

### Embedded Microcontroller System

Embedded means something that is attached to another thing. An embedded microcontroller system can be thought of as a computer hardware system having software embedded in it. An embedded system can be an independent system or it can be a part of a large system. An embedded system is a microcontroller or microprocessor based system which is designed to perform a specific task. For example, a fire alarm is an embedded system; it will sense only smoke.

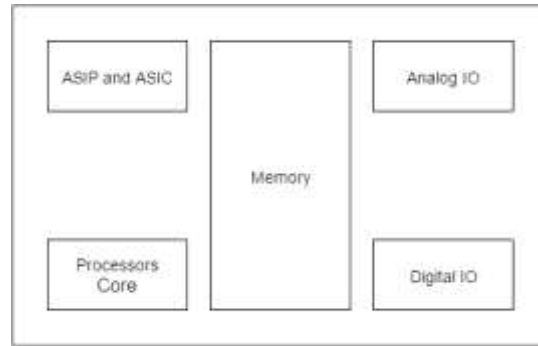
An embedded system has three components –

1. It has hardware.
2. It has application software.
3. It has Real Time Operating system (RTOS) that supervises the application software and provide mechanism to let the processor run a process as per scheduling by following a plan to control the latencies. RTOS defines the way the system works. It sets the rules during the execution of application program. A small scale embedded system may not have RTOS.

So we can define an embedded system as a Microcontroller based, software driven, reliable and real-time control system.

#### Characteristics of an Embedded Microcontroller System

1. **Single-functioned** – an embedded system usually performs a specialized operation and does the same repeatedly. For example: An iPod always functions as an iPod.
2. **Tightly constrained** – All computing systems have constraints on design. It must be of a size to fit on a single chip, must perform fast enough to process data in real time and consume minimum power to extend battery life.
3. **Reactive and Real time** – Many embedded systems must continually react to changes in the system's environment and must compute certain results in real time without any delay.
4. **Microprocessors based** – It must be microprocessor or microcontroller based.
5. **Memory** – It must have a memory, as its software usually embeds in ROM. It does not need any secondary memories in the computer.
6. **Connected** – It must have connected peripherals to connect input and output devices.
7. **HW-SW systems** – Software is used for more features and flexibility. Hardware is used for performance and security.



### Advantages

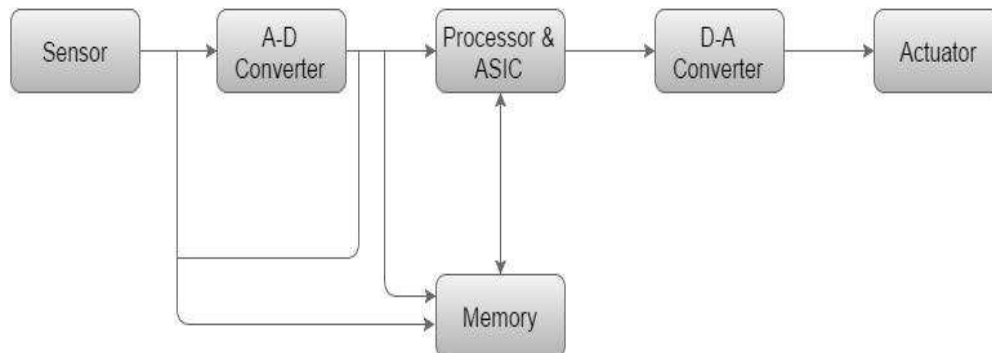
1. Easily Customizable
2. Low power consumption
3. Low cost
4. Enhanced performance

### Disadvantages

1. High development effort
2. Larger time to market

### Basic Structure of an Embedded System

The following illustration shows the basic structure of an embedded system:



1. **Sensor** – It measures the physical quantity and converts it to an electrical signal which can be read by an observer or by any electronic instrument like an A2D converter. A sensor stores the measured quantity to the memory.
2. **A-D Converter** – an analog-to-digital converter converts the analog signal sent by the sensor into a digital signal.
3. **Processor** – Processors process the data to measure the output and store it to the memory.
4. **D-A Converter** – A digital-to-analog converter converts the digital data fed by the processor to analog data

5. **Actuator** – An actuator compares the output given by the D-A Converter to the actual (expected) output stored in it and stores the approved output.

Processor is the heart of an embedded system. It is the basic unit that takes inputs and produces an output after processing the data. For an embedded system designer, it is necessary to have the knowledge of both microprocessors and microcontrollers.

### Processors in a System

A processor has two essential units –

1. Program Flow Control Unit (CU)
2. Execution Unit (EU)

The CU includes a fetch unit for fetching instructions from the memory. The EU has circuits that implement the instructions pertaining to data transfer operation and data conversion from one form to another.

The EU includes the Arithmetic and Logical Unit (ALU) and also the circuits that execute instructions for a program control task such as interrupt, or jump to another set of instructions.

A processor runs the cycles of fetch and executes the instructions in the same sequence as they are fetched from memory.

### Types of Processors

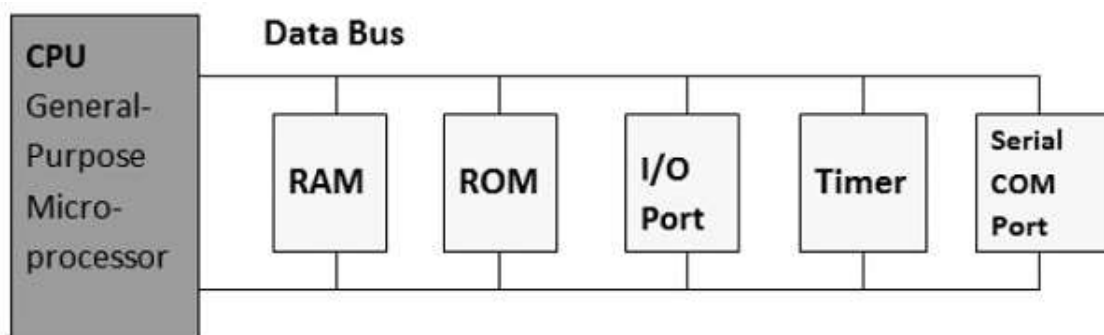
Processors can be of the following categories –

1. Microprocessor
2. Microcontroller
3. Digital Signal Processor

### Microprocessor

A microprocessor is a single VLSI chip having a CPU

Earlier generation microprocessors' fetch-and-execute cycle was guided by a clock frequency of the order of approximately 1 MHz. Processors now operate at a clock frequency of 2GHz



A SIMPLE BLOCK DIAGRAM OF A MICROPROCESSOR

## Microcontroller

A microcontroller is a single-chip VLSI unit (also called **microcomputer**) which, although having limited computational capabilities, possesses enhanced input/output capability and a number of on-chip functional units.

CPU	RAM	ROM
I/O Port	Timer	Serial COM Port

Microcontrollers are particularly used in embedded systems for real-time control applications with on-chip program memory and devices.

Let us now take look at the most notable differences between a microprocessor and a microcontroller.

Microprocessor	Microcontroller
Microprocessors are multitasking in nature. Can perform multiple tasks at a time. For example, on computer we can play music while writing text in text editor.	Single task oriented. For example, a washing machine is designed for washing clothes only.
RAM, ROM, I/O Ports, and Timers can be added externally and can vary in numbers.	RAM, ROM, I/O Ports, and Timers cannot be added externally. These components are to be embedded together on a chip and are fixed in numbers.
Designers can decide the number of memory or I/O ports needed.	Fixed number for memory or I/O makes a microcontroller ideal for a limited but specific task.
External support of external memory and I/O ports makes a microprocessor-based system heavier and costlier.	Microcontrollers are lightweight and cheaper than a microprocessor.
External devices require more space and their power consumption is higher.	A microcontroller-based system consumes less power and takes less space.