

ANDHRA LOYOLA INSTITUTE OF ENGINEERING AND TECHNOLOGY
DEPARTEMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
Embedded Systems (ES)

Year/Semester: IV/I

Section: ECE II

A.Y:2021-22

Teacher/Instructor: Mr. Y.Pavan Kumar

Designation : Assistant Professor

Course objectives:

- 1) The basic concepts of an embedded system are introduced.
- 2) The various elements of embedded hardware and their design principles are explained.
- 3) Different steps involved in the design and development of firmware for embedded systems is elaborated.
- 4) Internals of Real-Time operating system and the fundamentals of RTOS based embedded firmware design is discussed.
- 5) Fundamental issues in hardware software co-design were presented and explained.
- 6) Familiarise with the different IDEs for firmware development for different family of processors/controllers and embedded operating systems.
- 7) Embedded system implementation and testing tools are introduced and discussed.

Course Outcomes: After this course, the students will be

1.	Factual	CO1: Able to understand the basic concepts of Embedded Systems and identify the basic constituents in constructing an Embedded System.
2.	Conceptual	CO 2: Able to understand the operations of the hardware elements necessary in Embedded system design. CO 3: Able to understand the basics of embedded firmware and the mechanism of interrupt handling w.r.t embedded firmware design. CO 4: Able to learn the concepts of process, thread, multiprocessing, multithreading etc within an operating system and able to understand the hardware and software trade-offs.
3.	Procedural	CO5: Able to learn and practice various tools used in embedded software development.
4.	Applied	CO 6: Able to learn various platforms and tools for embedded system implementation and apply the knowledge in testing the system design.

Text Books:

1. Embedded Systems Architecture- By Tammy Noergaard, Elsevier Publications, 2013.
2. Embedded Systems-By Shibu.K.V-Tata McGraw Hill Education Private Limited, 2013.

References:

1. Embedded System Design, Frank Vahid, Tony Givargis, John Wiley Publications, 2013.
2. Embedded Systems-Lyla B.Das-Pearson Publications, 2013.

Contents/Activities:

1	Factual	1.NPTEL Videos & Online tutorials 2.Discussion on identifying the basic constituents in constructing an Embedded System.
2	Conceptual	1.NPTEL Videos & Online tutorials 2.Discussion on Embedded system design. 3.Discussion on mechanism of Interrupt handling and necessity of OS in Embedded system design.
3	Procedural	1.NPTEL Videos & Online tutorials 2.Discussion on steps involved in Embedded software development using various tools.
4	Applied	1.NPTEL Videos & Online tutorials 2.Discussion on Embedded system Implementation and Testing.

Schedule and Sequence:

Session/week/ Module	Topic	Objectives	Before Class - Videos, e-Books, Case studies	In-Class – Activities, Quiz	Post Class - Assignment, Discussion Forum
UNIT-1: INTRODUCTION					
1	Embedded System – Definition, History of Embedded Systems	To understand the basic concept of embedded system and its evolution.	1. https://www.youtube.com/watch?v=uFhDGagZzjs 2. https://www.youtube.com/watch?v=gp24Bf47Xww 3. https://www.youtube.com/watch?v=Xyn0Oh5jlTc	1.Introduction to Embedded systems (10min) 2.General system vs Embedded system (10min) 3.Definition of Embedded system (10min) 4.History of evolution of Embedded systems (20min)	Discussion on Embedded system definition Discussion on Historical evolution of Embedded systems.
2	Classification of Embedded systems, Application areas of Embedded Systems	To understand the embedded system classification and to familiarize with its application areas.	1. https://www.youtube.com/watch?v=FUWnYHBGw1o 2. https://www.youtube.com/watch?v=nccWuB5vpxI	1.Classification of Embedded systems(20min) 2.List of Application areas involving Embedded systems (25min)	Discussion on classification of Embedded systems. Discussion on applications of Embedded systems.

