Indian Institute of Technology Patna

Electrical Engineering Department

B.Tech – Electronics and Communication (ECE) Engineering

Course Curriculum

Semester I

Sl. No	Course Code	Course name	Credit Structure			
			L	**T**	**P**	**C**
1	CE111	Engineering Drawing	1	0	3	5
2	EE101	Electrical Sciences	3	1	0	8
3	HS103	Communicative English for Engineers	2	0.5	1	6
4	MA101	Mathematics-I	3	1	0	8
5	ME110	Workshop	0	0	3	3
6	PH103	Physics	3	1	0	8
7	PH110	Physics Laboratory	0	0	3	3
		NCC/NSS/NSO	0	0	0	0
		Total	**12**	**3.5**	**10**	**41**

Semester 2

Sl. No	Course Code	Course name	Credit Structure			
			L	**T**	**P**	**C**
1	CH101	Introduction to Chemistry	3	1	0	8
2	CS101	Programming and Data Structure	3	0	0	6
3	CS110	Programming and Data Structure Lab	0	0	3	3
4	EE103	Electrical Sciences Lab	0	0	3	3
5	MA102	Mathematics-II	3	1	0	8
6	ME102	Engineering Mechanics	3	1	0	8
7	CB102&CE102	Biology and Environmental Studies	3	0	0	6
8	CH110	Chemistry Laboratory	0	0	3	3
		NCC/NSS/NSO	0	0	0	0
		Total	**15**	**3**	**9**	**45**

Semester 3

Sl. No	Course Code	Course name	Credit Structure			
			L	**T**	**P**	**C**
1	MA201	Mathematics-III	3	1	0	8
2	HS2nn	HSS Elective	3	0	0	6
3	EE2xx	Semiconductor Devices	3	0	0	6
4	EE2xx	Digital Electronics	3	0	0	6
5	EE2xx	Network Analysis and Synthesis	3	0	0	6
6	EE2xx	Digital Electronics Lab	0	0	3	3
		Total	**15**	**1**	**3**	**35**

Semester 4

Sl. No	Course Code	Course name	Credit Structure			
			L	**T**	**P**	**C**
1	HS2nn	HSS Elective	3	0	0	6
2	XX2nn	Open Elective	3	0	0	6
3	MA225	Probability Theory and Random Processes	3	1	0	8
4	EE2xx	Signals and Systems	3	0	0	6
5	EE2xx	Microprocessor	3	0	0	6
6	EE2xx	Analog Electronics	3	0	0	6
7	EE2xx	Analog Electronics Lab	0	0	3	3
8	EE2xx	Microprocessor Lab	0	0	3	3
		Total	**18**	**1**	**6**	**44**

Semester 5

Sl. No	Course Code	Course name	Credit Structure			
			L	**T**	**P**	**C**
1	XX3nn	Open Elective	3	0	0	6
2	EE3xx	Analog Communications	3	0	0	6
3	EE3xx	Digital Signal Processing	3	0	0	6
4	EE350	Control Systems	3	0	0	6
5	EE3xx	Sensors and Instrumentation	3	0	0	6
6	EE3xx	Digital Signal Processing Lab	0	0	3	3
7	EE372	Control and Instrumentation Lab	0	0	3	3
		Total	**15**	**0**	**6**	**36**

Semester 6

Sl. No	Course Code	Course name	Credit Structure			
			L	**T**	**P**	**C**
1	HS3nn	HSS Elective	3	0	0	6
2	EE3xx	Engineering Electromagnetics	3	0	2	8
3	EE3xx	VLSI Design	3	0	0	6
4	EE3xx	Numerical Methods	3	0	0	6
5	EE3xx	Digital Communications	3	0	0	6
7	EE3xx	VLSI Lab	0	0	3	3
8	EE3xx	Analog and Digital Communications Lab	0	0	3	3
9	EE3xx	Numerical Simulations Lab	0	0	3	3
		Total	**15**	**0**	**11**	**41**

Semester 7

Sl. No	Course Code	Course name	Credit Structure			
			L	**T**	**P**	**C**
1	XX4nn	Open Elective	3	0	0	6
2	EExxx	Wireless Communications	3	0	0	6
3	EExxx	Microwave Theory	3	0	2	8
4	EExxx	Information Theory and Coding	3	0	0	6
5	EExxx	Communications Networks	3	0	0	6
6	EExxx	Communications Networks Lab	0	0	3	3
7	EExxx	BTP - I/Department Elective - I	3	0	0	6
		Total	**18**	**0**	**3**	**39**

Elective - I

EExxx Solid State Electronics

EExxx Other Department Electives

Semester 8

Sl. No	Course Code	Course name	Credit Structure			
			L	**T**	**P**	**C**
1	EExxx	Antenna and Wave Propagation	3	0	2	8
2	EEnnn	Departmental Elective – II	3	0	0	6
3	EE496	BTP – II / Two Courses	0	0	12	12
		Total	**6**	**0**	**12**	**24**
		Grand Total	**114**	**8.5**	**60**	**305**

Elective - II

EExxx Satellite Communication

EExxx Internet of Things

EExxx Other Department Elective

Program Learning Outcomes (PLO):

The graduates of this program will have

- a successful career in an Academia/Industry/Entrepreneur
- strong fundamentals in electronics and communications engineering.
- ability to design prototypes for real world problems related to electronics, communications and interdisciplinary fields.
- ability to develop soft skills such as effective communications in both verbal and written forms, body language, time managements, problem-solving, leadership, work in both team as well as individual in a professional manner

Semester 1

EE101 Electrical Sciences (3-1-0-8) Pre-requisites: Nil

Circuit Analysis Techniques, Circuit elements, Simple RL and RC Circuits, Kirchoff's law, Nodal Analysis, Mesh Analysis, Linearity and Superposition, Source Transformations, Thevnin's and Norton's Theorems, Time Domain Response of RC, RL and RLC circuits, Sinusoidal Forcing Function, Phasor Relationship for R, L and C, Impedance and Admittance, Instantaneous power, Real, reactive power and power factor.

Semiconductor Diode, Zener Diode, Rectifier Circuits, Clipper, Clamper, Bipolar Junction Transistors, Transistor Biasing, Transistor Small Signal Analysis, Transistor Amplifier, Operational Amplifiers, Op-amp Equivalent Circuit, Practical Op-amp Circuits, DC Offset, Constant Gain Multiplier, Voltage Summing, Voltage Buffer, Controlled Sources, Instrumentation Circuits, Active Filters and Oscillators.

Number Systems, Logic Gates, Boolean Theorem, Algebraic Simplification, K-map, Combinatorial Circuits, Encoder, Decoder, Combinatorial Circuit Design, Introduction to Sequential Circuits.

Magnetic Circuits, Mutually Coupled Circuits, Transformers, Equivalent Circuit and Performance, Analysis of Three-Phase Circuits, Power measurement in three phase system, Electromechanical Energy Conversion, Introduction to Rotating Machines.

Text

1. David V. Kerns, Jr. J. David Irwin, Essentials of Electrical and Computer Engineering, Pearson, 2004.

References:

1. C. K. Alexander, M. N. O. Sadiku, Fundamentals of Electric Circuits, 3rd Edition, McGraw-Hill, 2008.
2. W. H. Hayt and J. E. Kemmerly, Engineering Circuit Analysis, McGraw-Hill, 1993.
3. Donald A Neamen, Electronic Circuits; analysis and Design, 3rd Edition, Tata McGraw-Hill Publishing Company Limited.
4. Adel S. Sedra, Kenneth C. Smith, Microelectronic Circuits, 5th Edition, Oxford University Press, 2004. M
5. R. L. Boylestad and L. Nashelsky, Electronic Devices and Circuit Theory, 6th Edition, PHI, 2001.
6. M. M. Mano, M. D. Ciletti, Digital Design, 4th Edition, Pearson Education, 2008.
7. Floyd, Jain, Digital Fundamentals, 8th Edition, Pearson.
8. A. E. Fitzgerald, C. Kingsley Jr., S. D. Umans, Electric Machinery, 6th Edition, Tata McGraw-Hill, 2003.
9. D. P. Kothari, I. J. Nagrath, Electric Machines, 3rd Edition, McGraw-Hill, 2004.

