• Purpose of Embedded System

Each Embedded Systems are designed to serve the purpose of any one or a combination of the following tasks.

1. Data Collection/Storage/Representation:-

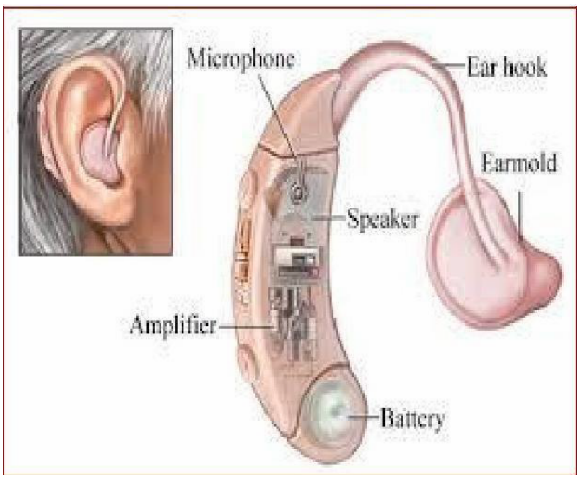
- Performs acquisition of data from the external world.
- The collected data can be either analog or digital
- Data collection is usually done for storage, analysis, manipulation and transmission.
- The collected data may be stored directly in the system or may be transmitted to some other systems or it may be processed by the system or it may be deleted instantly after giving a meaningful representation

2. Data Communication:-

- Embedded Data communication systems are deployed in applications ranging from complex satellite communication systems to simple home networking systems.
- Embedded Data communication systems are dedicated for data communication.
- The data communication can happen through a wired interface (like Ethernet, RS-232C/USB/IEEE1394 etc) or wireless interface (like Wi-Fi, GSM,/GPRS, Bluetooth, ZigBee etc)
- Network hubs, Routers, switches, Modems etc are typical examples for dedicated data transmission embedded systems

3. Data (Signal) Processing:-

- Embedded systems with Signal processing functionalities are employed in applications demanding signal processing like Speech coding, synthesis, audio video codec, transmission applications etc
- Computational intensive systems.
- Employs Digital Signal Processors (DSPs)



4. Monitoring:-

- Embedded systems coming under this category are specifically designed for monitoring purpose
- They are used for determining the state of some variables using input sensors
- They cannot impose control over variables.
- Electro Cardiogram (ECG) machine for monitoring the heart beat of a patient is a typical example for this
- The sensors used in ECG are the different Electrodes connected to the patient‟s body

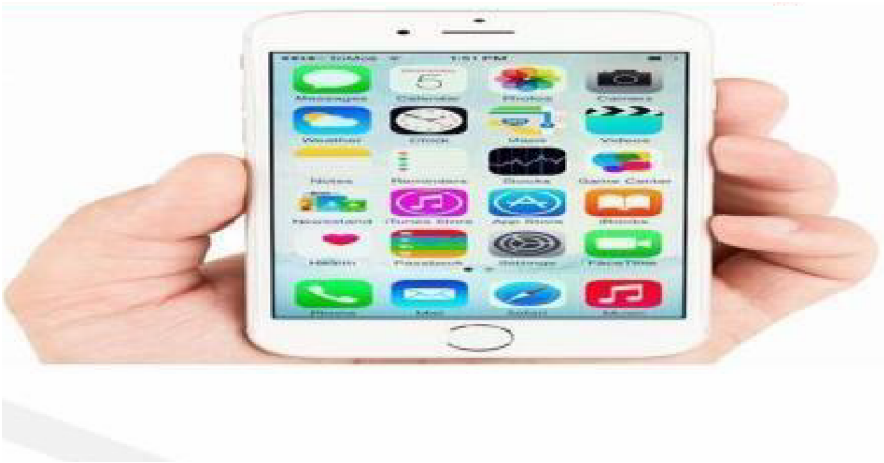
- Measuring instruments like Digital CRO, Digital Multi meter, Logic Analyzer etc used in Control & Instrumentation applications are also examples of embedded systems for monitoring purpose

