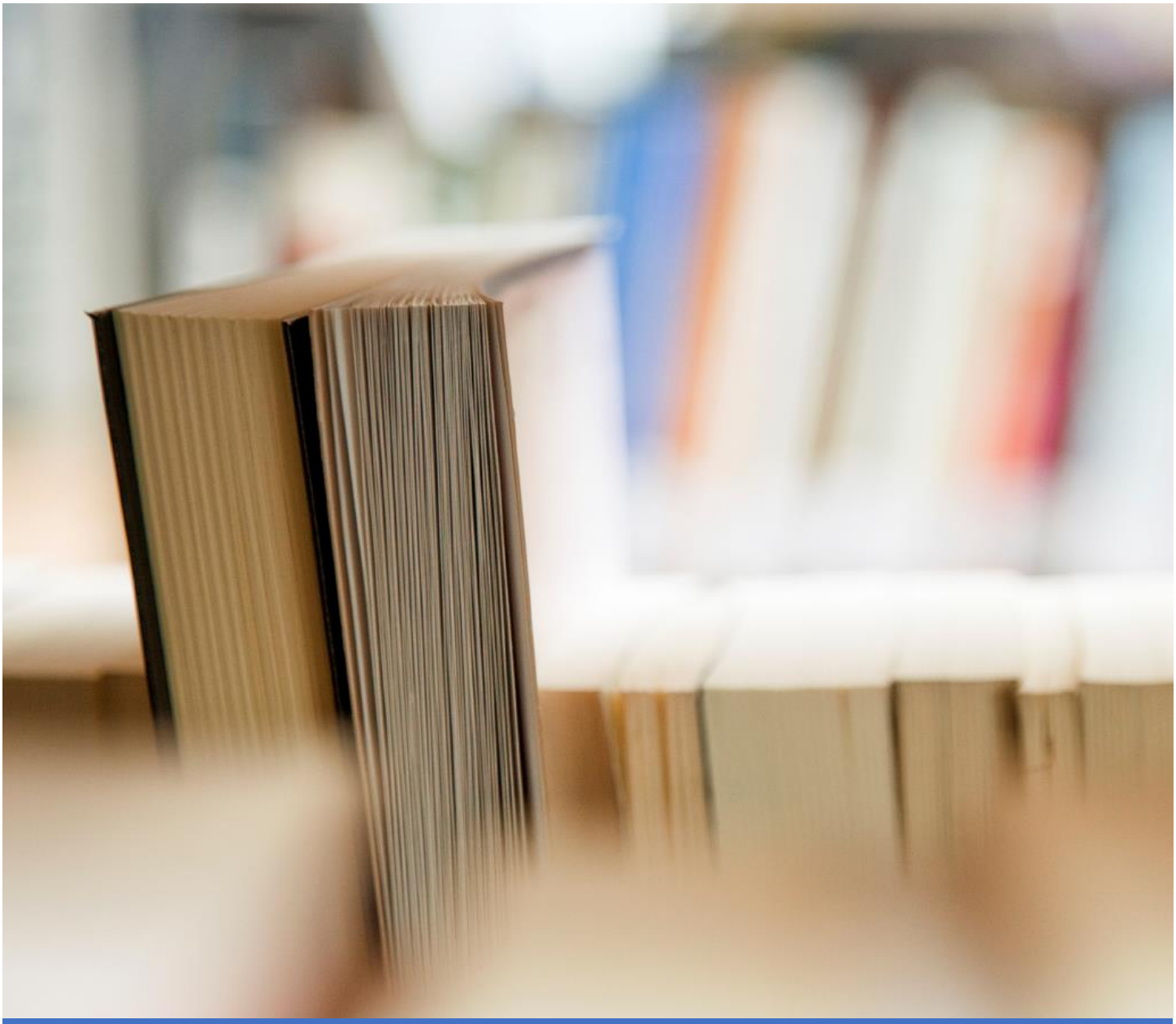

Prospectus – 2021 - 2025

Department of Electrical Engineering

Dr Naveen Babu

Electrical and Computer Engineering Program

Shiv Nadar University

Table of Contents

Department of Electrical Engineering

School of Engineering

UG Prospectus B.Tech. ECE with Specialization

I. Overview of Department of Electrical Engineering

The Electrical Engineering (EE) department is part of the School of Engineering (SoE) at SNU. Its vision is to be a catalyst in imparting quality education and conducting valued research for the benefit of society. Historically, the field of electrical engineering is one of the most important engineering disciplines that have changed the course of the world. Some of our important areas of teaching are electrical machines and drives, power electronics, power systems, integrated circuits and systems, control systems, machine intelligence, communication systems and signal processing. Sufficient emphasis is given to practical teaching and hands-on learning. Relevant laboratories have been established to meet the requirements of teaching and research. The vision of the department is to establish itself as a center of excellence in terms of research and teaching in its chosen areas. We are committed to establishing human and material infrastructure towards this cause. The department has formed research groups in some of the key areas and is in the process of collaborating with various renowned institutions.

The undergraduate program is broad-based and founded on the pedagogy of learning by doing. The postgraduate programs are getting formulated and are intended to provide advanced degrees in contemporary areas of industrial relevance. They also provide platforms for research avenues. The department has a vibrant doctoral research program. The doctoral program aims to conduct research both in fundamental and applied areas for societal use. The programs intend to fill the dearth in the supply of highly skilled professionals. It will also enable the students to gain high-end skills for intellectually challenging careers in industry. Our aim is to invoke in our students a sense of curiosity to question and to motivate them to think deeply about theoretical and applied problems in technology for society’s needs.