CLO :

After learning this course, the students will be able

1. to understand the basic principles of Electrical Engineering
2. to know various tools and techniques used in analyzing electrical circuits
3. to develop strong fundamentals on electrical engineering subjects

Semester 2

EE103 Electrical Sciences Laboratory (0-0-3-3) Pre-requisites: Nil

Experiments to verify Circuit Theorems
Experiments using diodes and bipolar junction transistor (BJT): design and analysis of half -wave and full-wave rectifiers, clipping circuits and Zener regulators, BJT characteristics and BJT amplifiers;
Experiments using operational amplifiers (op-amps): summing amplifier, comparator, precision rectifier, Astable and Monostable Multivibrators and oscillators;
Experiments using logic gates: combinational circuits such as staircase switch, majority detector, equality detector, multiplexer and demultiplexer;
Experiments using flip-flops: sequential circuits such as non-overlapping pulse generator, ripple counter, synchronous counter, pulse counter and numerical display.
Power Measurement by two Watt meter; Efficiency of Transformer.

References:

1. A. P. Malvino, Electronic Principles. New Delhi: Tata McGraw-Hill, 1993.
2. R. A. Gayakwad, Op-Amps and Linear Integrated Circuits. New Delhi: Prentice Hall of India, 2002.
3. R.J. Tocci: Digital Systems; PHI, 6e, 2001.

CLO :

After learning this course, the students will be able

1. to understand the practical aspects of basic electrical engineering
2. to develop circuits to verify the principles learned in the theory
3. to design a simple circuit for practical applications

Semester 3

EE2xx Semiconductor Devices (3-0-0-6) Pre-requisites: Nil

Energy bands; semiconductors; charge carriers: electrons and holes, effective mass, doping. Carrier concentration: Fermi level, temperature dependence of carrier concentration. Drift and diffusion of carriers: excess carriers; recombination and life time

p-n Junction: depletion region, forward and reverse- bias, depletion and diffusion capacitances, switching characteristics; breakdown mechanisms; SPICE model. Metal-semiconductor junctions: rectifying and ohmic contacts.

BJT: carrier distribution; current gain, transit time, secondary effects

MOSFET: MOS capacitor; CV and IV characteristics; threshold voltage; Short-channel effects. Body effect in MOSFET,

Other Semiconductor Devices: MESFET: Working mechanism, IV characteristics, HEMT: Working mechanism, IV characteristics, Tunnel Diode: Working mechanism, IV characteristics, Introduction to Power Semiconductor Devices (diode, HBT, and MOSFET)

Text Books:

1. Sze and Lee, Semiconductor Devices: Physics and Technology, 3rd edition, Wiley, 2013
2. Dutta, Semiconductor Devices and Circuits, Oxford University Press

References Books:

1. Milman, Halkias and Jit, Electronics Devices and Circuits, Tata McGraw-Hill, 2nd Edition
2. Sedra and Smith, Microelectronics Circuits, 6th edition, Oxford University Press.

CLO:

Students will be able to understand

1. major properties of semiconductor materials, explain energy band diagrams and connections with the device structures and properties;
2. understand and utilize the basic equations to analyze semiconductor devices;
3. design semiconductor devices and estimate device characteristics;

EE2xx Digital Electronics 3 0 0 6 Pre-requisites: Nil

Introduction: Analog versus Digital, Analog to Digital and Digital to Analog converter circuits; Number systems and their interconversion, Binary Arithmetic (Addition, Subtraction, Multiplication and Division), BCD codes, Excess-3 code, Gray code, Hamming code, Error Detection and Correction. Logic Gates and Logic Families: Digital Logic Gates, Various Logic Families: RTL, DTL, TTL and ECL; Working and their characteristics; MOS and CMOS devices Combinational Logic Design:Boolean Algebra, Basic Theorems and Properties of Boolean Algebra, Minimization of Logical functions, Karnaugh- Map method, Sum of Products and Product of Sums Simplification, NAND and NOR implementation, multiplexer/ demultiplexer, encoder/ decoder, adder/ subtractor, comparator and parity generators; Sequential circuits: latches and flip-flops (RS, JK, D, T, and Master Slave); Registers; Counters: ripple, ring, and shift register counters; Design and analysis of synchronous sequential finite state machine; Programmable logic devices.

Texts:

- C. H. Roth Jr., “Fundamentals of Logic Design”, 4/e, Jaico Publishers, 2002.
- J. F. Wakerly, “Digital Design - principles and practices”, 4/e, Pearson Education; 2006.
- Z. Kohavi, “Switching and Finite Automata Theory”, 2/e, Tata McGraw-Hill, 2008.

References:

- M. D. Ercegovac, T. Lang, and J.H. Moreno, “Introduction to Digital Systems”, John Wiley, 2000.
- V. P. Nelson, H. T. Nagle, B. D. Carroll & J. D. Irwin, “Digital Logic Circuit Analysis and Design”, Prentice-Hall, 1995.

CLO:

After studying this course the students would gain enough knowledge

1. Have a thorough understanding of the fundamental concepts and techniques used in digital electronics.
2. To understand and examine the structure of various number systems and its application in digital design.
3. The ability to understand, analyse and design various combinational and sequential circuits.
4. Ability to identify basic requirements for a design application and propose a cost effective solution.
5. The ability to identify and prevent various hazards and timing problems in a digital design.
6. To develop skill to build, and troubleshoot digital circuits.

EE2xx Network Analysis and Synthesis (3-0-0-6) Pre-requisites: Nil

Overview of network analysis techniques, network theorems, transient and steady state sinusoidal response.

Two-port networks, Z, Y, h and transmission parameters, combination of two ports, Analysis of common two port networks.

Network functions, parts of network functions, obtaining a network function from a given part. Network transmission criteria; delay and rise time.

Elements of network synthesis techniques. Butterworth and Chebyshev Approximation

Graph theory: basic definitions of loop (or tie set), cut-set, mesh matrices and their relationships, applications of graph theory in solving network equations.

Texts/ References:

1. F. F. Kuo, Network Analysis and Synthesis, John. Wiley, 2006.
2. M. E. Van Valkenburg, Network Analysis, Prentice Hall, 1980.
3. Introduction to Graph Theory (Dover Books on Mathematics) 2nd Edition by Richard J. Trudeau (Author)

CLO

After the successful completion of the course the students will be able to:

1. understanding the various laws and theorems related to electric networks.
2. understanding the concept of two port networks.
3. familiarization with network synthesis.

EE2xx Digital Electronics Laboratory 0 0 3 3 Pre-requisites: Nil

1. To study about the logic gates and verify their truth table.

2. Realisation of AND and OR gates using
(i) Diodes and resistors.
(ii) Universal gates

3. Design and implement half adder and full adder circuits and verifies the truth table using logic gates.

4. Design and implement half subtractor and full subtractor circuits and verify the truth table using logic gates.

5. Design and implement 4-bit binary to gray code converter and gray to binary code converter circuits.

6. Design and implement BCD to excess-3 code converter and excess-3 to BCD code converter.

7. Design and implement
(i) 2-Bit magnitude comparator using basic gates
(ii) 8-Bit magnitude comparator using IC 7485

8. Design and implement multiplexer and demultiplexer using logic gates and study of IC 74150 and IC 74154.

9. Design and implementation of the function using multiplexer
(i) F(A,B,C)=Σm(1,2,5,6)
(ii) F(A,B,C)=Σm(0,2,5,6,7)

10. Design and implement encoder and decoder using logic gates and study of IC 7445 and IC 74147.

11. Realization of SR, JK, D and T flip flop using gates.

12. Design and implement 3-bit synchronous up counter.

13. Design and implement a 3-bit asynchronous up/down counter.

14. Design BCD to seven segment display with decoder Using IC 7447.

CLO:

Upon successful completion of the course, the students will be able to

- Understand the digital signals, applications of ICs and logic circuits.
- Develop skills for designing combinational logic circuits and their practical implementation on breadboard.
- Analyze, design and implement sequential logic circuits.
- To understand the basic digital devices/circuits and to verify their operation

Semester 4

EE2xx Signals and Systems (3-0-0-6) Pre-requisites: Nil

Signals: classification of signals; signal operations: scaling, shifting and inversion; signal properties:
symmetry, periodicity and absolute integrability; elementary signals. Systems: classification of systems;
system properties: linearity, time/shift-invariance, causality, stability; continuous-time linear time
invariant (LTI) and discrete-time linear shift invariant (LSI) systems: impulse response and step response; response to an arbitrary input: convolution; system representation using differential and difference equations; Eigen functions of LTI/ LSI systems, frequency response and its relation to the impulse response. Signal representation: signal space and orthogonal bases; Fourier series representation of continuous-time and discrete-time signals; continuous-time Fourier transform and its properties; Parseval's relation, time-bandwidth product; discrete-time Fourier transform and its properties; relations among various Fourier representations. Sampling: sampling theorem; aliasing; signal reconstruction: ideal interpolator, zero-order hold, first-order hold; discrete Fourier transform and its properties. Laplace transform and Z-transform: definition, region of convergence, properties; transform-domain analysis of LTI/LSI systems, system function: poles and zeros; stability.