3	Purpose of Embedded Systems, Core of the Embedded System	To understand the purpose of embedded system and choosing appropriate processing unit for the system.	1. https://www.youtube.com/watch?v=gLzTB15z-ac 2. https://www.youtube.com/watch?v=slt2GEhH0T8 3. https://www.youtube.com/watch?v=UB-iNp-VdRI	1.Purpose of Embedded systems (15min) 2.Processing unit classification (35min)	Assignment: List of Processing units involved in embedded system
4	Memory	To understand the memory requirements within the embedded system.	1. https://www.youtube.com/watch?v=4WnTTL_7a1g 2. https://www.youtube.com/watch?v=r787m_IaR1I	1.Requirement of memory (5min) 2.Classification of Memory devices (30min) 3.Differentiation of memory devices (15min)	Assignment: Differentiation of various memory devices used in embedded system
5	Sensors and Actuators	To understand the appropriate input and output peripherals while finalizing an embedded system.	1. https://www.youtube.com/watch?v=F0cNJjfVe-U 2. https://www.youtube.com/watch?v=cx6z0mkVF9E 3.	1.Definition of Sensor and Actuator (10min) 2.operation of various sensors and actuators (40min)	Assignment: 1.List out various Sensing devices used in embedded system 2.List out various Output devices and Actuating devices used in embedded system

			https://www.youtube.com/watch?v=jrjMQ_GW3-c		
6	Communication Interface	To learn multiple communication technologies and to opt for proper technology.	1. https://www.youtube.com/watch?v=-cTHIYr6yxk 2. https://www.youtube.com/watch?v=vNMV3ArRZkw 3. https://www.youtube.com/watch?v=GwSeZwHh-LU	1.Importance of communication module in Embedded system (15min) 2.List of various modes of communication interfaces and their explanation (35min)	Assignment: List of various modes of Communication interfaces.
7	Embedded Firmware	To understand the basics of firmware and its importance in embedded system.	1. https://www.youtube.com/watch?v=IyGwvGzrqp8 2. https://www.youtube.com/watch?v=3YfZcNUhBKU	1.Definition of Firmware (10min) 2.Importance of Firmware and its operational steps in embedded system (40min)	Discussion on Firmware involvement in Embedded system.

8	Characteristics of an Embedded System	To familiarize with the characteristics of an embedded system.	1. https://www.youtube.com/watch?v=_iPJsg3L6g0 2. https://www.youtube.com/watch?v=_jirRF-UwP3Y 3. https://www.youtube.com/watch?v=_E12c9D8xb00	List of Characteristics of an embedded system (50min)	Discussion on Characteristics of embedded system
9	Quality Attributes of Embedded System	To know the important quality attributes to properly finalize the system.	1. https://www.youtube.com/watch?v=_iPJsg3L6g0 2. https://www.youtube.com/watch?v=_jirRF-UwP3Y 3. https://www.youtube.com/watch?v=_E12c9D8xb00	List of Quality Attributes of an embedded system (50min)	Discussion on Quality attributes of embedded system
11	Application Specific and Domain Specific examples of an Embedded System	To learn various case studies about real time applications of embedded systems.	1.	1.Application areas of	Discussion on Real-time case studies of

			https://www.youtube.com/watch?v=YzwXsh9fetY 2. https://www.youtube.com/watch?v=WOMuM2ANH_U	embedded system (10min) 2.Real-time examples of embedded system (40min)	embedded applications
UNIT-2: EMBEDDED HARDWARE DESIGN					
1	Analog electronic Components	To know the list of analog electronic components for designing an embedded system.	1. https://www.youtube.com/watch?v=6Maq5IyHSuc 2. https://www.youtube.com/watch?v=OEL5laB3hfU 3. https://www.youtube.com/watch?v=KSylo01n5FY	1.Importance of Analog electronic components (10min) 2.operation of various Analog electronic components (40min)	Assignment: List out various Analog electronic components required for designing an embedded system
2	Digital electronic Components	To know the list of digital electronic components for designing an embedded system.	1. https://www.youtube.com/watch?v=X2HPjppH7Rs&list=PLnQ-Hds	1.Importance of Digital electronic components (10min) 2.operation of various Digital	Assignment: List out various Digital electronic components required for

