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17) What is processor architecture? What are the different processor architectures available for processor design?

Ans - Processor Architecture - is a fluid term that is basically useful only in comparisons to something else

→ A processor is made of transistors. The transistors are arranged in a sort of hardware-based computer program that is designed to accept inputs and process them into outputs. The inputs are machine code. Various tools make the task of producing machine code more user-friendly (assemblers and compilers)

→ Architecture is about the processor design and interface, and not the bit depth.

Von Neumann Architecture - was first proposed by a computer scientist John Von Neumann. In this architecture, one data path or bus exists for both instruction and data. As a result, the CPU does one operation at a time. It either fetches an instruction from memory, or performs a read/write operation on data. So an instruction fetch and a data operation cannot occur simultaneously, sharing a common bus.

→ It supports simple hardware. It allows the use of a single, sequential memory.

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Today's processing speeds vastly outpace memory access times, and we employ a very fast but small amount of memory (cache) local to the processor.

Harvard Architecture - offers separate storage and signal buses for instructions and data. This architecture has data storage entirely contained within the CPU, and there is no access to the instruction storage as data. Computers have separate memory areas for program instructions and data using internal data buses, allowing simultaneous access to both instructions and data

→ Programs needed to be loaded by an operator; the processor couldn't boot itself. In it, there is no need to make the two memories share properties.

CISC and RISC

→ CISC is a complex Instruction Set Computer. It is a computer that can address a large number of instructions.

→ In the early 1980s, the computer designers recommended that computers should use fewer instructions with simple constructs so that they can be executed much faster within the CPU without having to use memory. Such computers are classified as Reduced Instruction set computer or RISC.

CISC	RISC
→ larger set of instructions easy to program	→ Smaller set of instructions difficult to program
→ Simpler design of compiler, considering larger set of instructions	→ complex design of compiler
→ Many addressing modes causing complex instruction formats	→ Few addressing mode, fix instruction format
→ Instruction length is variable	→ Instruction length varies
→ higher clock cycles per second	→ low clock cycle per second
→ Emphasis is on hardware	→ Emphasis is on software
→ Control unit implements large instruction set using micro-program unit	→ each instruction is to executed by hardware
→ Slower execution, as instructions are to be read from memory and decoded by the decoder unit	→ Faster execution, as each instruction is to be executed by hardware
→ Pipelining is not possible	→ Pipelining of instruction is possible, considering single clock cycle

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18) Explain the design process of ES.

Ans- A system designed with embedding of hardware and software together for a specific fun" with a larger area is embedded system design. In ESD, a microcontroller plays a vital role. Micro-controller is based on Harvard architecture, it is an important component of an ES. External processor, internal memory and i/o components are interfaced with the microcontroller. It occupies less area, less power consumption. The application of microcontroller is MP3, washing machines.

Elements of ES- a) Processor b) MicroProcessor c) Microcontroller d) Digital Signal Processor

Steps in the ESD Process-

Abstraction → Hardware-Software architecture → Extra Functional Properties → System related family of Design → Modular design → Mapping → User Interface Design → Refinement

Abstraction In this stage the problem related to the system is abstracted

Hardware-software architecture Proper knowledge of hardware and software to be known before starting any design process.

Extra Functional Properties Extra functions to be implemented are to be understood completely from the main design

System Related Family of Design When designing a system, one should refer to a previous system-related family of design

Modular Design Separate module designs must be made so that they can be used later on when required

Mapping Based on software mapping is done. For example, data flow and program flow are mapped into one

User Interface Design In user interface design it depends on user requirements, environment analysis and fun? of the system. For example, on a mobile phone if you want to reduce the power consumption of mobile phones we take care of other parameters, so that power consumption can be reduced

Refinement Every component and module must be refined appropriately so that the software team can understand.
Architectural description language is used to describe the software design

→ control Hierarchy → Partition of structure
→ Data Structure and Hierarchy → Software Procedure

19) What are the programming languages used in Embedded systems?

Ans- An embedded programming language is a programming language that developers use in ES. In general, the languages offer low-level access to the device hardware. Developers use several common programming languages for ES

a) C
b) C++
c) Python
d) MicroPython
e) Java
f) Javascript
g) Rust
h) Ada
i) Assembly

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20) Explain about significance of ES and classification of the ES.

Ans → ES are a huge part of the operation of the majority of the technology that we use in our day-to-day lives. Our home appliances, our smartphones, the heating and security systems that operate without interference in our homes; all of these use ES technology to fun^{n}.

→ Whilst the technology and expertise involved to build ES may not be particularly complex, without these fixed systems many of the systems and devices that we rely on without realising would stop working efficiently.

Classification
- Performance of Micro-Controllers.
- Performance and Functional Requirements

Based on Performance & Functional Requirements

1) Real Time ES - Is strictly time specific which means these ES provides output in a particular/defined time interval. These type of ES provide quick response in critical situations which gives most priority to time based task performance and generation of output. That's why RTES are used in defense sector, medical

and Health care sector, and some other industrial applications where output in the right time is given more importance.

a) Soft RTES - In these types of ES time/deadline is not so strictly followed. If deadline of the task is passed (means the system didn't give result in the defined time) still result or output is accepted.

b) Hard RTES - In these type of ES time/deadline of task is strictly followed. Task must be completed in b/w time frame (defined time interval) otherwise result/output may not be accepted.

