1. What is an Embedded System? Explain the different applications of Embedded System.

An embedded system is an electronic/electro-mechanical system designed to perform a specific function and is a combination of both hardware and firmware (software).

Every embedded system is unique, and the hardware as well as the firmware is highly specialised to the application domain. Embedded systems are becoming an inevitable part of any product or equipment in all fields including household appliances, telecommunications, medical equipment, industrial control, consumer products, etc.

MAJOR APPLICATION AREAS 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 multi meters, digital CROs, logic analyzers PLC systems, etc.

10. Banking & Retail: Automatic teller machines (ATM) and currency counters, point of sales (POS)

11. Card Readers: Barcode, smart card readers, hand held devices, etc.

2. Explain the various purposes of embedded system.

PURPOSE OF EMBEDDED SYSTEMS:

a.Data collection/Storage/Representation

b. Data communication

c. Data (signal) processing

d. Monitoring

e. Control

f. Application specific user interface.

1. Data Collection/Storage/Representation

- Embedded systems designed for the purpose of data collection performs acquisition of data from the external world.
- Data collection is usually done for storage, analysis, manipulation and transmission. Data can be either analog (continuous) or digital (discrete).
- Embedded systems with analog data capturing techniques collect data directly in the form of analog signals whereas embedded systems with digital data collection mechanism converts the analog signal to corresponding digital signal using analog to digital (A/D) converters and then collects the binary equivalent of the analog data. If the data is digital, it can be directly captured without any additional interface by digital embedded systems.
- A digital camera is a typical example of an embedded system with

data collection/storage/representation of data. Images are captured and the captured image may be stored within the memory of the camera. The captured image can also be presented to the user through a graphic LCD unit.

2. Data Communication

- Embedded data communication systems are deployed in applications ranging from complex satellite communication systems to simple home networking systems.
- The transmission is achieved either by a wire-line medium or by a wireless medium.
- Data can either be transmitted by analog means or by digital means.
- The data collecting embedded terminal itself can incorporate data communication units like wireless modules (Bluetooth, Wi-Fi, etc.) or wire-line modules (USB, TCP/IP, etc.).
- Network hubs, routers, switches, etc. are typical examples of dedicated data transmission embedded systems. They act as mediators in data communication and provide various features like data security, monitoring etc.

3. Data (Signal) Processing

- The data (voice, image, video, electrical signals and other measurable quantities) collected by embedded systems may be used for various kinds of data processing.
- Embedded systems with signal processing functionalities are employed in applications demanding signal processing like speech coding, synthesis, audio video codec, transmission applications, etc.
- A digital hearing aid is a typical example of an embedded system employing data processing. Digital hearing aid improves the hearing capacity of hearing impaired persons.

4. Monitoring

- Embedded systems falling under this category are specifically designed for monitoring purpose.
- Almost all embedded products coming under the medical domain are with monitoring functions only.
- They are used for determining the state of some variables using input sensors. They cannot impose control over variables.
- A very good example is the Electro Cardiogram (ECG) machine for monitoring the heartbeat of a patient.

- Some other examples of embedded systems with monitoring function are measuring instruments like digital CRO, digital multimeters, logic analyzers, etc. used in Control & Instrumentation

applications.

5. Control

- Embedded systems with control functionalities impose control over some variables according to the changes in input variables.
- A system with control functionality contains both sensors and actuators.
- Sensors are connected to the input port for capturing he 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 system used in our home to control the room temperature to a specified limit is a typical example for embedded system for control purpose.

6. Application Specific User Interface

- These are embedded systems with application-specific user interfaces like buttons, switches, keypad, lights, bells, display units, etc.
- Mobile phone is an example for this. In mobile phone the user interface is provided through the keypad, graphic LCD module, system speaker, vibration alert, etc.

3. Explain the different classifications of Embedded System.

- **Classification Based on deterministic behaviour**

o The classification based on deterministic system behaviour is applicable for 'Real Time' systems.

o The application/task execution behaviour for an embedded system can be either deterministic or non- deterministic.

o Based on the execution behaviour, Real Time embedded systems are classified into Hard and Soft.

- **Classification Based on triggering**

o Embedded Systems which are Reactive in nature (Like process control systems in industrial control applications) can be classified based on the trigger.

o Reactive systems can be either event triggered or time triggered.