Texts

1. A.V. Oppenheim, A.S. Willsky and H.S. Nawab, "Signals and Systems", Prentice Hall of India, 2006.
2. Simon Haykin, Barry van Veen, "Signals and Systems", John Wiley and Sons, 1998.

References

1. B. P. Lathi,"Signal Processing and Linear Systems", Oxford University Press, 1998.

CLO:

After the successful completion of the course the students will be able to:

1. Understand fundamental concepts of signals and systems
2. Understand applications of signals and systems
3. Analyse impulse response of systems
4. Understand frequency response using transforms such as CTFT, Laplace, DTFT, ZT, DFT

EE2xx Microprocessor (3-0-0-6) Pre-requisites: Digital Electronics

Introduction to Microprocessors: History and Evolution, types of microprocessors, Microcomputer Programming Languages, Microcomputer Architecture, Pipelining, Clocking, Intel 8085 Microprocessor, Register Architecture, Bus Organization, ALU, Control section, ISA of 8085, Instruction format, Addressing modes, Types of Instructions. Assembly Language Programming and Timing Diagram: Assembly language programming in 8085, Macros, Labels and Directives, Microprocessor timings, Micro instructions, Instruction cycle, Machine cycles, T-states, State transition diagrams, Timing diagram for different machine cycles, Memory and I/O interface. Serial I/O, Interrupts: Serial I/O using SID, SOD, Interrupts in 8085, RST instructions, Issues in implementing interrupts, Multiple interrupts and priorities, Interrupt handling in 8085, Enabling, Disabling & masking of interrupts. Data Transfer techniques: Data transfer techniques, Parallel & Programmed data transfer using 8155, Programmable parallel ports & handshake input/output, Asynchronous and Synchronous data transfer using 8251, PIC (8259), PPI (8255), DMA controller (8257). 16-Bit Microprocessors (Intel 8086): Introduction to a 16 bit microprocessor, Memory address space and data organisation, Segment registers and Memory segmentation, Generating a memory address, I/O address space, Addressing modes, Comparison of 8086 & 8088, Basic configurations of 8086/8088, Min. Mode, Max. Mode & System timing, Introduction to Instruction Set of 8086.

Books and References

1. Microprocessor Architecture, Programming & Applications with the 8085/8080A by R.S. Gaonkar, Wiley Eastern Ltd.
2. Microprocessors & Interfacing by D.V. Hall, McGraw Hill.
3. Microprocessors: Theory & Applications (Intel & Motorola) by M. Rafiquzzman, PHI.
4. INTEL 8086/88, 80186, 286, 386, 486, Pentium Pro & Pentium IV by Berry B. Bray.

CLO:

Upon successful completion of the course, the students will be able to

- Understand the architecture of 8085 and 8086
- Impart the knowledge about the instruction set
- Understand the basic idea about the data transfer schemes and its applications

EE2xx Analog Electronics (3-0-0-6) Pre-requisites: Nil

Course content:

1. Historical background of CMOS IC technology,
2. MOS device compact models in support of circuit simulations and design.
3. Concept of single-stage amplifiers, design methodology and various topologies.
4. Design of single-stage amplifiers and their frequency response.
5. Design of multistage amplifiers and their frequency response.
6. Design of current sources and mirrors, active loads.
7. Differential amplifiers, source-coupled pairs
8. Operational amplifiers, introduction
9. Op-amp design and performance measures,
10. Feedback, stability and compensation Op-amp design case studies,
11. Temperature and supply independent biasing Other analog circuits.

CLO:

1. The learning objectives of this course are analysis and design of CMOS analog integrated circuits at the transistor level, with an emphasis on intuitive design methods and quantitative performance measures with practical limitations.
2. Understand the basic electrical engineering principles and abstractions on which the design of electronic systems is based
3. By the end of this course students should be able to understand and design circuits for real world applications where information is represented by signals that are continuous both in time and in amplitude.

References/Texts:

1. Design of Analog CMOS Integrated Circuits, 1st Edition, Behzad Razavi, McGraw-Hill, 2001;
2. Tony Chan Carusone, David A. Johns and Kenneth W. Martin, Analog Integrated Circuit Design, 2nd Edition, Wiley, 2011.
3. Field-Effect Devices and Advanced MOS Devices, (volumes IV and VII of the Modular Series on Solid State Devices), Addison-Wesley.
4. Analysis and Design of Analog Integrated Circuits, Gray, Hurst, Lewis and Meyer, 4th Ed., Wiley, 2001.

EE2xx Analog Electronics Lab (3-0-3-3) Pre-requisites: Nil

Experiments using BJTs, FETs, op-amps and other integrated circuits: Multistage amplifiers, automatic gain controlled amplifiers, programmable gain amplifiers; frequency response of amplifiers; waveform generators; active filters.

Texts/References: •

A. P. Malvino, Electronic Principles, Tata McGraw-Hill, 1993.
R. A. Gayakwad, Op-Amps and Linear Integrated Circuits, Prentice Hall of India, 2002

CLO

1. The learning objectives of this lab are to design and implement different analog electronics sub-circuits and quantitative the performance
2. Understand the basic principles analog electronics on which the design of electronic systems is based.
3. To understand how the circuits are designed for real world applications and their limitations .

EE2xx Microprocessor Lab (3-0-0-6) Pre-requisites: Nil

List of Experiments
1. Write a program using 8085 Microprocessor for Decimal, Hexadecimal addition and subtraction of two Numbers.
2. Write a program using 8085 Microprocessor for addition and subtraction of two BCD numbers.
3. To perform multiplication and division of two 8 bit numbers using 8085.
4. To find the largest and smallest number in an array of data using the 8085 instruction set.
5. To write a program to arrange an array of data in ascending and descending order.
6. To convert given Hexadecimal number into its equivalent ASCII number and vice versa using 8085 instruction set.
7. To write a program to initiate 8251 and to check the transmission and reception of character.
8. To interface 8253 programmable interval timer to 8085 and verify the operation of 8253 in six different modes.
9. To interface DAC with 8085 to demonstrate the generation of square, sawtooth and triangular wave.
10. Serial communication between two 8085 through RS-232 C port.

Lab Learning Outcomes
Upon successful completion of the course, the students will be able to

- Write algorithms and programming task involved for a given problem
- Design and develop modular programming skills
- To provide skills for designing flowcharts and writing algorithms
- Trace and debug a program

Semester 5

EE3xx Analog Communications (3-0-0 -6) Pre-requisites: Signal and Systems

Review of Fourier Series and Transforms. Hilbert Transforms, Band passSignal and System Representation. Random Processes, Stationarity, Power Spectral Density, Gaussian Process, Noise.

Amplitude Modulation, DSBSC, SSB, VSB: Signal Representation, Generation and Demodulation.

Frequency Modulation: Signal Representation, Generation and Demodulation.

Mixing, Superheterodyne Receiver, Phase Recovery with PLLs.

Noise: in AM Receivers using Coherent Detection, in AM Receivers using Envelope Detection, in FM Receivers.

