

**EC8791-EMBEDDED AND REAL TIME SYSTEMS****UNIT – I  
INTRODUCTION TO EMBEDDED SYSTEM DESIGN  
PART–A**

- 1. Enumerate some embedded computers that exist from the origin of the embedded systems. (Dec 16)**  
Cell phones, calculators, printers, thermostats, video game consoles, CD players are some of the embedded computers that exist from the origin of embedded systems.
- 2. In what way interrupts differ from exceptions? (Dec 16)**  
Interrupts are used to handle external events (serial ports, keyboard). The processor handles interrupts after finishing the current instruction. Exceptions are used to handle instruction faults, (division by zero, undefined opcode). Exceptions are used as a variation of interrupt, which requires both prioritization and vectoring.
- 3. What is an embedded computer system?**  
Any device that includes a programmable computer but is not itself intended to be a general purpose computer is called an embedded computer system.
- 4. Mention the challenges in embedded computing system design. (Nov 2019)**  
How much hardware do we need, How do we meet deadlines, How do we minimize power consumption, How do we design for upgradeability.
- 5. Mention the reasons that make embedded computing machines design difficult.**  
Complex testing, Limited observability and controllability, restricted development environments.
- 6. What is design flow? (Nov 17)**  
The sequence of design methodology for fully and partially automated system.
- 7. What is bus protocol? (May 17)**  
Bus protocol is nothing but to transfer the information from one system to the another system there are two different set of bus protocol.
- 8. State the importance of design methodology.**  
It allows us to keep a score board on a design, It allows us to develop computer aided design tools, It makes it much easier for member so far design team to communicate.
- 9. Why microprocessor is used in embedded system? (Nov 17)**  
Microprocessors provide a very efficient way to implement an embedded system they also make it easy to design families of products that can be built to provide various feature sets at different price points.
- 10. What do you mean by quality and quality assurance related to embedded systems? (Dec 16)**  
Quality of a product or service is how well it satisfies the intended function. Quality assurance process is vital for the delivery of a satisfactory system.
- 11. List the issues in hardware and software design for an embedded system.**  
Choosing the right platform.  
Memory and processor sensitive software  
Allocation of addresses to memory, program segments and devices.  
Porting the issues of OS in an embedded platform.  
Performance and Performance Accelerators.

**12. List out some of the verifications requirements and specification related to the design flow (May 17)**

Choosing the right platform, Memory and processor sensitive software, Allocation of addresses to memory, program segments and devices. Porting the issues of OS in an embedded platform, Performance and Performance Accelerators.

**13. What is good requirement analysis? (May 18)**

Correctness, unambiguousness, completeness, verify ability, modifiability, traceability.

**14. What are the CRC Card methodology identifiers? (Nov 18,19)**

Classes, responsibilities, collaborators.

**15. Define Embedded Programming. (May 19)**

Embedded Programming is the process of developing the software for an embedded system to automate the system by getting the inputs and producing the corresponding outputs to actuators.

**PART- B**

1. Name three mechanisms by which a CMOS microprocessor consumes power and also specify several power saving strategies are used in CMOS CPU'S. (May 17)
2. Analyze the requirements for designing a GPS moving map in embedded system design process. (Dec 16)
3. How are the conceptual specifications and detailed specifications written in UML language to design the model train controller? (May 18)(Nov 17,18)
4. What are the several requirements of an embedded computing system design?. (May 17,18)
5. Explain in detail about the challenges in embedded computing system design. (May 19)
6. Briefly discuss about the design methodologies for an embedded computing system and explain on the importance of requirement analysis (Dec 16) (Nov 17,18)

**UNIT – II ARM PROCESSOR AND PERIPHERALS****PART – A****1. Write short notes on ARM Processor.**

ARM–Advanced RISC Machine (It is an 32-bit Microprocessor).

- 1) ARM is actually a family of RISC architectures that have been developed over many years. The ARM is a 32-bit Reduced Instruction Set Computer (RISC) instruction set architecture developed by Arm holdings.
- 2) ARM processor is made suitable for Low power application.