Presently the EE department offers the following programs: -

Undergraduate Programs:

Bachelor of Technology in Electronics and Communication Engineering (B. Tech. in ECE)

- with the option of doing minor in any other stream of interest.
- with the option of doing Specialisation in any of the FOUR areas of interest.

Detailed rules and regulations regarding B.Tech. Program in SNU can be found in UG handbook (available at: https://snulinks.snu.edu.in/snuPolicies/students/

Master Programs:

(I) M. Tech in RF and Microwave Engineering
(II) M.Tech in VLSI & Embedded Systems

Doctoral Programs:

(I) Ph.D. in Electrical Engineering / Electronics and Communication Engineering

Credit Break-up of UG Curriculum in Electrical and Computer Engineering

	Total number of Credits:	160	
S. No.	**Category**	**Credits**	
1	Core Common Curriculum (CCC)	18	36
2	University Wide Elective (UWE)	18	
3	Basic Sciences (BS)	20	
4	Engineering Sciences (ES)	13	
5	Major Core	50	
6	Major Elective	32	
7	Minor Project	3	
8	Internship / Major Project	6	
	Total Credits	**160**	

Detailed Break up Semester wise and Category wise

		Engineering Science (ES)			
S. No.	**Course Code**	**Course Title**	**L:T:P**	**Credits**	**Semester Offered**
1	ECE101	Basics of Electrical and Electronic Circuits	3:1:1	5	1
2	CSD101	Introduction to Computing and Programming	3:0:1	4	1
3	CSD102	Data Structures	3:0:1	4	2

		Basic Sciences (BS)			
S. No.	**Course Code**	**Course Title**	**L:T:P**	**Credits**	**Semester Offered**
1	MAT103	Mathematical Methods I	3-1-0	4	1
2	PHY101	Introduction to Physics I	3-1-0	4	1
3	MAT104	Mathematical Methods II	3-1-0	4	2
4	PHY102	Introduction to Physics II	3-1-1	5	2
5	MAT205	Mathematical Methods III - Probability and Statistics	3-0-0	3	3

		Major Core Courses			
S. No.	**Course Code**	**Course Title**	**L:T:P**	**Credits**	**Semester Offered**
1	ECE103	Digital Electronics	3:1:1	5	2
2	ECE102	Semiconductor Devices	3:0:0	3	3
3	ECE201	Electric Machines & Power Systems	3-0-1	4	3
4	ECE203	Signals and Systems	3-1-0	4	3
5	ECE202	Embedded Systems Hardware	3-0-1	4	3
6	ECE205	Electromagnetic Engineering	3-1-0	4	4
7	ECE204	Analog Circuits	3-0-1	4	4
8	ECE206	Power Electronics and Machine Drives	3-0-1	4	4
9	ECE207	Principles of Communication Engineering	3-0-1	4	4
10	ECE301	Control Systems	3-0-1	4	5
11	ECE302	Digital Signal Processing	3-0-1	4	5
12	ECE303	Computer Organization and Design	3-0-0	3	5
13	ECE304	Artificial Intelligence and Machine Learning	3-0-0	3	6

S. No.	Course Code	Major Elective Courses	L:T:P	Credits	Semester Offered	Specialization
1	ECE351	VLSI Design	3:0:1	4	5	Sensors and Nanoelectronics
2	ECE352	Photovoltaic/Renewable	3:0:0	3	5	Modern Energy Systems
3	ECE353	Microwave Engineering	3:0:0	3	5	Analog/RF and Communication Engineering
4	ECE354	Sensor, Measurement, and Actuators	3:0:1	4	5	1. Sensors and Nanoelectronics 2. Modern Energy Systems 3. Embedded Systems and Computer Engineering
5	ECE355	Scientific Computing using Matlab	2:0:1	3	5	Miscellaneous
6	ECE356	RF and Microwave Circuit Design	3:0:1	4	5	Analog/RF and Communication Engineering
7	ECE357	Introduction to Robotics	3:0:1	4	5	Embedded Systems and Computer Engineering
8	ECE360	IoT - Architecture, Communication Technology, and Applications	2:0:1	3	6	Embedded Systems and Computer Engineering
9	ECE361	Power System Analysis	3:0:1	4	6	Modern Energy Systems
10	ECE362	Digital Communication	3:1:1	5	6	Analog/RF and Communication Engineering
11	ECE363	Computer Communication Networks	3:0:1	4	6	1. Analog/RF and Communication Engineering 2. Embedded Systems and Computer Engineering
12	ECE364	Wireless and Mobile Communication	3:0:0	3	6	Analog/RF and Communication Engineering
13	ECE365	Object Oriented Programming	3:0:0	3	6	Miscellaneous
14	ECE366	Antenna Theory and Wave Propagation	3:0:1	4	6	Analog/RF and Communication Engineering
15	ECE367	Digital Design with FPGA	3:0:1	4	6	1. Embedded Systems and Computer Engineering 2. Sensors and Nanoelectronics
16	ECE368	Special Topics in Microwave Engineering	3:0:0	3	6	Analog/RF and Communication Engineering
17	ECE451	Design of Analog CMOS Circuits	3:0:0	3	7	Sensors and Nanoelectronics
18	ECE452	Power System Operation and Control	3:0:0	3	7	Modern Energy Systems
19	ECE453	Foundations of Deep Learning	3:0:0	3	7	Miscellaneous
20	ECE454	Optical Fiber Communication	3:0:1	4	7	Analog/RF and Communication Engineering
21	ECE455	Graph Signal Processing	3:0:1	4	7	Analog/RF and Communication Engineering
22	ECE456	High Voltage Engineering	3:0:0	3	7	Modern Energy Systems
23	ECE457	Information Theory and Coding	3:0:0	3	7	Analog/RF and Communication Engineering
24	ECE458	Radar Communications	3:0:0	3	7	Analog/RF and Communication Engineering