Sampling, Pulse-Amplitude Modulation. Quantization,

Pulse-Code Modulation. Noise considerations in PCM, Time Division Multiplexing, Delta Modulation. Intersymbol Interference, Introduction to Information Theory: concepts of Entropy and Source-Coding.

References-

1. H. Taub and D. L. Schilling, Principles of Communication Systems, 2/e, McGraw Hill, 1986.
2. Proakis J.J., Digital Communications, 2nd edition, Mc Graw Hill 1989.
3. S. Haykin, Digital Communications, Wiley-India, 2011.
4. B. P. Lathi, Modern Analog and Digital Communication systems, 3/e, Oxford University Press, 1998.

Course Learning Outcomes-:

1. Understand about basic building blocks communication systems
2. Know different modulation formats; their usage along with their advantages and limitations
3. Design and estimate performance of analog communication systems
4. Mathematically analyze analog communication systems for their efficacy in presence of various impairments

EE3xx Digital Signal Processing (3-0-0-6) Pre-requisites: Signals and Systems

Review of discrete time signals, systems and transforms.
Frequency selective filters: Ideal filter characteristics, lowpass, highpass, bandpass and bandstop filters, Paley-Wiener criterion, digital resonators, notch filters, comb filters, all-pass filters, inverse systems, minimum phase, maximum phase and mixed phase systems. Structures for discrete-time systems: Signal flow graph representation, basic structures for FIR and IIR systems (direct, parallel, cascade and polyphase forms), transposition theorem, ladder and lattice structures.
Design of FIR and IIR filters: Design of FIR filters using windows, frequency sampling, Remez algorithm and least mean square error methods; Design of IIR filters using impulse invariance, bilinear transformation and frequency transformations.
Discrete Fourier Transform (DFT): Computational problem, DFT relations, DFT properties, fast Fourier transform (FFT) algorithms (radix-2, decimation-in-time, decimation-in-frequency), Goertzel algorithm, linear convolution using DFT.
Multirate DSP: Decimation and Interpolation, Filter Banks, Perfect Reconstruction Filters, Polyphase representations

Texts

1. S. K. Mitra, Digital Signal Processing: A computer-Based Approach, TMH, 2/e, 2001.
2. A. V. Oppenheim and R. W. Shafer, Discrete-Time Signal Processing, PHI, 2/e, 2004.
3. J. G. Proakis and D. G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, PHI, 1997.

References

1. V.K. Ingle and J.G. Proakis, “Digital signal processing with MATLAB”, Cengage, 2008.
2. T. Bose, Digital Signal and Image Processing, John Wiley and Sons, Inc., Singapore, 2004.
3. L. R. Rabiner and B. Gold, Theory and Application of Digital Signal Processing, Prentice Hall India, 2005.
4. A. Antoniou, Digital Filters: Analysis, Design and Applications, Tata McGraw-Hill, New Delhi, 2003.
5. T. J. Cavicchi, Digital Signal Processing, John Wiley and Sons, Inc., Singapore, 2002.
6. E. C. Ifeachor and B. W. Jervis, Digital Signal Processing, Pearson Education, 2006.

CLO

After the completion of the course the student will be able to :

- Illustrate digital signals, systems and their significance.
- Understand the analytical tools such as Fourier transforms, Discrete Fourier transforms, Fast Fourier Transforms and Z-Transforms required for digital signal processing.
- Design and develop the basic digital system.
- Get familiarised with various structures of IIR and FIR systems. Design and realize various digital filters for digital signal processing.
- Interpret the finite word length effects on functioning of digital filters.

EE3xx Control Systems (3-0-0-6) Pre-requisites: Nil

Basic concepts: Notion of feedback, open- and closed-loop systems;

Modeling and representations of control systems: Ordinary differential equations, Transfer functions, Block diagrams, Signal flow graphs, State-space representations;

Performance and stability: Time-domain analysis, Second-order systems, Characteristic-equation and roots, Routh-Hurwitz criteria;

Frequency-domain techniques: Root-locus methods, Frequency responses, Bode-plots, Gain-margin and phase-margin, Nyquist plots;

Compensator design: Proportional, PI and PID controllers, Lead-lag compensators;

State-space concepts: Controllability, Observability, pole placement result, Minimal representations.

Text/References

1. Norman S. Nise, Control Systems Engineering, 4th edition, New York, John Wiley, 2003. (Indian edition)
2. G. Franklin, J.D. Powell and A. Emami-Naeini, Feedback Control of Dynamic Systems, Addison Wesley, 1986.
3. I.J. Nagrath and M. Gopal, Control System Engineering, 2nd Edn.Wiley Eastern, New Delhi, 1982.
4. C.L. Phillips and R.D. Harbour, Feedback Control Systems, Prentice Hall, 1985
5. B.C. Kuo, Automatic Control Systems, 4th Edn. Prentice Hall of India, New Delhi, 1985. (IIT BOMBAY)

CLO

The student will be able to

1. Formulate mathematical models for linear, time-invariant electrical, mechanical and electromechanical systems.
2. Construct block diagram and signal flow graph representations of linear, time-invariant systems.
3. Reduce block diagram and signal flow graph representations to a single transfer function.
4. Determine applications of closed loop systems.
5. Analyze and design control system specifications in the time domain.
6. Determine the stability of control systems.
7. Determine the relation between characteristic equation root location and control system performance.
8. Analyze the frequency response characteristics of a control system.
9. Apply feedback control techniques to contemporary automatic control systems.
10. Use MATLAB and Simulink to analyze open and closed loop control systems.

EExxx Sensors and Instrumentation (3-0-0-6) Pre-requisites: Nil

Definition of instrumentation. Static characteristics of measuring devices. Error analysis, standards and calibration. Dynamic characteristics of instrumentation systems. Electromechanical indicating instruments: ac/dc current and voltage meters, ohmmeter; loading effect. Measurement of power and energy; Instrument transformers. Measurement of resistance, inductance, capacitance. ac/dc bridges. Measurement of non electrical quantities: transducers classification; measurement of displacement, strain, pressure, flow, temperature, force, level and humidity. Signal conditioning; Instrumentation amplifier, isolation amplifier, and other special purpose amplifiers. Electromagnetic compatibility; shielding and grounding. Signal recovery, data transmission and telemetry. Data acquisition and conversion. Modern electronic test equipment: oscilloscope, DMM, frequency counter, wave/ network/ harmonic distortion/ spectrum analyzers, logic probe and logic analyzer. Data acquisition system; PC based instrumentation. Programmable logic controller: ladder diagram. Computer controlled test systems, serial and parallel interfaces, Field buses. Smart sensors.

Text:

- A. D. Helfrick and W. D. Cooper, Modern Electronic Instrumentation and Measuring Techniques, Pearson Education, 1996.
- M. M. S. Anand, Electronic Instruments and Instrumentation Technology, PHI, 2006.
- E. O. Deobelin, Measurement Systems - Application and Design, Tata McGraw-Hill, 1990.

References:

- B. E. Jones, Instrumentation, measurement, and Feedback, Tata McGraw-Hill, 2000.
- R. P. Areny and T. G. Webster, Sensors and Signal Conditioning, John Wiley, 1991.
- B. M. Oliver and J. M. Cage, Electronic Measurements and Instrumentation, McGraw-Hill, 1975.
- C. F. Coombs, Electronic Instruments Handbook, McGraw-Hill, 1995.
- R. A. Witte, Electronic Test Instruments, Pearson Education, 1995.
- B. G. Liptak, Instrument Engineers' Handbook: Process Measurement and Analysis, Chilton Book, 1995.

CLO

1. Know about fundamentals of measuring system.
2. Knowledge of common transducers for measuring strain, pressure, displacement, temp, flow etc so that decision of choosing appropriate sensor can be made.
3. Use of common instrument such as oscilloscope, DSO, wave analyser etc.
4. Programming of PLC for a particular application.

EE3xx Digital Signal Processing Laboratory (0-0-3-3) Pre-requisites: Nil

Familiarization of DSP development environments, basic experiments on signal addition, multiplication, vector operations; sampling and quantization; periodic waveform generation; pseudo-random sequence and white noise generation; correlation and convolution;
Design and implementation of finite impulse response (FIR) and infinite impulse response (IIR) filters. Real-time filtering of signals like speech/audio/biomedical signal.

