

# Minor Stream Courses (MSC)

## Minor Streams

- Minor Stream in VLSI
- Minor Stream in Embedded Systems
- Minor Stream in Signal Processing and Communication Technology
- Minor Stream in Space Technology
- Minor Stream in Technology for Digital Resilience Industry Integrated Program- L & T
- Minor Stream in Smart Infrastructure (Electronics) Industry Integrated Program- L & T

### Minor Stream: VLSI

Course Code	Course Name	Level	L	T	P	C	CIE	SE E	Total	Pre- requisite
241EC086	Digital System Design Through Verilog	IC	2		1	3	50	50	100	DELD
241EC022	Design for Testability	IC	3			3	50	50	100	DDTV
241EC023	CMOS Digital IC Design	IC	3			3	50	50	100	DELD
241EC030	Testing & Verification of VLSI Circuits	IC	3			3	50	50	100	VLSI, DFT
241EC024	Analog VLSI Design	IC	3			3	50	50	100	VLSI
241EC025	CMOS Mixed Signal IC Design	AC	2		1	3	50	50	100	CDICD, AVLSI
241EC028	Low Power VLSI Design	AC	3			3	50	50	100	VLSI
241EC027	FPGAs & ASIC Design	AC	3			3	50	50	100	DDTV
241EC029	SoC Design	AC	3			3	50	50	100	MPMC
241EC026	Digital Design Through System Verilog	AC	3			3	50	50	100	DDTV
241EC031	VLSI Physical Design	AC	2			2	50	50	100	LPVLSID
	<b>Total</b>		<b>30</b>		<b>2</b>	<b>32</b>				

## Digital System Design through Verilog

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code:241EC086</b>	<b>2</b>	<b>0</b>	<b>1</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Infer the design process of HDL based digital systems.
- CO2:** Interpret Verilog HDL modelling at various levels of abstraction.
- CO3:** Develop Combinational Logic Circuits using Verilog HDL Program.
- CO4:** Model sequential Logic Circuits using Verilog HDL Program.
- CO5:** Construct synchronous sequential circuits using finite state machines.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	3	1			2			1	2		1
<b>CO2</b>	2	3			2			2	2		1
<b>CO3</b>	2	3	3	2	2			2	2		1
<b>CO4</b>	2	3	3	2	2			2	2		1
<b>CO5</b>	2	3	3	1	2			2	2		1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>		2
<b>CO2</b>		2
<b>CO3</b>		2
<b>CO4</b>		2
<b>CO5</b>		2

## UNIT – I

### Introduction to Verilog HDL Design Concepts:

The Design flow for VHDL/Verilog HDL, Introduction to CAD Tools, Introduction to Verilog HDL , Structure of Verilog module, signals in Verilog code, identifier names, net and variable types, signal values, numbers and parameters, Operators,tasks and functions.

#### Practice:

1. Write a Verilog code to perform arithmetic and logic operations using operators.
2. Write a Verilog code to perform shift operation on the given data using shift Operators

## UNIT – II

### **Digital logic design using Verilog HDL:**

Structure of Verilog Data flow description, Verilog Structural description, Concurrent statements, Verilog Behavioral Description, Procedural statements, The case statement, If and if-else constructs, For loop, While loop, Programming at various Levels of abstractions- Logic gates, Half Adder, full Adder, Half Subtractor, full Subtractor, Verilog test bench, Introduction to Switch level Modelling.

#### **Practice:**

1. Verify the functionality of logic gates with the help of Verilog code using operators and gate primitives.
2. Design a full adder using two half-adders and an OR gate using structural modeling.
3. Design a full subtractor using if-else and case constructs.

## UNIT – III

### **Combinational logic circuit design using Verilog HDL:**

Dataflow and structural description of Multiplexers, Decoders, Encoders, Code converters, Arithmetic comparison circuits, Ripple-Carry Adder, Carry Look-Ahead Adder, Multiplier, Arithmetic and Logic Unit.

#### **Practice:**

1. Construct a BCD to 7-Segment decoder using continuous assignment statements.
2. Design a 8X3 encoder using for loop construct.
3. Design a n-bit ripple Carry adder using structural modeling.

## UNIT – IV

### **Sequential Logic Design using Verilog HDL:**

Latches and flip flops, Ring Counter, Johnson Counter, Design of Modulus N Synchronous Counters, Shift Registers, Universal Shift Registers, Behavioral description of sequential circuits using Verilog HDL.

#### **Practice:**

1. Construct a 4-bit ring Counter using Verilog Behavioral modeling.
2. Design a 4-bit universal shift register Verilog Structural modeling.

## UNIT – V

### **Synchronous Sequential Circuits using Verilog HDL:**

Basic design steps: State diagram, state table, state assignment, choice of flip flops and derivation of next state and output expressions, timing diagram. Mealy and Moore type FSM for serial adder, Verilog HDL code for the serial adder.

**Practice:**

1. Write a Verilog HDL code for the serial adder.

**Text Books:**

1. Fundamentals of Digital Logic with Verilog Design- Stephen Brown, Zvonko Vranesic, McGrawHill, 3<sup>rd</sup> Edition, ISBN: 978-0-07-338054-4.
2. Advanced digital design with the Verilog HDL, Michael D. Ciletti, Eastern economy Edition, PHI, ISBN: 9789332584464.

**Reference Books:**

1. A Verilog HDL primer by J.Bhaskar, Star galaxy publishing, 3<sup>rd</sup> Edition, 2018, ISBN: 9780984629244.
2. Design through Verilog HDL by T. R. Padmanabhan, B. Bala Tripura Sundari, A John Wiley & Sons, Inc., Publication, ISBN: 978-0-471-44148-9.

**Web Links:**

1. <http://nptel.ac.in/courses/117105080/> by Prof.D. Roy chauthry, IIT Kharagpur
2. <http://nptel.ac.in/courses/117106086/1> by Prof.S.Srinivasan, IIT Madras
3. [https://onlinecourses-archive.nptel.ac.in/noc17\\_cs21/course](https://onlinecourses-archive.nptel.ac.in/noc17_cs21/course) by Prof. Indranil Sen Gupta, IIT Kharagpur

## Design for Testability

**Course Code: 241EC022**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Interpret the fault modeling and logic simulation.
- CO2:** Develop test pattern for combinational logic circuits.
- CO3:** Develop test pattern for sequential logic circuits.
- CO4:** Outline the testable sequential circuits.
- CO5:** Outline the testable memory circuits.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	3	2									1
<b>CO2</b>	3	2									1
<b>CO3</b>	3	2									1
<b>CO4</b>	3	2	1								1
<b>CO5</b>	3	2	1								1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>		2
<b>CO2</b>		2
<b>CO3</b>		2
<b>CO4</b>		2
<b>CO5</b>		2

## UNIT – I

### Introduction to Testing:

Testing Philosophy, Role of Testing, Digital and Analog VLSI Testing, VLSI Technology Trends affecting Testing, Types of Testing, Fault Modeling: Defects, Errors and Faults, Functional Versus Structural Testing, Levels of Fault Models, Single Stuck-at Fault.

## UNIT – II

### Logic and Fault Simulation:

Simulation for Design Verification and Test Evaluation, Modeling Circuits for Simulation, Algorithms for True value Simulation, Algorithms for Fault Simulation.

### UNIT – III

SCOAP Controllability and Observability, High Level Testability Measures, Digital DFT and Scan Design: Ad-Hoc DFT Methods, Scan Design, Partial-Scan Design, Variations of Scan.

### UNIT – IV

#### **Built-In Self-Test:**

The Economic Case for BIST, Random Logic BIST: Definitions, BIST Process, Pattern Generation, Response Compaction, Built-In Logic Block Observers, Test-Per-Clock, Test-Per-Scan BIST Systems, Circular Self-Test Path System, Memory BIST, Delay Fault BIST.

### UNIT – V

#### **Boundary Scan Standard:**

Motivation, System Configuration with Boundary Scan: TAP Controller and Port, Boundary Scan Test Instructions, Pin Constraints of the Standard, Boundary Scan Description Language: BSDL Description Components, Pin Descriptions.

#### **Text Books:**

1. Essentials of Electronic Testing for Digital, Memory and Mixed Signal VLSI Circuits -M.L. Bushnell, V. D. Agrawal, Kluwer Academic Publishers, ISBN: 9780792379911.
2. Digital Systems and Testable Design, M. Abramovici, M.A.Breuer and A.D Friedman, Jaico Publishing House, ISBN: 0-9660176-3-3.

#### **Reference Books:**

1. Digital Circuits Testing and Testability - P.K. Lala, Academic Press, ISBN: 9780124343306.
2. Digital Systems and Testable Design - M. Abramovici, M.A.Breuer and A.D.Friedman, Jaico Publishing House, ISBN: 0-9660176-3-3.

#### **Web Links:**

1. <https://www.slideshare.net/labishettybhanu/trends-and-challenges-in-vlsi>
2. <http://www.engr.uconn.edu/~tehrani/teaching/test>
3. <http://nptel.ac.in/courses/106103116/34>
4. <http://eesemi.com/bist.html>

## CMOS Digital IC Design

**Course Code: 241EC023**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Summarize the design parameters of MOS logic.
- CO2:** Build combinational circuits using CMOS logic.
- CO3:** Build sequential circuits using CMOS logic.
- CO4:** Infer the dynamic characteristics of CMOS logic.
- CO5:** Analyze the semiconductor memories for logic design.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	3	2									1
<b>CO2</b>	3	2									1
<b>CO3</b>	3	2									1
<b>CO4</b>	3	2	1								1
<b>CO5</b>	3	2	1								1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>		2
<b>CO2</b>		2
<b>CO3</b>		2
<b>CO4</b>		2
<b>CO5</b>		2

### UNIT – I

#### MOS Design:

Pseudo NMOS Logic: Inverter, Inverter threshold voltage, Output high voltage, Output Low voltage, Gain at gate threshold voltage, Transient response, Rise time, Fall time, Pseudo NMOS logic gates, Transistor equivalency, CMOS Inverter logic.

### UNIT – II

#### Combinational MOS Logic Circuits:

MOS logic circuits with NMOS loads, Primitive CMOS logic gates – NOR & NAND gate, Complex Logic circuits design – Realizing Boolean expressions using NMOS gates and CMOS

gates, AOI and OIA gates, CMOS full adder, CMOS transmission gates, Designing with Transmission gates.

### UNIT – III

#### **Sequential MOS Logic Circuits:**

The behavior of bi-stable elements, SR Latch, Clocked latch and flip-flop circuits, CMOS D latch, and edge-triggered flip-flop.

### UNIT – IV

#### **Dynamic Logic Circuits:**

Basic principle, Voltage Bootstrapping, Synchronous dynamic pass transistor circuits, Dynamic CMOS transmission gate logic, High-performance Dynamic CMOS circuits.

### UNIT – V

#### **Semiconductor Memories:**

Types, RAM array organization, DRAM – Types, Operation, Leakage currents in DRAM cell and refresh operation, SRAM operation Leakage currents in SRAM cells, Flash Memory- NOR flash and NAND flash.

#### **Text Books:**

1. CMOS Digital Integrated Circuits Analysis and Design, Sung-Mo Kang, Yusuf Leblebici, TMH, 3<sup>rd</sup> Edition, ISBN: 9780072925074.
2. Digital Integrated Circuits, Jan M Rabaey, Pearson Education, 2<sup>nd</sup> Edition, ISBN: 9780130909961.

#### **Reference Books:**

1. Introduction to VLSI Systems: A Logic, Circuit and System Perspective, Ming - BO Lin, CRC Press, ISBN: 9781439868591.
2. Digital Integrated Circuits –A Design Perspective, JanM.Rabaey, Anantha Chandrakasan, Borivoje Nikolic, PHI, 2<sup>nd</sup> Edition, ISBN: 9789332573925.
3. Digital Integrated Circuit Design, Ken Martin, Oxford University Press, ISBN: 9780195125849.

#### **Web Links:**

1. <https://subodhtripathi.files.wordpress.com/2012/01/0072460539cmos1.pdf>
2. [https://onlinecourses.nptel.ac.in/noc21\\_ee09/preview\(By Prof. Sudeb Dasgupta, IIT Roorkee\)](https://onlinecourses.nptel.ac.in/noc21_ee09/preview(By Prof. Sudeb Dasgupta, IIT Roorkee))

### **Testing & Verification of VLSI Circuits**

**Course Code:241EC030**

**L T P C**  
**3 0 0 3**

**Course Outcomes:**

**At the end of the course, student will be able to:**

- CO1:** Infer the challenges in VLSI Testing at different abstraction levels.
- CO2:** Explain the fault models for generation of test vectors.
- CO3:** Analyze the observability and controllability parameters of circuit.
- CO4:** Make use of simulation techniques for designing and testing of VLSI circuits.
- CO5:** Identify characteristics of verification methods.

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	1	1									1
CO2	1	1									1
CO3	1	1									1
CO4	2	2	2								1
CO5	2	2									1

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2
CO1		2
CO2		2
CO3		2
CO4		2
CO5		2

**UNIT – I**

**Basics of Testing:**

Fault models, Combinational logic and fault simulation, Test generation for Combinational Circuits. Current sensing-based testing. Classification of sequential ATPG methods. Fault collapsing and simulation.

**UNIT – II**

**Universal test sets:**

Pseudo-exhaustive and iterative logic array testing. Clocking schemes for delay fault testing. Testability classifications for path delay faults. Test generation and fault simulation for path and gate delay faults.

### UNIT – III

#### **Delay fault testing:**

Introduction, Combinational test generation, Combinational fault simulation, Combinational delay fault diagnosis, Sequential test generation, Sequential fault simulation, Pitfalls in delay fault testing and some remedies, Unconventional delay fault testing techniques. CMOS testing: Testing of static and dynamic circuits. Fault diagnosis: Fault models for diagnosis, Cause- effect diagnosis, Effect-cause diagnosis.

### UNIT – IV

#### **High-level test synthesis:**

Introduction, RTL test generation, RTL fault simulation, RTL design for testability, RTL built-in self-test, Behavioral modification for testability, Behavioral synthesis for testability.

### UNIT – V

#### **Verification Techniques:**

Introduction to Hardware Verification and methodologies Binary Decision Diagrams (BDDs) and algorithms over BDDs Combinational equivalence checking Temporal Logics modelling sequential systems and model checking Symbolic model checking.

#### **Text Books:**

1. Testing of Digital Systems, N. Jha & S.D. Gupta, Cambridge, ISBN: 0 521 77356 3.
2. VLSI Test Principles and Architectures Design for Testability, W.W. Wen, Morgan Kaufmann Publishers, ISBN: 978-0123705976.

#### **Reference Books:**

1. Essentials of Electronic Testing for Digital, memory & Mixed signal VLSI Circuits, Michael L. Bushnell & Vishwani D. Agrawal, Kluwer Academic Publishers, ISBN: 9780792379911.
2. Digital circuit Testing and Testability, P. K. Lala, Academic Press, ISBN: 9780124343306.

**Web Links:**

1. [https://archive.nptel.ac.in/courses/106/103/106103116/\(Prof. Jatindra Kumar Deka, IIT Guwahati\)](https://archive.nptel.ac.in/courses/106/103/106103116/(Prof.%20Jatindra%20Kumar%20Deka,%20IIT%20Guwahati))
2. <https://www.maven-silicon.com/blog/difference-between-vlsi-verification-and-vlsi-testing/>

## Analog VLSI Design

Course Code: 241EC024

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Illustrate the MOS I/V, C-V Characteristics & Single Stage amplifie.
- CO2:** Analyze the characteristics of CMOS differential Amplifier & Current Mirrors.
- CO3:** Develop the knowledge of Bandgap Reference.
- CO4:** Analyze the two stage CMOS operational amplifiers.
- CO5:** Develop basic Analog layout & CMOS Processing based knowledge acquired in the course.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	3	1									1
<b>CO2</b>	1	3		2							1
<b>CO3</b>	1	3	2	2							1
<b>CO4</b>	2	3	2								1
<b>CO5</b>	2	2	3								1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>		1
<b>CO2</b>		3
<b>CO3</b>		2
<b>CO4</b>		3
<b>CO5</b>		3

## UNIT – I

**Introduction to Analog Design-** Basic MOS Device Physics, MOSFET Structure, MOS I/V Characteristics, MOS Transconductance, Second-Order Effects, MOS Device Capacitances. Single-Stage Amplifiers- Common-Source Stage with Resistive Load, CS Stage with Diode-Connected Load, CS Stage with Current-Source Load.

## UNIT – II

**Differential Amplifier-** Basic Differential Pair, Qualitative Analysis, Common-Mode Response. Differential Pair with MOS Load. Current Mirrors and Biasing Techniques- Basic Current Mirrors, Cascode Current Mirrors, Active Current Mirrors-Large Signal Analysis, Small Signal Analysis, Biasing Techniques – CS biasing, CG Biasing .

## UNIT – III

### **Band Gap References:**

General Considerations, Supply-Independent Biasing, Temperature-Independent References, PTAT Current Generation, Constant-Gm Biasing, Low-Voltage Band Gap References.

## UNIT – IV

### **MOS Operational Amplifier:**

General Considerations, One-Stage Op Amps, Two-Stage Op Amps, Gain Boosting, Output Swing Calculation, Common Mode Feedback– Basic Concepts, CM sensing Techniques, CM feedback Techniques, Input Range Limitations, Slew Rate, Power Supply Rejection.

## UNIT – V

### **CMOS Processing Technology:**

General Considerations, Photolithography, Oxidation, Ion Implantation, Deposition and Etching. Analog Layout Techniques- Antenna Effect ,Multifinger Transistors,Well Proximity Effect, Latch Up Prevention.

### **Text Books:**

1. Design of Analog CMOS Integrated Circuits by Behzad Razavi 2<sup>nd</sup> Edition, ISBN:9780071188395, 0071188398 .
2. R.Jacob Baker,H.W.Li, and D.E. Boyce CMOS Circuit Design, Layout and Simulation, Prentice-Hall of India, ISBN:9781118038239, 1118038231 .

### **Reference Books:**

1. Analog Integrated Circuit Design- David A. Johns, Ken Martin, Wiley Student Edn, ISBN:9788126517787, 8126517786
2. Analysis and Design of Analog Integrated Circuits, ISV by Meyer Gray,Hurst,Lewis. 5<sup>th</sup> Edition, ISBN:9788126521487, 8126521481 .