**2. What are the parameters used to evaluate the CPU performance?**

Pipelining and Caching.

**3. What are the Instruction set features useful for embedded programming?**

Instruction Sets can have a variety of characteristics/features including:

Fixed versus variable length, Addressing modes, Number of operands, Types of operations supported.

**4. State the functions of Co-Processor (May 19)**

Co-Processor is an additional computing device, which is coupled to the main processor for execution of certain complex instructions. The Co-Processor does not execute any portion of the

program by itself. It comes into operation only when the processor executes a coprocessor instruction.

**5. How traps are Handled in ARM Processor (Nov 17,19)**

Trap is also known as software interrupt. It is an instruction that explicitly generates an exception condition. The processor immediately switches on to the supervisor mode to handle the trap when encountered. The ARM processor provides SWI interrupt for software interrupts.

**6. Determine the average memory access time of a machine whose hit rate is 90% with a cache access times of 3ns and main memory access tie of 70ns. (Nov 18)**

Average Access time = Hit rate \* Cache Access time + Miss rate \* Main Memory Access time  
 $= 0.9 * 3\text{ns} + 0.1 * 70\text{ ns} = 9.7\text{ns}$

**7. What are the basic sources of CMOS power consumption? (May 19)**

The basic sources of CMOS power consumption can be given as Power Supply, Capacitive Toggling and Leakage.

**8. What is the difference between the Harvard and Von-Neumann architecture? (May 18)**

HARDWARD	VON-NEUMANN
Separate Program and Data memory	Common memory for Program and data
Program counter points program memory	Program counter holds address in memory of an instruction

**9. List the functions of ARM processor in supervisor mode. (May 18)(Nov 18)**

Exception, Prioritization, Vectoring, Traps.

**10. How is ARM processor different from other processors?**

ARM is RISC (Reduced Instruction Set Computing) architecture while other processor being a CISC (Computer Instruction Set Computing) one. In the ARM processor, arithmetic and logical operations cannot be performed directly on memory locations, while other processors allow such operations to directly reference main memory.

**11. What is the purpose of current program status register (CPSR) and Z-bit?**

**CPSR:** It is set automatically during every arithmetic, logical or shifting operations. The top 4 bits of CPSR hold useful information about the result. **Z-Bit:** The zero (Z) bit is set whenever a bit of the result is zero.

**12. Define CISC**

CISC refers to complex instruction set computers. As the name implies, these computers are having a wide variety of instructions that can perform very complex operations.

**Define RISC.**

RISC refers to reduced instruction set computers. These computers are having very simple instructions which are also very fewer in number.

**13. Define AMBA.**

AMBA stands for Advanced Microcontroller Bus Arbitration. It consists of the AHB (Advanced High Speed Bus) and the APB (Advanced Peripheral Bus)

**14. What is LPC214x family?**

LPC is a family of 32-bit ARM7 Microcontrollers founded by NXP Semiconductors (formerly known as Philips Semiconductors). All the LPC family of semiconductors have common features namely the on-chip S-RAM, on-chip Flash Memory, ISP, A/D, D/A, USB, External/Internal Timers, PWM Module, Capture/Compare Module etc.

**15. What is a Watch dog timer?**

Watch Dog timer is used to reset the processor whenever it enters into a locked state in case of hardware fault or program error to prevent failure of the system. The timer is regularly cleared if no errors are encountered, once the overflow of the timer occurs the system is forcefully reset.

