Curriculum Structure for Double Minor Degree in Embedded System

(In light of NEP 2020)

(NEP_Version II)

Offered By

Department of Electronics & Telecommunication Engineering

For students admitted in 2023-24 onwards

Government College of Engineering, Amravati

(An Autonomous Institute of Government of Maharashtra)
Near Kathora Naka, Amravati, Maharashtra
PIN 444604
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A. **Preamble:**

In line with the transformative Vision of National Education Policy (NEP) 2020, a flexible, multidisciplinary, and holistic education system, the Department of Electronics & Telecommunication Engineering is offering a Double Minor specialization in the domain of Embedded Systems and Industrial IoT. These courses are designed for students of Electrical Engineering, Instrumentation Engineering, Computer Science, Information Technology, Mechanical, and Civil Engineering, providing them with domain-complementary skills that are increasingly critical in the digital and automated era.

The Double Minor track empowers students to acquire industry-relevant knowledge and hands-on exposure in cutting-edge areas such as ARM-based embedded system design, real-time operating systems, system interfacing, design verification, industrial IoT, and edge computing. These courses not only align with the Industry 4.0 vision but also promote interdisciplinary learning, nurturing future-ready engineers capable of working across domains.

The courses are complimented through NPTEL-SWAYAM platforms, offered by premier institutes like IITs, ensuring academic rigor, national-level certification, and alignment with global technological standards. This approach supports student-centric learning, flexible credit transfer, and horizontal mobility, all of which are core tenets of NEP 2020.

B. **Embedded Systems and Industrial IoT skill set**

- Structured across five specialized courses from the 3rd to 7th semesters
- **Industry-relevant knowledge** in embedded systems and IoT technologies.
- **Hands-on exposure** to ARM-based system design, real-time operating systems, hardware interfacing, and system verification.
- **Insights into emerging technologies** such as Industrial IoT and Edge Computing.
- These courses are strategically aligned with the **Industry 4.0 paradigm**, fostering interdisciplinary learning and preparing students to become **future-ready engineers** capable of innovating across domains.

C. **Program-Specific Outcomes For Embedded Systems and Industrial IoT**

- **Embedded System Proficiency**: Apply principles of embedded system design—including microcontroller programming, real-time operating systems, and hardware interfacing—to develop efficient and reliable embedded applications.
- **Industrial IoT Integration**: Design and implement intelligent, connected systems using Industrial IoT technologies such as edge computing, cloud platforms, and smart sensing for applications in automation and smart infrastructure.
- **Interdisciplinary Application and Lifelong Learning**: Demonstrate the ability to apply embedded and IoT knowledge across engineering domains, while engaging in continuous learning through nationally recognized platforms in alignment with NEP 2020.

D. **Eligibility criteria:** Students enrolled in Computer Science & Engg, Information Technology, Electrical Engineering, Instrumentation Engineering, Mechanical, and Civil Engineering are eligible. The allotment of double minor degree programme will be as per the policy of the Institute.

Students with minimum **CGPA of 7.5** without backlog courses at the end of fourth semester and should have earned from 1 to 4 Sem total mentioned credits are eligible for admission to the UG Bachelor's Degree with Honours/ Research/ Double Minor. Courses under this category must be completed in online mode through SWAYAM/ NPTEL or equivalent platform which provides evaluation mechanism. Credits/Marks Obtained under this category are directly mapped to mention teaching evaluation scheme. At the time of registration, if mention course is not available on SWAYAM/ NPTEL or equivalent platform , then DFB will provide available alternative/equivalent course.

E. **Structure of the Honors course:**

E&Tc Department offer Double Minor (Embedded System)														
Category	**Course Code**	**Name of the Course**	**Teaching Scheme**				**Evaluation Scheme**							**Credits**
							Theory				**Practical**		**Total**	
			TH	TU	PR	Total	CT1	**CT2**	TA	ESE	ICA	ESE		
MN1	ET1541	Embedded System Design with ARM	03	00	00	03	15	15	10	60	00	00	100	3
MN2	ET1542	Embedded System Interfacing	03	00	00	03	15	15	10	60	00	00	100	3
MN3	ET1641	RTOS	03	00	00	03	15	15	10	60	00	00	100	3
MN4	ET1642	Embedded System Design Verification	03	00	00	03	15	15	10	60	00	00	100	3
MN5	ET1741	Industrial IoT	03	00	00	03	15	15	10	60	00	00	100	3
MN6	ET1742	IoT Edge	03	00	00	03	15	15	10	60	00	00	100	3
Total			18	--	--	18	--	--	--	--	--	--	600	**18**