**Web Links:**

1. [https://onlinecourses.nptel.ac.in/noc23\\_ee142/preview\(Prof. Imon Mondal, IIT Kanpur\)](https://onlinecourses.nptel.ac.in/noc23_ee142/preview(Prof. Imon Mondal, IIT Kanpur))
2. <https://nptel.ac.in/courses/117101105> (Prof. A.N. Chandorkar, IIT Bombay)

## CMOS Mixed Signal IC Design

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 241EC025</b>	<b>2</b>	<b>0</b>	<b>1</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Infer the characteristics of CMOS based Switched capacitor and PLL.
- CO2:** Analyze the performance of sampling circuits.
- CO3:** Demonstrate the non idealities of data converters.
- CO4:** Apply appropriate techniques and tools in development of data converters.
- CO5:** Model the frequency and Q tunable time domain filters.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	3	2			2			1	1		1
<b>CO2</b>	3	2			2			1	1		1
<b>CO3</b>	3	2			2			1	1		1
<b>CO4</b>	1	2	3		2			1	1		1
<b>CO5</b>	1	2	3		2			1	1		1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>		2
<b>CO2</b>		2
<b>CO3</b>		2
<b>CO4</b>		2
<b>CO5</b>		2

## UNIT – I

### PLL & Switched Capacitors:

Characterization of a comparator, Basic CMOS comparator design, Analog multiplier, PLL – simple PLL, charge-pump PLL, applications of PLL, Switched Capacitor circuits – basic principles, switched capacitor sensitive integrator and insensitive integrator, switched capacitor filter, switched capacitor amplifier.

#### Practice:

1. Design of PLL
2. Design of switched capacitor circuits.

## UNIT – II

### **Sampling Circuits:**

Basic sampling circuits for Analog signal sampling, performance metrics of sampling circuits, different types of sampling switches. Sample-and-Hold Architectures: Open-loop & closed-loop architectures, open-loop architecture with miller capacitance, multiplexed-input architectures, recycling architecture.

#### **Practice:**

1. Design Sample hold circuit.
2. Estimation of open loop Miller capacitance.

## UNIT – III

### **Digital-to-Analog Conversion:**

Input/output characteristics of an ideal D/A converter, performance metrics of D/A converter, Resistor string 3-bit DAC, Binary scale DACs, Cyclic DAC. D/A Converter architectures: Resistor-Ladder architectures, current-steering, Pipeline DAC.

#### **Practice:**

1. Design of basic DAC.
2. Design of Resistor string 3-bit DAC.

## UNIT – IV

### **Analog-To-Digital Conversion:**

Input/output characteristics and quantization error of an A/D converter, performance metrics of A/D converter. A/D converter architectures: Flash architectures, interpolate and folding architectures, pipelined architectures, Ramp type ADC, Integrating (Dual slope) ADC, Successive approximation architectures, Sigma Delta ADC , Design of Decimation filter.

#### **Practice:**

1. Design of basic ADC.
2. Design of Successive approximation ADC.

## UNIT – V

### **Analog CMOS Filters :**

Low Pass filters, active-RC fully differential integrator, Two transistor MOSFET- C integrator, gm-C Integrator, Active RC integrators.

#### **Practice:**

1. Design of first order filters.
2. Design of Gm-C Integrator.

**Text Books:**

1. Design of Analog CMOS Integrated Circuits, B.Razavi, 2<sup>nd</sup> Edition, McGrawHill, ISBN: 9780072524932.
2. CMOS Mixed-Signal Circuit Design, Jacob Bakeret, IEEE Press, ISBN: 9780471227540.

**Reference Books:**

1. Analog MOS Integrated Circuit for signal processing, R. Gregorian, G.C. Temes, John Wiley & Sons, ISBN: 978-0-471-09797-6.
2. Understanding Delta-Sigma Data Converters, Schreier & Themes, Wiley – IEEE Press, ISBN: 9781119258292.

**Web Links:**

1. <https://ioe.iitm.ac.in/project/rf-analog-and-mixed-signal-integrated-circuits/>
2. [https://link.springer.com/chapter/10.1007/978-0-387-35597-9\\_29](https://link.springer.com/chapter/10.1007/978-0-387-35597-9_29)
3. <https://www.ims.fraunhofer.de/en/Core-Competence/Smart-Sensor-Systems/Integrated-Sensor-Systems/Mixed-Signal-IC-Design.html>

## Low Power VLSI Design

<b>Course Code: 241EC028</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Outline the fundamentals of low-power logic design.
- CO2:** Interpret low-power design approaches.
- CO3:** Interpret the constraints for low power design through CAD Tools.
- CO4:** Contrast adder architectures for the efficient subsystem design.
- CO5:** Outline the low-power multiplier architectures.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	3	2									1
<b>CO2</b>	3	2									1
<b>CO3</b>	3	2									1
<b>CO4</b>	3	2	1								1
<b>CO5</b>	3	2	1								1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>		2
<b>CO2</b>		2
<b>CO3</b>		2
<b>CO4</b>		2
<b>CO5</b>		2

## UNIT – I

### Introduction:

Introduction to Low Power VLSI design, Importance of low power design, Challenges in low power VLSI design, Application of Low Power VLSI circuits, Power analysis of CMOS circuits, Themes of Low Power VLSI design, Supply voltage scaling, Reduction of load capacitances.

## UNIT – II

### Low Voltage Process Technology and Device Modelling:

CMOS device structure and process fabrication, Innovation on process technology for low power consumption, Multi-threshold process technology, Latch up problem in CMOS technology, Discussion on SPICE Models of MOS transistor, MOS Capacitances, CMOS Low voltage analytical model, Threshold voltage definitions, Different Short Channel Effects.

### **UNIT – III**

#### **Techniques for low power design at Logic Design Level:**

CMOS logic design style, CMOS Inverter design, Transfer characteristics of CMOS inverter, Delay calculation of CMOS Logic gates, Analysis of various logic design styles for their power consumption (CPL, Domino Logic, NORA CMOS, TSPC Logic, DCVSL, etc.).

### **UNIT – IV**

#### **Low power design techniques at Architectre and System Level:**

Importance of parallelism, Introduction to Pipelining, Low power design utilizing redundancy and Data Encoding, Importance of Regularity and Locality, Reduction of complexity to improve power consumption, Low power design techniques at system level.

### **UNIT – V**

#### **Low Power Random Access Memory Circuits:**

Introduction to Static RAM Design, Low power Bit-line Conditioning Circuits, Low Power Techniques, Sense Amplifiers, Dynamic RAM Design, Bit line capacitance reduction methodologies, Self-Refresh Techniques, Low Voltage DRAM Operations, and Leakage Power Analysis.

#### **Text Books:**

1. Low-power CMOS digital design, A.P.Chandrakasan and R.W.Broderson, Low Power CMOS Design, IEEE Press, ISBN: ISBN: 978-1-4615-2325-3.
2. Low-Power Digital VLSI Design: Circuits and Systems, A. Bellaouar and M. I. Elmasry, Springer, ISBN: ISBN : 9780792395874.

#### **Reference Books:**

1. Low-Power VLSI Circuits and Systems, Ajit Pal, Springer, ISBN: ISBN: 9788132219361.
2. Low Power Design Methodologies, Jan M. Rabaey, Massoud Pedram, Springer Science+Business Media,LLC, ISBN: ISBN: 978-1-46 13-5975-3.

**Web Links:**

1. <https://www.synopsys.com/glossary/what-is-low-power-design.html>
2. <https://resources.system-analysis.cadence.com/blog/msa2021-implementing-low-power-design-through-voltage-scaling-in-vlsi>
3. <https://link.springer.com/book/10.1007/978-1-4615-2355-0>

## FPGAs & ASIC Design

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 241EC027</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Compare the performance of different FPGAs and their programming Technologies.
- CO2:** Identify different SRAM and Anti-Fuse programmable FPGA architectures.
- CO3:** Develop digital circuits with ACT architectures.
- CO4:** Illustrate the different types of ASICs with I/O modules and their interconnects.
- CO5:** Explain the construction, simulation and testing of ASICs.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	2	3									1
CO2	2	3									1
CO3	1	2	3								1
CO4	3	2									1
CO5	3	2									1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1		2
CO2		2
CO3		2
CO4		2
CO5		2

## UNIT – I

### Field Programmable Gate Arrays:

Organization of FPGAs, FPGA Programming Technologies, Programmable Logic Block Architectures, Programmable Interconnects, Programmable I/O blocks in FPGAs, Dedicated Specialized Components of FPGAs, Applications of FPGAs.

## UNIT – II

### Programming FPGAs:

SRAM Programmable FPGAs, Introduction, Programming Technology, Device Architecture, The Xilinx XC2000, XC3000 and XC4000 Architectures. ACT FPGA Architectures: Anti-Fuse

Programmed FPGAs, Introduction, Programming Technology, Device Architecture, The Actel AC1, AC2 and ACT3 Architectures.

**Applications:**

Design Applications, General Design Issues, Counter Examples, A Fast Video Controller, A Position Tracker for a Robot Manipulator, A Fast DMA Controller, Designing Counters with ACT devices.

### UNIT – III

**Introduction to ASICs:** Types of ASICs, Design Flow, Case Study, Economics of ASICs, ASIC Cell Libraries, Transistors as resistors, Transistor Parasitic Capacitance, Logical Effort, Library Cell Design, Library Architecture, Gate-Array Design, Standard Cell Design, Data Path Cell Design.

### UNIT – IV

**Programmable ASICs and Programmable ASIC Logic Cells:**

The Anti fuse, Static RAM, EPROM and EEPROM Technology, Practical Issues, Specifications, PREDP Benchmarks, FPGA Economics, Actel ACT, Xilinx LCA, Altera Flex, Altera Max, DC Output, AC Output, DC input, AC input, Clock input, Power input, Xilinx I/O block, Other I/O Cells. Low Level Design Entry and Logic Synthesis: Schematic Entry, Low level Design Languages, PLA Tools, EDIF, A logic synthesis example, A Comparator/MUX, Inside a Logic Synthesizer, Synthesis of Viterbi Decoder, Verilog and Logic synthesis, VHDL and Logic Synthesis, Finite State Machine Synthesis, Memory Synthesis, The Engine Controller, Performance Driven Synthesis, Optimization of the viterbi decoder.

### UNIT – V

**Simulation, Test and ASIC Construction:**

Types of Simulation, The Comparator/MUX Example, Logic Systems, How Logic Simulation Works, Cell Models, Delay Models, Static Timing Analysis, Formal Verification, Switch Level Simulation, Transistor Level Simulation, The importance of test, Boundary Scan Test, Faults, Faults Simulation, Automatic Test Pattern Generator, Scan Test, Built in Self Test, A simple test Example, Physical Design, CAD Tools, System Partitioning, Estimating ASIC Size, Power Dissipation, FPGA Partitioning, Partitioning Methods.

**Text Books:**

1. Field Programmable Gate Array Technology, Stephen M. Trimberger, Springer International Edition, ISBN: 978-1461361831.

2. Application Specific Integrated Circuits, Michael John Sebastian Smith, Pearson Education, ISBN : 978-8177584080.

**Reference Books:**

1. Digital Design Using Field Programmable Gate Arrays, Pak K. Chan/Samiha Mourad, Pearson Low Price Edition, ISBN: 9788131724408.
2. Advanced ASIC Chip Synthesis using Synopsis Design compiler, Himanshu Bhatnagar, Kluwer Academic, 2<sup>nd</sup> Edition, ISBN: 9780792385370.

**Web Links:**

1. <https://nptel.ac.in/courses/117108040/> by Prof. Kuruvilla Varghese\
2. <http://www.eng.ucy.ac.cy/theocharides/Courses/ECE664/L5.pdf>

## SoC Design

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 241EC029</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Outcomes: At the end of the course student will be able to:**

- CO1:** Explain all the building blocks of SoC.
- CO2:** Classify the concept of processors and instruction handling.
- CO3:** Analyze vector, VLIW and superscalar processors.
- CO4:** Develop a Memory as part of SoC.
- CO5:** Illustrate the concepts of interconnect optimization and configuration in SoC.

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	1									1
CO2	3	2									1
CO3	2	2	1								1
CO4	2	2	2								1
CO5	2	2	1								1

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2
CO1		2
CO2		2
CO3		2
CO4		2
CO5		2

### UNIT – I

#### **Introduction to the System Approach:**

System Architecture, Components of the system, Hardware & Software, Processor Architectures, Memory and Addressing. System level interconnection, An approach for SOC Design, System Architecture and Complexity.

### UNIT – II

#### **Processors:**

Introduction , Processor Selection for SOC, Basic concepts in Processor Architecture, Basic concepts in Processor Micro Architecture, Basic elements in Instruction handling. Buffers:

minimizing Pipeline Delays, Branches, More Robust Processors, Vector Processors and Vector Instructions extensions, VLIW Processors, Superscalar Processors.

### **UNIT – III**

#### **Memory Design for SOC:**

Overview of SOC external memory, Internal Memory, Size, Scratchpads and Cache memory, Cache Organization, Cache data, Write Policies, Strategies for line replacement at miss time, Types of Cache, Split – I, and D – Caches, Multilevel Caches, Virtual to real translation , SOC Memory System, Models of Simple Processor – memory interaction.

### **UNIT – IV**

#### **Interconnect Customization:**

Inter Connect Architectures, Bus: Basic Architectures, SOC Standard Buses, Analytic Bus Models, Using the Bus model, Effects of Bus transactions and contention time. SOC Customization: An overview, Customizing Instruction Processor.

### **UNIT – V**

#### **Interconnect Configuration:**

Reconfiguration Technologies, Mapping design onto Reconfigurable devices, Instance Specific design, Customizable Soft Processor, Reconfiguration – overhead analysis and trade-off analysis on reconfigurable Parallelism.

#### **Text Books:**

1. Computer System Design System-on-Chip, Michael J. Flynn and Wayne Luk, Wiley India Pvt. Ltd, ISBN: 978-0470643365.
2. ARM System on Chip Architecture, Steve Furber, Addison Wesley Professional, 2<sup>nd</sup> Edition, ISBN : 9780201675191 .

#### **Reference Books:**

1. Design of System on a Chip: Devices and Components, Ricardo Reis, Springer 1<sup>st</sup> Edition, ISBN: 978-1441954541.
2. Co-Verification of Hardware and Software for ARM System on Chip Design (Embedded Technology), Jason Andrews, Newnes, BK and CDROM, ISBN: 978-0750677301.
3. System on Chip Verification–Methodologies and Techniques, Prakash Rashinkar, Peter Paterson and Leena Singh L, Kluwer Academic Publishers, ISBN: 978-0792372790.

**Web Links:**

1. <https://www.peterindia.net/System-On-ChipLinks.html>
2. <https://www.ieee-socc.org/>
3. <http://nptel.ac.in/courses/108102045/10> (Prof. Santanu Chaudhary, IIT Delhi)

## Digital Design Through System Verilog

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 241EC026</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

At the end of the course, student will be able to:

- CO1:** Summarize the basics of system verilog HDL.
- CO2:** Develop various combinational circuit using system verilog HDL
- CO3:** Illustrate various asynchronous sequential model circuits.
- CO4:** Make use of System Verilog concepts for sequential circuits design.
- CO5:** Interpret on various system model synthesis.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	3	2									1
<b>CO2</b>	2	1	3	1							1
<b>CO3</b>	3	2		1							1
<b>CO4</b>	2	1	2								1
<b>CO5</b>	2	3	1	1							1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>		3
<b>CO2</b>		3
<b>CO3</b>		3
<b>CO4</b>		3
<b>CO5</b>		3

### UNIT- I

**Introduction to System Verilog HDL:** Verilog as HDL, Levels of Design Description, Concurrency, Simulation and Synthesis, Functional Verification, System Tasks, Programming Language Interface (PLI), Module, Simulation and Synthesis Tools.

**Language Constructs and Conventions:** Introduction, Keywords, Identifiers, White Space Characters, Comments, Numbers, Strings, Logic Values, Strengths, Data Types, Scalars and Vectors, Parameters, Operators.

### UNIT-II

**Combinational Logic building blocks:** Introduction, multiplexers, Decoders, parameterizable decoder, seven segment decoder, priority encoder, adders, parity checker, three state buffers, design using System Verilog, test benches for combinational blocks.

### UNIT-III

**Sequential Logic Design using system verilog:** Latches and flip flops, Ring Counter, Johnson Counter, Design of Modulus-N Synchronous Counters, Shift Registers, Universal Shift Registers, Modeling of sequential circuits using System verilog.

**Asynchronous Sequential design:** Introduction, Asynchronous sequential circuits, design of asynchronous circuits, asynchronous state machines, setup and hold times, metastability using system verilog HDL.

### UNIT-IV

**Synchronous Sequential design:** Basic synchronous sequential systems, model of synchronous sequential systems, algorithmic state machines, synthesis from ASM charts, state machine in system verilog, test benches for state machines and complex sequential systems.

### UNIT-V

**System verilog synthesis:** Introduction, RTL synthesis-combinational logic, RTL synthesis rules, constraints-attributes, area and structural constraints, synthesis for FPGA, behavioural synthesis, timing simulations

#### Text Books:

1. System Verilog for Design, Sturt Sutherland, Simon Davidmann, Peter flake, 2<sup>nd</sup> Edition, ISBN: 9780387364957.
2. System Verilog Functional Verification, Sasaniman, Smith, 1<sup>st</sup> Edition, ISBN : 9780981656212.

#### Reference Books:

1. Fundamentals of Logic Design with Verilog Design by Stephen.Brown and ZvonkoVranesic, TMH, 2<sup>nd</sup> Edition, ISBN: 978-0077211646.
2. Advanced Digital Logic Design using Verilog, State Machine & Synthesis for FPGA – Sunggu Lee, Cengage Learning, ISBN: 9780534551612.

#### Web Links:

1. <http://nptel.ac.in/courses/117105080/> by Prof.D. Roy Chaudhry
2. <http://nptel.ac.in/courses/117106086/1> by Prof.S.Srinivasan

## VLSI Physical Design

**Course Code: 241EC031**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>2</b>	<b>0</b>	<b>0</b>	<b>2</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Explain the VLSI physical design cycle at various levels of abstraction
- CO2:** Choose different algorithms for system partitioning.
- CO3:** Develop floor planning for different VLSI Circuits.
- CO4:** Make use of placement & routing algorithms for placement and routing purpose.
- CO5:** Explain the concepts of timing closure involved in placement & routing..

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	3	2									
<b>CO2</b>	2	3									
<b>CO3</b>	2	1	3	1							
<b>CO4</b>	1	1	3	1							
<b>CO5</b>	2	2									

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>		2
<b>CO2</b>		2
<b>CO3</b>		2
<b>CO4</b>		2
<b>CO5</b>		2

### UNIT- I

#### Introduction to physical design automation

VLSI design flow, Physical design cycle, design styles, Layout layers and design rules, Physical design optimizations

### UNIT- II

#### Net list and system partitioning

Introduction, terminology, optimization goals, partitioning algorithms, a frame work for multi level partitioning

### UNIT-III

#### **Floor planning**

Introduction to floor planning, optimization goals, terminology, floor plan representations, floor planning algorithms, pin assignment, power and ground routing.