5.Control:-

- Embedded systems with control functionalities are used for imposing control over some variables according to the changes in input variables.
- Embedded system with control functionality contains both sensors and actuators
- Sensors are connected to the input port for capturing the changes in environmental variable or measuring variable.
- The actuators connected to the output port are controlled according to the changes in input variable to put an impact on the controlling variable to bring the controlled variable to the specified range
- Air conditioner for controlling room temperature is a typical example for embedded system with “Control” functionality
- Air conditioner contains a room temperature sensing element (sensor) which may be a thermistor and a handheld unit for setting up (feeding) the desired temperature
- The air compressor unit acts as the actuator. The compressor is controlled according to the current room temperature and the desired temperature set by the end user.

6. Application Specific User Interface:-

- Embedded systems which are designed for a specific application.
- Contains Application Specific User interface (rather than general standard UI) like key board, Display units etc.
- Aimed at a specific target group of users.
- Mobile handsets, Control units in industrial applications etc are examples.



Characteristics of Embedded systems:

Embedded systems possess certain specific characteristics and these are unique to each Embedded system.

1. Application and domain specific

2. Reactive and Real Time

3. Operates in harsh environments

4. Distributed

5. Small Size and weight

6. Power concerns

7. Single-functioned

8. Complex functionality

9. Tightly-constrained

10. Safety-critical

1. Application and Domain Specific

- Each E.S has certain functions to perform and they are developed in such a manner to do the intended functions only.
- They cannot be used for any other purpose.
- Ex – The embedded control units of the microwave oven cannot be replaced with AC‟S embedded control unit because the embedded control units of microwave oven and AC are specifically designed to perform certain specific tasks.

2. Reactive and Real Time

- E.S are in constant interaction with the real world through sensors and user-defined input devices which are connected to the input port of the system.

- Any changes in the real world are captured by the sensors or input devices in real time and the control algorithm running inside the unit reacts in a designed manner to bring the controlled output variables to the desired level.

- E.S produce changes in output in response to the changes in the input, so they are referred as reactive systems.

- Real Time system operation means the timing behavior of the system should be deterministic ie the system should respond to requests in a known amount of time.

- Example – E.S which are mission critical like flight control systems, Antilock Brake Systems (**ABS**) etc are Real Time systems.

3. Operates in Harsh Environment

- The design of E.S should take care of the operating conditions of the area where the system is going to implement.

- Ex – If the system needs to be deployed in a high temperature zone, then all the components used in the system should be of high temperature grade.

- Also, proper shock absorption techniques should be provided to systems which are going to be commissioned in places subject to high shock.

4. Distributed

- It means that embedded systems may be a part of a larger system.

- Many numbers of such distributed embedded systems form a single large embedded control unit.

- Ex – Automatic vending machine. It contains a card reader, a vending unit etc. Each of them are independent embedded units but they work together to perform the overall vending function.

5. Small Size and Weight

- Product aesthetics (size, weight, shape, style, etc) is an important factor in choosing a product.
- It is convenient to handle a compact device than a bulky product.

6. Power Concerns

- Power management is another important factor that needs to be considered in designing embedded systems.

- E.S should be designed in such a way as to minimize the heat dissipation by the system.

7. Single-functioned

- Dedicated to perform a single function

8. Complex functionality

- We have to run sophisticated algorithms or multiple algorithms in some applications.

9. Tightly-constrained

- Low cost, low power, small, fast, etc

10. Safety-critical

- Must not endanger human life and the environment

Quality Attributes of Embedded System:

Quality attributes are the non-functional requirements that need to be documented properly in any system design.

Quality attributes can be classified as
I. Operational quality attributes

II. Nonoperational quality attributes.

I. Operational Quality Attributes: The operational quality attributes represent the relevant quality attributes related to the embedded system when it is in the operational mode or online mode.
Operational Quality Attributes are:

1. Response :-

It is the measure of quickness of the system.
It tells how fast the system is tracking the changes in input variables. Most of the E.S demands fast response which should be almost real time.
Ex – Flight control application.