F. **Career Pathways:** Graduates will be equipped for roles in:

- Embedded Systems Design & Development: Hardware-software integration, real-time systems, and microcontroller-based applications
- Industrial IoT & Automation Engineering: Smart manufacturing, industrial communication, automation systems, and Industry 4.0
- IoT Systems & Edge Intelligence**:** Connected devices, cloud-edge integration, and AI/ML at the edge
- Research and higher education in signal processing and allied fields

MINOR COURSES FOR DOUBLE MINOR

Course Code	ET1541							Course category			MN
Course Name	EMBEDDED SYSTEM DESIGN WITH ARM										
Teaching Scheme				Examination Scheme							Credits
Th	Tu	Pr	Total	Theory					Practical		Total	
				CT1	CT2	TA	ESE	ESE Duration	ICA	ESE		
03	00	00	03	15	15	10	60	2 hrs 30 min	00	00	100	03

Course Objectives: Students undergoing this course are expected to

I. To study the concept of Embedded System Design.
II. To study architecture and inbuilt peripherals of ARM Microcontroller.
III. To recognize the importance task scheduling in real time embedded systems.
IV. To understand the developmental aspects of Internet of Things (IoT) based designs.

Course Contents:

Introduction to embedded systems and microcontrollers: Building blocks of Embedded systems: Core of the Embedded system, Memory Devices, Sensors and Actuators, Communication Interface, Embedded Firmware, Other System components, Characteristics of Embedded systems, Quality attributes of Embedded System.

Introduction to ARM Microcontroller: ARM microcontroller, History, Features and ARM family and its inbuilt Peripherals, Instruction set architecture of ARM microcontroller, and assembly language programming.

ARM Application and Programming: D/A and A/D converter, sensors, actuators and their interfacing Microcontroller development boards and embedded programming platforms

Features of ARM Microcontroller: Temperature sensing unit, Light sensing unit, Sound sensing unit, Feedback control system, relay control unit, driving electrical appliances like motors, bulb, pump, etc.

Introduction to IoT: Introduction to Internet of Things, smart home concepts, motion sensing using accelerometer, control of appliances over SMS

Text Book:

1. Embedded System Design: A Unified Hardware/Software Introduction, F. Vahid and T. Givargis, Wiley India Pvt. Ltd., 2002.
2. Introduction to Embedded System, Shibu K. V, McGraw Hill Education

Reference Book:

1. ARM System Developer's Guide: Design and Optimizing System Software, A.N. Sloss, D. Symes and C. Wright, Morgan Kaufman Publishers, 2004.

2. Computers as Components: Principles of Embedded Computing System Design, W. Wolf, Morgan Kaufman Publishers, 2008.

Web Resources:

http//Embedded System Design With ARM - Course

Course Outcome:

On completion of the course, students will be able to

ET1541.1 Recognize the concept of Embedded Systems.
ET1541.2 Articulate the architecture and inbuilt peripherals of ARM Microcontroller.
ET1541.3 Evaluate the programming of AVR Microcontroller in C.
ET1541.4 Compare task, process & threads in Real Time Embedded System.
ET1541.5 Access Internet of Things with Embedded Entities.

CO-PO-PSO Mapping as per NBA Jan -2016 Format:

CO	PO / PSO														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
ET1541.1	0	0	1	1	0	0	0	2	1	0	0	1	0	0	0
ET1541.2	1	0	0	0	1	0	0	1	0	0	1	0	0	0	0
ET1541.3	1	0	0	0	0	1	0	1	0	0	0	1	0	1	1
ET1541.4	0	0	0	0	0	0	0	1	1	2	0	1	0	0	2
ET1541.5	0	0	0	0	2	1	1	1	0	0	0	0	0	1	0

0 - Not correlated 1 - Weakly Correlated 2 - Moderately Correlated 3 - Strongly Correlated

CO-PO-PSO Mapping as per NBA 1-Jan-2025 Format

CO	PO/PSO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
ET1541.1	0	0	1	1	0	0	2	1	0	1	0	0	0	0
ET1541.2	1	0	0	0	1	0	1	0	0	0	1	0	0	0
ET1541.3	1	0	0	0	0	1	1	0	0	1	0	0	1	1
ET1541.4	0	0	0	0	0	0	1	1	2	1	0	0	0	2
ET1541.5	0	0	0	0	2	1	1	0	0	0	0	0	1	0

0 - Not correlated 1 - Weakly Correlated 2 - Moderately Correlated 3 - Strongly Correlated