### UNIT-IV

**Placement & Routing:** Global placement, Representation of routing regions, The global routing flow, single net routing, full net list routing, Detailed routing- horizontal and vertical constraints graph, channel routing algorithms, switch box routing.

### UNIT-V

**Timing Closure:** Introduction, timing analysis and performance constraints, timing driven placement, timing driven routing

#### **Text Books:**

1. VLSI Physical Design: From Graph Partitioning to Timing Closure-Andrew B. Kahng, Jens Lienig, Igor L. Markov, Jin Hu ,Springer, ISBN: 978-94-007-9020-9.
2. VLSI Physical Design Automation Theory and Practice by Sadiq M. Sait, Habib Youssef, world scientific, ISBN : 9789810238834.

#### **Reference Books:**

1. Modern VLSI DesignSystem-on-Chip Design by Wayne Wolf, Pearson education, 3<sup>rd</sup>Edition, ISBN: 978-8178086538.
2. Analog Integrated Circuit Design AutomationPlacement, Routing and Parasitic Extraction Techniques by Ricardo Martins, Nuno Lourenço, Nuno Horta, springer international publishing, ISBN: 978-3319816685.

#### **Web Links:**

1. <https://nptel.ac.in/courses/106105161> - by Prof. Indranil Sen Gupta, IIT Khargpur.
2. <https://nptel.ac.in/courses/117101004> - by Prof.D.K.Sharma, Prof. Sachin Patkar,Prof. Virendra singh, Prof.A.N.Chandorkar, IIT Bombay.
3. <https://nptel.ac.in/courses/117103125> - by Dr.Santosh Biswas, IIT Guwahati.

### Minor Stream: Embedded Systems

Course Code	Course Name	Level	L	T	P	C	CIE	SEE	Total	Pre-requisite
241EC038	Microcontrollers for Embedded Systems	IC	3			3	50	50	100	MPMC
241EC034	Embedded System Design	IC	2		1	3	50	50	100	-
241EC040	Programming Languages for Embedded System	IC	3			3	50	50	100	-
241EC042	Wireless LAN's & PAN's	IC	3			3	50	50	100	ESD
241EC039	Parallel Processing	IC	3			3	50	50	100	MPMC
241EC033	Embedded Computing	AC	2			2	50	50	100	ERTS
241EC032	Embedded & Real Time Systems	AC	3			3	50	50	100	ESD
241EC036	Hardware interfacing & Networking	AC	3			3	50	50	100	ESD
241EC035	Hardware & Software Co-Design	AC	3			3	50	50	100	ESD
241EC037	Internet of Things & its Applications	AC	2		1	3	50	50	100	-
241EC041	Smart Sensors & Devices for Agriculture	AC	3			3	50	50	100	IoT
<b>Total</b>			<b>30</b>		<b>2</b>	<b>32</b>				

## Microcontrollers for Embedded Systems

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 241EC038</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Explain the basic architecture and features of PIC microcontrollers.
- CO2:** Explain architecture and programming model of ARM 7TDMI.
- CO3:** Interpret the programmer's model of ARM cortex M3-processor.
- CO4:** Compare the various exceptions present in the processor.
- CO5:** Summarize the low power modes of MSP 430 micro controller.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	3	2									1
<b>CO2</b>	3	2									1
<b>CO3</b>	2	3	1	1							1
<b>CO4</b>	3	2									1
<b>CO5</b>	2	3									1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>		2
<b>CO2</b>		2
<b>CO3</b>		2
<b>CO4</b>		2
<b>CO5</b>		2

### UNIT – I

#### **PIC Microcontrollers:**

PIC16F877 Instructions Set, addressing modes, Assembly language Programs. PIC16F877

**Peripherals:** Timers, CCP modules, ADC modules, configuration word and programming.

### UNIT – II

#### **ARM7 Microcontroller:**

ARM7 microcontroller architecture, memory organization, description of functional units of microcontroller: ports, interrupts, on chip ADCs, DACs, serial peripheral interface, timers,

programmable counter array, Comparative study of ARM7 with ARM9 and ARM11 Programming and Applications.

### **UNIT-III**

#### **ARM Cortex-M3 processor:**

Applications, Programming model– Registers, Operation modes, Exceptions and Interrupts, Reset Sequence Instruction Set, Unified Assembler Language, Memory Maps, Memory Access Attributes, Permissions, Bit-Band Operations, Unaligned and Exclusive Transfers. Pipeline, Bus Interfaces.

### **UNIT- IV**

ARM Cortex-M3 processor Exceptions, Types, Priority, Vector Tables Interrupt Inputs and Pending behavior, Fault Exceptions, Supervisor and Pendable Service Call, Nested Vectored Interrupt Controller.

### **UNIT-V**

#### **MSP430 16 - BIT MICROCONTROLLER :**

The MSP430 Architecture, CPU Registers, Instruction Set, addressing modes, the MSP430 family viz. MSP430x2x, MSP430x4x, MSP430x5x. Low power aspects of MSP430 : low power modes, active Vs standby current consumption, FRAM Vs Flash for low power and reliability.

#### **Text Books:**

1. Micro Controller theory and Application ,Ajay .V. Deshmukh, TATA McGraw –Hill, 1<sup>st</sup> Edition, ISBN: 9780070585959.
2. ARM System Developer's Guide: Design in and Optimizing, Sloss Andrew N, Symes Dominic, Wright Chris, Morgan Kaufman Publication,ISBN: 978-1-55860-874-0.

#### **Reference Books:**

1. ARM System-on-Chip Architecture, Steve furber, Addison-Wesley Educational Publishe Inc, 2<sup>nd</sup> Edition, ISBN: 9780201675191
2. PIC Microcontroller and Embedded Systems: Using Assembly and C for PIC18Muhamr Ali Mazidi, Rolin D. Mc Kinlay, Danny Causey, Pearson Prentice Hall, ISBN: 9780136009023.
3. MSP 430 Micro controller basics, John H. Davies, Elsevier, ISBN: 978-0-7506-8276-3.

**Web Links:**

1. [http://nptel.ac.in/courses/117/106/117106086/\(ByProf.GoutamSaha,Electronics&ElectricCommunication Engineering Dept, IIT Kharagpur\).](http://nptel.ac.in/courses/117/106/117106086/(ByProf.GoutamSaha,Electronics&ElectricCommunicationEngineeringDept,IITKharagpur).)
2. [https://onlinecourses.nptel.ac.in/noc20\\_ee42/preview](https://onlinecourses.nptel.ac.in/noc20_ee42/preview)
3. <https://nptel.ac.in/courses/117106111>

## Embedded System Design

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 241EC034</b>	<b>2</b>	<b>0</b>	<b>1</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Summarize the building blocks of an Embedded system.
- CO2:** Interpret the hardware modules required to design an Embedded system.
- CO3:** Infer the firmware design approaches for an Embedded system.
- CO4:** Discuss the functionalities of Real time Operating Systems.
- CO5:** Develop Embedded systems based on their applications.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	3	2						1	1		1
<b>CO2</b>	3	2	1	1	2			1	1		1
<b>CO3</b>	2	3			2			1	1		1
<b>CO4</b>	2	3			2			1	1		1
<b>CO5</b>	2	2	3	1	2			1	1		1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>		2
<b>CO2</b>		2
<b>CO3</b>		2
<b>CO4</b>		2
<b>CO5</b>		2

### UNIT – I

#### Introduction:

Embedded System-Definition, History of embedded system, Characteristics of an embedded system, classification of embedded systems, Embedded System Architecture Quality attributes of embedded systems, Challenges in Embedded System Design, Examples of an embedded system.

### UNIT – II

#### Designing Embedded Computing Platform:

Introduction to Processors & Controllers, Sensors, Actuators, Analog and digital electronic components, I/O types and examples, Memory Classification, Timer and counting devices, Watchdog Timers, RTC, Wireless Protocols.

**Practice:**

1. Introduce Proteus & create a basic simulation in Proteus and write an Embedded C program to blink an LED?
2. Write an Embedded C Program to interface the switch with a microcontroller in Proteus to control an LED using I/O Ports

**UNIT – III****Embedded Firmware:**

Classification of OS, Embedded Firmware design approaches & development languages, POSIX Thread Programming, Pre-processors, Interpreters, Compilers and Linkers, Debugging tools, C versus Embedded C, ALP Programming.

**Practice:**

1. Write an Embedded C Program to interface a 16×2 LCD with a microcontroller and display messages.
2. Write an Embedded C Program to Interface stepper motor be controlled (CW/CCW rotation and speed control) using a microcontroller and Proteus simulation.

**UNIT – IV****Real-Time Operating Systems:**

Tasks, Process and Threads, Multiprocessing and Multitasking, Task Scheduling, Threads, Processes and Scheduling, Task communication, Task synchronization.

**Practice:**

1. Write an Embedded C Program for timer interrupts and external interrupts in a microcontroller demonstrate them through Proteus
2. configure UART serial communication and perform data transmission and reception using Embedded C?

**UNIT – V****Embedded System Development:**

The IDE, Types of files generated on cross- compilation, Deassembler/ Decompile, Simulators, Emulators and Debugging, Target hardware debugging, Boundary Scan, Embedded Software development process and tools.

Various wireless protocols and its applications: NFC, ZigBee, Bluetooth, Bluetooth Low Energy, Wi-Fi. CAN, Programming in Embedded C, Embedded system design using Arduino.

**Practice:**

1. Develop an Application to interface a 4×4 keypad with a microcontroller and display the key pressed using LCD or serial terminal in Proteus?
2. Design and simulate a complete embedded system application in Proteus using Embedded C (e.g., password door lock, digital clock, sensor system, etc.)

**Text Books:**

1. Embedded Systems, Shibu.K. V, Tata McGraw Hill Education Private Limited, ISBN: 978-9339219680.
2. Computers as Components – Principles of Embedded Computing System Design, Marilyn Wolf, Morgan Kaufmann Publisher (An imprint from Elsevier), 3<sup>rd</sup> Edition, ISBN: 0128053879.

**Reference Books:**

1. Embedded System Design, Frank Vahid and Tony Givargis, John Wiley Publications, ISBN: 9781222995374.
2. The Designer's Guide to the Cortex-M Processor Family - A Tutorial Approach, Trevor Martin, Elsevier Science, <sup>st</sup> Edition, ISBN: 9780080982991.

**Web Links:**

1. [http://www.artistembedded.org/docs/Events/2006/ChinaSchool/1\\_ESIntroduction.pdf](http://www.artistembedded.org/docs/Events/2006/ChinaSchool/1_ESIntroduction.pdf)
2. <http://web.cecs.pdx.edu/~mperkows/temp/hardware-software-codesign.pdf>
3. <http://www.vtt.fi/inf/pdf/publications/2004/P526.pdf>

## Programming Languages for Embedded System

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 241EC040</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Develop the moderate complex programs in embedded C.
- CO2:** Compare the different programming techniques in object-oriented programming.
- CO3:** Analyze the algorithm in C++.
- CO4:** Distinguish the different types of over loading & Inheritance.
- CO5:** Discuss the templates and scripting languages.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	2	2	3								1
<b>CO2</b>	3	2									1
<b>CO3</b>	2	3									1
<b>CO4</b>	2	3									1
<b>CO5</b>	2	3									1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>		2
<b>CO2</b>		2
<b>CO3</b>		2
<b>CO4</b>		2
<b>CO5</b>		2

## UNIT – I

### Embedded C Programming:

Bitwise operations, Dynamic memory allocation, OS services. Linked stack and queue, Sparse matrices, Binarytree. Interrupt handling in C, Code optimization issues. Embedded Software Development Cycle and Methods(Waterfall,Agile), Sample programs.

## UNIT – II

**Object Oriented Programming:**

Introduction to procedural, modular, object-oriented and generic programming techniques, Limitations of procedural programming, objects, classes, data members, methods, data encapsulation, data abstraction and information hiding, inheritance, polymorphism, Sample programs.

**UNIT – III****C++ Programming:**

“cin”, “cout”, formatting and I/O manipulators, new and delete operators, Defining a class, data members and methods, this pointer, constructors, destructors, friend function, dynamic memory allocation, Sample programs.

**UNIT – IV****Overloading and Inheritance:**

Need of operator overloading, overloading the assignment, Overloading using friends, type conversions, single inheritance, base and derived classes, friend Classes, types of inheritance, hybrid inheritance, multiple inheritance, virtual base class, Polymorphism, virtual functions.

**UNIT – V****Templates:**

Function template and class template, member function templates and template arguments,

**Exception Handling:**

syntax for exception handling code: try-catch- throw, Multiple Exceptions.

**Scripting Languages:**

Overview of Scripting Languages – PERL, CGI, VB Script, Java Script.

**PERL:**

Operators, Statements, Pattern Matching etc. Data Structures, Modules, Objects, Tied Variables, In-process Communication Threads, Compilation & Line Interfacing.

**Text Books:**

1. Embedded C, Michael J. Pont,, Pearson Education, 2<sup>nd</sup> Edition, ISBN: 978-8131715895.
2. Learning Perl .Randal L. Schwartz, O'Reilly Publications, 6<sup>th</sup> Edition, ISBN: 9781449303587.

**Reference Books:**

1. Data structures via C++”, A. Michael Berman, Oxford University Press, ISBN: 978-0195685787.
2. Algorithms in C++, Robert Sedgewick, Addison Wesley Publishing Company, ISBN: 9780768684766.
3. Operating System Concepts, Abraham Silberschatz, Peter B, Greg Gagne, John Willey & Sons, Kaufmann, ISBN: 978-1119800361.

### Web Links:

1. <https://www.geeksforgeeks.org/top-10-best-embedded-systems-programming-languages>
2. <https://skill-lync.com/blogs/most-popular-programming-languages-for-embedded-systems>
3. <https://www.digimat.in/nptel/courses/video/106105193/L01.html> by Professor IndranilGuptha IIT Kharagpur.

## Wireless LAN's & PAN's

**Course Code: 241EC042**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course student will be able to:**

- CO1:** Discuss the concept of Random Access protocols.
- CO2:** Explain the Wireless LAN Protocols.
- CO3:** Analyze the IEEE802.11 Standard for WLAN.
- CO4:** Interpret the Wireless PAN Protocols.
- CO5:** Illustrate the IEEE802.15 Standard for WPAN.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	3	2									1
<b>CO2</b>	3	2									1
<b>CO3</b>	1	3	1								1
<b>CO4</b>	1	3									1
<b>CO5</b>	3	2	1								1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>		2
<b>CO2</b>		2
<b>CO3</b>		2
<b>CO4</b>		2
<b>CO5</b>		2

## UNIT – I

### Wireless System & Random Access Protocols:

Introduction, First and Second Generation Cellular Systems, Cellular Communications from 1G to 3G, Wireless 4G systems, The Wireless Spectrum; Random Access Methods: Pure ALOHA, Slotted ALOHA, Carrier Sense Multiple Access (CSMA), Carrier Sense Multiple Access with Collision Detection (CSMA/CD), Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA).

## UNIT – II

### Wireless LANs:

Introduction, importance of Wireless LANs, WLAN Topologies, Transmission Techniques: Wired Networks, Wireless Networks, comparison of wired and Wireless LANs; WLAN Technologies: Infrared technology, UHF narrowband technology, Spread Spectrum technology.

### **UNIT – III**

#### **The IEEE 802.11 Standard for Wireless LANs:**

Network Architecture, Physical layer, The Medium Access Control Layer; MAC Layer issues: Hidden Terminal Problem, Reliability, Collision avoidance, Congestion avoidance, Congestion control, Security, The IEEE802.11e MAC protocol.

### **UNIT – IV**

#### **Wireless PANs:**

Introduction, importance of Wireless PANs, The Bluetooth technology: history and applications, technical overview, the Bluetooth specifications, piconet synchronization and Bluetooth clocks, Master-Slave Switch; Bluetooth security; Enhancements to Bluetooth: Bluetooth interference issues, Intra and Inter Piconet scheduling, Bridge selection, Traffic Engineering, QoS and Dynamics Slot Assignment, Scatternet formation.

### **UNIT – V**

#### **The IEEE 802.15 working Group for WPANs:**

The IEEE 802.15.3, The IEEE 802.15.4, ZigBee Technology, ZigBee components and network topologies, The IEEE 802.15.4 LR-WPAN Device architecture: Physical Layer, Data Link Layer, The Network Layer, Applications; IEEE 802.15.3a Ultra wide band.

#### **Text Books:**

1. Ad Hoc and Sensor Networks - Carlos de Morais Cordeiro and Dharma Prakash Agrawal, World Scientific, ISBN: 978-9814338882.
2. Wireless Communications and Networking - Vijay K.Garg, Morgan Kaufmann Publishers, ISBN: 978-0123735805.

#### **Reference Books:**

1. Principles of Wireless Networks - Kaveh Pahlaram, Prashant Krishnamurthy, PHI, ISBN:978-0130930033.
2. Guide to Wireless Communication- Marks Ciampor, Jeorge Olenewa, Cengage Learning, ISBN: 9781111307318.

**Web Links:**

1. <https://archive.nptel.ac.in/courses/106/105/106105183/>
2. <https://archive.nptel.ac.in/courses/108/108/108108179/>

## Parallel Processing

**Course Code: 241EC039**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Illustrate the Performance of Parallel Processing and Pipelining operation.
- CO2:** Categorise the processors based on Pipelining.
- CO3:** Make use of VLIW processor architecture Model to develop Processor architectures.
- CO4:** Develop solutions for issues in multithreaded processor architectures.
- CO5:** Explain Parallel Programming Techniques for Customizing applications.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2									
CO2	1	3									
CO3	1	2	1								
CO4	1	1	2								
CO5	2	3									

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1		2
CO2		2
CO3		3
CO4		3
CO5		1

### UNIT – I

Overview of Parallel Processing and Pipelining, Performance analysis, Scalability.

### UNIT – II

Principles and implementation of Pipelining, Classification of pipelining processors, Advanced pipelining techniques, Software pipelining.

### UNIT – III

VLIW processors Case study: Superscalar Architecture- Pentium, Intel Itanium Processor, Ultra SPARC, MIPS on FPGA, Vector and Array Processor, FFT Multiprocessor Architecture.

### UNIT – IV

Multithreaded Architecture, Multithreaded processors, Latency hiding techniques, Principles of multithreading, Issues and solutions.

### UNIT – V

Parallel Programming Techniques: Message passing program development, Synchronous and asynchronous message passing, Shared Memory Programming, Data Parallel Programming, Parallel Software Issues. Operating systems for multiprocessors systems Customizing applications on parallel processing platforms.

#### Text Books:

1. Computer Architecture and Parallel Processing, Kai Hwang, Faye A. Briggs, MGH International Edition, ISBN: 978-0070663541 .
2. Advanced Computer Architecture , Kai Hwang, TMH, ISBN: 978-0070316225 .