**PART – B**

- (i).How does branching and procedural has been performed in ARMprocessor.(May 17)  
(ii).Explain how ARM processor uses UART module to perform serial communication.
- (i).Explain the function of ARM processor instructions. (Nov 17)  
(ii).Discusson the operation of Coprocessor used with the ARM processor
- DiscussabouttheCPUperformanceandCPUpowerconsumption.(Nov 18)
- Draw and explain ARM architecture in detail. (Nov 18)
- Analyze the preference of ARM processor instruction set over CISC process (May 19)  
And i) Analyse the data operations of an ARM processor.  
ii) With neat sketches explain the ARM address translation mechanism(Nov 19)

**UNIT III - EMBEDDED PROGRAMMING****PART – A**

- What is data flow graph and control/data flow graph (CDFG)?(Dec 16),(Nov 18)**  
A data flow graph is a model of a program with no conditionals. Inahighlevelprogramminglanguage,acodesegmentwithnoconditionsandoneentrypointandexitpoint. A CDFG is the fundamental model for programs which has constructs that model both data operations (arithmetic and other computations) and control operations (conditionals).
- How the program validation can be done? (June '16)**  
Complex systems need testing to ensure that they work as they are intended. The subprograms can be analysed and testing methods can be identified that provide reasonable amount of testing while keeping the testing time within reasonable bounds.
- Listoutthevariouscompilationtechniques.**  
Therearethreetypesofcompilationtechniques:Analysisandoptimizationofexecutiontime,PowerenergyandprogramsizeProgramvalidationandtesting.
- Statethebasicprinciplesofbasiccompilationtechniques.**
  - 1.Compilationcombinestranslationandoptimization
  - 2.Thehighlevellanguageprogramistranslatedintolowerlevelformofinstructions;optimizationstrytogeneratebetterinstructionsequences3.Compilation=Translation+optimization.
- Nameanytwotechniquesusedtooptimizeexecutiontimeofprogram.**  
InstructionleveloptimizationandMachineindependentoptimization.
- How power can be optimized at the program level? (Nov 17)**  
Power optimization is done at the program level by many ways. Some of the ways can be given as avoiding power down mode, predictive shutdown. By avoiding power down mode much power gets saved. In predictive shutdown the power conservation is achieved by turning down the blocks when not used.
- Whatisthe disadvantage of nested loops in embedded programs? .(May 17)**  
Thedisadvantages of nested loops are it repeats the operation with n number of times with more delay. It will reduce the system performance.

**8. List the types of Co-verification techniques.(May 17)**

**Co-Verification** phase is about white box testing. Techniques include statement coverage, condition coverage, and decision coverage. - Demonstration: It is about black box testing. Techniques include error guessing, boundary-value analysis, and equivalence partitioning.

**9. Define compilation.**

Compilation combines translation and optimization. The high level language program is translated into the low level form of instructions; optimization is used to generate better instruction sequences.

**10. Write a note on assembler/interpreters for embedded systems. (May 19)**

Assembler translates high level language into machine language one by one translation. Interpreter constantly runs and interprets source code as a set of directives.

**11. Define compiler and cross compiler**

Compiler is software that translates high level language into machine code or machine language. A cross compiler is a kind of a compiler that runs on one type of machine but generates code for another machine. After compilation, the executable code is downloaded to the embedded system by a serial link or perhaps burned in a PROM and plugged in.

**12. What is meant by linking and loading? (May 19)**

Linking is the process of stitching several smaller pieces of the program together compiled by assembler to introduce modularity. Loading is the process of getting the starting address of the compiled small portions of the program to run consecutively.

**14. What is meant by Boot-block flash?**

Boot block flash is to keep the boot-up code in a protected block but it allows updates to other memory blocks on the device.

**15. What is meant by debugging?**

The process of identifying and correcting both hardware and software errors which deviates the system from intended way of operation is called debugging. Techniques used to identify and correct the bugs are called as the debugging techniques

**PART – B(C403.3)**

1. Explain the various debugging techniques in the development of debugging system. (May 16, Dec 16).
2. Discuss in detail the optimization of energy and power of an embedded system. (Dec 16) (Nov 18)
3. (i). Explain in detail about the compilation process in high level languages. .(May 17)(Nov 17)  
(ii). What are the program level performance analysis of embedded computing system design.
4. (i) Discuss in detail about the optimization of program size of an embedded system.(May 17)  
(ii) Discuss in detail various programming model?(May 17,18)
5. (i) Discuss briefly about Assembly and Linking.(May 18,Nov 19)  
(ii) What are program Validation and testing?(May 19,Nov 19)  
And  
(i) Describe about Basic compilation techniques  
(ii) Explain the debugging process(Nov 18)

**UNIT IV - REAL TIME SYSTEMS****PART – A(C403.4)**

1. What are real-time systems?



Real-time systems are systems that are bounded to give the response within a predefined period which is called as deadline. The deadline for the system is fixed considering the responsiveness and the constraints of the system.