			gVrOOv0t3-I9X8ZTrYqmGLSsSg 2. https://www.youtube.com/watch?v=Kxix-iQIU10&list=PLnQ-HdsgVrOOv0t3-I9X8ZTrYqmGLSsSg&index=2	electronic components (40min)	designing an embedded system
3	I/O Types and Examples	To learn the various Input/ Output mechanisms and selecting a proper mechanism for a system.	1. https://www.youtube.com/watch?v=0XybwAbup-w	1.List of various I/O modes (10min) 2.Operation of various I/O modes (40min)	Assignment: List of various I/O types and their operation in detail.
4	Serial Communication Devices	To understand the importance of serial communication in embedded system designing.	1. https://www.youtube.com/watch?v=IyGwvGzrqp8 2. https://www.youtube.com/watch?v=ODKOflL7sB4 3.	1.Concept of Serial communication (15min) 2.List of various Serial communication devices and their protocols (30min+45min)	Assignment: Differentiate between Synchronous and Asynchronous communication and their examples.

			https://www.youtube.com/watch?v=8ttajS2OM3U 4. https://www.youtube.com/watch?v=twaeLkE6eS8		
5	Parallel Device Ports	To learn the application of parallel communication mechanism wherever necessary in embedded system	1. https://www.youtube.com/watch?v=qY_RcIjWOo 2. https://www.youtube.com/watch?v=P6Q5QZAZ8yc 3. https://www.youtube.com/watch?v=EHdi72VVvB4	1. Concept of parallel communication (10min) 2. operation of various parallel communication devices (40min)	Assignment: Differentiate between Serial and Parallel communication mechanisms.
6	Wireless Devices	To understand the importance of wireless communication technologies for establishing the communication with embedded system.	1. https://www.youtube.com/watch?v=P3FqwQhVRnc 2. https://www.youtube.com/watch?v=5CNcpcpItg	1. List of various Wireless communication protocols (10min) 2. Operation of various wireless communication	Assignment: Comparison of various wireless communication protocols

				protocols (40min+45min)	
7	Timer and Counting Devices	To learn the operation of timing and counting devices required in the processing unit.	1. https://www.youtube.com/watch?v=C5xZkBItO-M 2. https://www.youtube.com/watch?v=YozRo7miOlA	1. Concept of Timers and Counters (20min) 2. Operation of Timing devices (40min) 3. Operation of Counting devices (40min)	Assignment: 1. Differentiate between Timers and Counters. 2. Explain the operation of Timing devices in embedded system
8	Watchdog Timer	To understand the importance of watchdog timer device for a controlled operation within an embedded system.	1. https://www.youtube.com/watch?v=O11dMyhWssA 2. https://www.youtube.com/watch?v=upKWLPF2eDA	1. Concept of Watchdog Timer (10min) 2. Applications involving Watchdog timer (40min)	Discussion on importance and operation of Watchdog timer.
9	Real-time Clock	To understand the importance of Real-Time Clock in embedded system	1. https://www.youtube.com/watch?v=NvIIvonHnDg 2.	1. Concept of Real-time Clock (10min) 2. Applications involving Real-time Clock (40min)	Discussion on importance and operation of Real-time Clock.

			https://www.youtube.com/watch?v=hFr6bEvnBU		
UNIT-3: EMBEDDED HARDWARE DESIGN					
1	Embedded Firmware Design Approaches	To learn and understand the designing approaches while developing the embedded firmware.	1. https://www.youtube.com/watch?v=LBe0-s7G1c4 2. https://www.youtube.com/watch?v=Xk-MFLosCIQ 3. https://www.youtube.com/watch?v=lp5ktjeuZ5A	1. Concept of Firmware (10min) 2. Designing approaches of embedded firmware (40min)	Discussion on Embedded firmware approaches
2	Embedded Firmware Development Languages	To learn and familiarize with the languages required to develop the embedded firmware.	1. https://www.youtube.com/watch?v=lnDg6WRPahE 2. https://www.youtube.com/watch?v=KD77tmBbpLc	Explanation of various firmware development languages (50min)	Discussion on programming languages used for firmware development
3	ISR Concept	To learn the importance of providing Interrupts within the embedded system development.	1.	1. Concept of Interrupts (15min)	Assignment: Consider a case study to explain the mechanism of ISR