#### Reference Books:

1. Computer Organization and Architecture, Designing for performance by William Stallings, Prentice Hall, Sixth edition, ISBN: 978-0134101613.
2. Scalable Parallel Computing by Kai Hwang, Zhiwei Xu, MGH, ISBN: 978-0070317987.
3. Digital Design and Computer Architecture by David Harris and Sarah Harris, Morgan, ISBN: 978-0123944245 .

#### Web Links:

1. <https://www.geeksforgeeks.org/what-is-parallel-processing/>
2. <https://nptel.ac.in/courses/106102114> by Dr. Subodh Kumar

## Embedded Computing

**Course Code: 241EC033**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>2</b>	<b>0</b>	<b>0</b>	<b>2</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Explain the concepts of Linux OS programming.
- CO2:** Interpret the different software development tools.
- CO3:** Illustrate different interfacing modules.
- CO4:** Discuss the networking basics.
- CO5:** Explain the IA32 Instruction Set.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	3	1									1
<b>CO2</b>		3									1
<b>CO3</b>	3	1									1
<b>CO4</b>	3	1									1
<b>CO5</b>	3	1									1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>		2
<b>CO2</b>		2
<b>CO3</b>		2
<b>CO4</b>		2
<b>CO5</b>		2

## UNIT – I

### Programming on Linux Platform:

System Calls, Scheduling, Memory Allocation, Timers, Embedded Linux, Root File System, Busy Box.

Operating System Overview: Processes, Tasks, Threads, Multi-Threading, Semaphore, Message Queue.

## UNIT – II

### Introduction to Software Development Tools:

GNU GCC, make, gdb, static and dynamic linking, C libraries, compiler options, code optimization switches, lint, code profiling tools.

## UNIT – III

### **Interfacing Modules:**

Sensor and actuator interface, data transfer and control, GPS, GSM module interfacing with data processing and display, OpenCV for machine vision, Audio signal processing.

## UNIT – IV

### **Networking Basics:**

Sockets, ports, UDP, TCP/IP, client server model, socket programming, 802.11, Bluetooth, ZigBee, SSH, firewalls, network security.

## UNIT – V

**IA32 Instruction Set:** application binary interface, exception and interrupt handling, interrupt latency, assemblers, assembler directives, macros, simulation and debugging tools.

### **Text Books:**

1. Modern Embedded Computing - Peter Barry and Patrick Crowley, Elsevier/Morgan Kaufmann, 1<sup>st</sup> Edition, ISBN: 978-0123914903.
2. Linux Application Development - Michael K. Johnson, Erik W. Troan, Addison Wesley, ISBN: 9780321563224.
3. Intel® 64 and IA-32 Architectures Software Developer Manuals.

### **Reference Books:**

1. Operating System Concepts by Abraham Silberschatz, Peter B. Galvin and Greg Gagne, ISBN: 978-1119800361.
2. The Design of the UNIX Operating System by Maurice J. Bach Prentice-Hall, ISBN: 978-0132017992.
3. UNIX Network Programming by W. Richard Stevens, ISBN: 978-8177583762.

### **Web Links:**

1. <https://archive.nptel.ac.in/courses/108/102/108102045/>
2. <https://archive.nptel.ac.in/courses/108/105/108105057/>

## Embedded & Real Time Systems

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 241EC032</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Summarize the services and tasks in RTOS.
- CO2:** Infer interrupts and timer services for embedded applications.
- CO3:** Outline memory management in embedded systems.
- CO4:** Illustrate program modeling for case studies.
- CO5:** Identify Fundamental Issues in Hardware software co- design

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	3	2									1
<b>CO2</b>	3	1									1
<b>CO3</b>	3	2									1
<b>CO4</b>	3	2									1
<b>CO5</b>		3									1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>		2
<b>CO2</b>		2
<b>CO3</b>		2
<b>CO4</b>		2
<b>CO5</b>		2

## UNIT – I

### Basic RTOS Concepts-I:

The scheduler, Kernel Objects and services, Key characteristics of an RTOS Task- Defining a Task, Task States and Scheduling, Typical Task Operations, Typical Task Structure, Synchronization, Communication and Concurrency, Inter Process communication Functions (Semaphores, Message Queues, Pipes, Event Registers, Signals and condition Variables). Process Management, Timer Functions.

## UNIT – II

### **Basic RTOS Concepts-II:**

Event Functions, File and IO Systems Management. Defining an RTOS, Interrupt Routines in RTOS Environment and Handling of Interrupt Source Calls, RTOS Task Scheduling Models, Interrupt Latency and Response of the Tasks as Performance Metrics, OS Security Issues.

## UNIT – III

### **Memory Management:**

Dynamic Memory Allocation in Embedded Systems, Fixed-Size Memory management in Embedded Systems, Blocking VS. Non-Blocking Memory Functions, Hardware Memory Management Units Modularizing an application for concurrency- An outside-in approach to decompose Applications, Guidelines and Recommendations for Identifying Concurrency, Schedulability Analysis.

## UNIT – IV

### **RTOS Programming:**

Basic Functions and Types of RTOS for Embedded Systems, RTOS mCOS-II, RTOS Vx Works. Case study of embedded system design and coding for an Automatic Chocolate Vending Machine (ACVM) Using Mucos RTOS, case study of digital camera hardware and software architecture.

## UNIT – V

### **Overview of Hardware – Software co design:**

Fundamental Issues in Hardware-Software co-design, Computation models in embedded system design, Introduction to Unified Modeling Language (UML), Hardware Software Tradeoffs.

### **Text Books:**

1. Embedded/Real-Time Systems Dr. K.V.K.K. Prasad, Dream Tech Publications, Blackpad book, ISBN: 978-8177224610.
2. Embedded Systems-Architecture, Programming and Design ,Rajkamal, Tata McGraw Hill Publications, Second Edition, ISBN: 978-0070667648.

**Reference Books:**

1. Embedding system building blocks, Labrosse, CMP publishers, ISBN:9780367447618.
2. Real time Systems Development”, Rob Williams, Butterworth Heinemann Publications, ISBN: 978-0750664714.
3. Embedded Systems Design: A Unified Hardware/Software Introduction - Frank Vahid, Tony Givargis, John & Wiley Publications, ISBN: 9788126508372.

**Web Links:**

1. <http://www.nptelvideos.in/2012/11/embedded-systems.html>
2. [http://www.dauniv.ac.in/Embedded\\_Sys.php](http://www.dauniv.ac.in/Embedded_Sys.php)
3. <https://sites.google.com/site/embeddedssystemddr/ppt>

## Hardware Interfacing & Networking

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 241EC036</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Explain the communication protocols of connecting Embedded Systems.
- CO2:** Illustrate the CAN electrical, mechanical standards and signaling methods.
- CO3:** Analyze a typical application based on CAN open protocol.
- CO4:** Interpret the LINbus, MODBUS, and Profibus protocols for software interfacing.
- CO5:** Make use of Ethernet in Embedded networks considering different issues.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	1	3									1
<b>CO2</b>	3	2									1
<b>CO3</b>	2	3									1
<b>CO4</b>	3	1									1
<b>CO5</b>	2	1	3								1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>		2
<b>CO2</b>		2
<b>CO3</b>		2
<b>CO4</b>		2
<b>CO5</b>		2

### UNIT – I

**Embedded Communication Protocols:** Embedded Networking: Introduction – Serial/Parallel Communication – Serial communication protocols -RS232 standard – RS485 – Synchronous Serial Protocols -Serial Peripheral Interface (SPI) – Inter Integrated Circuits (I2C) – PC Parallel port programming - ISA/PCI Bus protocols – Firewire.

### UNIT – II

**CAN Bus Introduction:**Introduction to CAN – Electrical properties – CAN signaling and data rates – CAN data frame format- Collision and arbitration- Design examples -Error handling – Error state diagram – CAN controller block diagram and working- Software for CAN controller interfacing- CAN development tools- Demonstration of a typical CAN connection definition.

## UNIT – III

### **CAN and CAN Open:**

CAN open overview. - Communication requirements for embedded networking- The object dictionary concept- Communication entries- SDO and PDO- PDO linking- Identifying objects COB-ID -EDS and DCF, PDO communication -SDO communication- Network management and safety critical feature.

## UNIT – IV

**Profibus, LIN Bus, MODBUS:** Profibus, network topologies- Network Configuration-Active components – Passive components: connectors, cables, etc- Testing of profibus – LIN bus basics- LINbus protocol; master slave configuration – Basics of MODBUS – MODBUS protocol – MODBUS application

## UNIT – V

**Ethernet Basics:** Elements of a network – Inside Ethernet – Building a Network: Hardware options – Cables, Connections and network speed – Design choices: Selecting components – Ethernet Controllers –Using the internet in local and internet communications – Inside the Internet protocol.

**Embedded Ethernet:** Exchanging messages using UDP and TCP – Serving web pages with Dynamic Data – Serving web pages that respond to user Input – Email for Embedded Systems – Using FTP – Keeping Devices and Network secure.

### **Text Books:**

1. Embedded Systems Design: A Unified Hardware/Software Introduction - Frank Vahid, Tony Givargis, John & Wiley Publications, ISBN: 9788126508372.
2. Embedded networking with CAN and CAN open by Olaf Pfeiffer, Andrew Ayre and Christian Keydel, Copper hill Technologies Corporation, ISBN: 978-0976511625.
3. Lin Application note AN1278 by SGS-Thompson, SGS - Thompson Ltd.

### **Reference Books:**

1. Modbus-IDA, MODBUS application protocol specification, Modbus-IDA,. Siemens, Profibus network manual, Siemens manual.
2. Profibus in practice: System Architecture and Design by Xiu Ji, CRC press, ISBN: 978-1507633045.
3. Embedded Ethernet and Internet Complete - Jan Axelson, Penram publications, ISBN: 978-1931448000.

**Web Links:**

1. <https://archive.nptel.ac.in/courses/108/102/108102045/>.
2. <https://archive.nptel.ac.in/courses/108/105/108105057/>.

## Hardware & Software Co-Design

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code:241EC035</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Analyze embedded system's hardware and software design issues.
- CO2:** Develop the applications on 8051, ADSP2106 and TMS320C60 processors.
- CO3:** Explain modern embedded architectures and compilation technologies.
- CO4:** Interpret the Design, co design by using design verification tools.
- CO5:** Develop a system from system level specification languages.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	2	3									
<b>CO2</b>	2	2	2								
<b>CO3</b>	3										
<b>CO4</b>	3	1									
<b>CO5</b>	2	2	1								

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>		2
<b>CO2</b>		2
<b>CO3</b>		2
<b>CO4</b>		2
<b>CO5</b>		2

### UNIT – I

**Co- Design Issues:** Co- Design Models, Architectures, Languages, A Generic Co-design Methodology.

**Co-Synthesis Algorithms:** Hardware software synthesis algorithms, hardware, software partitioning distributed system co synthesis.

### UNIT – II

**Prototyping and Emulation:** Prototyping and emulation techniques, prototyping and emulation environments, future developments in emulation and prototyping architecture specialization techniques, system communication infrastructure.

**Target Architectures:** Architecture Specialization techniques, System Communication infrastructure, Target Architecture and Application System classes, Architecture for control dominated systems (8051-Architectures for High performance control), Architecture for Data dominated systems (ADSP21060, TMS320C60), Mixed Systems.

### UNIT – III

**Compilation Techniques and Tools for Embedded Processor Architectures:** Modern embedded architectures, embedded software development needs, compilation technologies, practical consideration in a compiler development environment.

### UNIT – IV

**Design Specification and Verification:** Design,co-design, the co-design computational model, concurrency coordinating concurrent computations, interfacing components, design verification, implementation verification, verification tools, interface verification.

**Implementing the design-**The main software utility tool, CAD and the hardware, Translation tools, debugging tools, testing on host machine, simulators, Laboratory tools, System Boot-Up.

### UNIT – V

**Languages for System – Level Specification and Design-I:** System – level specification, design representation for system level synthesis, system level specification languages. Languages for System-Level Specification and Design-II: Heterogeneous specifications and multi-language co-simulation, the cosyma system.

#### Text Books:

1. Hardware / Software Co- Design Principles and Practice, Jorgen Staunstrup, Wayne Wolf, Springer, ISBN: 978-1441950185.
2. Hardware / Software Co- Design, Giovanni DeMicheli, Mariagiovanna Sami, Kluwer Academic Publishers, ISBN: 978-0792338833.

#### Reference Books:

1. A Practical Introduction to Hardware/Software Co-design, Patrick R.Schaumont, Springer Publications, ISBN: 978-1441959997.

#### Web Links:

1. <https://embedded.eecs.berkeley.edu/Research/hsc/abstract.html>
2. <http://ieeexplore.ieee.org/document/6172642/>
3. <http://www.tik.ee.ethz.ch/education/lectures/hswcd/>
4. <http://ieeexplore.ieee.org/document/715400/>

## Internet of Things & its Applications

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 241EC037</b>	<b>2</b>	<b>0</b>	<b>1</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Interpret the evolution of different internet technologies and need for IOT.
- CO2:** Identify different networking components in IOT with respect to OSI.
- CO3:** Infer the need of sensors and actuators used in IOT.
- CO4:** Outline the terminologies and technologies associated with IOT connectivity.
- CO5:** Summarize IOT applications for societal needs.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	3	1	1		2			1	1		1
<b>CO2</b>	2	3			2			1	1		1
<b>CO3</b>	3	2			2			1	1		1
<b>CO4</b>	3	2			2			1	1		1
<b>CO5</b>	3	2			2			1	1		1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>		2
<b>CO2</b>		2
<b>CO3</b>		1
<b>CO4</b>		2
<b>CO5</b>		1

## UNIT – I

### Introduction to IOT:

Introduction, Evolution of IOT, IOT and M2M, IOT -CPS, IOT-WoT, Various enablers of IOT and Complex interdependence technologies, Networking components of IOT.

#### Practice:

1. Study of active and passive sensors.
2. Study of Arduino/Raspberry pi/Node-MCU

## UNIT – II

**Networking Components in IOT:**

Introduction, Network types, Network reachability, OSI model, Internet Protocol suite, Datalink layer addressing, Network layer addressing, TCP/IP transport layer. Study of different operating systems for Raspberry Pi / Beagle board. Understanding the process of Os installation on Raspberry – Pi/ Beagle board.

**Practice:**

1. Interfacing of analog sensors with Arduino/Raspberry pi/Node-MCU
2. Interfacing of digital sensors with Arduino/Raspberry pi/Node-MCU.

**UNIT – III****IOT sensors and actuators:**

Introduction, Sensors and its characteristics, types of sensing, sensing considerations, Actuators, characteristics of actuators, types of actuators.

**Practice:**

1. Interfacing of actuators with Arduino/Raspberry pi/Node-MCU.
2. Control an actuator based on sensor input with Arduino/Raspberry pi/Node-MCU.

**UNIT – IV****IOT software and Protocols:**

Introduction, data protocols, MQTT, MQTT-SN, CoAP, XMPP, HTTP, Web Socket, Identification protocols, EPC, UCode.

**Practice:**

1. Deploy sensor data on a cloud platform.
2. Develop IoT model using soil moisture sensor for Agriculture application.

**UNIT – V****Connectivity Technologies in IOT:**

Introduction, IEEE 802 15 4, Zigbee, Communication topologies in Zigbee, Wireless HART network architecture, RFID, Lora, WI-Fi, Bluetooth. IOT Applications: IOT in agriculture, Smart irrigation Management system, IOT in health care systems.

**Practice:**

1. Develop IoT model using sensors and actuator for Home automation application.
2. Develop IoT model using sensors and actuator for smart city application.

**Text Books:**

1. Computer Networks, Andrew S. Tanenbaum and David J. Wetherall, Pearson Education, 5<sup>th</sup> Edition, ISBN: 978-0132126953.
2. Internet of Things, A Hands-on approach, Vijay madiseti, Arshdeep Bahga, University Press, 1<sup>st</sup> Edition, ISBN: 978-8173719547.

**Reference Books:**

1. Learning Internet of Things, Peter Waher, Packt Publishing, Editors Ovidiu Vermesan, ISBN: 978-1783553532.
2. Internet of Things—From Research and Innovation to Market Deployment, Peter Friess, River Publishers, ISBN: 978-8793102941.
3. Rethinking the Internet of Things: A Scalable Approach to Connecting Everything, Francis daCosta, 1<sup>st</sup> Edition, Apress Publications, ISBN: 978-1430257400.

**Web Links:**

1. [https://onlinecourses.nptel.ac.in/noc21\\_cs17/preview?mselkid=16aacd77c08211ec97fb643b5beb9cd2](https://onlinecourses.nptel.ac.in/noc21_cs17/preview?mselkid=16aacd77c08211ec97fb643b5beb9cd2) Introduction to internet of things - Course (nptel.ac.in)
2. [Design for internet of things By Prof. Prabhakar T V | IISc Bangalore Design for internet of things - Course \(nptel.ac.in\)](#)

## Smart Sensors & Devices for Agriculture

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 241EC041</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Analyze the characteristics of different types of sensors used in agriculture.
- CO2:** Interpret the need for remote sensing sensors for smart agriculture..
- CO3:** Apply nano sensors-based devices for precision agriculture based on the farmer's requirements.
- CO4:** Develop IoT-based sensor system for agriculture monitoring.
- CO5:** Develop AI, Edge, and Fog computing-based IoT networks for Agriculture applications.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	2	3									1
CO2	3	1									1
CO3	2	1									1
CO4	2		2								1
CO5	2		2								1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1		2
CO2		2
CO3		2
CO4		2
CO5		2

### UNIT – I

**Sensor Fundamentals and Characteristics:** Introduction to sensors, types of sensors, performance characteristics, and applications - Location sensors, Optical sensors, Electrochemical sensors, Mechanical sensors, Dielectric soil moisture sensors, Airflow sensors, pH sensors, Accelerometer sensors, Nano sensors, Nano biosensors, Application of sensors.

### UNIT – II

**Remote Sensing Sensors for Precision Agriculture:**

Classification of remote sensors, Selection of sensor parameters, Spatial resolution, Spectral resolution, Radiometric resolution, Temporal resolution; Optical infrared sensors, GPS sensors, Agricultural temperature sensors, LiDAR.

**UNIT – III**

**Nano Sensors in Agriculture:** Nanoparticles, Nanoparticles based nano sensors for agriculture, Nano sensors in pesticide detection in soil, Nano biosensors – basic principle and characteristics. Nano biosensors for microbial detection in soil.

**UNIT – IV****IoT-based Devices in Agriculture:**

Agricultural Informatics -technological Components, IoT Basics and Characteristics of IoT and its Applications in Agriculture, IoT Requirements, Issues & Challenges, IoT Architectures towards urban greening, G- IoT, G-IoT Applications, G-IoT challenges, and opportunities, Need for a smart e-monitoring system for agriculture, Case study on IoT based monitoring systems, Research Challenges.