Classification Based on Generation

o First Generation The early embedded systems were built around 8bit microprocessors like 8 and 4 bit microcontrollers. Simple in hardware circuits with firmware developed in Assembly code. Digital telephone keypads, stepper motor control units etc. are examples of this.

o Second Generation These are embedded systems built around 16bit microprocessors and 8 or 16 bit microcontrollers. Data Acquisition Systems, SCADA systems, etc. are examples of second generation embedded systems.

o Third Generation Built around powerful 32bit processors and 16bit microcontrollers .A new concept of application and domain specific processors/controllers like Digital Signal Processors (DSP) and Application Specific Integrated Circuits (ASICs) came into the picture.

The instruction set of processors became more complex and powerful and the concept of instruction pipelining also evolved. Example :

robotics, media, industrial process control, networking, etc

o Fourth Generation The advent of System on Chips (SoC), reconfigurable processors and multicore processors are bringing high performance, tight integration and miniaturisation into the embedded device market. Smart phone devices, mobile internet devices (MIDs), etc. are examples of fourth generation embedded systems.

Classification Based on Complexity and Performance

o **Small-Scale Embedded Systems**

Small-scale embedded systems are usually built around low performance and low cost 8 or 16 bit microprocessors/ microcontrollers. A small-scale embedded system may or may not contain an operating system for its functioning.

AExample: an electronic toy.

o **Medium-Scale Embedded Systems**

Embedded systems which are slightly complex in hardware and firmware (software) requirements fall under this category. Medium-scale embedded systems are usually built around medium performance, low cost 16 or 32 bit microprocessors/microcontrollers or digital signal processors. They usually contain an embedded operating system (either

general, purpose or real time operating system) for functioning.

o **Large-Scale Embedded Systems/Complex Systems Embedded systems**

which involve highly complex hardware and firmware requirements fall under this category. They are employed in mission critical applications demanding high performance. Such systems are commonly built around high performance 32 or 64 bit RISC processors/controllers or Reconfigurable System on Chip (RSoC) or multi-core processors and programmable logic devices.

4. Explain the components used as the core of an Embedded System.

1. Power Supply

A power supply is a crucial component of the embedded system design.

It is an electrical device mainly used to power up the electrical load.

Normally, a 5V power supply is required for the system, however, it can also range from 1.8 to 3.3V.

You can pick either one based on your requirements and application.

To work the embedded system properly, a smooth and efficient power supply is needed. Both wall adopter and battery can be used as a power supply. Some power supplies work as independent equipment while others are incorporated into the embedded technology they power.

2. Microcontroller

An embedded system is either a microcontroller-based or microprocessor-based system. They give a system computing power and are called integrated circuits.

The embedded hardware performance is mainly dependent on the processor which is normally called the brain of the embedded system.

Pick from a range of processors including 8-bit, 16-bit, and 32-bit processors.

They are different in terms of processing speed. For example, a 32-bit processor comes with more processing speed and can manipulate 32-bits at a time while an 8-bit processor comes with less processing speed and can manipulate 8-bits at a time.

For simple applications, an 8-bit processor would suffice while for complex and advanced applications, processors with more bits are used. The 8-bit processor is normally clocked to 8MHz while the 32-bit

processor can run up to hundreds of MHz.

3. ROM/RAM

Memory is essential to store important information in the embedded computer system.

Memory is integrated into a microcontroller or microprocessor.

There are two types of memories including ROM (read-only-memory) and RAM (random access memory). The former is called the code memory that stores the program code and is non-volatile which means it stays stored in the system when the power supply is removed. While latter is called the data memory and is a volatile memory which means it is used for temporally storing the information and is removed from the system when the power supply is turned off.

4. Timers / Counters

Sometimes you need to create a delay before a specific function. Timers are used in such cases. While at times you want to count the number of times a particular event occurs. Counters are used in such cases. If an up counter is used in the system, it will count up from the initial value to 0xFF and if it is down counter, it will count down to 0x00. The counters

are integrated using register-type circuits like a flip-flop.

5. Communication Ports

Communication ports are used in embedded systems to establish communication with other embedded systems. There are several communication ports including USB, UART, USB, I2C, SPI, and RS-485. For simple applications, communications ports are utilized from the microcontroller, and for complex and advanced applications these ports are externally installed inside the embedded systems.

