1. Write any two differences between microprocessor and microcontroller.
2. What is a microcontroller and what are the characteristics of microcontroller
3. Give the overview of 8051 microcontroller family
4. Explain the architecture of 8051 with a neat diagram.

**Microprocessor**

As its name implies, it is a processing device that converts data into information based on some sets of instructions. It is a very compact electronic chip due to which it is referred to as the **microprocessor**.

In other words, a processing device implemented on a single chip is called a microprocessor. A microprocessor is the most crucial component of a computer or any other computing device. Because, it is entirely responsible for processing data based on instructions to produce information.

In microcomputers, the microprocessor is used as the CPU (Central Processing Unit). A typical microprocessor consists of two major parts namely ALU (Arithmetic Logic Unit) and CU (Control Unit). Intel 8085 or 8086 processing chips are the examples of microprocessors.

Modern microprocessors consist of a small memory unit (cache memory) in addition to the ALU and CU. Now−a−days, microprocessors are being widely used in several applications such as desktop publishing, power plant control, millimeters, medical instruments, etc.

**Microcontroller**

A **microcontroller** is an electronic system which consists of a processing element, a small memory (RAM, ROM, EPROM), I/O ports, etc. on a single chip. Therefore, a microcontroller is a tiny resemblance of a microcomputer. It is a quite small and low−cost electronic device which is used in several electronic appliances as the main functioning device.

In electronic systems such washing machines, air conditioners, refrigerators, etc., microcontrollers are used to automate the operation of the device based on user's instructions.

Hence, a microcontroller is the backbone of all embedded systems like microwave oven, washing machine, smart refrigerators, etc.

| MICROPROCESSOR | MICROCONTROLLER |
|---|---|
| Center of a computer system. | Center of embedded system. |
| Memory and I/O components are external to it. | Memory and I/O components are internal to it. |
| Large Circuit | Smaller Circuit |
| Not compatible with compact systems | Compatible with compact systems. |
| Higher cost | Lower Cost |
| High Power Consumption | Low Power Consumption |
| Mostly don't have power features | Mostly have power features. |
| Mainly present in personal computers. | Mainly present in washing machines, music players, and embedded systems. |
| Less number of registers. | More number of registers. |
| Follows Von Neumann model | Follows Harvard architecture |
| Made on a silicon-based integrated chip. | Byproduct microprocessors and peripherals. |
| RAM, ROM, and other peripherals are absent. | RAM, ROM, and other peripherals are present. |
| Has an external bus to interface with devices. | Uses an internal controlling bus for communication. |
| Has a high speed. | Speed depends on the architecture. |
| Ideal for general purpose to handle more data. | Ideal for the specific applications. |
| Complex and Expensive | Simple and affordable |
| Requires more instructions | Requires less instructions |

**Characteristics of a microcontroller:**

1. It is a small computer. It has processor and some other components.
2. Used in automatically controlled devices.
3. Used in Embedded systems.
4. It has less computational capacity than microprocessor. So it is used for simpler tasks only.
5. Do not have math coprocessors.
6. Perform tasks – fetch, decode and execute.
7. It has memory, both RAM and ROM with some other I/O devices too.
8. Power consumption is less in microcontroller.
9. Optimize interrupt latency.
10. Bit manipulation is powerful.

11. Used to handle real time tasks and they are single programmed, self-sufficient and task oriented.

**Types of Microcontrollers**

Microcontrollers are divided into various categories based on memory, architecture, bits and instruction sets. Following is the list of their types −

Bit

Based on bit configuration, the microcontroller is further divided into three categories.