25	ECE459	Computational Electromagnetics	3:0:0	3	7	Analog/RF and Communication Engineering
26	ECE460	Switchgear and Protection	3:0:0	3	8	Modern Energy Systems
27	ECE461	HVDC Transmission	3:0:0	3	8	Modern Energy Systems
28	ECE462	WBG Devices for Power Circuits	3:0:0	3	8	1. Sensors and Nanoelectronics 2. Modern Energy Systems
29	ECE463	Satellite Communications	3:0:0	3	8	Analog/RF and Communication Engineering
30	ECE464	Advance Electromagnetics Engineering	3:0:0	3	8	Analog/RF and Communication Engineering

Semester wise course break up

First Semester				
S. No.	**Course Code**	**Course Title**	**L:T:P**	**Credits**
1	CCC704	CCC704 (Environmental)		3
2	MAT103	Mathematical Methods I	3-1-0	4
3	PHY101	Introduction to Physics I	3-1-0	4
4	ECE101	Basics of Electrical and Electronic Circuits (ECE)	3-1-1	5
5	CSD101	Introduction to Computing and Programming	3-0-1	4
		Semester Credits		**20**

Second Semester				
S. No.	**Course Code**	**Course Title**	**L:T:P**	**Credits**
1		CCC		3
2	MAT104	Mathematical Methods II	3-1-0	4
3	PHY102	Introduction to Physics II	3-1-1	5
4	ECE103	Digital Electronics	3-1-1	5
5	ECE102	Semiconductor Devices	3-0-0	3
	ECE101	Basics of Electrical and Electronic Circuits (Non ECE)	3-1-1	Five*
		Semester Credits		**20**

Third Semester				
S. No.	**Course Code**	**Course Title**	**L:T:P**	**Credits**
1		CCC		3
2	MAT205	Mathematical Methods III - Probability and Statistics	3-0-0	3
3	ECE201	Electric Machines & Power Systems	3-0-1	4
4	CSD102	Data Structures	3-0-1	4
5	ECE202	Embedded Systems Hardware	3-0-1	4
6	ECE203	Signals and Systems	3-1-0	4
	ECE103	Digital Electronics (Non ECE)	3-1-1	5
		Semester Credits		**22**

Fourth Semester				
S. No.	**Course Code**	**Course Title**	**L:T:P**	**Credits**
1		CCC		3
2	DES211	UWE/Design		3
3	ECE205	Electromagnetic Engineering	3-1-0	4
4	ECE204	Analog Circuits	3-0-1	4
5	ECE206	Power Electronics and Machine Drives	3-0-1	4
6	ECE207	Principles of Communication Engineering	3-0-1	4
		Semester Credits		**22**

Fifth Semester				
S. No.	**Course Code**	**Course Title**	**L:T:P**	**Credits**
1		UWE - 1		3
2	ECE301	Control Systems	3-0-1	4
3	ECE302	Digital Signal Processing	3-0-1	4
4	ECE303	Computer Organization and Design	3-0-0	3
5		**Major Elective - 1**		3
6		**Major Elective - 2**		3
		Semester Credits		**20**
		Major Elective Courses		
	ECE351	VLSI Design		
	ECE352	Photovoltaic/Renewable		
	ECE353	Microwave Engineering		
	ECE354	Sensor, Measurement, and Actuators		
	ECE355	Scientific Computing using Matlab		
	ECE356	RF and Microwave Circuit Design		
	ECE357	Introduction to Robotics		

Sixth Semester				
S. No.	**Course Code**	**Course Title**	**L:T:P**	**Credits**
1		CCC		3
2		UWE - 2		3
3		UWE - 3		3
4	ECE304	Artificial Intelligence and Machine Learning	3-0-0	3
5		Major Elective - 3		3
6		Major Elective - 4		4
7		Major Elective - 5		3
		Semester Credits		**22**
		Major Elective Courses		
	ECE360	IoT - Architecture, Communication Technology, and Applications		
	ECE361	Power System Analysis		

ECE362	Analog and Digital Communication
ECE363	Computer Communication Networks
ECE364	Wireless and Mobile Communication
ECE365	Object Oriented Programming
ECE366	Antenna Theory and Wave Propagation
ECE367	Digital Design with FPGA
ECE368	Special Topics in Microwave Engineering

Seventh Semester				
S. No.	**Course Code**	**Course Title**	**L:T:P**	**Credits**
1		CCC		3
2		Major Elective - 6		3
3		Major Elective - 7		3
4		Major Elective - 8		3
5		UWE - 4		3
6		UWE - 5		3
7	ECE498	Minor Project	0-0-3	3
		Semester Credits		**21**

	Major Elective Courses
ECE451	Design of CMOS Analog Circuits
ECE452	Power System Operation and Control
ECE453	Foundations of Deep Learning
ECE454	Optical Fiber Communication
ECE455	Graph Signal Processing
ECE456	High Voltage Engineering
ECE457	Information Theory and Coding
ECE458	Radar Communications
ECE459	Computational Electromagnetics

		Eighth Semester		
S. No.	**Course Code**	**Course Title**	**L:T:P**	**Credits**
1		Major Elective (Online Course/Offline Course) -9	3-0-0	3
2		Major Elective (Online Course/Offline Course) -10	3-0-0	3
3	ECE499	Major Project	0-0-6	6
		Semester Credits		**12**

	Major Elective Courses
ECE460	Switchgear and Protection
ECE461	HVDC Transmission
ECE462	WBG Devices for Power Circuits
ECE463	Satellite Communications
ECE464	Advance Electromagnetics Engineering

Specialisation

Requirement for Specialization Tracks: Student must earn a minimum of 16 Credits from a particular specialization (out of required 16 credits, 3 credits may optionally be earned from electives under "Miscellaneous" category). A student may choose to graduate without any particular specialization.