			https://www.youtube.com/watch?v=YBI9gljYAaQ 2. https://www.youtube.com/watch?v=gxgGv-eMD_0	2.Explanation of Interrupt Service Routine (35min)	
4	Interrupt Sources	To understand the various sources of interrupts for handling multiple events.	1. https://www.youtube.com/watch?v=Kju5UMLC7hg 2. https://www.youtube.com/watch?v=mA1TbzXtZSM	1.List of various interrupt sources (10min) 2.Explanation of various interrupt sources in different architectures (40min)	Assignment: Consider an architecture to explain the various sources of interrupt.
5	Interrupt Servicing Mechanism	To understand the handling of interrupts and learn the usage of interrupt vector tables.	1. https://www.dauniv.ac.in/public/frontend/assets/coursematerial/embeddedsystems/Chap_6_Lesson05EmSys3EIntr_Vectors.pdf	1.Difference of vectored and non-vectored interrupts (20min) 2.Explanation of Interrupt vector table (30min) 3.Explanation of maskable and non maskable	Assignment: 1.Explain the operation of Interrupt vector table 2.Differentiate between Maskable & Non maskable interrupts

				interrupt servicing mechanism (40min)	
6	Multiple Interrupts	To understand the possibility of handling multiple interrupt sources and their events.	1. https://www.youtube.com/watch?v=W_yvQS0HjoE 2. https://www.youtube.com/watch?v=m2SLffi8VWY 3. https://www.youtube.com/watch?v=z0JPJ3cq-uo 4. https://www.youtube.com/watch?v=bbhXlqZw2n4	Explanation of handling multiple interrupt sources (50min)	Discussion on handling multiple interrupts
7	Direct Memory Access (DMA)	To understand the mechanism of Direct Memory Access and its application in I/O transfer.	1. https://www.youtube.com/watch?v=Th0JT3Ba2oY 2.	Concept of Direct Memory Access and its operation (50min)	Assignment: Explain the operation of Direct Memory Access (DMA)

			https://www.youtube.com/watch?v=wipo2SesoE		
8	Device Driver Programming	To understand the concept of Device drivers and its relevant approaches for programming.	1. https://www.edn.com/embedded-systems-architecture-device-drivers-part-1-interrupt-handling/ 2. https://pace.edu.in/images/course-materials/Embedded_system/module3/Chap_4Lesson05Device%20Driver.pdf	1. Concept of Device Drivers. (10min) 2. Explanation of Device drivers for various devices in embedded system (40min+40min)	Assignment: Discuss the importance of Device Drivers in embedded system
9	Concepts of C Vs Embedded C	To understand and analyze the concepts of C and Embedded C.	1. https://www.youtube.com/watch?v=mwrfGFATB3o 2. https://www.youtube.com/watch?v=kiAx5lSFoUk	1. Brief discussion of C language (30min) 2. Differences between C & Embedded C (20min+40min)	Discussion on C vs Embedded C

10	Compiler Vs Cross-Compiler	To understand the steps involved in various compilation stages of Compiler and Cross-Compiler.	1. https://www.youtube.com/watch?v=CEVNB_QEtcI 2. https://www.youtube.com/watch?v=e4ax90XmUBc	1. Definition of Compilers and Cross-compilers (10min) 2. Explanation of steps involved in Compiler and Cross-compiler (40min)	Discussion on Compilers and Cross-compilers
UNIT-4: REAL-TIME OPERATING SYSTEM					
1	Operating System Basics	To familiarize with the concepts of Operating Systems basics.	https://www.youtube.com/watch?v=RozoeWzT7IM	1. Explanation of basic concepts of Operating Systems.(45min)	Discussion on Concept of Operating Systems.
2	Types of Operating Systems	To understand the classification of Operating Systems.	https://www.youtube.com/watch?v=RozoeWzT7IM	Classification of Operating systems.(45min)	Discussion on various types of Operating systems
3	Tasks	To understand the importance of Task concept in OS	https://www.youtube.com/watch?v=ITc09gOrqZk	Definition of Task.(10min) Explanation(35min)	Assignment: Explain the concept of Task in OS
4	Processes	To know the importance of Process in OS	https://www.youtube.com/watch?v=OrM7nZcxXZU	1. Definition of Process(10min)	Discussion on Process concept.