Implementation of basic digital modulation schemes

Applications of Digital Signal Processing in Medical Signal Processing, Digital Image Processing, Video Processing. The experiments can be done in MatLab.
The experiments are to be done on TMS320C6XXX DSP Trainer Kit.

Texts/References:

1. TMS320C6XXX CPU and Instruction Set Reference Guide, Texas Instruments, 2000 (www.ti.com)
2. V. K. Ingle and J. G. Proakis, Digital signal processing using MATLAB, Thompson Brooks/Cole, Singapore, 2007.
3. MATLAB and Signal Processing Toolbox User's Guide (www.mathworks.com)

CLO

- Experimental concepts of DSP and its applications using MATLAB Software
- To understand about the basic signal generation
- To learn Fourier Transform Concepts
- To design FIR filters CO5 To design IIR filters.
- Demonstrate their abilities towards DSP processor based implementation of DSP systems

EE372 Control and Instrumentation Laboratory (0-0-3-3) Pre-requisites: Nil

1. a) Measurement of low resistance using Kelvin's double bridge b) Measurement of Capacitance and Inductance using AC bridges

2. To Study the FEEDBACK DC Modular Servo System and to obtain the characteristics of the constituent components. Also, to set up a closed loop position control system and study the system performance.

3. Design a PD/PID controller for the FEEDBACK Magnetic Levitation System

4. Determine the transfer function of black box from the Bode plot

5. Traffic light control by PLC

6. Measurement of strain by strain gauge

7. Study of temperature sensors: thermistor, thermocouple, RTD

8. Measurement of displacement by resistive, inductive and capacitive sensors

9. Study and design of controller for FEEDBACK Inverted Pendulum System

Text/References:

1. C. D. Johnson, Process Control Instrumentation Technology, Prentice Hall, 2003.
2. R. P. Areny and T. G. Webster, Sensor and Signal Conditioning, John Wiley, 1991.
3. C. F. Coombs, Electronic Instruments Handbook, McGraw-Hill, 1995.
4. K. Ogata, Modern Control Engineering, Prentice Hall India, 2002.
5. G. F. Franklin, J. D. Powell and A. E. Emami-Naeini, Feedback Control of Dynamic Systems; Prentice Hall Inc., 2002.

CLO

1. Able to analyze the performance and working of D.C and A.C. servo motors and synchronous motors. Able to design P,PI,PD and PID controllers
2. Able to design lag, lead and lag–lead compensators
3. Able to control the temperature using PID controller
4. Able to determine the transfer function of D.C.motor
5. Able to control the position of D.C servo motor

Semester 6

EE3xx VLSI Design (3-0-0-6) Pre-requisites: Digital Electronics and Microprocessors

Introduction VLSI. Basics on fabrication process. Design Methodologies: Full and Semi Custom design flow. MOS circuits: static and Dynamic logic and characteristics. Architectural design: examples, HDL and test bench writing, synthesis and Timing analysis, Introduction to Physical design and verification. Introduction to FPGA architectures, FPGA based digital Systems, Computer arithmetic, Semiconductor Memory circuits design, Introduction to memory refreshing circuits, Introduction to IC testing and validations: Fault model, DFT, Scanned FF, scan Chain method.

Texts:

1. W. Wolf, Modern VLSI Design - System on Chip design, 3/e, Pearson Education, 2004.
2. J.M. Rabaey, A. Chandrakasan and B. Nikolic, Digital Integrated Circuits- A Design Perspective, 2/e, Prentice Hall of India, 2003.
3. N. Weste and D. Harris, CMOS VLSI Design: A Circuits and Systems Perspective, 3/e, Pearson Education India, 2007.
4. “Application Specific Integrated Circuit”, Michael John Sebastian Smith, Addison Wesley.

References:

1. CMOS Circuit Design, Layout and Simulation, R. Jacob baker, Wiley Publications.
2. Kang and Leblevici, CMOS Digital Integrated Circuits Analysis and Design, 3/e, McGraw Hill, 2003. J. P. Uyemura, Introduction to VLSI Circuits and Systems, John Wiley & Sons (Asia), 2002.

CLO

After going through this course, students shall be exposure to

1. design and implementation methods of VLSI Chip starting from full custom circuit to semi-custom architecture.
2. HDL coding style for both design and test bench shall be learned.
3. FPGA Architectures and FPGA prototype of digital systems
4. Basic VLSI testing and validation methodologies.

EE3xx Digital Communications (3-0-0-6) Pre-requisites: Analog Communications

Overview of Random Variables, Random Processes and Linear Algebra: Signal Space Concepts, Orthogonal Representation of Signals, Gram-Schmidt Procedure and Karhunen-Loeve (KL) Expansion. Communication Channel Models, Bandpass & Lowpass Signals

Digital Modulation Schemes and their Performance Analysis: Memoryless and with Memory

Modulation Methods, Pulse Amplitude Modulation (PAM), Phase Modulation, Quadrature Amplitude Modulation (QAM), Continuous-Phase Frequency-Shift Keying (CPFSK), and Continuous-Phase Modulation (CPM)

Optimum Receiver in Presence of Additive White Gaussian Noise: Maximum a Posteriori Probability (MAP) and Maximum Likelihood (ML) Receivers, Coherent versus Non-coherent Detection, Binary Signal Detection in AWGN, M-ary Signal Detection in AWGN. Probability of Error Analysis

Receiver Synchronization: Signal Parameter Estimation, Carrier Phase Estimation, Symbol Timing Estimation, Joint Estimation of Carrier Phase and Symbol Timing

Channel Estimation and Equalization: Zero-Forcing Algorithm, Least-Mean-Square (LMS) Algorithm, Recursive Least Square Algorithms, Linear and Decision Feedback Equalization, Channel Impulse Response, Pilot Symbol, Non-Data-aided and Data-aided Channel Estimation

Text Books:

1. J. G. Proakis, M. Salehi, Digital Communications, McGraw Hill, 5thEdition, 2008.
2. R. G. Gallager, Principles of Digital Communication, Cambridge University Press, 2009
3. K. S. Haykin, Digital Communications, Wiley-India, 2011

Reference Books

1. P. B Crilly, A. B. Carlson, Communication Systems, Tata McGraw-Hill Education, 5th Edition, 2011.
2. U. Madhow, Fundamentals of Digital Communication, Cambridge University Press, 2008
3. J.M Wozencraft, I.M. Jacobs, Principles of Communication Engineering, JohnWiley, 1965.
4. A. Glover, P. M. Grant, Digital Communications, Pearson, 5th Impression, 2012.
5. P. Z. Peeples, Digital Communication Systems, Prentice Hall International, 1987.

CLO:

After the successful completion of the course the students will be able to:

- Understand fundamentals as well as advanced concepts in digital communications such as modulation, demodulation, detection, channel estimation and equalization.
- Implement various digital communications techniques
- Compare different techniques and apply for different applications.

EE3xx VLSI Laboratory (0-0-3-3) Prerequisite: Nil

Introduction to EDA tools, Experiments on Full Custom Design, Semi Custom Design and FPGA based digital system design and implementation

Texts/References:

1. Muhammad H. Rashid, Introduction to PSpice Using OrCAD for Circuits and Electronics, 3/e, PHI, 2006
2. Charles H Roth Jr., Digital systems design using VHDL, 8/e, Thomson Learning Inc, 2006
3. Charles H Roth Jr., Fundamentals of Logic Design, 5/e, Thomson Learning Inc, 2007.
4. J.M. Rabaey, A. Chandrakasan and B. Nikolic, Digital Integrated Circuits- A Design Perspective, 2/e, PHI, 2003.
5. P. E. Allen and D. R. Holberg, CMOS Analog Circuit Design, 2/e, Oxford University Press, 1997.

