it.
- The microcontrollers is the integration of a microprocessor with memory and input/output interfaces, and other peripherals such as timers, on a single chip.
- A controller has pins for external connections of input and output, power, clock and control signals.
- The pins for the inputs/outputs are grouped into units called input/output ports. Usually ports have eight lines in order to be able to transfer an 8-bit word of data.

#### Examples of Microcontrollers

- Motorola M68HC11 family: widely used for control systems. There are number of versions in the family with differences in the RAM, ROM, EPROM, EEPROM. For example, the version 68HC11A8 has 8 K ROM, 512 bytes EPROM, 256 bytes RAM, 16-bit timer system, 8-channel 8-bit ADC and 5 ports (A, B, C, D, E).
- Intel 8051 with four parallel input/output ports. The 8051AH version has 4 K ROM bytes, 128 bytes RAM, two timers and interrupt control for five interrupt sources.
- Microchip microcontrollers:

#### Applications Temperature Measurement System



#### Washing Machine



Microcontroller