**2. What is Hard Real-Time?**

Hard Real-time is applied in systems, where missing a deadline causes failure of the system. It is mainly followed in critical systems.

**3. What is Soft Real-Time?**

Soft Real-time is applied in systems, where missing a deadline causes degraded performance of the system. It is mainly followed in critical systems.

**4. Define Sampling Period.**

The length  $T$  of time between any two consecutive instants where samples are collected from the incoming signals namely sensor data or any other electrical signal is called as sampling period. The sampling period plays a key role in the effective functionality of the system

**5. Define Multi Rate Systems**

Multi Rate systems are systems that have more than one degree of freedom. Its state is defined by multiple state variables. In multi rate systems multiple processes run at different rates having different instantiation times and different deadlines.

**6. What is Dead-beat Control?**

A discrete-time control scheme that has no continuous-time equivalence is deadbeat control. In response to a step change in the reference input, a dead-beat controller brings the system to desired state by exerting on the system a fixed number of control commands.

**7. What is a Deadline?**

A deadline for a process is given as the time instant at which the process needs to be completed with its execution. The deadline is fixed based on the execution time of the process.

**8. Define Release Time.**

Release time of a process is given as the time instant at which the process becomes ready for execution. The process can only be taken for execution when the release time is met. Based on data dependencies further delay in execution of the process can happen.

**9. What is meant by response time?**

The response time of a process is given as the length of time from the release time of the process to the instant when it gets completed.

**10. Define Relative Deadline.**

The maximum allowable response time of the process can be given as the relative deadline of the process. Relative deadline of a process is considered when multiple process executions are happening simultaneously.

**11. What is meant by tardiness of a job?**

The tardiness of a job measures how late it completes relative to its deadline. Its tardiness is zero if the job completes at or before its deadline.

**12. What are sporadic or aperiodic jobs?**

The jobs which are triggered on the occurrence of external event are called as sporadic or aperiodic jobs. The release times of these jobs are not known until the triggering event occurs.

**13. Define Periodic Task Model**

A periodic task model can be defined as the workload model whose occurrence is deterministic in nature. The scheduling algorithms for these models have better performance and well understood behaviour.

**14. Define criticality of jobs.**

Criticality of jobs or importance of jobs can be given as the positive number that indicates how critical the job is with respect to other jobs. More critical the job is the bigger the criticality number of the job becomes.

**15. What is called as a scheduler?**

The model which executes the scheduling algorithms and resource access controls of the jobs is called as a scheduler.

**PART-B**

1. Explain in detail the Air Traffic Control System Hierarchy with relevant diagrams.
2. Explain about the radar signal processing and tracking system.
3. Compare hard real time vs soft real time systems in detail.
4. Explain with relevant diagrams the model of real-time systems.
5. Explain in detail about Least Slack Time or Minimum Laxity First Algorithm, also with example give the scheduling of processes done by the algorithm.
6. Explain about Clock Driven scheduling by formulation a network flow graph.

**UNIT V-PROCESSES AND OPERATING SYSTEMS****PART A****1. Define tasks and processes. (Dec 16)**

Tasks are part of system functionality whose application level organization is reflected in the structure of the program. Process is a single execution of a program having its own state that includes not only its registers but also its memory.

**2. Write about scheduling states present in the embedded system design./ Define the various process states. (Dec 16)**

1) A process can be in any one of these three scheduling states. They are: Waiting state- A process waiting for data from an I/O device or another process. 2) Ready state- Any process that could execute, 3) Executing- a process having all its data and ready to run and is selected by the scheduler.

**3. What are the strategies used for power optimization in multi-processing? (June '16)**

Multiprocessing for low power embedded computing requires several processors running at slower clock rates consuming less power than a single large processor. Performance scales linearly with power supply voltage but power scales with  $V^2$ .