6. Output And Input

Input is required to interact with the embedded system. A sensor can be used to provide input to the system. The microcontroller used in the system can be configured as an input or output port. In the microcontroller, there are a fixed number of input and output ports that you can utilize as per your requirement.

5. Differentiate between Microprocessor and Microcontroller.

1.Microprocessor is the heart of Computer system.

1.Micro Controller is the heart of an embedded system.

2.It is only a processor, so memory and I/O components need to be connected externally

2.Micro Controller has a processor along with internal memory and I/O components.

3.Memory and I/O has to be connected externally, so the circuit becomes large.

3.Memory and I/O are already present, and the internal circuit is small.

4.You can't use it in compact systems

4.You can use it in compact systems.

5.Cost of the entire system is high

5.Cost of the entire system is low

6.Most of the microprocessors do not have power saving features.

6.Most of the microcontrollers offer power-saving mode.

7.It is mainly used in personal computers.

7.It is used mainly in a washing machine, MP3 players, and embedded systems.

8.Microprocessors are based on Von Neumann model

8.Micro controllers are based on Harvard architecture

9.It uses an external bus to interface to RAM, ROM, and other peripherals.

9.It uses an internal controlling bus.

10.It's complex and expensive, with a large number of instructions to process.

10.It's simple and inexpensive with less number of instructions to

process.

6. Differentiate between Big Endian and Little Endian.

???

7. Differentiate between RISC and CISC processors.

1.RISC is a reduced instruction set.

1.CISC is a complex instruction set.

2.The number of instructions is less as compared to CISC.

2.The number of instructions is more as compared to RISC.

3.The addressing modes are less.

3.The addressing modes are more.

4.It works in a fixed instruction format.

4.It works in a variable instruction format.

5.The RISC consumes low power.

5.The CISC consumes high power.

6.The RISC processors are highly pipelined.

6.The CISC processors are less pipelined.

7.It optimizes the performance by focusing on software.

7.It optimizes the performance by focusing on hardware.

8.Requires more RAM.

8.Requires less RAM.

8. What is Programmable Logic Device(PLD)? Explain

Different types of PLDs.

Introduction:

- An IC that contains large numbers of gates, flip-flops, etc. that can be configured by the user to perform different functions is called a Programmable Logic Device (PLD).
- The internal logic gates and/or connections of PLDs can be changed/configured by a programming process.
- One of the simplest programming technologies is to use fuses. In the original state of the device, all the fuses are intact.
- Programming the device involves blowing those fuses along the paths that must be removed in order to obtain the particular configuration of the desired logic function.
- PLDs are typically built with an array of AND gates (AND-array) and an array of OR gates (OR-array).

Three Fundamental Types of PLDs:

- The three fundamental types of PLDs differ in the placement of programmable connections in the AND-OR arrays. Figure shows

the locations of the programmable connections for the three types.

- The PROM (Programmable Read Only Memory) has a fixed AND array (constructed as a decoder) and programmable connections for the output OR gates array. The PROM implements Boolean functions in sum-of-min terms form.
- The PAL (Programmable Array Logic) device has a programmable AND array and fixed connections for the OR array.
- The PLA (Programmable Logic Array) has programmable connections for both AND and OR arrays. So it is the most flexible type of PLD.

PROM (Programmable Read Only Memory):

- The input lines to the AND array are hard-wired and the output lines to the OR array are programmable.
- Each AND gate generates one of the possible AD products (.e., i minterms).

The PLA (Programmable Logic Array):

- In PLAs, instead of using a decoder as in PROMs, a number (k) of AND gates is used where k < 2n, (n is the number of inputs).
- Each of the AND gates can be programmed to generate a product term of the input variables and does not generate all the minterms as in the ROM.
- The AND and OR gates inside the PLA are initially fabricated with the links (fuses) among them.
- The specific Boolean functions are implemented in sum of products form by opening appropriate links and leaving the desired connections.

The PAL (Programmable Array Logic):

- The PAL device is a PLD with a fixed OR array and a programmable AND array.
- As only AND gates are programmable, the PAL device is easier to program but it is not as flexible as the PLA.
- The device shown in the figure has 4 inputs and 4 outputs. Each input has a buffer-inverter gate, and each output is generated by a fixed OR gate.
- The device has 4 sections, each composed of a 3-wide AND-OR

array, meaning that there are 3 programmable AND gates in each section.

- Each AND gate has 10 programmable input connections indicating by 10 vertical lines intersecting each horizontal line. The horizontal line symbolizes the multiple input configuration of an AND gate.

9. Explain Commercial Off-the-Shelf (COTS).

- Commercial off-the-shelf or commercially available off-the-shelf (COTS) products are packaged or canned (ready-made) hardware or software, which are adapted aftermarket to the needs of the purchasing organization, rather than the commissioning of custom-made, or bespoke, solutions. A related term, Mil-COTS, refers to COTS products for use by the U.S. military.
- In the context of the U.S. government, the Federal Acquisition Regulation (FAR) has defined "COTS" as a formal term for commercial items, including services, available in the commercial marketplace that can be bought and used under government contract.
- For example, Microsoft is a COTS software provider. Goods and

construction materials may qualify as COTS but bulk cargo does not. Services associated with the commercial items may also qualify as COTS, including installation services, training services, and cloud services.

- COTS purchases are alternatives to custom software or one-off developments –government-funded developments or otherwise.
- Although COTS products can be used out of the box, in practice the COTS product must be configured to achieve the needs of the business and integrated to existing organizational systems. Extending the functionality of COTS products via custom development is also an option, however this decision should be carefully considered due to the long term support and maintenance implications. Such customized functionality is not supported by the COTS vendor, so brings its own sets of issues when upgrading the COTS product.
- The use of COTS has been mandated across many government and business programs, as such products may offer significant savings in procurement, development, and maintenance.
- Motivations for using COTS components include hopes for reduction system whole of life costs.
- In the 1990s, many regarded COTS as extremely effective in

reducing the time and cost of software development.[citation needed] COTS software came with many not-so-obvious tradeoffs—a reduction in initial cost and development time over an increase in software component-integration work, dependency on the vendor, security issues and incompatibilities from future changes.

10. What is Read-Write Memory? Explain the categories of Read-Write Memory.

What is Read-Only Memory (ROM)?

ROM stands for Read-Only Memory. It is a non-volatile memory that is used to stores important information which is used to operate the system. As its name refers to read-only memory, we can only read the programs and data stored on it. It is also a primary memory unit of the computer system. It contains some electronic fuses that can be programmed for a piece of specific information. The information stored in the ROM in binary format. It is also known as permanent memory.

Features of ROM (Read-Only Memory):

- ROM is a non-volatile memory.
- Information stored in ROM is permanent.
- Information and programs stored on it, we can only read.
- Information and programs are stored on ROM in binary format.
- It is used in the start-up process of the computer.

Types of Read-Only Memory (ROM):

- MROM (Masked read-only memory)
- PROM (Programmable read-only memory)
- EPROM (Erasable programmable read-only memory)
- EEPROM (Electrically erasable programmable read-only memory)

Now we will discuss the types of ROM one by one:

1. MROM (Masked read-only memory): We know that ROM is as old as semiconductor technology. MROM was the very first ROM that consists of a grid of word lines and bit lines joined together transistor switches. This type of ROM data is physically encoded in the circuit and only be programmed during fabrication. It was not so expensive.

2. PROM (Programmable read-only memory): PROM is a form of digital memory. In this type of ROM, each bit is locked by a fuse or anti-fuse. The data stored in it are permanently stored and can not be changed or erasable. It is used in low-level programs such as firmware or microcode.

3. EPROM (Erasable programmable read-only memory): EPROM also called EROM, is a type of PROM but it can be reprogrammed. The data stored in EPROM can be erased and reprogrammed again by ultraviolet light. Reprogrammed of it is limited. Before the era of EEPROM and flash memory, EPROM was used in microcontrollers.

4. EEPROM (Electrically erasable programmable read-only memory): As its name refers, it can be programmed and erased electrically. The data and program of this ROM can be erased and programmed about ten thousand times. The duration of erasing and programming of the EEPROM is near about 4ms to 10ms. It is used in microcontrollers and remote keyless systems.

Advantages of ROM:

It is cheaper than RAM and it is non-volatile memory.

It is more reliable as compared to RAM.

Its circuit is simple as compared to RAM.

It doesn ṭ need refreshing time because it is static.

It is easy to test.

Disadvantages of ROM:

It is a read-only memory, so it cannot be modified.

It is slower as compared to RAM.