**UNIT – V****AI, Edge, and IoT Frameworks for Agriculture:**

A fog computing-based IoT framework for prediction of crop disease using big data analytics Renewable energy and AI-powered IoT - Architecture and system design, User operability, Applications, Advantages, and Limitations.

**Text Books:**

1. AI, Edge and IoT-based Smart Agriculture, Ajith Abraham, Sujata Dash, Joel J.P.C. Rodrigues, Biswaranjan Acharya, Subhendu Kumar Pani Elsevier Science,2021, ISBN: 9780128236949.
2. Remote Sensing: Techniques in Agriculture , D.D. Sahu , Agrobios, ISBN: 9788177543483.

**Reference Books:**

1. Nanosensors for Agriculture, Adil Denizli, Tuan Anh Nguyen, Susai Rajendran, Ghulam Yasin, Ashok Kumar, Elsevier Science,2021, ISBN: 978-0128245545.

2. Agricultural Internet of Things and Decision Support for Precision Smart Farming, Annamaria Castrignano, Gabriele Buttafuoco, Raj Khosla, Abdul Mouazen, Dimitrios Moshou, Olivier Naud, Elsevier Science, 2020, ISBN: 978-0128183731.
3. Internet of Things (IoT) Enabled Automation in Agriculture: Enabled Automation in Agriculture, Rajesh Singh, New India Publishing Agency- Nipa, 2018, ISBN: 9781003364702.

**Web Links:**

1. <https://nptel.ac.in/courses/108108147Sensors and Actuators, IISc Bangalore>  
[Prof. Hardik Jeetendra Pandya.](#)

### Minor Stream: Signal Processing and Communication Technology

Course Code	Course Name	Level	L	T	P	C	CIE	SEE	Total	Pre-requisite
241EC045	Fundamentals of Speech Processing	IC	2		1	3	50	50	100	S&S
241EC046	Information Theory & Coding Techniques	IC	2		1	3	50	50	100	-
241EC044	Digital Signal Processors & Architectures	IC	3			3	50	50	100	DSP
241EC043	Digital Image Processing	IC	2		1	3	50	50	100	S&S
241EC049	Radar Engineering	IC	3			3	50	50	100	ADCM
241EC051	Soft Computing Techniques	AC	3			3	50	50	100	-
241EC047	Optical Communications	AC	3			3	50	50	100	ADCM
241EC050	Satellite Communications	AC	3			3	50	50	100	ADCM
241EC048	Pattern Recognition	AC	2			2	50	50	100	DIP
241EC052	Wireless Communications	AC	3			3	50	50	100	ADCM
241EC053	Wireless Sensor Networks	AC	3			3	50	50	100	IOT
<b>Total</b>			<b>29</b>		<b>3</b>	<b>32</b>				

## Fundamentals of Speech Processing

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 241EC045</b>	<b>2</b>	<b>0</b>	<b>1</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Interpret the basic concepts of speech production and perception.
- CO2:** Classify the concepts of analysis and processing of speech signals .
- CO3:** Analyze the enhancement of speech signals in the presence of different background noises.
- CO4:** Interpret the concepts pattern recognition system and different statistical modeling approaches.
- CO5:** Analyze the applications of speech processing including speaker recognition and speech recognition.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	2	1	3		1			1	1		1
<b>CO2</b>	2	3			1			1	1		1
<b>CO3</b>	2	3	2		1			1	1		1
<b>CO4</b>	2	3	2		1			1	1		1
<b>CO5</b>	2	2	3		1			1	1		1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>	2	
<b>CO2</b>	2	
<b>CO3</b>	2	
<b>CO4</b>	2	
<b>CO5</b>	2	

## UNIT – I

### Introduction to Speech Processing:

Speech Fundamentals, Speech production and perception, information sources in speech signal, linguistic aspect of speech, acoustic and articulatory phonetics, nature of speech, models for speech analysis and perception, short-term processing of speech, time, frequency and time-frequency analysis, development of short-term Fourier transform (STFT), transform and filter-bank views of STFT.

### Practice:

1. Manual speech signal-to-symbol transformation for speech signal.
2. Time-varying nature of the speech signal in the time domain as well as frequency domain.

## UNIT – II

### **Speech Analysis:**

Basis and development cepstrum analysis of speech, real and complex cepstrum, pitch detection, formant estimation, Mel-frequency cepstral coefficient (MFCC), delta and delta-delta MFCC, Linear Prediction (LP) analysis, LP analysis of speech, solution of LP equation using Levinson-Durbin's method, normalized error, LP spectrum, LP cepstrum, LP residual.

### **Practice:**

1. Analyze speech signals by computing the cepstrum for various voiced and unvoiced sounds.
2. Analyze the characteristics of speech using linear prediction (LP) analysis.

## UNIT – III

### **Speech enhancement:**

objective, issues, enhancement of noisy speech, reverberant speech and multi-speaker speech using time, frequency and time-frequency approaches.

### **Practice:**

1. Spectrographic Analysis of voiced, unvoiced and plosive Speech.
2. Short-time spectrum analysis of speech signals, the effect of size of the analysis window (less than one pitch period, one pitch period, two to four pitch periods).

## UNIT – IV

### **Basic concepts of pattern recognition:**

Feature extraction, modeling, testing, Objective, issues, block diagram description of automatic speech recognition (ASR) system, development of ASR system using vector quantization (VQ), dynamic time warping (DTW), Hidden Markov Model (HMM) and Neural networks (NN).

### **Practice:**

1. Analyze speech signals by computing the cepstrum for various voiced and unvoiced sounds.
2. Analyze effects of sampling (aliasing) and quantization on speech signals by playing them at different sampling rates and bits per sample.

## UNIT – V

**Speech Recognition:**

Objective, issues, block diagram description of speaker recognition system, classification of speaker recognition systems, development of speaker recognition system using VQ, Gaussian mixture model (GMM), Adapted-GMM and I-vector.

**Practice:**

1. Speaker voice activity detection in speech.
2. Reconstruct the spectrum of various components (source, system) using the spectrum.

**Text Books:**

1. Digital Processing of Speech Signals, L.R. Rabiner and R.W. Schafer, Pearson Education, Delhi, India, ISBN: 978813170513.
2. Fundamentals of speech recognition, L. R. Rabiner, B. H. Juang and B. Yegnanarayana, Pearson Education, ISBN: 8177585606.

**Reference Books:**

1. Discrete-Time Processing of Speech Signals, J. R. Deller, Jr., J. H. L. Hansen and J. G. Proakis, Wiley-IEEE Press, NY, USA, ISBN: 0780353862.
2. Discrete time processing of speech signals, T. F. Quatieri, Pearson Education, ISBN: 013242942X.
3. Speech and Audio Processing, Dr.Shaila D.Apte -, First Edition, WILEY, ISBN: 978-8126534081.
4. Statistical Methods of Speech Recognition, Frederick Jelinek, MIT Press, 2022, ISBN: 9780262546607.

**Web Links:**

1. <https://archive.nptel.ac.in/courses/117/105/117105145/#/> Prof. S.K. Das Mandal
2. <https://www.cse.iitb.ac.in/~pjyothi/cs753/index.html/> Prof. Preethi Jyothi
3. <https://ssp-iiith.vlabs.ac.in/Introduction.html/> Speech Signal Processing Lab
4. <https://vlab.amrita.edu/index.php?sub=59&brch=164/> Speech Signal Processing Lab

## Information Theory & Coding Techniques

**Course Code: 241EC046**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>2</b>	<b>0</b>	<b>1</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Explain the basics of Information theory.
- CO2:** Implement the various types of source coding algorithms and analyze their performance.
- CO3:** Design a channel coding scheme for a communication system.
- CO4:** Discuss the different types of entropy and coding theorem for Gaussian channels.
- CO5:** Evaluate the performance of coding techniques and error corrections.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	3	2	1				1	2	1		1
<b>CO2</b>	3	3	1				1	2	1		1
<b>CO3</b>	3	3	2				1	2	1		1
<b>CO4</b>	2	3	2				1	2	1		1
<b>CO5</b>	2	3	2				1	2	1		1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>	2	
<b>CO2</b>	2	
<b>CO3</b>	2	
<b>CO4</b>	2	
<b>CO5</b>	2	

## UNIT – I

### Information Theory:

Entropy, Joint Entropy and Conditional Entropy, Relative Entropy and Mutual Information, Chain Rules, Data-Processing Inequality, Fano's Inequality.

### Practice:

1. Write a program using matlab for the determination of various entropies and mutual information of a given channel. Test various types of channel such as
  - a) Noise free channel
  - b) Error free channel
  - c) Binary symmetric channel
  - d) Noisy channel

## UNIT – II

**Source Coding:**

Shannon –Fano Coding, Optimality of Huffman Coding, Capacity of a Gaussian channel, bandwidth –S/N trade off, Capacity of discrete channels, Related Problems.

**Practice:**

1. Minimize coding redundancy using Source Encoder and Decoder using hardware kit.
2. Analyze the channel coding techniques in time and frequency domain using hardware kit.
3. Write a program for generation and evaluation of variable length source coding using matlab.
  - a) Shannon –Fano coding and decoding.
4. Write a program for generation and evaluation of variable length source coding using matlab.
  - a) Huffman coding and decoding.

**UNIT – III****Linear Block Codes:**

Introduction, Matrix description of Linear Block Codes, Error detection and error correction capabilities of Linear block codes, Hamming codes, Binary Cyclic Codes, Algebraic structure, Encoding, Syndrome calculation, BCH Codes.

**Practice:**

1. Perform error detection and correction using Linear Block Code-Encoder and Decoder using hardware kit.
2. Write a program for encoding and decoding of BCH codes using matlab.

**UNIT – IV****Cyclic Codes:**

Description, Generator and Parity-check Matrices, Encoding, Syndrome Computation and Error Detection, Decoding, Cyclic Hamming Codes, shortened cyclic codes, Error-trapping decoding for cyclic codes, Majority logic decoding for cyclic codes, shortened cyclic codes – Turbo code.

**Practice:**

1. Perform error detection and correction using Binary Cyclic Code – Encoder and Decoder using hardware kit.

**UNIT – V****Convolutional Codes:**

Encoding of Convolutional Codes- Structural and Distance Properties, state, tree, trellis diagrams, maximum likelihood decoding, Sequential decoding, Majority- logic decoding of

Convolution codes. Application of Viterbi Decoding and Sequential Decoding, Applications of Convolutional codes in ARQ system. Low Density Parity Check (LDPC) codes.

**Practice:**

1. Perform error detection and correction using Convolution Code – Encoder and Decoder using hardware kit.
2. Implementation of ARQ technique using matlab.

**Text Books:**

1. Information theory and coding - K. N. Hari Bhat , D. Ganesh Rao ,Cengage India Private Limited, First Edition, ISBN: 978-9386650924.
2. Information theory and coding by Anoop Singh poonia,Rupal Bansal,Ashirwad publisher,Fifth Edition, ISBN: 8190571109.

**Reference Books:**

1. Digital Communications, John Proakis, TMH, 5<sup>th</sup> Edition, ISBN: 978-0072957167.
2. Information Theory and Coding (Wiley India: 2015) by Dr. Mrualidhar Kulkarni Dr. Shivaprakash K S, Wiley, 2<sup>nd</sup> Edition, ISBN: 9788126553051.

**Web Links:**

1. [NPTEL :Electrical Engineering - NOC:Information Theory, Coding and Cryptography by IIT Delhi.](https://archive.nptel.ac.in/courses/108/102/108102117/)  
<https://archive.nptel.ac.in/courses/108/102/108102117/>
2. <https://archive.nptel.ac.in/noc/courses/noc18/SEM2/noc18-ee39/>

## Digital Signal Processors & Architectures

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code:241EC044</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Summarize the concepts of number formats and various DSP related errors.
- CO2:** Illustrate the architectural features of Programmable digital signal processors.
- CO3:** Infer the TMS320C54XX processor architecture details, addressing modes and on-Chip peripherals.
- CO4:** Implement the basic DSP algorithms using digital signal processors.
- CO5:** Interpret the interfacing of devices with digital signal processors.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	3	2									1
<b>CO2</b>	3	1									1
<b>CO3</b>	2	3	1								1
<b>CO4</b>	2	3	2								1
<b>CO5</b>	2	3									1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>	2	
<b>CO2</b>	2	
<b>CO3</b>	2	
<b>CO4</b>	2	
<b>CO5</b>	2	

## UNIT – I

### Computational Accuracy in DSP implementations:

Review of Digital signal processing, Number formats for signals and coefficients in DSP systems, Dynamic Range and Precision, Sources of error in DSP implementations, A/D Conversion errors, DSP Computational errors, D/A Conversion Errors.

## UNIT – II

### **Architectures for Programmable DSP Devices:**

Basic Architectural features, DSP Computational Building Blocks, Bus Architecture and Memory, Data Addressing Capabilities, Address Generation Unit, Programmability and Program Execution, Speed Issues, Features for External interfacing.

## UNIT – III

### **Programmable Digital Signal Processors:**

Commercial Digital signal-processing Devices, Data Addressing modes of TMS320C54XX Processors, Memory space of TMS320C54XX Processors, Program Control, TMS320C54XX Instructions and Programming, On Chip Peripherals, Interrupts of TMS320C54XX Processors, Pipeline Operation of TMS320C54XX Processors. Architectural features of TMS320C67XX Processors.

## UNIT – IV

### **Implementations of basic DSP algorithms:**

The Q-notation, FIR Filters, IIR Filters, Interpolation Filters, Decimation Filters, PID Controller, Adaptive Filters, An FFT Algorithm for DFT Computation, A Butterfly Computation, Overflow and scaling, Bit-Reversed index generation, An 8-Point FFT implementation on the TMS320C54XX, Computation of the signal spectrum.

## UNIT – V

### **Interfacing Memory and I/O Peripherals to Programmable DSP Devices:**

Memory space organization, External bus interfacing signals, Memory interface, Parallel I/O interface, Programmed I/O, Interrupts, Direct memory access (DMA).

### **Text Books:**

1. Digital Signal Processing, Avtar Singh and S. Srinivasan, Thomson Press, ISBN: 9788131500347.
2. Digital Signal Processing: Principles, Algorithms & Applications – J.G. Proakis & D.G. Manolakis, PHI, 4<sup>th</sup> Edition, ISBN: 9788131710005..

**Reference Books:**

1. A Practical Approach to Digital Signal Processing, K Padmanabhan, R.Vijayarajeswaran, and Ananthi S, New Age International, 2<sup>nd</sup> Edition, ISBN: 978-8122432428.
2. Embedded Signal Processing with the Micro Signal Architecture, Woon-Seng Gan, and Sen M. Kuo, Wiley-IEEE Press, 1<sup>st</sup> Edition, ISBN. 978-0471738411.
3. DSP Processor Fundamentals, Architectures & Features, Lapsley et al, S. Chand &Co, 1<sup>st</sup> Edition, ISBN: 978-8126523542.

**Web Links:**

1. <https://nptel.ac.in/courses/108/101/108101174> NPTEL course on “Digital Signal Processing and its Applications”.
2. <https://nptel.ac.in/courses/108106149> NPTEL course on “Mapping Signal Processing Algorithms to Architectures”.
3. <https://www.analog.com/en/design-center/landing-pages/001/beginners-guide-to-dsp.html>
4. <https://www.dspguide.com/ch28/3.html>

## Digital Image Processing

<b>Course Code: 241EC043</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	<b>2</b>	<b>0</b>	<b>1</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Interpret the concepts of digital image processing and image transforms.
- CO2:** Apply spatial and frequency domain techniques for image enhancement and Restoration.
- CO3:** Apply discontinuity and similarity based techniques for image segmentation.
- CO4:** Perform compression techniques for images.
- CO5:** Utilize color models for image processing applications.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	3	2	1	1	1			1	1		1
<b>CO2</b>	3	2	2	1	1			1	1		1
<b>CO3</b>	3	2	2	1	1			1	1		1
<b>CO4</b>	3	2	2	1	1			1	1		1
<b>CO5</b>	3	2	2	1	1			1	1		1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>	2	
<b>CO2</b>	2	
<b>CO3</b>	2	
<b>CO4</b>	2	
<b>CO5</b>	2	

### UNIT – I

**Introduction:** Introduction to Image Processing, Fundamental steps in digital image processing, Components of an image processing system, Image sensing and acquisition, Image sampling and quantization, Some basic relationships between pixels, An introduction to the mathematical tools used in digital image processing.

**Image Transforms:** Need for image transforms, Discrete Fourier transform (DFT) of one variable, Extension to functions of two variables, some properties of the 2-D Discrete Fourier transform, Importance of Phase, DCT, DST, Walsh-Hadamard transform, KLT, Haar transform, Radon Transform

**Practice:**

1. Compute arithmetic and logical operations on images
2. Compute DFT, DCT and DST of an image also calculate phase

**UNIT – II**

**Image Enhancement:** Back ground, basic intensity transformation methods, histogram processing, fundamentals of spatial filtering, smoothing and sharpening spatial filters, Combining spatial enhancement methods. The basics of filtering in the frequency domain, image smoothing and sharpening using frequency domain filters, selective filtering.

**Practice:**

1. Obtain the enhancement of a low contrast image using histogram equalization
2. Perform unsharp masking and high boost filtering to sharpen the image.

**UNIT – III**

**Image Restoration and Reconstruction:** A model of the image degradation/ Restoration process, Noise models, restoration in the presence of noise only- Spatial Filtering, Periodic Noise Reduction by frequency domain filtering, Linear, Position –Invariant Degradations, Estimating the degradation function, Inverse filtering, Minimum mean square error (Wiener) filtering, constrained least squares filtering, geometric mean filter.

**Practice:**

1. Compute the denoised image using mean filters for the removal of noise and compare the results in terms of PSNR.
2. Compute the denoised image using order-statistics filters for the removal noise and compare the results in terms of PSNR.
3. Perform deblurring using inverse filter and Wiener filter.

**UNIT – IV**

**Image Segmentation:** Fundamentals, point, line, edge detection, thresholding, region – based segmentation, Hough Transform.

**Image Compression:** Fundamentals, Basic compression methods: Huffman coding, Golomb coding, Arithmetic coding, LZW coding, Run-Length coding, Symbol-Based coding, Bit-Plane coding, Block Transform coding, Predictive coding.

**Practice:**

1. Compute the edge of an image using Sobel and Prewitt operator.
2. Compress image using Huffman coding and Arithmetic coding techniques

## UNIT – V

**Color Image Processing:** Color fundamentals, color models, pseudo color image processing, basics of full color image processing, color transformations, smoothing and sharpening. Image segmentation based on color, noise in color images.