CLO

After going through this Lab course, students shall get exposure to

1. Various EDA tools and soft skills for designing VLSI Chip
2. Full custom Circuit simulation and verification.
3. Design and simulation of digital VLSI Systems using HDL
4. Synthesis and Physical design along with analysis
5. FPGA Implementation and prototype of digital VLSI systems

EE3xx Analog and Digital Communications Lab (0-0-3-3)
Prerequisite: Signal and Systems

Amplitude modulation and demodulation (AM with carrier & DSB-SC AM); frequency modulation and demodulation (using VCO & PLL); automatic gain control (AGC); pulse amplitude modulation (PAM): Natural Sampling and Flat Top Sampling; Pulse pulse code modulation (PCM); Pulse Width Modulation and Demodulation; Pulse Position Modulation and Demodulation.

Pseudo-random (PN) sequence generation; Amplitude shift keying (ASK) Generation and Detection; Frequency shift keying (FSK) Generation and Detection; Binary phase shift keying (BPSK) Generation and Detection; binary frequency shift keying (BFSK) Generation and Detection; Quadrature phase shift keying (QPSK) Generation and Detection; Orthogonal frequency division multiple access; Code division multiple access (CDMA) and direct sequence spread spectrum (DSSS) system.

Text/References:

1. H. Taub and D. L. Schilling: Principles of Communication Systems; Tata McGraw-Hill, 2008.

2. J. G. Proakis and S. Salehi: Communication Systems Engineering; Pearson, 2006.
3. W. Tomasi, Electronic Communications Systems - Fundamentals through advanced, 4/e, Pearson, 2003.
4. S.S. Haykin, An Introduction to Analog and Digital Communication Systems, Wiley Eastern 1989.

CLO: After attending this laboratory course the student will be able to

1. Design transmitter and receivers for different analog and digital modulation formats from scratch using both discrete component and software configurable system
2. Understand baseband, passband modulation and demodulation techniques using experiments.
3. Understand the advantages and disadvantages of various modulation and demodulation techniques
4. Perform encoding and decoding using self-made hardware system and estimate their performance
5. Observe and understand the evolution of signals at different stages of analog and digital communication systems

Semester 7

Course Code: EExxx Wireless Communication 3-0-0-6 Pre-requisites: Analog and Digital Communications

Introduction: Basic understanding of the different modes of communication, introductory discussion on the evaluation of 1G to 5G, various channel environments, the concept of single and multipath channel environments,

Random Signal Theory: Joint Probability, Statistical independence, Cumulative Distribution function, and Probability Density function, Error function, Rayleigh and Gaussian Probability Density, Stationary, and Ergodic Process, Power Spectral Density of digital data.

Baseband Data Transmission: Base band Signal receiver, Probability of error, Optimum filter, Matched filter, Coherent reception, ISI and Turbo Equalization. Digital Modulation Techniques: Performance Analysis of BPSK, DPSK, QPSK, Mary PSK, BFSK, M-ary FSK, MSK, QAM, OFDM for wireless transmission.

Propagation & Fading: Propagation path loss, Free-space propagation model, Outdoor propagation models (Okumura model & Hata model), Indoor propagation models (Partition Losses in the same floor and between floors), Multipath fading, time dispersive and frequency dispersive channels, delay spread and coherence bandwidth, LCR and ADF.

Mobile Radio Interferences & System Capacity: Co-channel Interference and System Capacity, Channel planning for Wireless Systems, Adjacent channel interferences, Power control for reducing interference, Inter-symbol Interference; The Cellular Concept: Frequency Assignment and Channel Assignment, Frequency Reuse, Handoff, Sectoring, Microcell zone, Spectral efficiency,

Multiple Access techniques: FDMA, TDMA, CDMA, OFDMA, OFDM-CDMA, MIMO-OFDM, and QoS issues. Multiuser Detection: Linear and Non-Linear Multiuser Detectors, BER Analysis, Turbo Multiuser Receiver, Iterative Interference Cancellation, Capacity Analysis, BER Analysis, Multiuser Detection for 4G wireless Systems.

Texts/References:

1. D. Tse, P. Viswanath, Fundamentals of Wireless Communications, Cambridge Press, (2005)
2. G. L. Stuber, Principles of Mobile Communication, Kluwer Acdemic, (1996)
3. J. G. Proakis, Digital Communications, McGraw-Hill, (1995)
4. T. S. Rappaport, Wireless Communications: Principles and Practice, Prentice Hall, (1996)
5. A. J. Viterbi, CDMA Systems: Principles of Spread Spectrum Communication, Addison Wesley, (1995)
6. Andrey Goldsmith, Wireless Communication, Cambridge Press S. Verdu, Multiuser Detection, Cambridge University Press, (1998)
7. H. Wymeersch, Iterative Receiver Design, Cambridge University Press, (2007)

CLO:

After the successful completion of the course the students will be able to:

1. Get better understating of different application-oriented topics like data transmission techniques, channel modeling, probability of error analysis, etc.
2. work in industry and solve practical problems on wireless communication for 5G and beyond.
3. understand recent research papers, white papers, etc. related to 5G and its applications and will be able to find the particular area of research in wireless communication.

Course Code: EExxx Information Theory and Coding 3-0-0-6

Pre-requisites: Analog and Digital Communications

Information Theory: The concept of Amount of Information, Average Information, Entropy, Information rate, Source Coding: Fixed and Variable Length Codes, Kraft Inequality, Shannon-Fano Algorithm, Huffman Algorithm.

Shannon's Theorem, Channel Capacity, Capacity of a Gaussian Channel, Bandwidth-S/N Trade-off. Channel Coding, Channel Models, Channel Capacity Theorem, Shannon Limit.

Error Control Coding: Introduction, Forward & Backward error Correction, Hamming Weight and Hamming Distance, Linear Block Codes, Encoding and decoding of Linear Block-codes, Parity Check Matrix, Syndrome Decoding, Hamming Codes.

Convolutional and Turbo Codes: Introduction, Polynomial description of Convolutional Codes, generating function, Matrix description of Convolutional Codes, Viterbi Decoding of Convolutional codes. Turbo Codes, Turbo Encoder, and Decoder, LDPC, Encoder and Decoder of LDPC

Texts/References:

1. R. Bose, Information Theory and applications, 2nd Edition, TMH, (2008)

2. J. G. Proakis, Digital Communications, McGraw-Hill, (2010)

3. D. Tse, P. Viswanath, Fundamentals of Wireless Communications, Cambridge Press, (2005)

CLO:

After the successful completion of the course the students will be able to:

1. Apply the basic knowledge of the information theory to design the channel performance.

2. Apply linear block codes for error detection and correction.

3. Design Convolution codes and Turbo codes for error correction.

4. Design LDPC codes to obtain good error performance.

Course Code: EExxx Communication Networks 3-0-0-6 Pre-requisites: Analog and Digital Communications

Overview of Communications Networks — Introduction to Internet, Layering Concept, OSI Model, TCP/IP Model, Introduction to Protocols, Topology, Performance Metrics, Devices at different layers

Overview of Data link Control and Media access control: Ethernet, Wireless LANs, Bluetooth, WiFi, 6LowPAN, Zigbee. Packet and Circuit Switching, Queuing Theory, Stop and wait protocol, sliding window protocol, Medium access protocols: Aloha, slotted aloha, CSMA, CSMA CD, and collision - free protocols, FDDI, token ring

Routing: Protocols, Types of Routing, Algorithms, IP Protocol, Addressing: IPV4 Address, IPv6 Addressing, Transition from IPv4 to IPv6

Transport Layer: Protocols - User Datagram Protocols (UDP) and Transmission Control Protocols (TCP), Flow, Error and Congestion Control: Congestion avoidance, QoS in networks

Application Layer: Client Server Model, World Wide Web and HTTP, DNS, Electronic Mail

Text/References:

1. A. S. Tanenbaum, Computer Networks, 5th edition, Prentice-Hall, Inc., 2010.
2. J. Kurose and K. Ross, "Computer Networking: A Top-Down Approach Featuring the Internet"
3. W. Stallings, Data and Computer Communications, 10th edition, Prentice-Hall, Inc., 2013.
4. R. Gallager and D. P. Bertsekas, Data Networks, 2nd edition, Prentice-Hall, Inc., 1991.