2. Throughput :-

It deals with the efficiency of a system.

It can be defined as the rate of production or operation of a defined process over a stated period of time.

The rates can be expressed in terms of products, batches produced or any other meaningful measurements.

Ex – In case of card reader, throughput means how many transactions the reader can perform in a minute or in an hour or in a day.

Throughput is generally measured in terms of "Benchmark".

A Benchmark is a reference point by which something can be measured.

3. Reliability :-

It is a measure of how much we can rely upon the proper functioning of the system.

Mean Time Between Failure (MTBF) and Mean Time To Repair (MTTR) are the terms used in determining system reliability.

MTBF gives the frequency of failures in hours/weeks/months.

MTTR specifies how long the system is allowed to be out of order following a failure.

For embedded system with critical application need, it should be of the order of minutes.

4. Maintainability:-

It deals with support and maintenance to the end user or client in case of technical issues and product failure or on the basis of a routine system checkup.

Reliability and maintainability are complementary to each other.

A more reliable system means a system with less corrective maintainability requirements and vice versa.

Maintainability can be broadly classified into two categories- 1. Scheduled or Periodic maintenance (Preventive maintenance) 2. Corrective maintenance to unexpected failures

5. Security:-

Confidentiality, Integrity and availability are the three major measures of information security.

Confidentiality deals with protection of data and application from unauthorized disclosure.

Integrity deals with the protection of data and application from unauthorized modification.

Availability deals with protection of data and application from unauthorized users.

6. Safety :-

Safety deals with the possible damages that can happen to the operator, public and the environment due to the breakdown of an Embedded System.

The breakdown of an embedded system may occur due to a hardware failure or a firmware failure.

Safety analysis is a must in product engineering to evaluate the anticipated damages and determine the best course of action to bring down the consequences of damage to an acceptable level.

II. Non-Operational Quality Attributes:

The quality attributes that needs to be addressed for the product not on the basis of operational aspects are grouped under this category.

1. Testability and Debug-ability:-

Testability deals with how easily one can test the design, application and by which means it can be done.

For an E.S testability is applicable to both the embedded hardware and firmware.

Embedded hardware testing ensures that the peripherals and total hardware functions in

The desired manner, whereas firmware testing ensures that the firmware is functioning in the expected way**.**

Debug-ability is a means of debugging the product from unexpected behavior in the system

Debug-ability is two level process

1.Hardware level 2.software level

1. Hardware level: It is used for finding the issues created by hardware problems.

2. **Software level:** It is employed for finding the errors created by the flaws in the software.

2. Evolvability :-

It is a term which is closely related to Biology.

It is referred as the non-heritable variation.

For an embedded system availability refers to the ease with which the embedded product can be modified to take advantage of new firmware or hardware technologies.

3. Portability:-

It is the measure of system independence.

An embedded product is said to be portable if the product is capable of functioning in various environments, target processors and embedded operating systems.

„Porting" represents the migration of embedded firmware written for one target processor to a different target processor.

4. Time-to-Prototype and Market:-

It is the time elapsed between the conceptualization of a product and the time at which the product is ready for selling.

The commercial embedded product market is highly competitive and time to market the product is critical factor in the success of commercial embedded product.

There may be multiple players in embedded industry who develop products of the same category (like mobile phone)

5. Per Unit Cost and Revenue:-

Cost is a factor which is closely monitored by both end user and product manufacturer.

Cost is highly sensitive factor for commercial products

Any failure to position the cost of a commercial product at a nominal rate may lead to the failure of the product in the market.

Proper market study and cost benefit analysis should be carried out before taking a decision on the per-unit cost of the embedded product.

The ultimate aim of the product is to generate marginal profit so the budget and total cost should be properly balanced to provide a marginal profit.