



# SYED AMMAL ENGINEERING COLLEGE

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## DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

### EC6703 - EMBEDDED AND REAL TIME SYSTEMS

#### Unit-I

#### INTRODUCTION TO EMBEDDED COMPUTING AND ARM PROCESSORS

##### 1. What is an embedded system?

An embedded system employs a combination of hardware & software (a “computational engine”) to perform a specific function; is part of a larger system that may not be a “computer”; works in a reactive and time-constrained environment.

##### 2. What are the typical characteristics of an embedded system?

Typical characteristics:

- a. Perform a single or tightly knit set of functions;
- b. Increasingly high-performance & real-time constrained;
- c. Power, cost and reliability are often important attributes

Application specific processor design can be a significant component of some embedded systems.

Other characteristics:

- Application specific
- Digital signal processing in ECS
- Reactive
- Real-time
- Distributed

##### 3. What are the advantages of embedded system?

- Customization yields lower area
- power and cost.

##### 4. What are the disadvantages of embedded system ?

- Higher HW/software development overhead design,

- compilers, debuggers etc.,
- may result in delayed time to market

5. What are the applications of an embedded system?

Embedded Systems: Applications:

- Consumer electronics, e.g., cameras, camcorders,
- Consumer products, e.g., washers, microwave ovens,
- Automobiles (anti-lock braking, engine control,)
- Industrial process controllers & avionics/defence applications
- Computer/Communication

6. What are the real-time requirements of an embedded system?

Hard-real time systems: where there is a high penalty for missing a deadline

e.g., control systems for aircraft/space probes/nuclear reactors; refresh rates for video, or DRAM.

Soft real-time systems: where there is a steadily increasing penalty if a deadline is missed.

e.g., laser printer: rated by pages-per-minute, but can take differing times to print a page (depending on the \"complexity\" of the page) without harming the machine or the customer

7. What are the functional requirements of embedded system?

Data Collection

- Sensor requirements
- Signal conditioning
- Alarm monitoring

Direct Digital Control

- Actuators

Man-Machine Interaction

- Informs the operator of the current state of the controlled object
- Assists the operator in controlling the system.

8. What are the various embedded system requirements?

Types of requirements imposed by embedded applications:

- Functional requirements
- Temporal requirements
- Dependability requirements

9. What are the temporal requirements?

Tasks may have deadlines

- Minimal latency jitter

- Minimal error detection latency
- Timing requirements due to tight software control loops
- Human interface requirements.

10. Give the classification of embedded system.

- Multi-dimensional classifications
- Hard versus software systems
- Fail-safe versus fail-operational systems
- Guaranteed-response versus best-effort
- Resource-adequate versus resource-inadequate
- Event-triggered versus time-triggered.

11. What are the main components of an embedded system?

Three main components of embedded systems:

- The Hardware
- Application Software
- RTOS

12. Define embedded microcontroller.

An embedded microcontroller is particularly suited for embedded applications to perform dedicated task or operation.

Example: 68HC11xx, 8051, PIC, 16F877, etc.

13. What are the various classifications of embedded systems?

- . Small scale embedded systems
- . Medium scale embedded systems
- . Sophisticated embedded systems

14. What are the two essential units of a processor on an embedded system?

- . Program flow control unit (CU)
- . Execution unit (EU)

15. What does the execution unit of a processor in an embedded system do?

The execution unit implements data transfer and data conversion. It includes ALU and circuits that execute instruction for jump, interrupt, etc.

16. Give examples for general purpose processor.

- . Microprocessor
- . Microcontroller
- . Embedded processor
- . Digital Signal Processor
- . Media Processor

17. Define microprocessor.

A microprocessor fetches and processes the set of general-purpose instructions such as data transfer, ALU operations, stack operations, I/O operations and other program control operations.