			https://www.youtube.com/watch?v=O3EyzlZxx3g	2.Difference between Task and Process(10min) 3.concept of Process(30min)	
5	Threads	To familiarize with the concept of Threads	https://www.youtube.com/watch?v=wVsWEABeKWk	Differentiate between the Task, Process and Threads.(45min)	Assignment: Differentiate between the Task, Process and Threads.
6	Multiprocessing & Multitasking	To understand the basics of Multiprocessing and Multitasking	https://www.youtube.com/watch?v=NdTnVA6Eq9s https://www.youtube.com/watch?v=wVsWEABeKWk	1. Definition of Multiprocessing & Multitasking.(10 min) 2. Importance (35min)	Discussion on Multiprocessing and Multitasking.
7	Task Scheduling	To understand the properties and features of Task Scheduling	https://www.youtube.com/watch?v=95yUbClyf3E	1.Need of Scheduling(10min) 2.Importance of Task Scheduling (40min)	Discussion on Task Scheduling and TCB
8	Processes and Scheduling	To know the scheduling mechanism of Processes	https://www.youtube.com/watch?v=95yUbClyf3E	Explanation of Process Scheduling (45min)	Discussion on Process Scheduling

9	Task Communication	To understand the Communication between tasks within the OS.	https://www.youtube.com/watch?v=wP49MIONttk	Concept of Communication between Tasks and their resource sharing (40min + 45min)	Discussion on Task Communication
10	Task Synchronisation	To understand the resource sharing during task synchronization	https://www.youtube.com/watch?v=N9HVKtNAfz4	1.Resource sharing (15min) 2.Task synchronization (45min + 30min)	Discussion on Task Synchronization
11	Device Drivers	To understand the importance of Device drivers	https://www.youtube.com/watch?v=IbVBW2qZfhw	1.Definition(10min) 2.Role of Device drivers in OS (40min)	Case study related discussion on Device drivers
HARDWARE SOFTWARE CO-DESIGN					
12	Fundamental Issues	To list out the fundamental issues of Hardware Software Co-design	https://www.youtube.com/watch?v=-N1I3wiQPI0	1.Meaning of Hardware Software co-design (10min) 2.Fundamental issues (35min)	Discussion on Fundamental issues of Hardware Software Co-design
13	Computational Models	Understanding the Computational models required in H/W S/W Co-design	https://www.youtube.com/watch?v=RKYQRRQsuLA	Usage of Computational models (45min)	Discussion on Computational models.
14	Hardware Software Trade-offs	Identifying the H/W S/W Trade-offs	https://www.youtube.com/watch?v=BWCsYnCj2Xk	Trade-offs necessity on H/W S/W CO-design (45min)	Discussion on Trade-offs.

15	Integration of Hardware and Firmware	Understand the Integration process and requirements of Hardware and Firmware	https://www.youtube.com/watch?v=v0eZKCCwXms	Requirement of H/W & F/W integration (45min)	Discussion on Integration of H/w and F/W
16	ICE	Understand the In-circuit Emulation of Embedded System design	https://www.youtube.com/watch?v=9vfiTH4F1hI	Use of various ICE techniques.	Discussion on ICE
UNIT-5: EMBEDDED SYSTEM DEVELOPMENT					
1	Integrated Development Environment	1.To observe the Synthesized net list of gate level modelling 2.To observe the synthesized net list of data flow modelling	https://www.youtube.com/watch?v=FBX5GDr9Nwg	Introduction(5 min) Explanation of synthesis of Net list of structured primitives with an example (25 min) Explanation of synthesis of set of continuous assignment statements with an example (20 min)	Assignment: Write and draw the synthesised deign of 2x1 MUX with continuous assignment statement
2	Cross-Compilation Files	To observe the synthesized net list of behavioural flow modelling	https://www.youtube.com/watch?v=oq_TsDsrDq8	1.Definition of cyclic behavior (10 min) 2.A simple Example(40 min)	Assignment: Write and draw the synthesised deign of 2-bit counter with continuous assignment statement