**Morphological Image Processing:** Dialation, Erosion, Opening, Closing.

**Practice:**

1. Compute smoothing on color images with and without noise
2. Compute sharpening on color images

**Text Books:**

1. Digital Image Processing, R. C. Gonzalez and R. E. Woods, Prentice Hall, 4<sup>th</sup> Edition, 2018, ISBN: 978-9353062989
2. Digital Image Processing, Jayaraman, S.Esakkiraja and T.Veerakumar, Tata McGrawHill Education, 2ndEdition, ISBN: 9780070144798

**Reference Books:**

1. Fundamentals of Digital Image Processing, Anil K. Jain, Prentice Hall of India, 9<sup>th</sup> Edition, ISBN: 978-9332551916.
2. Digital Image Processing, S Sridhar, Oxford higher Eeducation Publication, 2<sup>nd</sup> Edition, ISBN. . 978-0199459353.
3. Digital Image Processing using MATLAB, R. C. Gonzalez and R. E. Woods, Prentice Hall, 3<sup>rd</sup> Edition, ISBN: 978-0131687288.

**Web Links:**

1. [http://nptel.ac.in/courses/117105079/\(Digital Image Processing, IIT Kharagpur Prof. P.K. Biswas\)](http://nptel.ac.in/courses/117105079/(Digital%20Image%20Processing,%20IIT%20Kharagpur%20Prof.%20P.K.%20Biswas))
2. [https://www.coursera.org/learn/digital#ratings\(Fundamentals of digital image and video processing, Aggelos K. Katsaggelos, University of North westren\)](https://www.coursera.org/learn/digital#ratings(Fundamentals%20of%20digital%20image%20and%20video%20processing,%20Aggelos%20K.%20Katsaggelos,%20University%20of%20North%20westren))
3. <https://sisu.ut.ee/imageprocessing/avaleht>

## RADAR Engineering

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 241EC049</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Model the RADAR range equation.
- CO2:** Outline the working principle of CW and FM-CW RADARs.
- CO3:** Illustrate the principle of MTI RADAR and its characteristics.
- CO4:** Infer the RADAR tracking techniques.
- CO5:** Analyze matched filter receiver characteristics and subsystems of RADAR receiver.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	3	2									1
<b>CO2</b>	2	3									1
<b>CO3</b>	3	2									1
<b>CO4</b>	3	2									1
<b>CO5</b>	2	3									1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>	2	
<b>CO2</b>	2	
<b>CO3</b>	2	
<b>CO4</b>	2	
<b>CO5</b>	2	

## UNIT – I

### Basics of Radar:

Introduction, nature of radar, Prediction of Range Performance, Minimum Detectable Signal, Receiver Noise, Illustrative Problems. Radar Equation: Modified Radar Range Equation, SNR, probability of detection, probability of False Alarm, Integration of Radar Pulses, Radar Cross Section of Targets (simple targets - sphere, cone-sphere), Transmitter Power, PRF and Range Ambiguities, System Losses (qualitative treatment), Illustrative Problems.

## UNIT – II

### **CW and Frequency Modulated Radar:**

Doppler Effect, CW Radar – Block Diagram, Isolation between Transmitter and Receiver, Non-zero IF Receiver, Receiver Bandwidth Requirements, Applications of CW radar. Illustrative Problems. FM-CW Radar, FM-CW altimeter, Multiple Frequency CW Radar.

## UNIT – III

### **MTI and Pulse Doppler Radar:**

Introduction, Principle, MTI Radar with - Power Amplifier Transmitter and Power Oscillator Transmitter, Delay Line Cancellers – Filter Characteristics, Blind Speeds, Double Cancellation, Range Gated Doppler Filters, Limitations to MTI Performance, MTI versus Pulse Doppler Radar.

## UNIT – IV

### **Tracking Radar:**

Tracking with Radar, Sequential Lobing, Conical Scan, Mono pulse Tracking Radar – Amplitude Comparison Mono pulse (one- and two- coordinates), Phase Comparison Mono pulse, Tracking in Range, Acquisition and Scanning Patterns, Comparison of Trackers.

## UNIT – V

### **Detection of Radar Signals in Noise:**

Introduction, Matched Filter Receiver – Response Characteristics and Derivation, Correlation detection and Cross-correlation Receiver, Efficiency of Non-Matched Filters, Matched Filter with Non-white Noise, Noise Figure and Noise Temperature.

**Radar Receivers:** Displays – types. Duplexers – Branch type and Balanced type, Circulators as Duplexers. Introduction to Phased Array Antennas – Basic Concepts, Radiation Pattern, Beam Steering and Beam Width changes, Series versus parallel feeds, Applications, Advantages and Limitations, Radomes.

### **Text Books:**

1. Introduction to Radar Systems, Merrill I. Skolnik, TMH Special Indian Edition, 2<sup>nd</sup> Edition, ISBN: 9780070634411.
2. Radar: Principles, Technology, Applications, Byron Edde, Pearson Education, ISBN: 9788131713839.

### **Reference Books:**

1. Radar Principles – Peebles, Jr., P.Z., Wiley, New York, ISBN: 9780471252054.
2. Radar Handbook, Merrill I. Skolnik, McGraw Hill, Third, 3rd Edition, ISBN: 9780471252054.
3. Introduction to Radar System, KK Sharma, S.K. Kataria & Sons, 1<sup>st</sup> Edition, 2023, ISBN: 9789350142615.

**Web Links:**

1. <https://www.jlab.org/ir/MITSeries/V1-1.pdf>
2. <https://ocw.mit.edu/resources/res-ll-001-introduction-to-radar-systems-spring-2007>, Dr. Robert M. O'Donnell
3. [https://onlinecourses.nptel.ac.in/noc24\\_ee104/previewPrinciples\\_and\\_Techniques\\_of\\_Modern\\_Radar\\_Systems](https://onlinecourses.nptel.ac.in/noc24_ee104/previewPrinciples_and_Techniques_of_Modern_Radar_Systems) Dr. Amitabha Bhattacharya, IIT Kharagpur- NPTEL course

## Soft Computing Techniques

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 241EC051</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Discuss the basic concepts of soft computing techniques.
- CO2:** Explain Fuzzy systems, components and their applications.
- CO3:** Demonstrate Fuzzy modeling and control schemes for nonlinear systems.
- CO4:** Infer Genetic Algorithm for solving the optimization problems.
- CO5:** Develop proficiency in the Back Propagation algorithm for training Multilayer Perceptron networks.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	3	2									
<b>CO2</b>	3	3									
<b>CO3</b>	3	3	1								
<b>CO4</b>	2	3	1								
<b>CO5</b>	2	3	1								

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>	2	
<b>CO2</b>	2	
<b>CO3</b>	2	
<b>CO4</b>	2	
<b>CO5</b>	2	

## UNIT – I

### Introduction:

Concept of computing systems, Soft computing versus Hard computing, Characteristics of Soft computing, Introduction to Fuzzy Computing, Neural Computing, Some applications of Soft computing techniques.

## UNIT – II

### **Fuzzy Sets and Fuzzy Logic:**

Introduction, Fuzzy Sets Versus Crisp Sets, Operations on Fuzzy Sets, Extension Principle, Fuzzy Relations and Relation Equations, Fuzzy Numbers, Linguistic Variables, Fuzzy Logic, Linguistic Hedges, Applications.

## UNIT – III

### **Inference in Fuzzy Logic:**

Fuzzy if-then rules, Fuzzy implications and Fuzzy algorithms, Fuzzifications, Inferencing, and De-fuzzifications, Fuzzy modeling and control schemes for nonlinear systems, Fuzzy Pattern Recognition, Fuzzy Image Processing, Fuzzy Database.

## UNIT – IV

### **Genetic Algorithm:**

Basic concept of Genetic algorithm and detail algorithmic steps, Search space, working principle. Encoding: binary, Octal, Hexadecimal, permutation, Value and Tree. Decoding, fitness function, Selection: Roulette wheel, Boltzmann, Tournament, Rank and Steady-state. Crossover: single-point, two-point, multi-point, uniform, matrix and crossover rate, Mutation: mutation, mutation rate, Ant-colony optimization, Particle Swarm Optimization, Solving problems using GA.

## UNIT – V

### **Artificial Neural Networks:**

Concept of Artificial Neural Networks and its basic mathematical model, McCulloch-Pitts neuron model, Single Neuron/Perceptron networks: training methodology, Typical application to linearly separable problems. Feed-forward Multilayer Perceptron, Multilayer Perceptron: Back propagation algorithm, virtues and limitation of BP algorithm, Modifications to back-propagation, Hopfield network.

### **Text Books:**

1. Neural Networks, Fuzzy Systems and Evolutionary Algorithms: Synthesis and Applications, 2<sup>nd</sup> Edition, S. Rajasekharan, G. A. Vijayalakshmi Pal, Prentice Hall India, ISBN : 978-8120353343
2. Foundations of Neural Networks, Fuzzy Systems, and Knowledge Engineering, Nikola K. Kasabov, MIT Press, ISBN : 0-262-11212-4

**Reference Books:**

1. Neural Networks and Learning Machine, Simon Haykins, Prentice Hall India, 3<sup>rd</sup> Edition, ISBN: 978-0-13-147139-9
2. Fuzzy Logic with Engineering Application, Timothy J. Ross, Wiley, 3<sup>rd</sup> Edition, ISBN: 0-470-86075-8

**Web Links:**

1. <https://archive.nptel.ac.in/courses/106/105/106105173/> (Prof. Debasis Samanta, IIT Kharagpur)
2. [https://onlinecourses.nptel.ac.in/noc21\\_ge07/preview](https://onlinecourses.nptel.ac.in/noc21_ge07/preview)
3. <https://www.udemy.com/course/geneticalgorithm/?couponCode=LEADERSALE24A>
4. <https://www.udemy.com/course/fuzzylogic/>

## Optical Communications

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 241EC047</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Realize the significance of optical fiber communications.
- CO2:** Recognize the construction and characteristics of optical fiber cable.
- CO3:** Illustrate the knowledge of optical signal sources and power launching.
- CO4:** Examine and understand the operation of various optical detectors.
- CO5:** Summarize the performance metrics of optical systems and WDM system.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	3	2	2								1
<b>CO2</b>	3	1	3								1
<b>CO3</b>	2	3	2								1
<b>CO4</b>	3	2	2								1
<b>CO5</b>	2	3	1								1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>	2	
<b>CO2</b>	2	
<b>CO3</b>	2	
<b>CO4</b>	2	
<b>CO5</b>	2	

## UNIT – I

### Overview of Optical Fiber Communication:

The general optical fiber communication system, Optical fiber wave guides, Ray theory transmission, Total Internal Reflection, acceptance angle, Cylindrical fibers- Modes Fiber materials, fiber fabrication techniques, fiber optic cables, classification of Optical Fibers: single mode fibers, graded index fibers.

## UNIT – II

### **Signal Distortion In Optical Fibers:**

Attenuation, absorption, scattering and bending losses, core and cladding losses, information capacity determination, group delay, Types of dispersion - material dispersion, wave-guide dispersion, polarization mode dispersion, intermodal dispersion, pulse broadening.

## UNIT – III

### **Optical Sources:**

Intrinsic and extrinsic materials-direct and indirect band gaps-LED-LED structures surface emitting LED-edge emitting LED-quantum efficiency and LED power-light source materials modulation of LED.

## UNIT – IV

### **Optical Detectors:**

Physical principles of PIN and APD, detector response time, temperature effect on avalanche gain, comparison of photo detectors.

## UNIT – V

### **Optical System Design:**

Considerations, component choice, multiplexing, point-to-point links, system considerations, link power budget with examples. WDM –passive DWDM components-elements of optical networks-SONET/SDH.

### **Text Books:**

1. Optical Fiber Communications, Gerd Keiser, Tata Mc Graw-Hill International edition, 5<sup>th</sup> Edition, ISBN: 978-1259006876.
2. Optical Fiber Communications , John M. Senior, PHI, 3<sup>rd</sup> Edition, ISBN: 978-9332535787

**Reference Books:**

1. Fiber Optic Communication, J. C. Palais, Pearson Prentice Hall, ISBN: 978-8131717912.
2. Optoelectronics and Photonics: Principles and Practices, S.O. Kasap, Pearson Prentice Hall, 2<sup>nd</sup> Edition, ISBN: 978-0132151498.

**Web Links:**

1. [http://nptel.ac.in/courses/117104127/2,Prof. Shanti Bhattacharya, IIT Madras.](http://nptel.ac.in/courses/117104127/2,Prof.ShantiBhattacharya,IITMadras.)
2. <https://www.linktionary.com/f/fiber-optic.html>

## Satellite Communications

<b>Course Code: 241EC050</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Summarize the trends of satellite communications.
- CO2:** Illustrate the orbital effects on satellite communication and associated sub systems.
- CO3:** Compare the multiple access techniques.
- CO4:** Analyze the parameters to enhance the satellite link performance and the satellite based link designs.
- CO5:** Outline the satellite-based navigation systems.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	3	2	2								1
<b>CO2</b>	3	2	2								1
<b>CO3</b>	2	3	2								1
<b>CO4</b>	2	2	3								1
<b>CO5</b>	2	2	2								1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>	2	
<b>CO2</b>	2	
<b>CO3</b>	2	
<b>CO4</b>	2	
<b>CO5</b>	2	

## UNIT – I

### Introduction:

Origin of satellite communications, historical back-ground, basic concepts of satellite communications, frequency allocations for satellite services, future trends of satellite communications. Orbital mechanics and launchers: orbital mechanics, look angle determination, orbital perturbations, orbital determination, launches and launch vehicles, orbital effects in communication systems performance.

## UNIT – II

### **Satellite Subsystems:**

Introduction-attitude and orbit control system, telemetry, tracking, commanding and monitoring, power systems, communication subsystems, satellite antennas subsystems, propulsion subsystems equipment reliability and space qualification.

## UNIT – III

### **Multiple Accesses Techniques:**

Frequency Division Multiple Access (FDMA), intermodulation, calculation of C/N. Time Division Multiple Access (TDMA), frame structure, slotted aloha spread spectrum methodology.

## UNIT – IV

### **Satellite Link Design:**

Basic link analysis, uplink and downlink design equation, free space loss-atmospheric effects, ionospheric scintillation, rain induced attenuation and interference, system noise temperature, link design with and without frequency reuse.

## UNIT – V

### **Satellite Applications:**

Mobile satellite services: GSM, LEO, MEO, Satellite Navigational System-GPS, Satellite applications, VSAT , DTH television principles – Direct broadcast radios ,INSAT ,IRS satellites ,PSLVs ,GSLVs.

### **Text Books:**

1. Satellite Communications ,Timothy Pratt & Jeremy Allnut, WSE, John Wiley & Sons Publications, 3<sup>rd</sup> Edition, October2019, ISBN:978-1119482178.
2. Satellite Communications Engineering-,Wilbur L. Pritchard, Robert A Nelson, and Henri G. Suyderhoud, Pearson Publications, 2<sup>nd</sup>Edition, ISBN: 978-0137914685.

### **Reference Books:**

1. Satellite Communication, D.C Agarwal & Rishabh Anand, Khanna Publications, 1<sup>st</sup>Edition, 2021, ISBN: 978-8194752844.
2. Satellite Communications: Design Principles- M. Richharia, B S publications, 2<sup>nd</sup>Edition, ISBN: 978-0070523746.

**Web Links:**

1. <https://archive.nptel.ac.in/courses/117/105/117105131/>, Prof. Kalyan Kumar Bandyopadhyay, IIT Kharagpur.
2. <https://www.coursera.org/learn/satellite-communications>.

## Pattern Recognition

<b>Course Code: 241EC048</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	<b>2</b>	<b>0</b>	<b>0</b>	<b>2</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Summarize the various techniques involved in pattern recognition.
- CO2:** Categorize the various pattern recognition techniques into supervised and unsupervised.
- CO3:** Illustrate the artificial neural network-based pattern recognition.
- CO4:** Discuss the applications of pattern recognition in various applications.
- CO5:** Evaluate the performance of speech recognition systems and optimize them for real-world applications.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	3	2	2								
<b>CO2</b>	3	3	2								
<b>CO3</b>	3	2	3								
<b>CO4</b>	2	2	2								
<b>CO5</b>	3	3	3								

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>	2	
<b>CO2</b>	2	
<b>CO3</b>	2	
<b>CO4</b>	2	
<b>CO5</b>	2	

## UNIT – I

### Introduction:

Fundamental concepts and blocks of a typical pattern recognition system. Decision functions- role and types, pattern and weight space, properties and implementation of decision functions.

## UNIT – II

### **Feature Identification and Feature Selection:**

Feature identification, selection and extraction. Distance measures, clustering transformation and feature ordering, clustering in feature selection, feature selection through maximization and approximations.

## UNIT – III

### **Pattern Classification:**

Pattern classification by distance functions. Clusters and cluster seeking algorithms. Pattern classification by likelihood functions. Baye's classifier and performance measures.

## UNIT – IV

### **Artificial Neural Network:**

Artificial neural network model, Neural network-based pattern associators, Feed forward networks and training by back-propagation- ART networks.

## UNIT – V

### **Applications of Statistical and Neural Network:**

Applications of statistical and neural network – based pattern classifiers in speech recognition, image recognition and target recognition.

### **Text Books:**

1. Pattern Recognition Principles by J.I. Tou & R.C. Gonzalez, Addison-Wesley, ISBN: 9780201075878.
2. Pattern Recognition - Statistical, Structural and Neural Approaches by R. Schalkoff, John Wiley, ISBN: 978-8126513703.

### **Reference Books:**

1. Pattern Recognition - A Statistical Approach by P.A. Devijer & J. Kittler, Prentice-Hall, ISBN: 978-0136542360.
2. Pattern recognition and machine learning by Christopher. M. Bishop, Springer, ISBN: 978-1493938438.

### **Web Links:**

1. <https://www.geeksforgeeks.org/pattern-recognition-introduction>
2. <https://archive.nptel.ac.in/courses/117/105/117105101/>

## Wireless Communications

<b>Course Code: 241EC052</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Illustrate the basic concepts of cellular networks.
- CO2:** Interpret concepts of mobile radio propagation.
- CO3:** Distinguish the concepts of modulation techniques and diversity.
- CO4:** Analyse the concepts of multiple access techniques.
- CO5:** Infer the wireless networking methods.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	3	2	1								1
<b>CO2</b>	2	2	1								1
<b>CO3</b>	2	2	1								1
<b>CO4</b>	2	2	1								1
<b>CO5</b>	2	2	1								1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>	2	
<b>CO2</b>	2	
<b>CO3</b>	2	
<b>CO4</b>	2	
<b>CO5</b>	2	

## UNIT – I

### Cellular System Design:

Introduction-frequency reuse, channel assignment strategies, Handoff strategies: prioritizing handoffs, practical handoff considerations, Interference and system capacity: Co-channel interference and system capacity, channel planning for wireless systems, adjacent channel interference, power control for reducing interference, trunking and grade of service.