18. What is the need for LCD and LED displays?

Uses of LCD and LED display:

- . It is used for displaying and messaging.
- . Example: Traffic light status indicator, remote controls, signals, etc.,
- . The system must provide necessary circuit and software for the output to LCD controller.

19. Give some examples for small scale embedded systems.

68HC05, PIC 16F8x, 8051, etc.

20. Give some examples for medium scale embedded systems.

8051, 80251, 80x86, 80196, 68HC11xx

21. Give some examples for sophisticated embedded systems.

ARM7, Power PC, Intel 80960, etc.

## **Unit- II**

### **EMBEDDED COMPUTING PLATFORM DESIGN**

1. Define bus.

Buses: The exchange of information.

Information is transferred between units of the microcomputer by collections of conductors called buses. There will be one conductor for each bit of information to be passed, e.g., 16 lines for a 16 bit address bus. There will be address, control, and data buses .

2. Give the advantages of interrupts .

The use of interrupts generally falls into the following categories,

- Input/output data transfers for peripheral devices

- Input signals to be used for timing purposes
- Emergency situations (power-down)
- Real-Time-executives/Multitasking
- Event driven programs

3. Give the steps for accomplishing input output data transfer.

#### ACCOMPLISHING INPUT/OUTPUT DATA TRANSFER

There are three main methods used to perform/control input/output data transfers. They are,

- Software programming (scanning or polling)
- interrupt controlled
- Direct memory access (DMA)

4. What do you meant by bus arbitration?

Bus Arbitration: Most processors use special control lines for bus arbitration,( i.e.) controlling the use of the address and data bus,

- an input which the DMAC uses to request the bus
- an output(s) indicating the bus status
- an output indicating acceptance of the DMAC\'s bus request

5. What do you meant by timer frequency?

A timer counts up a value every two clock cycles, and can be setup to count from an arbitrary value (Time) up to it\'s maximum value (256 in an 8-bit timer). The timer input clock is prescaled by N from the System Clock, meaning that N system cycles correspond to one timer clock cycle. Thus, the formula for base timer frequency in an 8-bit timer is  $Clk/2*N*(256-Time)$ .

6. What is an IDE?

An integrated development environment (IDE) (also known as an integrated design environment and integrated debugging environment) is computer software to help computer programmers develop software.

7. Define Object oriented interfacing.

In general, an interface is a device or a system that unrelated entities use to interact. According to this definition, a remote control is an interface between you and a television set, the English language is an interface between two people, and for e.g. protocol of behavior enforced in the military is the interface between people of different ranks.

#### 8. Define compilation.

Compilation comes translation and optimization. The high level language program is translated into lower level form of instructions, optimizations try to generate better instruction sequences.

Compilation = Translation + optimization

#### 9. Define frame buffer.

A frame buffer is a RAM that is attached to the system bus. The microprocessor writes values into the frame buffer in any order. The pixels in the frame buffer are generally written to the display in raster order by reading pixels sequentially.

### **Unit –III**

## **PROCESS AND OPERATING SYSTEMS**

#### 1. Define process.

A process is a program that performs a specific function.

#### 2. Define task and Task state.

A task is a program that is within a process. It has the following states:

1. Ready
2. Running
3. Blocked
4. Idle

#### 3. Define (TCB)

The TCB stands for Task Control Block which holds the control of all the tasks within the block. It has separate stack and program counter for each task.

#### 4. What is a thread?

A thread otherwise called a lightweight process (LWP) is a basic unit of CPU utilization, it comprises of a thread id, a program counter, a register set and a stack. It shares with other threads belonging to the same process its code section, data section, and operating system resources such as open files and signals.

## 5. What are the benefits of multithreaded programming?

The benefits of multithreaded programming can be broken down into four major categories:

- Responsiveness
- Resource sharing
- Economy
- Utilization of multiprocessor architectures

## 6. Define RTOS.

A real-time operating system (RTOS) is an operating system that has been developed for real-time applications. It is typically used for embedded applications, such as mobile telephones, industrial robots, or scientific research equipment.