CLO:
The students will be able to understand:
1. the network layered architecture and the protocol stack
2. the principles upon which the Internet and other computer networks are built;
3. how those principles translate into deployed protocols

Course Code: EExxx Communication Network Lab 0-0-3-3 Pre-requisites: Analog and Digital Communications

Implementation of Error Detection, Error Correction Techniques, Stop and Wait Protocol and sliding window, Go back-N Protocol, Selective repeat protocols

Performance evaluation of CSMA/CA and CSMA/CD protocols.

Implementation of Routing Algorithms: distance vector routing and link state routing

Basics of Socket Programming, Implementation of IP address configuration

Overview of simulator like Network Simulator (NS) and Netsim

Text/References:

1. A. S. Tanenbaum, Computer Networks, 5th edition, Prentice-Hall, Inc., 2010.
2. J. Kurose and K. Ross, "Computer Networking: A Top-Down Approach Featuring the Internet"
3. W. Stallings, Data and Computer Communications, 10th edition, Prentice-Hall, Inc., 2013.
4. R. Gallager and D. P. Bertsekas, Data Networks, 2nd edition, Prentice-Hall, Inc., 1991.

CLO:
At the end of course, the students will be able to
1. Understand the organisation of communications networks; including the layering concepts
2. Understand and implement different protocols.
3. Understand the mathematical foundations along with implementation of the algorithms related to networks

Elective

Course Code: EExxx Internet of Things (IoT) 3-0-0-6 Pre-requisites: Nil

1. Overview: Motivation, Applications and Objectives of Internet of Things (IoT), Cyber-Physical Systems and Wireless Sensor Networks.

2. Identification/Devices in IoT: Sensors and Actuators, Sensor Types, Sensor Characteristics, Actuator Types, Controlling IoT Devices; Radio Frequency Identification (RFID) Technology, Mobile Sensing, Network Topology.
Connectivity Protocols in IoT: Bluetooth Low Energy, 6LoWPAN, ZigBee, NFC, Sigfox and LoRa

Data messaging Protocols in IoT: Message Queue Telemetry Transport (MQTT), Hyper-Text Transport Protocol (HTTP), Constrained Application Protocol (CoAP), Data Distribution Service (DDS)

3. IoT Protocols: IoT Standardization, Open Systems Interconnection (OSI), Transmission Control Protocol/Internet Protocol (TCP/IP), Internet Protocol (IP) Suite: IPv4, IPv6 and Internet Routing

4. Localization in IoT: Localization using Received Signal Strength (RSS), Phase, Time domain phase difference of arrival (TD-PDOA), Frequency domain phase difference of arrival (FD-PDOA), Space domain phase difference of arrival (SD-PDOA); Event Detection and Tracking using Signal Processing Methods

5. Signal Processing and Machine Learning for Data Analytics: Computation and Decision Making for Heterogeneous Devices. Feature Engineering, Validation Methods, Understanding the Bias–Variance Tradeoff, Sensor Fusion, Edge Computing

6. Security and Privacy Issues in IoT: Examples of Cyber-Physical Infrastructure Threat, Smart Car Hacking, Smart Home Hacking, Wearable Device Vulnerabilities; Techniques to Secure IoT: Segmentation, Defence-In-Depth, Defence-In-Breadth, User-Configurable Data Collection, Pattern Obfuscation, End-To-End Security, Tamper Security.

7. Use Cases of IoT for Smart Environments: Development of IoT Projects for Healthcare, Agriculture, Smart City, Retail, Manufacturing, amongst others using hardware such as Arduino, Raspberry Pi and LibeliumWaspMote.

Text Books:

1) The Internet of Things: Enabling technologies, platforms, and use cases, Raj, Pethuru, and Anupama C. Raman, Auerbach Publications, 2017.

2) Internet of Things from hype to reality: the road to digitization, Rayes, Ammar, and Samer Salam, Springer, 2016.

Reference Books:

3) Handbook on Securing Cyber-Physical Critical Infrastructure: Foundations and Challenges, S. K. Das, K. Kant and N. Zhang, Morgan Kauffman, 2012.

4) Smart Environments: Technology, Protocols and Applications, D. J. Cook and S. K. Das, John Wiley, 2005

5) Cyber-physical systems: foundations, principles and applications, Song, Houbing, et al., eds, Morgan Kaufmann, 2016.

6) The Internet of things: from RFID to the next-generation pervasive networked systems , Yan, Lu, et al., eds, CRC Press, 2008.

7) Learning internet of things , Waher, Peter, Packt Publishing Ltd, 2015.

8) IoT technical challenges and solutions, Pal, Arpan, and Balamuralidhar Purushothaman, Artech House, 2016.

CLO:

After the successful completion of the course the students will be able to:

1. fundamentally understand the building blocks of the Internet of Things application.
2. apply the knowledge involving programming and data analysis.

Course Code: EExxx Solid State Electronics 3-0-0-6 Pre-requisites: Nil

Introduction to Quantum Mechanics and Energy Band Theory, Definitions of metal, insulator and semiconductor based on existence of energy bands in crystalline material, Classification of semiconductor materials, Charge transport in metals and pure and doped semiconductors, Continuity and Poisson equations, Principles of semiconductor processing; Moore's Law, Ideal PN junction: electrostatic behaviour of depletion layer; physical explanation and derivation of static current-voltage characteristic, The Metal-Semiconductor Field-Effect Transistor (MOSFET); MOS capacitor; DC characteristic; applications, The Bipolar Junction Transistor (BJT): structure of NPN and PNP bipolars; operating principles; characteristics; applications

CLO:

The student will have insight in: - classical waves and the wave equation. - basic concepts of quantum mechanics. - basic mechanisms behind chemical bonds in crystalline materials. - most important crystal structures and basic crystallography. - what a rec iprocal lattice is and how it is used. - important models explaining energy band structure in solids. - the concepts: band gap, Fermi level, Fermi-Dirac distribution, density of states. Skills: The student can: - describe harmonic waves mathematically. - use quantum mechanical formalism to solve simple one-dimensional problems. - make use of the reciprocal lattice as a tool for analysis of crystalline materials.

Books:

(1) The Oxford Solid State Basics, Steven H. Simone, Oxford University Press, 2013
(2) Introduction to Solid state physics, Charles Kittel, Wiley, 2012
(3) Physics of Semiconductor Devices, M. Shur, Pearson, 2019

EE5XX SATELLITE COMMUNICATION 3 0 0 6

Introduction to Satellite Communications: Origin, History, Current Technology State and Overview of Satellite System Engineering.

Orbital Aspects of Earth Satellites: Orbital Mechanics and Orbital Elements, Azimuth and Elevation, Coverage Angle and Slant Range, Placement of a Satellite in a Geostationary Orbit.

Satellite Link Design: Basic Radio Transmission Theory, System Noise Temperature and G/T Ratio, Uplink and Downlink Design, Interference Analysis, Carrier-to-Noise plus Interference Ratio, Interference to and from Adjacent Satellite Systems, Terrestrial Interference, Cross-polarization Interference, Intermodulation Interference, Design of Satellite Links for Specified Carrier-to-Noise plus Interference Ratio, Digital Satellite Link.

Propagation on Satellite-Earth Paths and Its Influence on Link Design: Absorbitive Attenuation Noise by Atmospheric Gases, Rain Attenuation, Noise due to Rain, Rain Depolarization, Tropospheric Multipath and Scintillation Effects.

Multiple Access Techniques in Satellite Communications: Frequency Division Multiple Access, FDMA, SCPC, MCPC. Time Division Multiple Access, TDMA: random (ALOHA, S-ALOHA) and time synchronized access. Code Division Multiple Access, CDMA, Fixed and On-demand Assignment.

Satellite Networking: Advantages and Disadvantages of Multibeam Satellites, Interconnection by Transponder Hopping, Interconnection by On-board Switching, Interconnection by Beam Scanning, On-Board Processing, Intersatellite Links.
Types of Satellite Networks: Fixed Point Satellite Network, INTELSAT, Mobile Satellite Network, INMARSAT, Low Earth Orbit and Medium Earth Orbit Satellite Systems, Very Small Aperture Terminal (VSAT) Network, Direct Broadcast Satellite Systems, Global Positioning System.