Ex- Traffic control system, Military usage in defense sector, Medical usage in health sector

2) Stand Alone ES - are independent systems which can work by themselves, they don't depend on a host system. It takes input in digital or analog form and provides the output.

Ex- MP3 Players, Microwave Ovens, Calculator

3) Networked ES - are connected to a network which may be wired or wireless to provide o/p to the attached device. They communicate with embedded web servers through network.

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Ex- Home Security systems, ATM Machine, Card Swipe machine

4) Mobile ES- are small and easy to use and requires less resources. They are the most preferred ES. In portability POV mob ES are also best

Ex- MP3 Player, Mobile Phone, Digital Camera

Based on Performance & Micro-Controller-

1) Small scale ES- are designed using an 8-bit or 16-bit MC. They can be powered by a battery. The processor uses very less/limited resources of memory and processing speed. Mainly these systems doesn't act as an independent system they act as any component of computer system but they did not compute and dedicated for a specific task.

2) Medium Scale ES- are designed using an 16 bit or 32 bit MC. These medium scale ES are faster than that of small scale ES. Integration of hardware and software is complex in these systems. Java, C, C++, are the programming languages that are used to develop medium scale ES. Different type of software tools like compiler, debugger, simulator etc are used to develop these type of systems.

3) Sophisticated or Complex ES - are designed using multiple 32-bit or 64-bit microcontroller. These systems are developed to perform large scale complex functions. These systems have high hardware and software complexities. We use both hardware and software components to design final systems or hardware products.

Q1) Explain about the components used as core of an ES. Also mention their commonly used application.

Ans- ES are domain and application specific and are built around a central core. The core of the ES falls into any of the following categories.

General Purpose and Domain Specific Processors -
→ MicroProcessors
→ Microcontrollers
→ Digital Signal Processors
→ Application Specific Integrated Circuits (ASIC)
→ Programmable logic device (PLD's)
→ Commercial off-the shelf components (COTS)

a) Microprocessors - A mP is a Si chip representing a CPU.
→ A mP is a dependent unit and it requires the combination of other hardware like memory, timer unit, and interrupt controller etc. for proper functioning.

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→ MP is a controlling unit of a micro-computer, fabricated on a small chip capable of performing ALU operations and communicating with the other devices connected to it

→ MP is consists of an ALU, register array, and a control unit. ALU performs arithmetical and logical operations on the data recieved from memory or an input device. Register array consists of registers identified by letters like B, C, D, E, H, L and accumulator. The control unit controls the flow of data and instructions within the computer.

OR

→ A mP is a single VLSI chip having a CPU. In addition, it may also have other units such as coaches, floating point processing arithmetic unit, and pipelining units that help in faster processing of instructions

b) MicroController - is a single chip VLSI unit (also called microcomputer) which, although having limited computational capabilities, possesses enhanced I/O capability and a number of on-chip functional units.

→ MC are particularly used in ES for real-time control applications with on chip program memory and devices

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c) Digital Signal Processors - DSP are powerful special purpose 8/16/32 bit MP designed to meet the computational demands and power constraints of today's Embedded audio, video and communication applications.

→ DSP are 2 to 3 times faster than general purpose MP in signal processing applications. This is because of the architectural difference b/w DSP and general purpose MP.

d) Application Specific ICs (ASIC) - is a microchip design to perform a specific and unique applications. Because of using single chip for integrates several functions there by reduces the system development cost.

→ Most of the ASICs are proprietary (which having some trade name) products, it is referred as Application Specific Standard Products (ASSP)

e) PLDs - A PLD is an electronic component. It used to build digital circuits which are reconfigurable. A logic gate has a fixed fun^n but a PLD doesn't have a defined fun^n at the time of manufacture

→ PLDs offer customers a wide range of logic capacity, features, speed, voltage characteristics.

f) Commercial off-the-shelf components - A COTS product is one which is used as 'as-is'.

→ The COTs components itself maybe develop around a general purpose or domain specific processor or an ASIC's or PLDs

→ The major advantage of using COTs is that they are readily available in the market, one chip and a developer can cut down his/her development time to a great extent.

22) Explain the classification of ES.

Ans- Already done.

23) Explain the ip/op devices used in ES.

Ans-

24) What is an ES? List out its applications. Explain why the processors play a vital role in ES.

Ans- Central Heating Systems, GPS Systems, Fitness Trackers, Medical devices, Automotive Systems, Transit and Fare Collection, ATMs, Factory Robots, Electric Vehicle Charging Stations, Interactive Kiosks.

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→ The processor plays a vital role in the ES and is considered as its brain. The processor is known as to be responsible for taking the decision of the performance of this system. There are numerous types of processors present in the market among which the one as per requirement maybe chosen.

→ The lesser bit indicates that the requirement of smaller applications in the ES.

25) What is the difference b/w RISC & CISC?

Ans- Already done

26) How the software is embedded on to the system? Explain.

Ans-

27) Explain the techniques used for selection of memory in ES.

Ans- Selection of suitable memory is very much essential step in high performance applications, because the challenges and limitations of the system performance are often decided upon the type of memory architecture

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System memory requirements depend primarily on the nature of the application that is planned to run on the system. Memory performance and capacity requirements for low cost systems are small, whereas memory throughput can be the most crucial requirement in a complex, high performance system.

- Speed
- Data storage size and capacity
- Bus width
- Latency
- Power Consumption
- Cost