## 7. Define task and task rates.

An RTOS facilitates the creation of real-time systems, but does not guarantee that they are real-time; this requires correct development of the system level software. Nor does an RTOS necessarily have high throughput — rather they allow, through specialized scheduling algorithms and deterministic behavior, the guarantee that system deadlines can be met. That is, an RTOS is valued more for how quickly it can respond to an event than for the total amount of work it can do. Key factors in evaluating an RTOS are therefore maximal interrupt and thread latency.

## 8. Define CPU scheduling.

CPU scheduling is the process of switching the CPU among various processes. CPU scheduling is the basis of multi-programmed operating systems. By switching the CPU among processes, the operating system can make the computer more productive.

## 9. Define Synchronization.

Message passing can be either blocking or non-blocking. Blocking is considered to be synchronous and non-blocking is considered to be asynchronous.

## 10. Define Inter process communication.

Inter-process communication (IPC) is a set of techniques for the exchange of data among multiple threads in one or more processes. Processes may be running on one or more computers connected by a network. IPC techniques are divided into methods for message passing, synchronization, shared memory, and remote procedure calls (RPC). The method of IPC used may vary based on the

bandwidth and latency of communication between the threads, and the type of data being communicated.

11. What is a semaphore?

Semaphores --software, blocking, OS assistance solution to the mutual exclusion problem basically a non-negative integer variable that saves the number of wakeup signals sent so they are not lost if the process is not sleeping another interpretation we will see is that the semaphore value represents the number of resources available .

12. When the error will occur when we use the semaphore?

- i. When the process interchanges the order in which the wait and signal operations on the semaphore muted.
- ii. When a process replaces a signal (mute) with wait (mute).
- iii. When a process omits the wait (mute), or the signal (mute), or both.

13. Define Remote Procedure Call.

Remote Procedure Calls (RPC) is a facility that allows a process on one machine to call a procedure that is executed by another process on either the same machine or a remote machine. Internally, RPC uses sockets as the underlying communication mechanism.

14. What is a Dispatcher?

The dispatcher is the module that gives control of the CPU to the process selected by the short-term scheduler. This function involves:

- Switching context
- Switching to user mode
- Jumping to the proper location in the user program to restart that program.

15. What is dispatch latency?

The time taken by the dispatcher to stop one process and start another running is known as dispatch latency.

16. What are the various scheduling criteria for CPU scheduling?

The various scheduling criteria are

- CPU utilization
- Throughput
- Turnaround time
- Waiting time
- Response time

17. Define throughput?

Throughput in CPU scheduling is the number of processes that are completed per unit time. For long processes, this rate may be one process per hour; for short transactions, throughput might be 10 processes per second.

18. What is turnaround time?

Turnaround time is the interval from the time of submission to the time of completion of a process. It is the sum of the periods spent waiting to get into memory, waiting in the ready queue, executing on the CPU, and doing I/O.

19. Define race condition.

When several process access and manipulate same data concurrently, then the outcome of the execution depends on particular order in which the access takes place is called race condition. To avoid race condition, only one process at a time can manipulate the shared variable.

20. What is critical section problem?

Consider a system consists of 'n' processes. Each process has segment of code called a critical section, in which the process may be changing common variables, updating a table, writing a file. When one process is executing in its critical section, no other process can allowed executing in its critical section.

## **Unit –IV**

### **SYSTEM DESIGN TECHNIQUES AND NETWORKS**

#### 1. Define accelerator.

An accelerator is one important category of processing element for embedded multiprocessor. It is attached to CPU buses to quickly execute certain key functions. It provides large performance for many applications with computational kernels. It provides critical speedups for low-latency I/O functions.

#### 2. What is meant by processing element?

Processing element is a unit which is responsible for performing computation. It may be programmable or not. Accelerator is one kind of processing element.