3	Deassembler/Decompiler	To observe the net list of synthesized of priority structures	https://www.youtube.com/watch?v=DB1IOkDT1D0	1.definition of priority structures (10 min) 2.a simple example (40 min)	Assignment: Write and draw the synthesised design of 4x1 mux using 2x1 mux
4	Simulators	Verifying the netlist results of don't care conditions	https://www.youtube.com/watch?v=CpTvACCBf-U	Simple Design which is having the don't care conditions (25 min) Generating the synthesized design for it(25 min)	Assignment: Write and draw the synthesised design of 4-bit priority encoder
5	Emulators and Debugging	To observe the synthesized generated unwanted components list in net list	https://www.youtube.com/watch?v=IEp_vQyKx0c	Simple Design which is having the accidental latches conditions (25 min) Generating the synthesized design for it(25 min)	Assignment: Write and draw the synthesised design of 2-bit subtractor
6	Target Hardware Debugging	To observe the synthesized generated components list in net list	https://www.youtube.com/watch?v=S4ckIeifpN0	Simple Design which is having the intentional latches conditions (25 min) Generating the synthesized design for it(25 min)	Assignment: Write and draw the synthesised design of 2-bit ALU with operations like add, xor, inversion, nand and nor

7	Boundary Scan	To verify the net list for a sequential logic	https://www.youtube.com/watch?v=UuDf3q5aBjM	A program for 4-bit parallel loading register(25 min) A program for Data swapping (15 min) A program for An empty register(10 min)	Assignment: Write and draw the synthesised design of MOD-10 counter
8	Embedded Software Development process and Tools	To verify the net list for a state machine based sequential logic	https://www.youtube.com/watch?v=XVCrWrOVdyY	Synthesis of BCD-Excess-3 code converter (50 min)	Assignment: Write and draw the synthesised design of 4-bit Binary- BCD converter
UNIT-6: EMBEDDED SYSTEM IMPLEMENTATION AND TESTING					
1	Software Utility Tool	To implement and verify the functionality of static RAM Memory	https://www.youtube.com/watch?v=WqAeVjAly6I	1.Introduction(5 min) 2.Design of Static RAM with R/W(15 min) 3.Verilog model of Static RAM(30 min)	Assignment: Write a verilog model for DRAM with stimulus
2	CAD and Hardware	To design and verify the transfer of data through 486 bus Model	https://www.youtube.com/watch?v=WqAeVjAly6I	1.Definition of bus (5 min) 2.History of 486 bus model(10 min) 3.Implementation through verilog (35 min)	Discussion forum: Comparison of latest bus architectures

3	Pre-Processors	To understand the interfacing model of memory to microprocessor bus	https://www.youtube.com/watch?v=509GC9oKk-Q	1.A simplified bus inter bus unit (10 min) 2.SM chart of interface unit (15 min) 3.Timing waveforms of interfacing units(25 min)	Assignment: Design a memory circuit with 8086 microprocessor
5	Interpreters	To understand and verify the UART design through verilog modelling	https://www.youtube.com/watch?v=qcEBXrqFLe8	1.UART transmitter and receiver architectures (20 min) 2.Verilog models of UART transmitter and receivers (30 min)	Assignment: Write a verilog model for USART with stimulus
6	Compilers and Linkers	To design and verify the microcontroller of the central processing unit using verilog modelling	https://www.youtube.com/watch?v=QNBKWHneOxk	1.Micro-controller design(15 min) 2.Verilog model of micro controller CPU (35 min)	Quiz: quiz on unit-6

Evaluation:

Formative Assessment – 50%

Summative Assessment – 50%