Texts:
1. Digital Satellite Communications, 2/e, McGraw-Hill, 1990.Tri T. Ha
2. Satellite Communications, John Willey and Sons, 2000T. Pratt, C.W. Bostian
3. Satellite Communications Systems Engineering, Pearson Education, 2/e; 2003 W.L. Prichard, H.G. Suyderhoud and R.A. Nelson

Reference:
1. E. G. Larsson and P. Stoica, Information Theory, Space-Time Block Coding for Wireless Communications, Cambridge University Press, 2003

CLO: After completing this course the students will be able to
1. Understand the concept of conventional and future satellite communication technology
2. Understand the concept of different orbits of satellite
3. Design and estimate the satellite link budget
4. Understand the challenges and solutions to establish satellite-to-satellite and ground-to-satellite communication link
5. Gain knowledge on different transmitter and receiver configurations for satellite communication

Engineering Electromagnetics (3-0-0- 6)

Pre-requisites: None

Review of Maxwell's equations, wave equation and plane waves: Helmholtz wave equation, Solution to wave equations and plane waves, wave polarization, poynting vector and power flow in EM fields.

Wave Propagation, Wave propagations in unbounded medium. boundary conditions, reflection and refraction of plane waves.

Transmission Lines: distributed parameter circuits, traveling and standing waves, impedance matching, smith chart. waveguides: parallel-plane guide, TE, TM and TEM waves, rectangular waveguides, resonators. Planar transmission lines: stripline, microstripline, application of numerical techniques. Hands-on on transmission line design.

Radiation: Antenna fundamentals, potentials, hertzian dipole, short loop, different antenna types, antenna parameters, antenna measurement techniques. Simulation and Analysis.

Radio-wave propagation: ground-wave, sky-wave, space-wave.

References:

1. M. N. O. Sadiku: Elements of Electromagnetics; Oxford University Press, 2000, 3/e.
2. R. F. Harrington: Time-Harmonic Electromagnetic Fields, Wiley-IEEE, 2001, 2/e.
3. J. Griffiths: Introduction to Electrodynamics, PHI, 1999, 3/e.
4. K. E. Lonngren & S. V. Savov: Fundamentals Electromagnetics with MATLAB, PHI, 2005, 1/e.
5. D. K. Cheng: Field and Wave Electromagnetics; Pearson, 2001, 2/e.
6. N. Ida, Engineering Electromagnetics, Springer, 2000, 1/e.

Course Learning Outcomes-:

Following are the major learning outcome of the course-

1. To make the students more familiar with Frequency dependent circuit designs.
2. To understand various aspects of wave propagation and mechanism.
3. Students will be able to visualise various field interactions and phenomena.
4. Hands on with several electromagnetic simulators and components.

Antenna Design and Characterization (3-0-0; 6)

Pre-requisites: Engineering Electromagnetics

Antenna fundamentals and definitions; Radiation integral and Auxiliary Potential
Functions, Reaction and reciprocity theorems; Wire antennas infinitesimal dipole, small dipole, finite length dipole, half-wave dipole, and loop antennas;

Antenna arrays – two-element array, N-element linear array, planar array, and circular array;

Different Types of Antennas: Dipoles and Matching Techniques, Travelling Wave Antennas, Broadband Antennas, Frequency Independent Antennas, Antenna Miniaturization, and Fractal Antennas, Aperture, and Horn Antennas, Microstrip Antennas, Antenna Polarization, Microstrip Patch Antennas, Reflector Antennas;

Antenna Measurements: Antenna Ranges, Radiation Patterns, Gain Measurements, Directivity, Measurements, Radiation Efficiency, Impedance Measurements, Current Measurements, Polarization Measurements;

Antennas for millimeter-wave communication;

References-

1. C.A. Balanis, "Antenna Theory Analysis and Design", Wiley & Sons, Third Edition.

2.Gosling, William. “Radio Antennas and Propagation: Radio Engineering Fundamentals”, Elsevier, 1998.
3. Kraus, John Daniel, and Ronald J. Marhefka. "Antennas for all applications.", aaa. 2002.
4.Kraus, John D., Ronald J. Marhefka, and Ahmad S. Khan, “Antennas and wave propagation”, Tata McGraw-Hill Education, 2006.
5.Sharawi, Mohammad S., “Printed MIMO antenna engineering”, Artech House, 2014.

Course Learning Outcomes-:

Following are the major learning outcome of the course-

1. To learn antenna fundamentals and its practical aspects.
2. To understand designing techniques and various applications of antenna technologies.
3. Students will learn several simulation and designing techniques of high frequency antennas.
4. To know about the application and designing of next generation radiation blocks.

Core -

RF Systems (3-0-0 ; 6)

Pre-requisites: Engineering Electromagnetics

Microstrip Transmission line, propagation module, Scattering parameters, signal flow graphs and Network analyser. Circular Waveguides

Microwave Filters, couplers, power dividers, resonators, phase shifters, and frequency selective surfaces.

Measurement Fundamentals, VNA, Spectrum analyzer, and techniques.

Oscillators, LNA, and switching networks. Noise in Microwave circuits.

RF systems, RF Front end. Software defined Radio, design and analysis.

Microwave systems, graphene, and metamaterials.

References:

1. David M. Pozar, Microwave Engineering, Wiley India Private Limited; Fourth edition (14 May 2013).

2. C. A. Balanis: Antenna Theory: Analysis and Design, John Wiley, 2005, 3/e.

3. R. E. Collin, Foundations for Microwave Engineering, Wiley-Blackwell; 2nd Edition

4. D. M. Sullivan: Electromagnetic Simulation using the FDTD Method, Wiley-IEEE, 2000, 1/e.

5. B. S. Guru & H. R. Hiziroglu: Electromagnetic Field Theory Fundamentals, Thomson, 1997, 1/e

Course Learning Outcomes-:

The students will be able to learn the design of microwave coupler and dividers, filters and their implementation, microwave amplifiers, active microwave devices, oscillators and mixers. A slight introduction of network analysis is covered. It also highlights the distortions caused by the noise in microwave circuits. Microwave systems are also discussed.

RF Systems Lab (0-0-3; 3)

Pre-requisites: Engineering Electromagnetics

Microstrip Transmission line, Scattering parameters, and Network analyser.

Microwave Filters, couplers, power dividers, resonators, phase shifters.

Measurement Fundamentals, VNA, Spectrum analyzer, and techniques.

Oscillators, LNA, and switching networks. Noise in Microwave circuits.

Software defined Radio, design and analysis.

References:

1. David M. Pozar, Microwave Engineering, Wiley India Private Limited; Fourth edition (14 May 2013).

2. C. A. Balanis: Antenna Theory: Analysis and Design, John Wiley, 2005, 3/e.

3. R. E. Collin, Foundations for Microwave Engineering, Wiley-Blackwell; 2nd Edition

4. D. M. Sullivan: Electromagnetic Simulation using the FDTD Method, Wiley-IEEE, 2000, 1/e.

5. B. S. Guru & H. R. Hiziroglu: Electromagnetic Field Theory Fundamentals, Thomson, 1997, 1/e

Elective-

High-Frequency Systems (Design and Characterisation) 3-0-0-6

Generation of EM Waves, Propagation of EM waves in Guided and Unguided Media, Transmission Lines, Microstrip Lines, Fabrication Techniques;

Network Parameters, High-Frequency Network Parameters, Scattering Parameters, Signal Flow Graphs, Smith Chart Concepts, Impedance Matching, Microstrip Line Designing, and Characterization;

Noise in Microwave Circuits, High-Frequency measurement Techniques, The calibration techniques, error, and post-calibration;

High-Frequency Future Generation Communication Networks, 5G and Beyond, Architecture and Deployments, Characterization Techniques for High-Frequency Circuits, Measurement Techniques;

mmWave Wireless Communications, Radar Systems, Detection and Ranging, High Power Microwave Propagation, FMCW Radars, High-Frequency Detection using AI and ML Techniques;

Main References

1. David M. Pozar, “Microwave Engineering”, Wiley, 4th Edition.

2. Robert E. Collin, “Foundations for Microwave Engineering”, Wiley, 2nd Edition.