Course Code	ET1542							Course category			MN
Course Name	EMBEDDED SYSTEM INTERFACING										
Teaching Scheme				Examination Scheme							Credits
Th	Tu	Pr	Total	Theory					Practical		Total	
				CT1	CT2	TA	ESE	ESE Duration	ICA	ESE		
03	00	00	03	15	15	10	60	2 hrs 30 min	00	00	100	03

Course Objectives: Students undergoing this course are expected to

I. To understand core of the Embedded System
II. To develop practical technical skills among the students to integrate various sensing, actuation units
III. To recognize the importance task scheduling in real time embedded systems.
IV. To get acquainted with architecture & design of an Embedded System.

Course Content

Introduction: Overview of embedded system; Importance of sensors, actuators and interfacing circuits in embedded control system; Characteristics; Applications. Embedded Sensors and Actuators**:** Various types of important sensors, actuators and their working principles: e.g. thermal, mechanical, electrical, magnetic, optical, chemical, smart material and meta material based.

Interfacing Aspects of Sensors and Actuators to Embedded Controller and their Communication Protocols: Signal conditioning circuits; Various Op-Amp based interfacing circuit implementation: Amplifier, Filter, ADC, DAC etc.; Various Serial Communication protocols for interfacing.

Advancement in Interfacing Schemes of Resistive Sensors for Linearity Improvement and Error Reduction: Resistive sensor examples; non-idealities in basic interfacing circuits; Linearization techniques; Error reduction schemes due to environmental effects and remote communication.

Advanced Techniques for Direct Interfacing of Resistive Sensors with Embedded controller: Embedded controller-based excitation system; Direct interfacing schemes of various resistive sensors topologies (e.g., single, differential and bridge type) to microcontrollers; Interfacing scheme for sensor array.

Advanced Techniques for Direct Interfacing of Capacitive Sensors with Embedded Controller: Capacitive sensor examples; Interfacing scheme for different capacitive sensor configurations; Direct interfacing schemes. Advancement in Design of Interfacing Circuits for Lossy Capacitive Sensors; Lossy Capacitive sensor characteristics; Various advanced interfacing schemes for lossy capacitive sensor.

Miniaturization Technology for Smart Sensors and Actuators: Background of miniaturization; Miniaturized device fabrication process technology for Smart sensors and actuators. Miniaturized Sensors, Actuators and their Interfacing Electronics**:** Various types of important MEMS sensors and actuators: Design and operation; Interfacing Electronics for MEMS Devices; System-on-Chip integration; Application.

Text Book:

1. Sensors, Actuators, and their Interfaces, Nathan Ida,1st ed., SciTech Publishing, 2014.
2. Analog Interfacing to Embedded Microprocessor Systems, Stuart R. Ball, Elsevier, 2004.
3. Advanced Interfacing Techniques for Sensors, B. George, J. Roy, V. Jagadeesh Kumar, S. C. Mukhopadhyay, 1st ed., Springer, 2017

Reference Book:

1.Sensors and Signal Conditioning, John G. Webster and Ramón Pallás-Areny, John Wiley & Sons, 2nd ed., 2000.
2. Fundamentals of Microfabrication and Nanotechnology, Marc Madou, 3rd ed., 2018.
3. Smart Sensors and MEMS, S. Nihtianov, A. Luque, 1st ed., Elsevier, 2014
4. Instrument Engineers Handbook, Bela G Liptak, CRC press, 4th ed., 2003.
5. Understanding Automotive Electronics: An Engineering Perspective, William B. Ribbens, Elsevier, 8th ed., 2017.

Web Resources:

https://onlinecourses.nptel.ac.in/noc24_ee68/preview

Course Outcome: On completion of the course, students will be able to

ET1542.1 Recognize the concept of Embedded Systems

ET1542.2 Summarize the quality attributes of Embedded System

ET1542.3 Perform effectively as entry level Embedded Systems professionals

ET1542.4 Interfacing Aspects of Sensors and Actuators to Embedded Controller and their Communication Protocols

ET1542.5 Direct Interfacing of Resistive Sensors and Capacitive Sensors with Embedded Controller

CO-PO-PSO Mapping as per NBA Jan -2016 Format

CO	PO / PSO														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
ET1542.1	1	0	0	0	0	1	0	2	1	0	0	1	0	0	0
ET1542.2	1	0	0	0	1	0	0	1	0	0	1	0	1	0	0
ET1542.3	1	0	0	0	0	1	0	1	0	0	0	1	0	1	1
ET1542.4	0	0	0	0	0	0	0	1	1	2	0	1	1	0	2
ET1542.5	0	0	0	0	2	1	1	1	0	0	0	0	1	1	0

0 - Not correlated 1 - Weakly Correlated 2 - Moderately Correlated 3 - Strongly Correlated

CO-PO-PSO Mapping as per NBA 1-Jan-2025 Format

CO	PO/PSO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
ET1542.1	1	0	0	0	0	1	2	1	0	1	0	0	0	0
ET1542.2	1	0	0	0	1	0	1	0	0	0	1	1	0	0
ET1542.3	1	0	0	0	0	1	1	0	0	1	0	0	1	1
ET1542.4	0	0	0	0	0	0	1	1	2	1	0	1	0	2
ET1542.5	0	0	0	0	2	1	1	0	0	0	0	1	1	0

0 - Not correlated 1 - Weakly Correlated 2 - Moderately Correlated 3 - Strongly Correlated

Course Code	ET1641							Course category			MN
Course Name	REAL TIME OPERATING SYSTEM										
Teaching Scheme				Examination Scheme							Credits
Th	Tu	Pr	Total	Theory					Practical		Total	
				CT1	CT2	TA	ESE	ESE Duration	ICA	ESE		
03	00	00	03	15	15	10	60	2 hrs 30 min	00	00	100	03

Course Objectives: Students undergoing this course are expected

I. To introduce the principles shared by many real-time operating systems,
II. To Understand use in the development of embedded multitasking application software
III. To Study UNIX as Real Operating system.

Course Contents:

Introduction: Introduction to Operating System: Computer Hardware Organization, BIOS and Boot Process, Multi-threading concepts, Processes, Threads, Scheduling

Basics of Real-Time Concepts: Terminology: RTOS concepts and definitions, real-time design issues, examples, Hardware Considerations: logic states, CPU, memory, I/O, Architectures, RTOS building blocks, Real-Time Kernel Basics of Tast Scheduling. Cyclic Executives, Cyclic Scheduler.

Process Management: Concepts, scheduling, IPC, RPC, CPU Scheduling, scheduling criteria, scheduling algorithms Threads: Multi-threading models, threading issues, thread libraries, synchronization Mutex: creating, deleting, prioritizing mutex, mutex internals.

Inter Process Communication: Messages, Buffers, mailboxes, queues, semaphores, deadlock, priority inversion, Pipes Management: - Process stack management, run-time buffer size, swapping, overlays, block/page management, replacement algorithms and real time garbage collection.

RMA Generalization, Resource Sharing among Real time tasks, Solution and Priority inversion problem, Highest Locker protocol.

Case Studies: Case study Linux POSIX system, RTLinux / RTAI, Windows system, Vxworks, uItron Kernel Design Issues: structure, process states, data structures, inter-task communication mechanism, Linux Scheduling

Text Book:

1. J. J Labrosse, MicroC/OS-II: The Real –Time Kernel, Newnes, 2002.
2. Jane W. S. Liu, Real-time systems, Prentice Hall, 2000.

Reference Book:

1.W. Richard Stevens, Advanced Programming in the UNIX® Environment, 2nd Edition, Pearson Education India, 2011.
2. Philips A. Laplante, Real-Time System Design and Analysis, 3rd Edition, John Wley& Sons, 2004 3. Doug Abbott, Linux for Embedded and Real-Time Applications, Newnes, 2nd Edition, 2011.

Web Resources:

https://archive.nptel.ac.in/courses/106/105/106105172/

Course Outcome:

On completion of the course, students will be able to
ET1641.1 Understand the fundamental concepts of real-time operating systems.
ET1641.2 Understand hardware Consideration in RTOS.
ET1641.3 Understand Process Management and Synchronization.
ET1641.4 Access the Concept of RMA Generalization.
ET1641.5 Case Studies In Different Area of RTO

CO-PO-PSO Mapping as per NBA Jan-2016 Format

CO	PO / PSO														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
ET1641.1	0	0	0	1	1	0	0	0	0	1	0	0	2	0	0
ET1641.2	0	1	0	1	0	0	2	0	0	2	1	1	0	0	0
ET1641.3	2	1	0	0	0	0	0	0	1	0	0	0	0	1	1
ET1641.4	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0
ET1641.5	1	0	0	0	0	0	0	2	0	0	0	0	2	0	0

0 - Not correlated 1 - Weakly Correlated 2 - Moderately Correlated 3 - Strongly Correlated