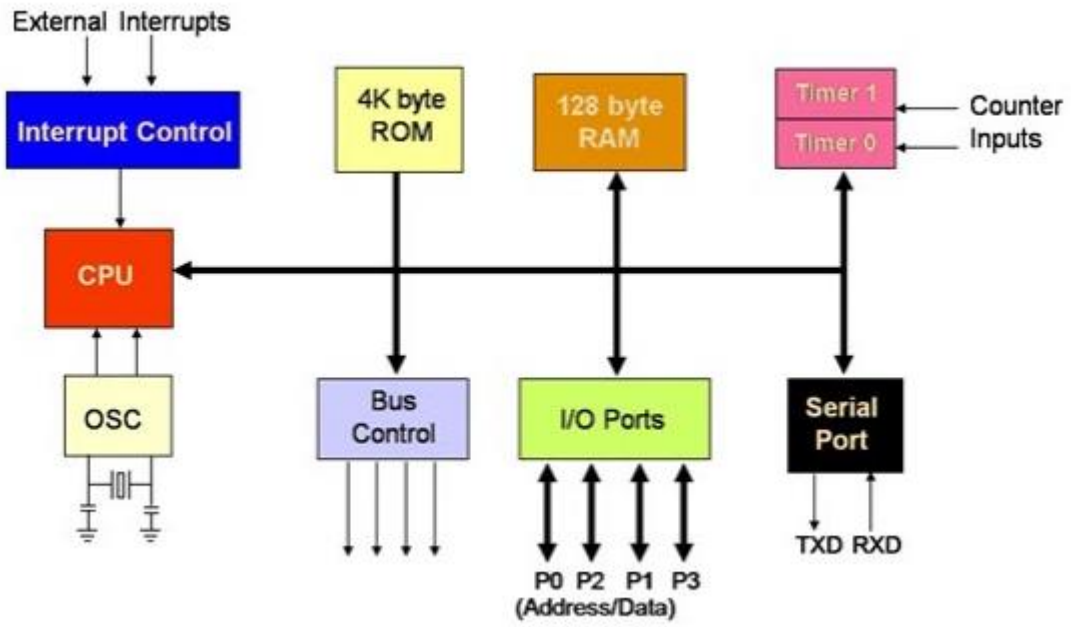
1. 8-bit microcontroller − This type of microcontroller is used to execute arithmetic and logical operations like addition, subtraction, multiplication division, etc. For example, Intel 8031 and 8051 are 8 bits microcontroller.
2. 16-bit microcontroller − This type of microcontroller is used to perform arithmetic and logical operations where higher accuracy and performance is required. For example, Intel 8096 is a 16-bit microcontroller.
3. 32-bit microcontroller − This type of microcontroller is generally used in automatically controlled appliances like automatic operational machines, medical appliances, etc.

**Applications of Microcontrollers**

1. Microcontrollers are widely used in various different devices such as −
2. Light sensing and controlling devices like LED.
3. Temperature sensing and controlling devices like microwave oven, chimneys.
4. Fire detection and safety devices like Fire alarm.
5. Measuring devices like Volt Meter.

# 8051 Microcontroller Architecture

Let's see the internal architecture of 8051 Microcontroller represented in form of block diagram as shown below:

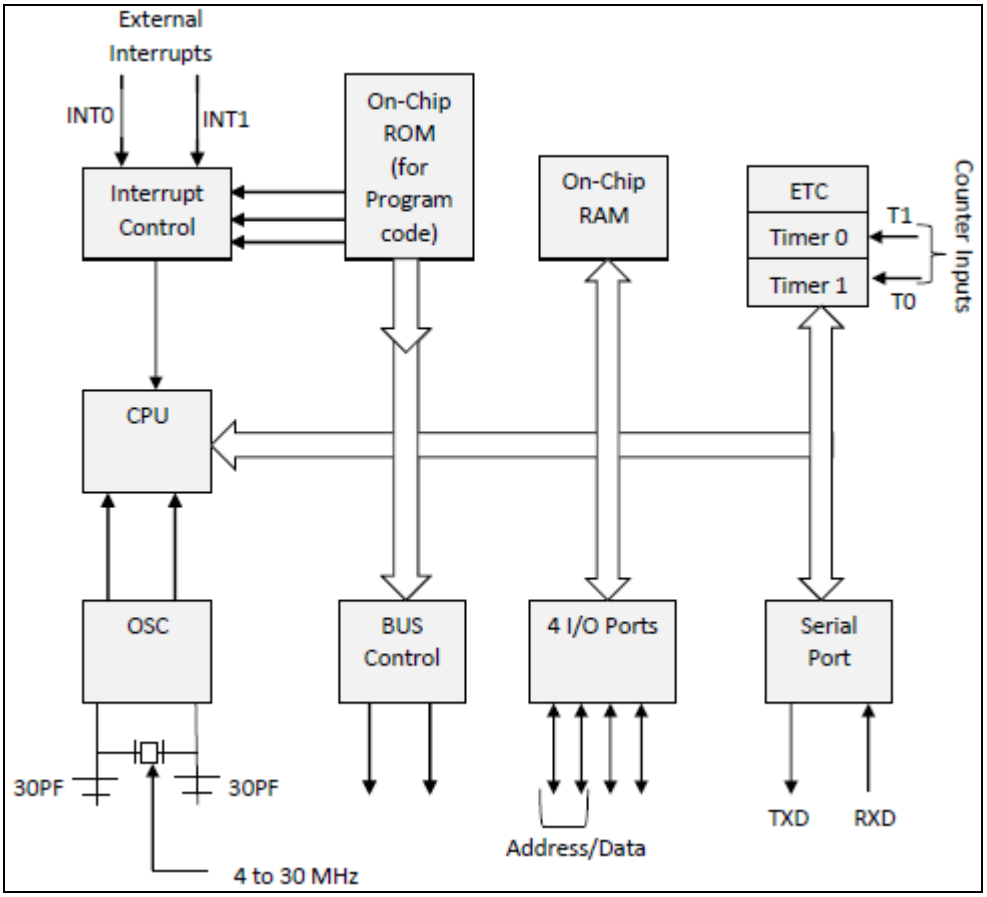



8051 microcontroller is designed by Intel in 1981. It is an 8-bit microcontroller. It is built with 40 pins DIP (dual inline package), 4kb of ROM storage and 128 bytes of RAM storage, 2 16-bit timers. It consists of are four parallel 8-bit ports, which are programmable as well as addressable as per the requirement. An on-chip crystal oscillator is integrated in the microcontroller having crystal frequency of 12 MHz.

**Let us now discuss the architecture of 8051 Microcontroller.**

In the following diagram, the system bus connects all the support devices to the CPU. The system bus consists of an 8-bit data bus, a 16-bit address bus and bus control signals. All other devices like program memory, ports, data memory,

serial interface, interrupt control, timers, and the CPU are all interfaced together through the system bus.




Basic components present internally inside 8051 Microcontroller architecture are:

**CPU (Central Processing Unit)**: CPU act as a mind of any processing machine. It synchronizes and manages all processes that are carried out in microcontroller. User has no power to control the functioning of CPU. It interprets the program stored in ROM and carries out from storage and then performs it projected duty. CPU manages the different types of registers available in 8051 microcontroller.

**Interrupts**: Interrupts is a sub-routine call that given by the microcontroller when some other program with high priority is request for acquiring the system buses the n interrupts occur in current running program.

Interrupts provide a method to postpone or delay the current process, performs a sub-routine task and then restart the standard program again.

**Types of interrupt in 8051 Microcontroller:**

Let's see the five sources of interrupts in 8051 Microcontroller:

- Timer 0 overflow interrupt - TF0
- Timer 1 overflow interrupt - TF1
- External hardware interrupt - INT0
- External hardware interrupt - INT1
- Serial communication interrupt - RI/TI

**Memory**: For operation Micro-controller required a program. This program guides the microcontroller to perform the specific tasks. This program installed in microcontroller required some on chip memory for the storage of the program.

Microcontroller also required memory for storage of data and operands for the short duration. In microcontroller 8051 there is code or program memory of 4 KB that is it has 4 KB ROM and it also comprise of data memory (RAM) of 128 bytes.

**Bus** : Bus is a group of wires which uses as a communication canal or acts as means of data transfer. The different bus configuration includes 8, 16 or more cables. Therefore, a bus can bear 8 bits, 16 bits all together.

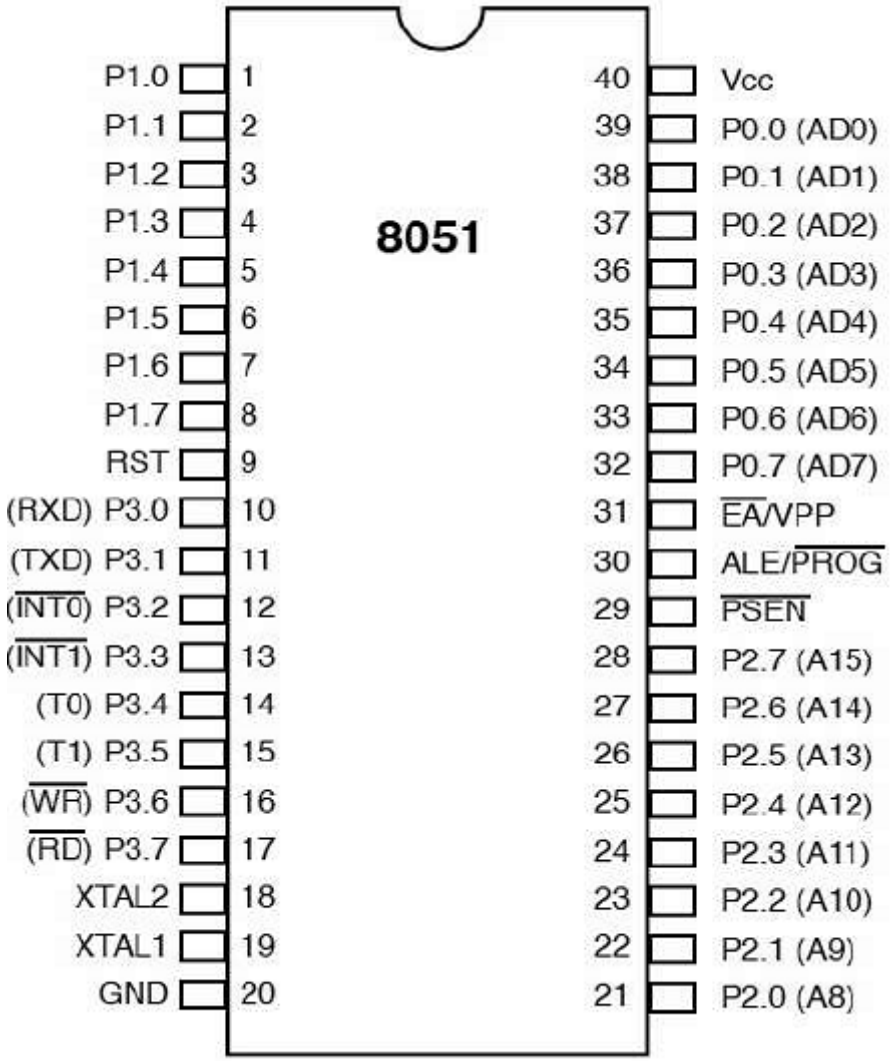
**Types of buses in 8051 Microcontroller:**

Let's see the two types of bus used in 8051 microcontroller:

- **Address Bus**: 8051 microcontrollers is consisting of 16 bit address bus. It is generally be used for transferring the data from Central Processing Unit to Memory.
- **Data bus**: 8051 microcontroller is consisting of 8 bits data bus. It is generally be used for transferring the data from one peripherals position to other peripherals.

**Oscillator**: As the microcontroller is digital circuit therefore it needs timer for their operation. To perform timer operation inside microcontroller it required externally connected or on-chip oscillator. Microcontroller is used inside an embedded system for managing the function of devices. Therefore, 8051 uses the two 16 bit counters and timers. For the operation of this timers and counters the oscillator is used inside microcontroller.

**The pin diagram of 8051 microcontroller looks as follows −**




- **Pins 1 to 8** − these pins are known as Port 1. This port doesn't serve any other functions. It is internally pulled up, bi-directional I/O port.
- **Pin 9** − It is a RESET pin, which is used to reset the microcontroller to its initial values.
- **Pins 10 to 17** − these pins are known as Port 3. This port serves some functions like interrupts, timer input, control signals, serial communication signals RxD and TxD, etc.

- **Pins 18 & 19** − these pins are used for interfacing an external crystal to get the system clock.
- **Pin 20** − this pin provides the power supply to the circuit.
- **Pins 21 to 28** − these pins are known as Port 2. It serves as I/O port. Higher order address bus signals are also multiplexed using this port.
- **Pin 29** − this is PSEN pin which stands for Program Store Enable. It is used to read a signal from the external program memory.
- **Pin 30** − this is EA pin which stands for External Access input. It is used to enable/disable the external memory interfacing.
- **Pin 31** − this is ALE pin which stands for Address Latch Enable. It is used to demultiplex the address-data signal of port.
- **Pins 32 to 39** − these pins are known as Port 0. It serves as I/O port. Lower order address and data bus signals are multiplexed using this port.
- **Pin 40** − this pin is used to provide power supply to the circuit.

## Microcontrollers 8051 Input Output Ports

8051 microcontrollers have 4 I/O ports each of 8-bit, which can be configured as input or output. Hence, total 32 input/output pins allow the microcontroller to be connected with the peripheral devices.

- **Pin configuration**, i.e. the pin can be configured as 1 for input and 0 for output as per the logic state.
    - **Input/Output (I/O) pin** − All the circuits within the microcontroller must be connected to one of its pins except P0 port because it does not have pull-up resistors built-in.
    - **Input pin** − Logic 1 is applied to a bit of the P register. The output FE transistor is turned off and the other pin remains connected to the power supply voltage over a pull-up resistor of high resistance.
- **Port 0** − The P0 (zero) port is characterized by two functions −

- When the external memory is used then the lower address byte (addresses A0A7) is applied on it, else all bits of this port are configured as input/output.
- When P0 port is configured as an output then other ports consisting of pins with built-in pull-up resistor connected by its end to 5V power supply, the pins of this port have this resistor left out.

Input Configuration

If any pin of this port is configured as an input, then it acts as if it “floats”, i.e. the input has unlimited input resistance and in-determined potential.

Output Configuration

When the pin is configured as an output, then it acts as an “open drain”. By applying logic 0 to a port bit, the appropriate pin will be connected to ground (0V), and applying logic 1, the external output will keep on “floating”.

In order to apply logic 1 (5V) on this output pin, it is necessary to build an external pullup resistor.

Port 1

P1 is a true I/O port as it doesn’t have any alternative functions as in P0, but this port can be configured as general I/O only. It has a built-in pull-up resistor and is completely compatible with TTL circuits.

Port 2

P2 is similar to P0 when the external memory is used. Pins of this port occupy addresses intended for the external memory chip. This port can be used for higher address byte with addresses A8-A15. When no memory is added then this port can be used as a general input/output port similar to Port 1.

Port 3

In this port, functions are similar to other ports except that the logic 1 must be applied to appropriate bit of the P3 register.

Pins Current Limitations

- When pins are configured as an output (i.e. logic 0), then the single port pins can receive a current of 10mA.
- When these pins are configured as inputs (i.e. logic 1), then built-in pull-up resistors provide very weak current, but can activate up to 4 TTL inputs of LS series.
- If all 8 bits of a port are active, then the total current must be limited to 15mA (port P0: 26mA).
- If all ports (32 bits) are active, then the total maximum current must be limited to 71mA.