#### 3. Define multiprocessor.

A multiprocessor is any computer system with two or more processors coupled together. It is used in any application such as scientific, business, embedded system design, etc.

#### 4. What is the advantage of multiprocessors used in embedded system design?

The usage of multiprocessors in embedded system design has the following main advantages

1. Real time performance is high
2. Power consumption is very low
3. Low cost

#### 5. Define distributed embedded systems.

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

#### 6. Define packets.

In networks data can be transmitted in the form of packets only. A packet is one unit of binary data capable of being routed through a network. Packets are improved communication performance and reliability. Each packet sends a message between two network devices

7. Define arbitration.

Arbitration is the process of controlling simultaneous access of buses in distributed system.

Arbitration has two types

1. Fixed priority arbitration
2. Fair arbitration

8. Write down the networks for distributed embedded systems.

1. Point-to-point network
2. Cross bar network
3. Multistage network
4. Direct network

9. Define blocking.

Blocking refers to when an input terminal cannot be connected to an output terminal because there is not path available between them, i.e., all possible intermediate switches are occupied. Blocking means that there are some combinations of source and destinations for which messages cannot be delivered simultaneously.

10. Distinguish multistage network from direct network.

Multistage network: multistage network transmits messages from source to destination via some intermediate routing nodes to guide the data packets  
Direct network: in direct network message go from source to destination without going through any memory element or intermediate nodes.

11. Define I2C bus.

The I2C bus is a multimaster bus used to link microcontroller into system. It has two lines, one is serial data link (SDL) for data and the serial clock line (SCL) indicates when valid data are on the data line.

12. Define Ethernet.

Ethernet is a kind of local area network for general purpose computing. Because of its low cost it will use as a network for embedded computing. Ethernet is particularly useful when PCs are used as platform.

13. Define message passing?

Message passing is the style of interprocess communication. Distributed embedded system do not have shared memory, so they must communicate by passing messages known as message passing.

14. Define message delay.

To analyze the performance of the networks, it must be important to determine the delay incurred by transmitting messages. This message delay for a single message with no contention can be modeled as  $T_m = t_x + t_n + t_r$

15. Define internet protocol.

The IP is the fundamental protocol on the internet and it provides connectionless packet based communication. Industrial automation is a good application area for internet based embedded system.

## **UNIT-V**

### **CASE STUDY**

1. Define compressor.

Data compressor technique is process of reducing the amount of data needed for storage or transmission of a given piece of information using encoding techniques.

2. Define software modem

A software modem or soft modem is a modem with minimal hardware capacities designed to use a host computer's resources to perform most of the tasks performed by dedicated hardware in a traditional modem.

3. Applications of software modem

- Modem emulation
- Remote wakeup
- Device monitor
- Telecommunication

#### 4. Define STB

STB-Set Top Box is a device used to interface a video delivery services such as cable or satellite with a consumer television. Set top boxes for cable TV is traditionally based on analog circuit for television signal with a small amount of user interface functionality provided by a microcontroller.

#### 5. What is system on silicon?

Systems on silicon are the process of built as multiple chips connected on a printer circuit board. Many enabled systems are single chip systems known as systems on silicon or systems on a chip.

#### 6. Define ASIP.

An application specific instruction processor (ASIP) is a GPU whose instruction set has been optimized for a particular set of applications.

#### 7. List out some examples of hardware co-systems.

- a. Automobiles
- b. GPS
- c. Microwaves
- d. Network routers
- e. ATM machines
- f. Aircrafts

#### 8. What are the hardware requirements of STB?

- a. Processor
- b. Modem
- c. Decoder
- d. Graphic processor
- e. Front end amplifier

#### 9. How many methods in data compression class?

There are three methods are available for data compressor class.

- a. Encode method
- b. New symbol table method
- c. Flush method

#### 10. Advantages of software modem

- a. It can be easily upgradable of newer modem
- b. It is less cost and less weight
- c. Low power consumption