CO-PO-PSO Mapping as per NBA 1-Jan-2025 Format

CO	PO / PSO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
ET1641.1	0	0	0	1	1	0	0	0	1	0	0	2	0	0
ET1641.2	0	1	0	1	0	0	2	0	2	1	1	0	0	0
ET1641.3	2	1	0	0	0	0	0	1	0	0	0	0	1	1
ET1641.4	0	0	0	0	1	0	1	0	0	1	0	0	0	0
ET1641.5	1	0	0	0	0	0	2	0	0	0	0	2	0	0

0 - Not correlated 1 - Weakly Correlated 2 - Moderately Correlated 3 - Strongly Correlated

Course Code	ET1642							Course category			MN
Course Name	EMBEDDED SYSTEM DESIGN VERIFICATION										
Teaching Scheme				Examination Scheme							Credits
Th	Tu	Pr	Total	Theory					Practical		Total	
				CT1	CT2	TA	ESE	ESE Duration	ICA	ESE		
03	00	00	03	15	15	10	60	2 hrs 30 min	00	00	100	03

Course Objectives: Students undergoing this course are expected

I. To introduce the principles and modelling technique in Embedded system Design
II. To Understand use in the development of embedded multitasking application software
III. To get acquainted with architecture & design of an Embedded System.
IV. To Understand Digital testing and Embedded System hardware Testing.

Course Content:

Introduction: Introduction to Hardware design, Hardware and software Portioning, Architectural Synthesis of hardware, system level design: uniprocessor scheduling, Multiprocessor scheduling.

Temporal logic: Introduction and basic operators of temporal logic. Syntax and Semantics of CTL. Equivalence between CTL formulas, Model checking Algorithm.

BDD and Symbolic model checking: Binary decision diagram, use of OBDDs for state transition System, Symbolic Model checking.

Introduction to Digital Testing: Introduction to Digital VLSI Testing, Automatic test pattern generation (ATPG). Introduction to Embedded system hardware testing: Scan chain based sequential circuit testing, Software-Hardware co-validation fault modes and high-level testing for complex embedded system.

Embedded System hardware testing: Testing for Embedded cores, Bus and Memory Testing. Advanced in embedded system hardware testing: Testing for advanced faults in real time embedded System. BIST for embedded Systems.

Text Book:

1. Introduction to Embedded System, Shibu K. V., McGraw Hill Education
2. Embedded Real-time Systems Programming, S.V. Iyer & Pankaj Gupta, McGraw Hill Education
3. AVR Microcontroller and Embedded systems using assembly and C, Muhammad Ali Mazidi, Sarmad Naimi and Sephers Naimi, Pearson Education, Inc. publishing as Prentice Hall 2013.

Reference Book:

1. Embedded Systems, Rajkamal, 2nd Edition, Tata McGraw Hill
2. Scheduling in Real Time Systems, Cottet, Delacroix & Mammeri, John Wiley & Sons.

Web Resources:

https://archive.nptel.ac.in/courses/106/103/106103182/

Course Outcome:

On completion of the course, students will be able to

ET1642.1 Understand Hardware design And Interfaces in embedded System.
ET1642.2 Understand Temporal logic, Syntax and Semantics of CTL
ET1642.3 Understand BDD and Symbolic model checking.
ET1642.4 Knowledge of Digital Testing
ET1642.5 Access to Advanced hardware testing.

CO-PO-PSO Mapping as per NBA Jan-2016 Format

CO	PO / PSO														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
ET1642.1	0	0	0	1	1	0	0	0	0	1	0	0	2	0	0
ET1642.2	0	1	0	1	0	0	2	0	0	2	1	1	0	0	0
ET1642.3	2	1	0	0	0	0	0	0	1	0	0	0	0	1	1
ET1642.4	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0
ET1642.5	1	0	0	0	0	0	0	2	0	0	0	0	2	0	0

0- Not Correlated 1-Weakly Correlated 2-Moderately Correlated 3- Strongly Correlated

CO-PO-PSO Mapping as per NBA 1-Jan-2025 Format

CO	PO / PSO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
ET1642.1	0	0	0	1	1	0	0	0	1	0	0	2	0	0
ET1642.2	0	1	0	1	0	0	2	0	2	1	1	0	0	0
ET1642.3	2	1	0	0	0	0	0	1	0	0	0	0	1	1
ET1642.4	0	0	0	0	1	0	1	0	0	1	0	0	0	0
ET1642.5	1	0	0	0	0	0	2	0	0	0	0	2	0	0

0 - Not correlated 1 - Weakly Correlated 2 - Moderately Correlated 3 - Strongly Correlated