## UNIT – II

### **Mobile Radio Propagation:**

Large scale path loss: Introduction to radio wave propagation, free space propagation model, small scale multipath propagation, fading effects due to multipath time delay spread, fading effects due to Doppler spread.

## UNIT – III

### **Modulation Techniques and Diversity:**

Digital Modulation: Factors that influence the choice of digital modulation, Spread Spectrum Modulation Techniques: Pseudo- Noise (PN) Sequences, Direct Sequence Spread Spectrum (DS-SS) - Diversity techniques: Practical space diversity considerations, polarization diversity, frequency diversity, time diversity.

## UNIT – IV

### **Multiple Access Techniques:**

Introduction to multiple access-Spread Spectrum Multiple Access, Code Division Multiple Access (CDMA), Orthogonal Frequency Division Multiple Access (OFDMA), Space Division Multiple Access (SDMA), Packet Reservation Multiple Access (PRMA), Capacity of Cellular Systems.

## UNIT – V

### **Wireless Networking:**

Network transmission hierarchy, traffic routing in wireless networks: Circuit switching, packet switching, cellular packet, switched architecture, network databases: distributed database for mobility management, Universal Mobile Telecommunication Systems (UMTS).

### **Text Books:**

1. Wireless Communications, Rappaport, Pearson Education, 2<sup>nd</sup> Edition, ISBN: 9788131731864
2. Wireless Communication, Andrea Goldsmith, Cambridge University Press, ISBN: 9780521837163

### **Reference Books:**

1. Wireless Communications, Andreas.F. Molisch, John Wiley, India, 3<sup>rd</sup> Edition, November 2022, ISBN: 9781119117209

2. Wireless Communication, Upena Dalal, Oxford University Press, 1<sup>st</sup> Edition, ISBN: 9780198060666

**Web Links:**

1. [https://onlinecourses.nptel.ac.in/noc21\\_ee66/preview](https://onlinecourses.nptel.ac.in/noc21_ee66/preview), by Prof. R. David Koilpillai, IIT, Madras.
2. <https://archive.nptel.ac.in/courses/117/104/117104117/> by Prof. Aditya K Jagannatham, IIT, Kanpur.

## Wireless Sensor Networks

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 241EC053</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Identify the components of Wireless Sensor Networks.
- CO2:** Develop node architecture for specific applications.
- CO3:** Realize the challenges in establishment of infrastructure.
- CO4:** Program sensor network platforms using specialized operating system.
- CO5:** Summarize the challenges in Sensor Network protocols.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	3	2	2								1
<b>CO2</b>	3	2	3								1
<b>CO3</b>	2	3	2								1
<b>CO4</b>	2	2	2								1
<b>CO5</b>	2	1	1								1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PO	PSO1	PSO2
<b>CO1</b>	2	
<b>CO2</b>	2	
<b>CO3</b>	2	
<b>CO4</b>	2	
<b>CO5</b>	2	

## UNIT – I

### Introduction:

Constraints and Challenges, Opportunities and Challenges in Wireless Sensor Networks, Advantages of Sensor Networks (Energy Advantage and Detection Advantage), Sensor Network Applications, Smart Transportation, Collaborative Processing

## UNIT – II

### Sensor Network Architecture and Applications:

Introduction, Functional Architecture for Sensor Networks, Sample Implementation Architectures, Classification of WSNs, Characteristics, Technical Challenges, and Design Directions, Technical Approaches, Coverage in Wireless Sensor Networks, Location in Wireless Sensor Networks, Data Gathering and Processing.

### UNIT – III

#### **Infrastructure Establishment:**

Topology Control, Clustering, Time Synchronization, Localization and Localization Services.

### UNIT – IV

#### **Sensor Network Platforms and Tools:**

Individual Components of SN Nodes, Sensor Network Node, WSNs as Embedded Systems, Sensor Node Hardware, Sensor Network Programming Challenges.

### UNIT – V

#### **Taxonomy of Routing Techniques:**

Routing Protocols, Applications/Application Layer Protocols, Localization Protocols, Time Synchronization Protocols, Transport Layer Protocols, Network Layer Protocols, Data Link Layer Protocols.

#### **Text Books:**

1. Wireless Sensor Networks, F. Zhao, C Guibas, Morgan Kaufmann, Elsevier, ISBN: 978-1558609143.
2. Hand book of Sensor Networks, Mohammad Ilyas, Imad Mahgoub, , CRC Press, ISBN: 9780429205576.

#### **Reference Books:**

1. Wireless Sensor Networks- Technology, Protocols, and Applications, Kazem Sohraby, Daniel Minoli, & Taieb Znati, John Wiley, ISBN: 978-0-470-11275-5.
2. Wireless Sensor Networks- An Information Processing Approach, Feng Zhao & Leonidas J. Guibas, Elsevier, ISBN: 9781558609143.

#### **Web Links:**

1. <https://archive.nptel.ac.in/noc/courses/noc17/SEM1/noc17-cs07/>, Prof.S Misra, IIT-Madras

2. [https://onlinecourses.nptel.ac.in/noc22\\_ee72/preview,Prof.Aditya K Jagannatham, IIT-Madras.](https://onlinecourses.nptel.ac.in/noc22_ee72/preview,Prof.Aditya_K_Jagannatham,IIT-Madras.)

### Minor Stream: Space Technology

Course Code	Course Name	Level	L	T	P	C	CIE	SEE	Total	Pre-requisite
241EC054	Introduction to Space Laws	IC	3			3	50	50	100	-
241EC055	Aircraft Communication Systems	IC	3			3	50	50	100	-
241EC057	Aircraft Navigation Systems	IC	3			3	50	50	100	-
241EC062	Missile & Space Vehicle Guidance & Control	IC	2			2	50	50	100	-
241EC060	Flight Control Systems	IC	3			3	50	50	100	-
241EC058	Avionics Embedded Systems	IC	3			3	50	50	100	-
241EC059	Avionics Network Technology	AC	3			3	50	50	100	-
241EC064	Unmanned Aircraft Systems	AC	3			3	50	50	100	-
241EC056	Aerospace Electromagnetic Compatibility	AC	3			3	50	50	100	-
241EC061	Global Navigation Satellite Systems & Applications	AC	3			3	50	50	100	SC
241EC063	Remote Sensing & Digital Image Processing of Satellite Data	AC	3			3	50	50	100	DIP
<b>Total</b>			<b>32</b>			<b>32</b>				

## Introduction to Space Laws

<b>Course Code: 241EC054</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Infer the foundational principles and treaties of international space law, including the Outer Space Treaty, the Moon Agreement, and the Rescue Agreement.
- CO2:** Ability to summarize key provisions of major space treaties.
- CO3:** Critical analysis of national space policies and their alignment with international laws.
- CO4:** Discuss the legal implications of space resource utilization.
- CO5:** Discuss the legal obligations for environmental protection in space.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	2	1	1								1
<b>CO2</b>	2	1	2								1
<b>CO3</b>	2	1	2								1
<b>CO4</b>	2	1	2								1
<b>CO5</b>	2	1	2								1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>	2	
<b>CO2</b>	2	
<b>CO3</b>	2	
<b>CO4</b>	2	
<b>CO5</b>	2	

### UNIT-I

Basic concepts of international law and space law: Introduction to international law, The Outer Space Treaty and the fundamental principles of space law, Other space treaties and General Assembly resolutions, National regulations, commercialization and privatization.

## UNIT-II

**Remote sensing/GIS, satellite meteorology and global climate + international law:** International law relating to remote sensing, National legislation for remote sensing, Regional and global agreements on remote sensing, Sources of remote sensing data.

## UNIT-III

**International laws on Satellite communications:** Overview of international law on satellite communications, Technical standards and national licensing, International trade in satellite communication services and global mobile personal communication services, Satellite broadcasting.

## UNIT-IV

**International law on Global navigation satellite systems (GNSS):** International institutional context for GNSS operations, GNSS providers and GNSS augmentation, GNSS users, Legal framework for GNSS services, GNSS services.

## UNIT-V

**Space Law relating to commercial space activities:** Legal issues in emerging trends of space activities - Human space flight, tourism, resource utilization, small satellite constellations, IPR.

### Text Books:

1. Space Law - A treatise, Francis Lyall and Paul B. Larsen, Ashgate publishing Limited, England, ISBN: 978-1472447821.
2. Recent trends in international space law and policy, V.S Mani, S.Bhatt, V.Balakista Reddy, Asia Law house, ISBN: 978-9385556791.

### Reference Books:

1. Handbook of space law, Frans von der Dunk, Fabio Tronchetti, Edward Elgar Publishing Limited, UK, ISBN: 978-1784713638.  
Recent Developments in Space Law - Opportunities & Challenges, R. Venkata Rao
2. V. Gopalkrishnan, Kumar Abhijeet, Springer, ISBN: 978-9811049255.

## Aircraft Communication Systems

**Course Code: 241EC055**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Outcomes:**

**At the end of the course, student will be able to:**

- CO1:** Explain the terminology of aircraft communication.
- CO2:** Learn the wave propagation types to be used for effective communication.
- CO3:** Aware of encryption standards in communication systems
- CO4:** Examine and understand the aircraft data links, communication band allotted for different satellites.
- CO5:** Get brief insight of future airborne communication systems – software defined radio.

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	3	2									1
<b>CO2</b>	3	1									1
<b>CO3</b>	2	3	2								1
<b>CO4</b>	3	2	2								1
<b>CO5</b>	2	3									1

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2
<b>CO1</b>	2	
<b>CO2</b>	2	
<b>CO3</b>	2	
<b>CO4</b>	2	
<b>CO5</b>	2	

**UNIT-I**

**Introduction:** The Isotropic Power Source and Free Space Path Loss, Radio Geometry - Radio Horizon Calculations, Earth Bulge Factor – k Factor, Great-circle Distances.

**UNIT-II**

**Wave Propagation:** Radio wave propagation – LOS, Complex Propagation: Refraction, Absorption, Non-LOS Propagation, Communication Frequency Bands and Allotment, Legacy and Modern Communications.

### UNIT-III

**Encryption standards in Communication Systems:** Introduction to Cryptography, crypto systems and types. Traditional ciphers - Caesar Cipher, Transposition Cipher, Substitution Cipher.

### UNIT-IV

**Aircraft and UAV Data Links:** Aircraft Data Link: VHF data link – ACARS, VDL 2, VDL 3, and VDL 4. UHF data link - Link-11, Link-16. SELCAL, ALE and HF Data link. UAV Data link functions and attributes, Video & Telemetry Links.

### UNIT-V

**Future Airborne Communication Systems:** Software Defined Radio (SDR)- Need, characteristics and benefits, design principles, RF front end implementation – purpose, receiver topologies and importance of components.

#### Text Books:

1. Radio Communication Systems and Networks– Dale Stacey, Wiley, ISBN :978-0470018590.
2. Software Radio: A Modern Approach to Radio Engineering, Jeffrey H. Reed, PEA publication, ISBN: 9780130811585.

#### Reference Books:

1. Future Aeronautical Communications, Simon Plass., InTech, ISBN: 978-9533076256.
2. Cryptography and Network Security Principles and Practice, William Stallings, Pearson 6<sup>th</sup> Edition, ISBN: 978-9332518773.

#### Web Links:

1. <https://nptel.ac.in/courses/101101079>
2. [Fiber-Optic Cable \(Linktionary term\)](#)

## Aircraft Navigation Systems

<b>Course Code: 241EC057</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Describe the various types of radio navigation systems.
- CO2:** Explain the architecture and components of inertial navigation systems.
- CO3:** Design and implement inertial navigation systems.
- CO4:** Demonstrate knowledge of practical applications of satellite and hybrid navigation systems.
- CO5:** Discuss the integration and interoperability of landing aids.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	2	3									1
CO2	2	3									1
CO3	3	1	1								1
CO4	2	3	1								1
CO5	3	1									1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	2	
CO2	2	
CO3	2	
CO4	2	
CO5	2	

## UNIT – I

### Radio Navigation Systems

Different Types of navigation, Automatic Direction Finder, VHF Omni-directional Range, Distance Measuring Equipment, Tactical Air Navigation, VORTAC, Doppler Navigation –Beam Configurations.

## UNIT – II

### **Inertial Navigation Sensors**

Accelerometer - operating principle, classification- open loop pendulous, closed loop pendulous, vibrating beam and interferometric fibre optic accelerometer.

Gyroscope – Coriolis vibrating gyro, optical gyro – RLG, IFOG – Principle of operation, construction and working.

## UNIT – III

### **Inertial Navigation System**

Inertial navigation, Geometry of earth, gravitation and gravity, Reference frame ECI, LPI, ECEF and ENU. Navigation in rotating earth frame, Inertial system, Strap-down navigation.

## UNIT – IV

### **Satellite and Hybrid Navigation System**

GPS, position and velocity determination- Error sources, GDOP, position computation process. Velocity measurement, Precise Point Positioning (PPP), Integrated inertial navigation – processing of measurements, Complimentary nature of sensors, GNSS and INS fusion using Kalman filter.

## UNIT – V

### **Landing aids, Secondary Surveillance Radar (SSR)**

Low visibility operation, Mechanics of landing. Instrument Landing System (ILS), Satellite Landing Systems, Carrier-Landing Systems. Introduction, SSR modes, Interrogation, Mode-S.

### **Text Books:**

1. Avionics Navigation Systems, Myron Kayton, Walter R. Fried, Wiley-Inter science 2<sup>nd</sup> Edition, ISBN: 978-0471547952.
2. Fundamentals of Navigation and inertial sensors, Amitava Bose, K.N.Bhat, Thomas Kurian, PHI learning Private limited, ISBN: 978-81-203-4859-2.
3. Radar Principles, Technology, Applications, Byron Edde, LPE, Pearson, ISBN: 978-0137523467

### **Reference Books:**

B. Tech (ECE) Curriculum-2024

1. Aircraft Communications & Navigation Systems: Principles Operation and Maintenance, Mike Tooley, David Wyatt, Butterworth-Heinemann an imprint of Elsevier, ISBN: 9780750681377.
2. Global Positioning Systems, Inertial Navigation and Integration, Mohinder S. Grewal, Lawrence R. Weill, Angus P. Andrews, Wiley-Inter science, 2<sup>nd</sup> Edition, ISBN: 978-0470041901.

**Web Links:**

1. [https://onlinecourses.nptel.ac.in/noc23\\_ce94/](https://onlinecourses.nptel.ac.in/noc23_ce94/)
2. [https://onlinecourses.nptel.ac.in/noc21\\_ae12/](https://onlinecourses.nptel.ac.in/noc21_ae12/)

## Missile & Space Vehicle Guidance & Control

<b>Course Code: 241EC062</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	<b>2</b>	<b>0</b>	<b>0</b>	<b>2</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

**CO1:** Discuss the basic of Missile Airframes and autopilots.

**CO2:** Explain the Missile guidance laws and control.

**CO3:** Describe the launch of strategic missiles.

**CO4:** Summarize the orbital mechanics of system.

**CO5:** Demonstrate the satellite guidance in free space.

### Mapping of course outcomes with program outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	2	1									1
CO 2	3	2									1
CO 3	2	3									1
CO 4	2	3									1
CO 5	2	2									1

### Mapping of course outcomes with program Specific Outcomes:

CO/PSO	PSO 1	PSO 2
CO 1	3	
CO 2	2	
CO 3	2	
CO 4	2	
CO 5	2	

## UNIT– I

### Missile Airframes, Autopilots and Control

Missile aerodynamics: - Force Equations, Moment Equations, Phases of missile flight, Missile control configurations. Missile Mathematical Model, Autopilots - Definitions, Types of Autopilots, Example Applications, Open-loop autopilots, inertial instruments, and feedback.

## UNIT – II

### Missile Guidance Laws

Tactical Guidance Intercept Techniques, Derivation of the Fundamental Guidance Equations, explicit, Proportional Navigation, Augmented Proportional Navigation, beam riding, bank to turn missile guidance, Three-Dimensional Proportional Navigation.

### **UNIT – III**

#### **Strategic Missiles**

Introduction, The Two-Body Problem, Lambert's Theorem, First-Order Motion of a Ballistic Missile Correlated Velocity and Velocity-to-Be-Gained Concepts, Derivation of the Force Equation for Ballistic Missiles, Atmospheric Re-Entry, Ballistic Missile Intercept.

### **UNIT – IV**

#### **Orbital Mechanics**

Orbital Transfers: Impulse Transfer between Circular Orbits, Hohmann Transfer, Other Coplanar and Non-coplanar Transfers-Orbital Plane Changes.

### **UNIT – V**

#### **Satellite Guidance**

Space Flight, Space Vehicle Trajectories, Launch Vehicle Guidance Implicit and Explicit Guidance-Open loop and Closed loop Guidance, FE guidance- F. guidance-VG guidance-Q guidance-Delta guidance.

#### **Text Books:**

1. Fundamentals of Astrodynamics, Roger.R. Bate, Dover Publications, ISBN: 978-0486600611.
2. Navigation and Guidance in Space, Edwards V.B. Stearns, Prentice Hall, ISBN: B0007E24DA.

#### **Reference Books:**

1. Space Flight Dynamics, William Wiesel, Tata McGrawHill, Third Edition, ISBN: 978-1452879598.
2. Missile Guidance and Control systems, GM Siouris, Springer, ISBN: 978-0-387-00726.

**Web Links:**

1. <https://archive.nptel.ac.in/courses/101/108/101108054/>, Debasish Gose, IISc Bangalore.
2. <https://apps.dtic.mil/sti/tr/pdf/AD0813281.pdf>

## Flight Control Systems

**Course Code: 241EC060**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Discuss the static stability of an aircraft.
- CO2:** Interpret the Equations of Motions under different conditions.
- CO3:** Aware of Aircraft Response to Control or Atmospheric Inputs.
- CO4:** Infer classical control theory in aircraft design.
- CO5:** Interpret the essence of Auto pilot and aircraft design.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	3	2									1
<b>CO2</b>	3	1									1
<b>CO3</b>	2	3									1
<b>CO4</b>	3	2									1
<b>CO5</b>	2	3									1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>	2	
<b>CO2</b>	2	
<b>CO3</b>	2	
<b>CO4</b>	2	
<b>CO5</b>	2	

### UNIT -I

**Static Stability and Control:** Introduction, Longitudinal Control, Stick Forces, Definition of Directional Stability, Directional Control, Roll Stability, Roll Control.

### UNIT-II

**Aircraft Equations of Motion-1:** Introduction, Derivation of rigid Body Equations of Motion, Orientation and Position of the Airplane, Gravitational and Thrust Forces, Small Disturbance theory, Aerodynamic Force and Moment Representation.

### UNIT -III

**Aircraft Equations of Motion-2:** Pure Pitching Motion, Stick Fixed Longitudinal Motion, Longitudinal Approximations, Influence of Stability Derivatives, Pure Rolling Motion, Pure Yawing Motion, Lateral Direction Equations of Motion.