Electrical department for ECE program offers following FOUR specialisation tracks

- **Modern Energy Systems**
- **Analog/RF and Communication Engineering**
- **Embedded Systems and Computer Engineering**
- **Sensors and Nanoelectronics**

Students may earn their specialisation and get their degree BTech in Electrical and Computer Engineering with specialisation in “any of the four areas mentioned above”.

List of courses to earn specialisation

S. No.	Course Code	Basket of courses for specialization in 'Modern Energy Systems'	L:T:P	Credits	Semester Offered
1	ECE352	Photovoltaic/Renewable	3:0:0	3	5
2	ECE354	Sensor, Measurement, and Actuators	3:0:1	4	5
3	ECE361	Power System Analysis	3:0:1	4	6
4	ECE452	Power System Operation and Control	3:0:0	3	7
5	ECE456	High Voltage Engineering	3:0:0	3	7
6	ECE460	Switchgear and Protection	3:0:0	3	8
7	ECE461	HVDC Transmission	3:0:0	3	8
8	ECE462	WBG Devices for Power Circuits	3:0:0	3	8

S. No.	Course Code	Basket of courses for specialization in 'Analog/RF and Communication Engineering'	L:T:P	Credits	Semester Offered
1	ECE453	Microwave Engineering	3:0:0	3	5
2	ECE356	RF and Microwave Circuit Design	3:0:1	4	5
3	ECE362	Analog and Digital Communication	3:1:1	5	6
4	ECE363	Computer Communication Networks	3:0:1	4	6
5	ECE364	Wireless and Mobile Communication	3:0:0	3	6
6	ECE366	Antenna Theory and Wave Propagation	3:0:1	4	6
7	ECE368	Special Topics in Microwave Engineering	3:0:0	3	6
8	ECE454	Optical Fiber Communication	3:0:1	4	7
9	ECE455	Graph Signal Processing	3:0:1	4	7
10	ECE457	Information Theory and Coding	3:0:0	3	7
11	ECE458	Radar Communications	3:0:0	3	7
12	ECE459	Computational Electromagnetics	3:0:0	3	7
13	ECE463	Satellite Communications	3:0:0	3	8
14	ECE464	Advance Electromagnetics Engineering	3:0:0	3	8

S. No.	Course Code	Basket of courses for specialization in 'Embedded Systems and Computer Engineering'	L:T:P	Credits	Semester Offered
1	ECE357	Introduction to Robotics	3:0:1	4	5
2	ECE354	Sensor, Measurement, and Actuators	3:0:1	4	5
3	ECE360	IoT - Architecture, Communication Technology, and Applications	2:0:1	3	6
4	ECE363	Computer Communication Networks	3:0:1	4	6
5	ECE367	Digital Design with FPGA	3:0:1	4	6

S. No.	Course Code	Basket of courses for specialization in 'Sensors and Nanoelectronics'	L:T:P	Credits	Semester Offered
1	ECE351	VLSI Design	3:0:1	4	5
2	ECE354	Sensor, Measurement, and Actuators	3:0:1	4	5
3	ECE367	Digital Design with FPGA	3:0:1	4	6
4	ECE451	Design of Analog CMOS Circuits	3:0:0	3	7
5	ECE462	WBG Devices for Power Circuits	3:0:0	3	8

Syllabus of offered courses

ECE 101: ***Basics of Electrical & Electronic Circuits***		
Unit	**Course Unit description**	**Number of Lecture hours**
Unit I:	*Basic Components of Electrical Circuits (4-5):* Fundamental electrical variables – charge, current, voltage & power; Independent Voltage & Current sources; Ideal circuit elements - Resistor, Capacitor & Inductor; Controlled Source models – VCVS, VCCS, CCVS & CCCS - definitions & circuit models; Concepts of Linearity, Time-invariance & Passivity.	4-5
Unit II:	*Linear D-C Circuits:* Kirchhoff's laws, Series & Parallel combinations of resistances, Voltage & Current divisions, Analysis of resistive circuits using Loop & Node equations – with independent sources, and with both independent and controlled sources.	5-6
Unit III:	*Time-domain Analysis of LTI Circuits:* Natural & forced responses of basic RC & RL circuits, Natural & forced responses of Series & Parallel RLC circuits.	4-5
Unit IV:	*Sinusoidal Steady State Analysis of A-C Circuits:* Notions of phasors, impedance, admittance & transfer function; Frequency response vs transient response; Responses of RC, RL & RLC circuits – series & parallel Resonance; Simple passive Filters & their Bode plots; Loop & Node Analysis of a-c circuits with independent & controlled sources.	*6-7*
Unit V:	*Useful Circuit Analysis Techniques:* Superposition, Source transformations, Thevenin's equivalent, Norton's equivalent, Maximum Power transfer, Delta-wye conversions,	*6-7*
Unit VI:	*Basic Amplifiers:* Amplifier parameters & controlled source models; VCVS model of an Opamp; Amplifiers using ideal OPAMP; Frequency response of basic OPAMP-based amplifiers.	*6-7*

Unit VII:	Waveform Generators: Condition of harmonic oscillation; RC and LC oscillator circuits; Square wave generator using 555 Timer and Digital inverters (TTL/CMOS). *Additional Topics (if time permits may be included with Lab. Experiments)* *D-C Power Supply: Half-wave and Full-wave Rectifiers, Shunt Capacitor filter, Voltage Regulator, Regulated D-C Power Supply.* *Wave Shaping Circuits: Diode Clippers; Precision Clippers using Diode and Opamp; Diode Clamp; Peak Detector and Peak Hold circuits; Sample and Hold circuit.*	5-6
	Recommended Text book(s)	
	1. *Engineering Circuit Analysis – Hayt, Kemmerly & Durbin, Tata McGraw Hill,* 2. *Electronic Devices and Circuit Theory by Robert L. Boyalsted, Pearson Publication.*	
	Reference Text Books	
	1. Circuit theory and analysis by Robert L. Boyalsted, Pearson publication. *2. The Art of Electronics – Horowitz & Hill, Cambridge University Press.*	

ECE102: SEMICONDUCTOR DEVICES		
UNIT	**COURSE UNIT DESCRIPTION**	**NUMBER OF LECTURE HOURS**
UNIT I:	***Basic Semiconductor Properties and band theory***: Crystal Structure and Systems, Miller Indices and notation for directions and planes, Concept of holes, Energy bands, E-k diagrams, Band-structure, *Conductivity* effective mass	3
UNIT II:	***Equilibrium Carrier Statistics:*** Density of states (DoS), Fermi function, Equilibrium electron and hole concentrations	2
UNIT III:	***Recombination-Generation Processes:*** Recombination-generation statistics, Low-level injection	2
UNIT IV:	***Carrier Transport:*** Drift current, Diffusion current, Continuity Equations, Quasi-Fermi levels	3
UNIT V:	**Application of above-developed theory to devices**: - P-N junctions: **6 hours** - Metal Semiconductor devices: **1 hour** - MOS capacitors (MOSCAP): **3 hours** - Bipolar Junction Transistors (BJTs): **6 hours** - MOSFETs: **8 hours** - Power semiconductor devices like SCRs, Thyristors & Triacs, IGBTs and Power MOSFETs: **4 hours**	28
UNIT VI:	***Integrated Circuits:*** Brief introduction to how above semiconductor devices are fabricated in an integrated circuit (IC)	1
	RECOMMENDED TEXT BOOK(S)	
	1. *Solid State Electronic Devices*, Ben G. Streetman and Sanjay Banerjee; Pearson Prentice Hall Publishers	
	REFERENCE TEXT BOOKS	
	1. *Advanced Semiconductor Fundamentals, Volume VI of the Purdue Modular Series on Solid State Devices*, Robert F. Pierret; Pearson Prentice Hall Publishers **2.** *Physics of Semiconductor Devices*, S. M. Sze; John Wiley & Sons	

ECE103: DIGITAL ELECTRONICS		
UNIT	**COURSE UNIT DESCRIPTION**	**NUMBER OF LECTURE HOURS**
UNIT I:	**Digital Processing of Information-** Analog and Digital representations of information; Information processing steps – logic and arithmetic; Range of digital circuits and systems.	**3**
UNIT II:	**Number Systems and Arithmetic** - Positional number systems – Binary, Decimal, Octal, Hexadecimal; Signed number representations; Arithmetic operations.	**6**
UNIT III:	**Digital Logic** – Binary variables; Basic logic operations – AND, OR, NOT; Basic gates; Essentials of Boolean algebra; De Morgan's laws; Truth Table; Boolean functions; Transforming a logical problem statement into a Boolean expression.	**3**
UNIT IV:	**Combinational Circuit Design** – Realisation of Boolean functions using gates; Karnaugh map; Minimisation of Boolean functions; Multiplexer-based realisation of K-maps; Combinational circuit design using multiplexers and gates.	**7**
UNIT V:	**Sequential Circuit Design** – Latches and Flip-flops; Ripple counters; Sequence generator using flip-flops; State Table and State Diagram; Synchronous counters; Shift Registers; Ring and MLS counter, Introduction to Memories.	**11**
UNIT VI:	**Hardware Description Language** – VLSI digital design flow; Need for HDL; Language reference manuals for Verilog – syntax and semantics; Verification and synthesis of Verilog designs.	**9**
UNIT VII:	**Processor Architecture** - Processor as a programmable digital system; Basic constituents of a processor – Programmable ALU, Register array and Program sequencer; A simple single-bus architecture and its Instruction Set.	**6**
	RECOMMENDED TEXT BOOK(S)	
	1. M. Morris Mano and Ciletti M.D., "Digital Design", 4th Edition, Prentice-Hall 2006. **2.** T.L. Floyd, "Digital Fundamentals", 10th Edition, Pearson education, 2011.	
	REFERENCE TEXT BOOKS	
	i) R.P. Jain, "Modern Digital Electronics", 3rd Edition, Tata McGraw Hill, 2003. ii) M. Morris Mano, "Digital Logic and Computer Design", PHI, 2005. iii) Taub and Schilling, "Digital Integrated Electronics", McGraw Hill, International Edition. IV) A.P. Malvino and D.P. Leach, "Digital Principles and Applications", 6th Edition, Tata McGraw-Hill, 2008	

ECE201: ELECTRIC MACHINES AND POWER SYSTEMS
Transformers: Different types of transformers, Transformer Construction, Core and Shell type of transformers, Core materials and laminated core, Cooling systems, Equivalent circuit of a transformer, OC test, SC test, Voltage regulation and efficiency, Testing of transformers, Polarity test, three-phase transformer connections, Auto-transformer, Applications. **DC Machines:** Construction and working principle of DC motors and generators, commutation process, armature reaction, types of dc motors and their operating characteristics, starters, speed control of dc motors, losses and efficiency of dc motors, applications. **Three-phase Induction motors:** Construction, rotating magnetic field, principle of operation of three-phase Induction motors, equivalent circuit diagram, Torque-slip characteristics, no-load and blocked rotor tests, starting of induction motor, speed control of induction motors, losses and efficiency, applications.

Single-phase Induction motors: Construction, Main and starting windings, starting methods, split phase starting, capacitor split phase starting, torque-slip characteristics, applications.

Three-phase Synchronous machines and electric power generation: Construction**,** Types of synchronous machines, Concepts of three-phase circuits, open-circuit and short-circuit characteristics, synchronous reactance, voltage regulation of the alternators, active and reactive power flow, synchronization process, two reaction theory of salient pole type synchronous machines, power-angle characteristics, damper winding, types of power plants.

Modeling and analysis of transmission lines: Types of overhead lines, poles and towers, Transmission line voltage levels in our country, conductors, resistance, inductance and capacitance of transmission lines (without derivation), Short, Medium, and long transmission lines, T-and pi-models of medium and long transmission lines, Voltage regulation, efficiency, active and reactive power flow through a transmission line, Equations of long transmission line (without derivation), Ferranti effect, Surge impedance loading. Corona phenomenon.

Overhead Line Insulators: Types of insulators, Potential distribution over a string of suspension insulators, String efficiency, Methods of equalising the potential, grading rings, arcing horns.

Distribution System: Primary distribution and secondary distribution, overhead and underground distribution, radial, ring main, interconnected distributions systems, voltage drop calculations, tap changing transformers.

- **Text Books:**
  1. D. P. Kothari and I. J. Nagrath, *Electrical Machines*. McGraw- Hill Higher Education, 4th edition, 2010.
  2. S. J. Chapman, Electric Machinery Fundamentals. McGraw-Hill, Inc. 5th edition, 2012.
  3. P. S. Bhimbra, *Electrical Machinery*. Khanna publishers, 2012.
  4. C. L. Wadhwa, *Electrical Power Systems*. New Age Publication, 6th edition, 2014.
- **Reference Books:**
  1. Fitzgerald and Kingsley, *Electrical Machinery*. McGraw- Hill Higher Education, 7th edition, 2013.
  2. M. G. Say, *The Performance and Design of Alternating Current Machines*. CBS Publishers, 3rd Edition,
  3. T. Gonen, *Electric Power Transmission System Engineering: Analysis and Design*. CRC Press, Taylor and Francis Group, New York, 2009.
  4. W. D. Stevenson Jr. and J. J. Grainger, *Power System Analysis*. McGraw Hill, 2017.

ECE202: EMBEDDED SYSTEMS HARDWARE		
UNIT	**COURSE UNIT DESCRIPTION**	**NUMBER OF LECTURE HOURS**
UNIT I:	**Embedded system basics and microprocessors:** **Introduction to the embedded system**: i) components of embedded system, ii) characteristics of embedded system, iii) challenges in embedded system design, and iv) architecture of a general embedded systems **Microprocessor:** i) introduction, ii) generations of microprocessors, iii) classification of the microprocessor, iv) introduction to 8085 microprocessors, v) pinout and signals of 8085, vi) functional block diagram of 8085, vii) addressing modes and interrupts in 8085, and viii) instruction sets and programming in 8085.	**6**
UNIT II:	**8-bit microcontrollers:** **8051 microcontroller:** i) features and introduction of 8051, ii) block diagram and pinouts, iii) programming model, iv) Internal RAM	**10**

	organization, v) interrupts, vi) C programming of 8051, and vii) interfacing some important peripherals to 8051. **Arduino:** i) introduction to Arduino (development board and IDE), ii) programming to Arduino, and iii) interfacing some important peripherals to Arduino.	
UNIT III:	**32-bit microcontrollers:** i) overview, ii) functional block diagram, iii) Integrated Development Environment, iv) General purpose input-output (GPIO), v) Analog interface, vi) Timers, vii) Hardware Abstraction Layer (HAL).	**8**
UNIT IV:	**Communication Protocol:** i) overview of Serial Peripheral Interface Protocol (SPI protocol), ii) overview of Inter –IC (I2C) communication protocol, iii) overview of Universal Asynchronous Receiver/Transmitter (UART) protocol, iv) overview of USB communication technology, and v) overview of RFID communication technology.	**8**
UNIT V:	**Hands on experience on simple embedded systems:** i) ADC and DAC, ii) PID control, iii) sensors and actuators, iv) position and movement control, v) data communication interfaces, and vi) Internet of Things.	**8**
	RECOMMENDED TEXT BOOK(S)	
	1. Ramesh S. Gaonkar, "*Microprocessor - Architecture, Programming and Applications with the 8085*", 5th edition, Penram International Publishing Private Limited. **2.** Ayala, Kenneth J. "*The 8051 Microcontroller Architecture Programming and Applications",* West Publishing Company. **3.** Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin D. McKinlay, "*The 8051 Microcontroller and Embedded Systems Using Assembly and C",* 2nd edition. **4.** Simon Monk, "*Programming Arduino Getting Started with Sketches*", McGraw-Hill Education. **5.** Donald Norris, "*Programming with STM32 Getting Started with the Nucleo Board and C/C++*", McGraw-Hill Education.	
	REFERENCE TEXT BOOKS	
	1. KCS Murti, "*Design Principles for Embedded Systems*", Springer Verlag, Singapore, First Edition.	

ECE203: Signal and Systems
1. Classification and representation of signals and systems, Continuous time & Discrete time signals and systems, Impulse and Step response of a system, linear systems, linearity, time invariance, causality, signal properties -LTI systems, Convolution 2. Fourier series, Fourier transform and properties, relation between Fourier transform and Fourier series, Sampling and reconstruction, Group delay, Phase delay, DFT. 3. Laplace transforms- representation of signals using continuous time complex exponentials, relation of Laplace and Fourier transform, concept of ROC and transfer function- block diagram representation, Inverse Laplace transform, properties, analysis and characterization of LTI systems using Laplace transforms. 4. Z transforms- representation of signals using discrete time complex exponentials-properties, inverse Z transforms, ROC, Analysis and characterization of LTI systems using Z transforms, block diagram, transfer functions **5.** Introduction to random variable and random process, State space analysis, Introduction to Two port networks and parameters.
RECOMMENDED TEXT BOOK(S)
1. A.V. Oppenheim, A.S. Willsky & S.H. Nawab, "Signals & Systems", 2nd edition, PHI, 1997. 2. Lathi, B. P., "Principles of Linear Systems and Signals", 2nd Ed., Oxford University Press. 3. S. Haykin & B. Van Veen, "Signals and Systems", 2nd edition, John Wiley & sons, 2004. 4. Ziemer and Tranter, "Signals and Systems, 4th edition, Pearson LPE.

ECE204: Analog Circuits

1. **Review of BJT and MOSFET:** Review of physical properties and basic I-V equations of BJT and MOSFET; various biasing operating modes of BJT and MOSFET, Low-frequency incremental equivalent circuits
2. **Two-Port Networks and their parameters:** Hybrid Parameters of BJT.
3. **Transistor biasing schemes:** Resistive Biasing and Current Mirror Biasing
4. **Small-signal Analysis of Amplifiers:** Single-stage amplifiers-CE, CB and CC and their MOSFET counterparts.
5. **Multi-transistor Amplifiers:** Darlington pair, Difference amplifier, and Active load and Cascode amplifier.
6. **Frequency Response:** High-frequency model and Frequency Response of different types of amplifiers.
7. **Basic Operational AmplifierDesign:** Frequency Response of Op-Amp, gain margin, phase margin, compensation of gain margin and phase margin, Negative feedback and its impact on amplifier performance - gain and bandwidth, design of two-stage Opamp.
8. **A few applications of OpAmps** e.g. oscillators, filters.

RECOMMENDED BOOK(S)

- **Text Books**

1. Microelectronic Circuits: Theory And Applications: Fifth Edition, by Sedra, Adel S.; Smith, Kenneth C., Oxford University Press, 2007
2. Electronic Devices and Circuits, Sixth Edition by Theodore F Bogart, Pearson, 2011.

- **Reference Books**

1. Microelectronics: Circuit Analysis and Design (ISE), 4th Edition by Donal A Neamen, Mc-Graw Hill 2021.
2. Electronic Devices and Circuit Theory: 9th Edition by Robert Boyelstad, Pearson, 2007.
3. Operational Amplifiers with Linear Integrated Circuits, 4th Edition, by William D. Stanley, Pearson, 2004.

ECE205: Electromagnetic Engineering

1. Review of vector algebra and calculus, coordinate transformations, Scalar and Vector fields, Vector calculus, Divergence, the Divergence Theorem, Curl and Stokes theorem.
2. **Electrostatics:** Coulomb's Law and concept of Electric Field, Electric field due to charge distribution, Gauss's law, Electric potential, Electric field in materials, Conductors and Dielectrics, Material polarization, Boundary conditions, Resistance and capacitance, Method of Images, Poisson's and Laplace's equations.
3. **Magnetostatics**: Bio-Savart law, Ampere's Law and its applications, Maxwell's equation for static EM fields, Magnetic materials, Boundary conditions, Inductor and inductance, magnetization, magnetic energy.
4. **Maxwell's Equations:** Faraday's law, Inconsistency of Amperes law, Continuity equation, Displacement current, Maxwell's equations, Boundary conditions, different forms of Maxwell's equations.
5. **Transmission Line:** Transmission line parameters and equations, characteristic impedance, open and short circuited lines, standing wave and reflection losses. Impedance matching, Smith Chart, Simple and double stub matching.
6. **EM Wave Propagation**: Wave propagation in free space, Conductors and dielectrics, Polarization, Phasor notation, Phase velocity, Group velocity; Reflection at the surface of the conductive medium, Surface Impedance, Depth of penetration, Poynting theorem, Poynting Vectors and power loss in a plane conductor.

7. **Antenna and Radiation:** Scalar and vector potentials. Radiation from a current filament, half-wave dipole and small loop antennas. Antenna characteristics, radiation pattern, radiation intensity, directivity and power gain., Effective area and Friis equation.
8. **Electromagnetic Interference and Electromagnetic Compatibility:** Introduction to Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC).
9. **Bio-Electromagnetics**: Retinal optic fibers, Heart dipole field, Biological fields.

RECOMMENDED BOOK(S)

1. Engineering Electromagnetics - **William H. Hayt, Jr.**
2. Elements of Electromagnetics- **M. N. O. Sadiku,** Oxford University Press.
3. Field and wave electromagnetics - **D. K. Cheng,** pearson.
4. Electromagnetic Waves & Radiation Systems, **Jordon E C Balmain**.
5. Electromagnetic Field Theory & Transmission Lines, **G S N Raju**, Pearson
6. Electromagnetics with Applications, **Kraus & Fleisch**, TMH.

ECE206: Power Electronics and Machine Drives

1. Introduction to power electronic circuits, Examples of power electronic converters and range of controlled power.
2. Active mode versus switched mode operation, losses in switches, cooling requirements, heatsink specifications
3. Brief description of construction and working of power diodes, thyristors, power MOSFET and IGBT, their switching characteristics.
4. Different methods of triggering a thyristor, gate drive circuits for IGBT and MOSFET. Static and dynamic switching characteristics of power diode and thyristor, requirement of snubber circuits.
5. AC to DC conversion (uncontrolled type):- Uncontrolled rectifier using diodes for both single-phase and three-phase ac input, discussion on output filter and ac source current.
6. AC to DC controlled conversion using thyristors for both single-phase and three-phase ac supply. Half controlled and fully controlled rectifiers for resistive and inductive loads, Waveforms of supply and load side currents and voltages, expression for output voltage, Concept of distortion and displacement power factor, harmonic distortion factors /THD etc.
7. DC to DC conversion: Concept of buck and boost converter assuming ideal switches and diodes. Practical buck and boost converter using thyristors, MOSFETs and IGBTs. Advantage of higher frequency switching, switching losses, limitations due to switching speed, stray inductance etc.
8. Switched Mode Power Supply Circuits: fly-back and forward types, considerations on high frequency transformer design, practical SMPS circuits.
9. DC to AC conversion (Inversion): Inverters for DC to single phase AC conversion, DC to three phase AC conversion, PWM Inverter, PWM techniques, Sine wave PWM (SPWM) and selective harmonic elimination type PWM techniques.
10. AC to AC conversion: phase angle control using TRIACs
11. Introduction to Electric Drives: What is Electric Drive? Different components of Electric Drive, Different types of Electric Drives.
12. Dynamics of Electric Drives: Fundamentals of speed-torque relations, multi-quadrant operation in speed-torque plane, Nature and classification of load torques, Calculation of time and energy spent in transient operations, steady state stability of drives.
13. DC Motor Drives: Overview of different types of dc motors and their torque-speed characteristics, starting and braking methods of dc motors, conventional speed control methods, modern speed control methods using power electronic converters, time and energy loss calculations during starting and braking of separately excited dc motor.
14. Induction Motor Drives: Overview of 3-phase Induction motor torque-speed characteristics, squirrel-cage and slip-ring induction motor, different types of starting and braking of induction motor, time and energy loss calculations in transient operation of induction motor, Speed

control of 3-phase induction motor using conventional methods and using power electronic converters, V/f control and slip power recovery based control of induction motor speed and torque, torque-speed characteristics and speed control of single phase induction motor.

15. Brushless DC motor, Switched Reluctance Motor &Stepper Motor Drives: Brief mention of Construction, operation and control of these drives.

RECOMMENDED BOOK(S)

1. Power electronics: circuits, devices and applications, by m.h.rashid Pearson publishers, india
2. Power electronics: converters, applications and design by ned mohan, undeland and robbins, john wiley & sons .
3. Fundamentals of electrical drives by g.k.dubey, crc press.

ECE207: Principle of Communication Engineering

1. **Review of signals and systems:** Fourier Transform & its properties, Hilbert Transform, Complex envelope representation of band-pass signals and systems.
2. **Principles of Amplitude Modulation Systems:** Full AM, DSB-SC, SSB, VSB modulation and demodulation schemes.
3. **Angle Modulation and Multiplexing:** Representation of FM and PM signals, Generation of FM signals-direct FM, Indirect FM, Demodulation of FM signals-frequency discriminator method, Phase-locked loop (PLL) method. Frequency division multiplexing and Quadrature multiplexing.
4. **Pulse Modulation:** The sampling theorem, pulse-amplitude modulation, quantization, PCM-TDM.
5. **Principles of baseband Digital Data transmission:** Line Codes and their Power Spectra, Effects of Filtering of Digital Data---ISI, Pulse Shaping: Nyquist's Criterion for Zero ISI, Pulses Having the Zero ISI Property, Nyquist's Pulse-Shaping Criterion, Transmitter and Receiver Filters for Zero ISI.
6. **Digital Modulation Techniques:** Amplitude-shift keying, phase-shift keying, frequency-shift keying, M-ary modulation, signal constellations.
7. **Analog Communication (AM/FM Systems) in the presence of noise:** Review of white Gaussian noise: autocorrelation function and power spectral density, Noise in linear receivers using coherent detection, Noise in AM receivers using envelope detection, Noise in FM receivers, pre-emphasis and de-emphasis in FM.

RECOMMENDED BOOK(S)

1 Simon Haykin, "Communication Systems", 4th Edition, John Wiley & Sons, 2001.
2 Rodger E. Ziemer and William H. