MODULE -1: EMBEDDED SYSTEMS AND AVR MICROCONTROLLER

An embedded system is an electronic/electro-mechanical system designed to perform a specific function and is a combination of both hardware and firmware. Embedded systems are important part of almost all products in the filed of household appliances, telecommunications, medical equipment, industrial control, consumer products, etc.
Examples are: Digital camera, AC, Washing machines, sprinklers, printers, network routers, bar code readers, ATM etc.

FEATURES (CHARACTERSTICS) OF EMBEDDED SYSTEMS

- Usually performs specialised functions
- Constrained design (size, cost, power consumption etc.)
- Reactive and real time
- Usually microprocessor or microcontroller based
- Programs are kept in ROM.
- Secondary memory not needed
- It requires very limited resources
- It requires very limited user interface

COMPARISON WITH GENERAL PURPOSE COMPUTERS:

General purpose Computing System	Embedded System
It uses generic hardware and OS	It uses special hardware and embedded OS
Designed to execute several applications	Designed to execute specific application
Possible to re-install OS and modify the applications	The firmware is non-alterable by the user
Responses are not time critical	Responses, in some cases, are time critical
Always, faster is better	It depends on application specific reqirements such as power, memory etc.

CLASSIFICATION OF EMBEDDED SYSTEMS

Embedded Systems can be classified based on the following criteria:

1. Based on Generation
2. Based on complexity and performance
3. Based on deterministic behaviour
4. Based on triggering

1. Classification based on generation

- *First generation*
  - 8 bit microprocessors such as 8085, Z80 were used
  - Eg: Digital telephone keypads

- *Second generation*
  - 8 or 16 bit microcontrollers were used.
  - Instruction set was more complex
  - Eg: Data Acquisition Systems

- *Third generation*
  - 32 bit processors or 16 bit microcontrollers are used
  - Digital Signal Processors (DSP) and Application Specific Integrated Circuits (ASICs) are also used.
  - It uses the concepts of instruction pipelining
  - Eg: Robotics, networking

- *Fourth generation*
  - It uses System on Chip (SoC) and multicore processors.
  - SoC integrates several functionalities on a chip
  - Uses high performance real time operating systems (RTOS)
  - Eg: Smart Phone.

2. Classification based on complexity and performance

- Small-Scale Embedded Systems
  - used for simple applications
  - performance requirements are not time critical
  - may or may not contain an operating system for its functioning.
  - Eg: Electronic toy
- Medium-Scale Embedded Systems
  - Hardware and firmware (software) requirements are slightly complex
  - Low cost 16 or 32 bit microprocessors/microcontrollers or DSPs are used
  - Usually contain an embedded operating system (GPOS/RTOS)
- Large-Scale Embedded Systems
  - Hardware and firmware (software) requirements are more complex
  - Commonly built using high performance 32 or 64 bit RISC processors/controllers
  - It uses high performance Real Time Operating System (RTOS)

APPLICATIONS OF EMBEDDED SYSTEMS

Following is a list of major application area of embedded systems:

1. Consumer electronics: Camcorders, cameras, etc
2. Household appliances: Television, DVD players, washing machine, fridge, microwave oven, etc.
3. Home automation and security systems: Air conditioners, sprinklers, intruder detection alarms, closed circuit television cameras, fire alarms, etc.
4. Automotive industry: Anti-lock breaking systems (ABS), engine control, ignition systems, automatic navigation systems, etc.
5. Telecom: Cellular telephones, telephone switches, handset multimedia applications, etc.
6. Computer peripherals: Printers, scanners, fax machines, etc
7. Computer networking systems: Network routers, switches, hubs, firewalls, etc.
8. Healthcare: Different kinds of scanners, EEG, ECG machines etc.
9. Measurement & Instrumentation: Digital multimeters, digital CROs, logic analysers PLC systems, etc.
10. Banking & Retail: Automatic teller machines (ATM) and currency counters, point of sales (POS)

PURPOSE OF EMBEDDED SYSTEMS

Embedded systems are used in various applications. So their purpose of application can be one or more of the following:

- Data collection/Storage/Representation
  Eg: CRO, Digital Camera

- Data communication
  Eg: Network hubs, routers, switches
- Data (signal) processing
  Eg: Digital hearing aid, Speech coding
- Monitoring
  Eg: ECG, Digital multimeter
- Control
  Eg: Air Conditioner
- Application specific user interface
  Eg: Mobile phone

BUILDING BLOCKS OF EMBEDDED SYSTEMS

A typical embedded system contains a single chip controller, which acts as the master brain of the system. The single chip controller can be a microprocessor or microcontroller or a Field Programmable Gate Array (FPGA) device or a Digital Signal Processor (DSP) etc.
An embedded system may have the following functional block.

- System core : The processing unit of the system
- Input port (Sensors) : To receive input signals provided by the end users or Sensors which are connected to the input ports
- Output port (Actuators) : To send control signals to the Actuators or devices connected to the O/p ports
- Memory : To store the program (control algorithm) and other configuration details
- Communication interface : To communicate with external world.

- Other supporting Ics : Other components needed for the application for which the embedded system is designed. Thismay vary fom sytem to system.