### UNIT -IV

**Aircraft Response to Control or Atmospheric Inputs:** Longitudinal Flying Qualities, Lateral Flying Qualities, Inertial Coupling, Equations of Motion in a Non Uniform Atmosphere, Pure Vertical or Plunging Motion.

### UNIT -V

**Control Theory applied to Aircraft design:** Applications of Classical Control Theory to Aircraft Autopilot Design: Aircraft Transfer Functions Displacement Autopilot, Stability Augmentation, and Instrument Landing.

#### Text Books:

1. Flight Dynamics, Simulation, and Control for Rigid and Flexible Aircraft, Ranjan Vepa, CRC Press Taylor & Francis Group, ISBN: 9781466573352 .
2. Flight Stability and Automatic Control, Robert C Nelson, Tata McGraw-Hill, Second Edition, ISBN : 978-0070661103.

#### Reference Books:

1. Automatic control of Aircraft and missiles, Blakelock, J.H, John Wiley Sons, New York, ISBN: 978-0471506515.
2. Aircraft control & simulation, Stevens B.L & Lewis F.L, John Wiley Sons, New York, ISBN: 978-0471371458.

#### Web Links:

1. <https://nptel.ac.in/courses/101104330>

## Avionics Embedded Systems

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 241EC058</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Summarize the building blocks of an embedded system.
- CO2:** Apply standard guidelines for development of Aircraft Systems.
- CO3:** Illustrate the services and tasks in RTOS.
- CO4:** Compare continuous dynamics and discrete dynamic mechanics.
- CO5:** Distinguish state machines based on computational models.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2										1
CO2	2	2									1
CO3	2										1
CO4	2	2									1
CO5	2	2									1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1		2
CO2		2
CO3		2
CO4		2
CO5		2

## UNIT - I

### Introduction to Embedded Systems

Categories, Overview of architecture, Characteristics, Recent trends, Architecture of Embedded systems: Hardware Architecture: CPU, Memory, Clock, Watch dog timer, I/O, Debug port, Communication interface, Power Supply.

## UNIT – II

## **Embedded System Development**

Development Process, Requirements, Design, Implementation, Integration and Testing, Packaging, Configuration Management. ARP-4754 Standard for systems engineering guidelines.

### **UNIT – III**

#### **RTOS**

Real time concepts, Kernel Structure, Tasks and Scheduler, Time Management, Event Control blocks, Semaphore management, Mutex, Event Management, Message mail box management, Message Queue management, memory management.

### **UNIT – IV**

#### **Modelling Dynamic Behaviors-1**

Continuous Dynamics: Newtonian Mechanics, Actor Models, Properties of Systems, Feedback Control.

**Discrete Dynamics:** Discrete Systems, The Notion of State, Finite-State Machines, Extended State Machines, Non-determinism, Behaviors and Traces.

### **UNIT – V**

#### **Modelling Dynamic Behaviors-2**

Composition of State Machines: Concurrent Composition, Hierarchical State Machines. Concurrent Models of Computation: Structure of Models, Synchronous-Reactive Models, Dataflow Models of Computation.

#### **Text Books:**

1. Introduction to Embedded Systems: A cyber physical systems approach by Edward Ashford Lee and Sanjit Arun kumar Seshia, MIT Press, Second Edition, ISBN: 978-0262533812.
2. Embedded /Real-Time Systems: Concepts, Design & Programming by K.V.K.K.Prasad, Dream tech Press, ISBN: 978-8177224610 .

#### **Reference Books:**

1. Embedded System Design: A Unified Hardware/Software Approach by Frank Vahid, Tony Givargis, Wiley India Edition, 3<sup>rd</sup> Edition, ISBN: 978-8126508372.
2. Computers as Components-Principles of Embedded Computer System Design by Wayne Wolf, Morgan Kaufman Publisher, ISBN: 9780128053874.
3. Embedded Systems Architecture, Programming and Design by Rajkamal Tata McGraw Hill, 2<sup>nd</sup> Edition, ISBN: 978-0070667648.

#### **Web Links:**

1. <http://www.nptelvideos.in/2012/11/embedded-systems.html>

## Avionics Network Technology

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 241EC059</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Demonstrate the design and operation of optical access networks
- CO2:** Study protocols and standards unique to aviation communications
- CO3:** Compare sensor network with hoc network
- CO4:** Explore different network topologies suitable for wireless sensor networks
- CO5:** Explore the integration of smart antenna systems with various communication systems.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	2	3	1								1
<b>CO2</b>	2	1	2								1
<b>CO3</b>	2	3	2								1
<b>CO4</b>	3	3	2								1
<b>CO5</b>	3	1	1								1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>	2	
<b>CO2</b>	2	
<b>CO3</b>	2	
<b>CO4</b>	2	
<b>CO5</b>	2	

### UNIT– I

**Optical Networks:** Fiber channel-WDMLAN-Fiber channel-RF over fiber -Highly integrated photonics (HIP)-Routing in optics- Amplification in optics.

### UNIT – II

**ATN (Aeronautical Telecommunication Network):** ATN Concepts – ATN functionality – ATN Components – End Systems – ATN physical and administrative structures – ATN planning and implementation process – ATN Router.

### UNIT – III

**Wireless Sensor Network Attributes:** Introduction-Challenges for wireless sensor networks-Comparison of sensor network with hoc network-single node architecture-Hardware components-energy consumption of sensor nodes.

### UNIT – IV

**Wireless Sensor Network Architecture:** Network architecture-sensor network scenarios-types of sources and sinks-single hop versus multi hop networks-multiple sinks and sources-Design, principles :- Development of wireless sensor networks.

### UNIT – V

#### **Wideband Wireless Communication and Networks for Military Avionics**

Communication data link (CDL)-IP based routing in FBW-Smart antenna networking.

#### **Text Books:**

1. Avionics Data Buses by Carry Spitzer, Fifth Edition, ISBN: 978-1138076983.
2. Smart Antennas for Wireless Communication by Frank Gross, Wiley Publications, Second Edition, ISBN: 978-0071447898.

#### **References Books:**

1. Wireless Sensor Networks by C.S.Raghavendra Krishna, M.Sivalingam and Taripznati, Springer publication.
2. Wireless Sensor Networks: Architecture and Protocol by H.Callaway, Edgar, CRS press, ISBN : 978-0849318238.

#### **Web Links:**

- 1.[https://onlinecourses.nptel.ac.in/noc20\\_ae03](https://onlinecourses.nptel.ac.in/noc20_ae03)
- 2.[https://onlinecourses-archive.nptel.ac.in/noc18\\_cs09](https://onlinecourses-archive.nptel.ac.in/noc18_cs09)

## Unmanned Aircraft Systems

<b>Course Code: 241EC064</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

- CO1:** Explain the basic concepts of UAV.
- CO2:** Discuss the basics of airframe.
- CO3:** Describe the Avionics hardware.
- CO4:** Summarize the design considerations for communications payload and control.
- CO5:** Summarize the UAV certification standards.

### Mapping of course outcomes with program outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
<b>CO1</b>	2	1									1
<b>CO2</b>	3	2									1
<b>CO3</b>	2	3									1
<b>CO4</b>	2	3									1
<b>CO5</b>	2	2									1

### Mapping of course outcomes with program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>	2	
<b>CO2</b>	2	
<b>CO3</b>	2	
<b>CO4</b>	2	
<b>CO5</b>	2	

### UNIT- I

#### Introduction to UAV:

History and Overview, Classes and Missions of UAV's, System composition, few applications of Unmanned Aircraft Systems.

### UNIT – II

#### Design of UAV Systems

Introduction to design and selection of system, Aerodynamics and airframe configurations, Characteristics of Aircraft Types, Design of stealth, Data links.

### **UNIT – III**

#### **Communication and Navigation of UAV**

Communication media: Radio communication, Mid-Air collision (MAC) Avoidance, Data Rate and Bandwidth Usage, Antenna Types, NAVSTAR Global Positioning System, TACAN, LORAN-C, Radio Tracking, Inertial Navigation and Control Stations.

### **UNIT – IV**

#### **Development of UAV Systems**

System development and certification, System ground testing -UAV component testing, sub-system testing, control station testing and System in flight testing.

### **UNIT – V**

#### **UAV Payloads**

Surveillance payloads-overview, image sensors, Weapon payloads, Design issues related to Carriage and delivery of weapons, other issues related to combat operations, other payloads.

#### **Text Books:**

1. Introduction to UAV Systems by Paul Gerin Fahlstorm, Wiley Publication, Fourth Edition, ISBN: 9781118396780.
2. Unmanned Aircraft Systems-UVAS Design, Development and Deployment by Reg Austin, Wiley Publication, Third Edition, ISBN: 978-0470058190.

#### **Reference Books:**

1. Remote sensing and activation using UAV by Haiyang Chao and Yang Quan Chen, IEEE Press, ISBN: 978-1118122761.
2. Unmanned Aircraft Design A review of fundamentals by Mohammad H. Sadraey, Morgan & Claypool Publishers series, ISBN: 978-1681731681.

#### **Web Links:**

1. <https://archive.nptel.ac.in/courses/101/104/101104073/,Prof..SaderlaSubrahamanyam,II T Kanpur.>
2. [https://www.icao.int/meetings/uas/documents/circular%20328\\_en.pdf](https://www.icao.int/meetings/uas/documents/circular%20328_en.pdf)

## Aerospace Electromagnetic Compatibility

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 241EC056</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

At the end of the course, student will be able to:

- CO1:** Explain the concepts of EMI and EMC in transmission.
- CO2:** Analyse the EMI effect on aircraft.
- CO3:** Describes the various procedures for radiated measurement systems.
- CO4:** Analyse the effect of EMI on flight control systems.
- CO5:** Analyse the effect of EMI on unmanned flight control systems.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	1									1
CO2	2	3									1
CO3	3	2									1
CO4	2	3									1
CO5	2	3									1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	2	
CO2	2	
CO3	2	
CO4	2	
CO5	2	

### UNIT – I

#### Introduction to Sources of EMI and EMC

Electromagnetic environment, Concepts, Practical experiences & concerns, Natural and Nuclear sources of EMI, Electromagnetic emissions, Cross talk in transmission lines, Transients in power supply lines, Electromagnetic Interference Principles and types of grounding, Shielding and bonding.

## UNIT – II

### **Effects of EMI on Aircraft and Analysis**

HEMP Threat to Aircraft, HEMP Coupling to Aircraft, Lighting interactions with Aircraft, Avionic Equipment functional verification in presence of lighting induced electrical transients.

## UNIT – III

### **Avionics Subsystems Radiated and Conducted Measurement**

Motivations for Testing, Test Plans for Avionics Sub-Systems. Open area test sites and measurements. Anechoic chamber, TEM cell, GTEM Cell, Conducted EMI from equipment, Immunity to conducted EMI, Detectors and measurements.

## UNIT – IV

### **EMI Effects in Flight Control Systems and their Mitigations.**

Analysis of the Contemporary Aerial EME, Elements of FBW System and Their Susceptibility to EMI, EMI Susceptibilities of FMS, EMC Test Methodologies of FCS.

## UNIT – V

### **EMI Effects on Unmanned Flight Control Systems**

EMI Susceptibilities of UAV Flight Control System, How EMI Couples to FCS, Modeling and Simulation, Some Special Considerations for EMI Mitigation.

### **Text Books:**

1. Engineering Electromagnetic Compatibility by Dr.V.P. Kodali, IEEE Publication, Printed in India by S. Chand & Co. Ltd, New Delhi, ISBN: 978-0780347434.
2. Handbook of Aerospace Electromagnetic Compatibility, Reinaldo J. Perez, IEEE Publication, Published by John Wiley & Sons, ISBN: 978-1118910511.

### **Reference Books:**

1. Introduction to Electromagnetic Compatibility, Clayton R Paul, John Wiley, ISBN: 978-0471755005.
2. Principles and Techniques of EMC, Christos Christopoulos, CRC press, 2<sup>nd</sup> Edition, ISBN: 978-0849370359.
3. Handbook of Aerospace Electromagnetic Compatibility Editor(s): Dr. Reinaldo J. Perez, ISBN: 9781118910511.

**Web Links:**

1. <https://www.amazon.in/Handbook-Aerospace-Electromagnetic-Compatibility-Reinaldo/dp/1118910516>
2. <https://www.amazon.in/Handbook-Aerospace-Electromagnetic-Compatibility-Reinaldo-ebook/dp/B07L8DZP4F>
3. [https://books.google.co.in/books/about/Handbook\\_of\\_Aerospace\\_Electromagnetic\\_Co.html?id=ac95DwAAQBAJ&redir\\_esc=y](https://books.google.co.in/books/about/Handbook_of_Aerospace_Electromagnetic_Co.html?id=ac95DwAAQBAJ&redir_esc=y)

## Global Navigation Satellite Systems & Applications

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 241EC061</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

**CO1:** Illustrate the usage of GNSS in position determination

**CO2:** Classify various navigation satellite systems

**CO3:** Interpret the GNSS errors and correction methods

**CO4:** Utilize the GNSS for developing applications

**CO5:** Summarize the current trends and opportunities of GNSS

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2									1
CO2	3	2									1
CO3	2	3									1
CO4	2										1
CO5	3										1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	2	
CO2	2	
CO3	2	
CO4	2	
CO5	2	

### UNIT– I

Introduction to Global Navigation Satellite System (GNSS), How position is determined by the GNSS, NAVSTAR - Global Positioning System

### UNIT – II

Global Navigation Satellite System (GLONASS), BeiDou Navigation Satellite System (BDS), Indian Regional Navigation Satellite System (IRNSS), GALILEO, Quasi-Zenith Satellite System (QZSS)

### **UNIT – III**

Differential Global Navigation Satellite System (DGNSS), REAL-TIME KINEMATIC (RTK), Satellite Based Augmentation System (SBAS), GNSS Errors, GNSS Correction Methods.

### **UNIT – IV**

Why altitude estimated by GNSS receivers is not very accurate, Global Navigation Satellite Systems (GNSS) Applications.

### **UNIT – V**

GNSS: Current Trends and Future, Opportunities in India

#### **Text Books:**

1. Environmental Monitoring using GNSS: Global Navigation Satellite Systems, Awange J. L, Springer, London, ISBN: 978-3540882558.
2. Global Navigation Satellite Systems: Insights into GPS, Glonass, Galileo, Compass, and Others, BS Publications, New Delhi, ISBN: 978-8178002200.

#### **Reference Books:**

1. GNSS – Global Navigation Satellite Systems, Hofmann-Wellenhof, B, Lichtenegger, W, Springer, Verlag Wien, ISBN : 978-3211730126.
2. Global Positioning Systems, Inertial Navigation, and Integration, Grewal, M. S, Weill, L. R, Andrews, John Wiley & Sons, New York.
3. GNSS Systems and Engineering: The Chinese Beidou Navigation and Position Location Satellite, Tan, S., John Wiley & Sons, Singapore, ISBN: 978-1118897034.

#### **Web Links:**

1. [https://onlinecourses.nptel.ac.in/noc23\\_ce94](https://onlinecourses.nptel.ac.in/noc23_ce94) By Prof. Arun K. Saraf, IIT Roorkee
2. <https://www.spiceworks.com/tech/iot/articles/what-is-gnss/>

## Remote Sensing & Digital Image Processing of Satellite Data

<b>Course Code: 241EC063</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

**At the end of the course, student will be able to:**

**CO1:** Outline the electromagnetic concepts in remote sensing technology

**CO2:** Contrast satellites based on the remote sensing

**CO3:** Make use of image interpretation for remote sensing

**CO4:** Illustrate about image acquisition and enhancement techniques

**CO5:** Utilize the multispectral transforms for image processing

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
<b>CO1</b>	3	2									1
<b>CO2</b>	3	2									1
<b>CO3</b>	2	2									1
<b>CO4</b>	3	2									1
<b>CO5</b>	2	2									1

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>	2	
<b>CO2</b>	2	
<b>CO3</b>	2	
<b>CO4</b>	2	
<b>CO5</b>	2	

### UNIT - I

Development of remote sensing technology and advantages, Different platforms of remote sensing, EM spectrum, solar reflection and thermal emission remote sensing, Interaction of EM radiation with atmosphere including atmospheric scattering, absorption and emission.

### UNIT – II

Interaction mechanisms of EM radiation with ground, spectral response curves, Principles of image interpretation, Multi Spectral scanners and imaging devices, Salient characteristics of LANDSAT, IRS, Cartosat, Resource Sat etc. sensors, Image characteristics and different resolutions in Remote Sensing.

### **UNIT – III**

Image interpretation of different geological landforms, rock types and structures, Remote Sensing integration with GIS and GPS, Georeferencing Technique, Basic image enhancement techniques, Spatial filtering techniques, Image classification techniques, InSAR Technique and its applications, Hyper spectral Remote Sensing, Integrated applications of RS and GIS in groundwater studies, Limitations of Remote Sensing Technique.

### **UNIT – IV**

Different techniques of Image acquisition, Image characteristics and different resolutions in Remote Sensing, EM spectrum, solar reflection and thermal emission remote sensing, Colour representations and transforms, Image Histograms and statistics, Geometric transformations /Georeferencing Technique, Image enhancement techniques.

### **UNIT – V**

Multispectral transforms: scatter plot, principal component analysis and decorrelation stretch, Spatial filtering techniques, Frequency domain - Fourier transformation, Basic Image Compression techniques and different image file formats, Image classification techniques, Principles of image interpretation, SAR Interferometry (InSAR) Technique, Image merging and mosaicking techniques, Applications of Image Analysis, Limitations and future of Digital Image Processing Technique.

### **Text Books:**

1. Introduction to Remote Sensing, James B. Campbell and Randolph H. Wynne, The Guildford Press, New York, 5<sup>th</sup> Edition, ISBN: 978-1609181765.
2. Remote Sensing and Image Interpretation, Lillesand, T.M., Kiefer, R.W. and Chapman, J.W., John Wiley & Sons, 7<sup>th</sup> Edition, ISBN: 978-1118343289.

### **Reference Books:**

1. Image Interpretation in Geology by Drury, S. A., Allen & Unwin, 2<sup>nd</sup> Edition, ISBN: 978-0412488801.
2. Introduction to Remote Sensing, Cracknell, A.P., Tylor & Francis, London, 2<sup>nd</sup> Edition, ISBN: 978-0849392559.
3. Digital Image Processing by Gonzalez, Rafael C. and Richard E. Woods, Pearson Education, London, 3<sup>rd</sup> Edition, ISBN: 978-0131687288.

### **Web Links:**

1. [https://onlinecourses.nptel.ac.in/noc19\\_ce38](https://onlinecourses.nptel.ac.in/noc19_ce38) By Prof. Arun K. Saraf , IIT Roorkee
2. <https://www.geeksforgeeks.org/satellite-image-processing/>