**4. Define kernel.**

The kernel is the part of OS that determines processing time, activated by timer. The length of timer is called time quantum.

**5. Define CPU utilization. (Nov 19)**

It is a measure of the efficiency of the CPU. It is the ratio of the CPU time that is being used for useful computation to the total available CPU time.

**6. Define context switching. (May 18)**

These set of registers that define a process are known as its context and switching from one process registers set to another is known as context switching.

**7. Define rate monotonic scheduling. (Nov 18)**

It is a static scheduling policy which defines that fixed priorities are sufficient to efficiently schedule the processes in many situations.

**8. Define priority inversion. (May 17, 19)**

It is a situation in which the low priority process blocks the execution of a higher priority process by keeping hold of its resources.

**9. State the major functions of POSIX RTOS. (Nov 17)**

It is a Linux based OS. It has dual kernel based OS Core. It uses concepts like the Semaphores, Message Queue etc.

**10. Define Multitasking. (Nov 18) (Nov 19)**

The capability of the processor to execute multiple tasks simultaneously without hindering the outcome of each task with respect to time can be given as multitasking.

**11. Define multi-processing systems. (Nov 19)**

System in which there is more than one CPU is called as multiprocessor system. The simultaneous process of a number of different processes by different processors at the same time is termed as multiprocessing.

**14. List the advantages and limitations of Priority based process scheduling. (Nov 17) (May 19)**

Advantages of Priority based scheduling can be given as

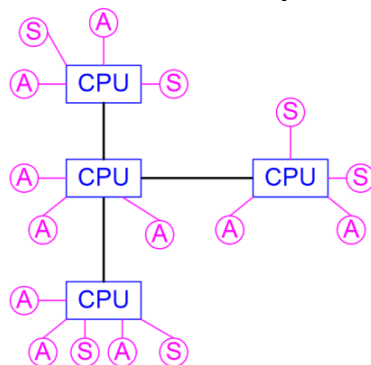
- Since process priorities are taken into consideration the execution slot is given to the process with the highest priority.
- Efficiency of the scheduling is greatly increased as dead slots or idle slots are removed.

Limitations of Priority Based Scheduling

It is done as two types as static and dynamic. The static scheduling requires less hardware resources but the CPU utilization is less but dynamic scheduling uses more hardware resources but the CPU utilization is better than the other.

**13. What is a distributed embedded architecture give the block diagram? (Nov 17) (May 18)**

In a distributed embedded system several processing elements are connected by a network that allows them to communicate. More than one computer or group of computer and PEs are connected via a network that forms distributed embedded systems.



S – Sensors, A- Actuators

**14. Distinguish multi-stage network from direct network. (Nov 18)**

**Multi-stage network:** Multi-stage network transmits messages from source to destination via some intermediate routing nodes to guide the data packets.





Direct network: Indirect network message goes from source to destination without going through any memory element or intermediate nodes.

**15. Distinguish single hop network from multi hop network. (Nov 19)**

In single hop network a message is received at its destination directly from the source without going through any other network node. In multi hop network messages are routed through network nodes to get to their destinations.

**16. What is MPSoCs?**

A multiprocessor system –on-chip that uses multiple cores usually targeted for embedded system.

**PART B**

1. Explain with a neat diagram inter process communication. **(May 16,17,19)(Nov 17, 18)**
2. Explain the real time operating system called Windows CE and POSIX in detail. **(Nov 17, 18,19)**
3. (i) Explain in detail earliest deadline first scheduling. **.(May 17)**  
(ii) Discuss in detail multi-tasking and multi-processing. **(Dec 16),(May 18)**
4. Discuss the various scheduling policies with example. **(May 18), (June 16)**
5. Explain how multiple processes are handled by Preemptive real time operating system. **(Nov 17)(May 19)(Nov 19)**
6. Discuss in detail about several interconnected networks especially used for distributed embedded computing. **(May 16,18)(Nov 18,19)**

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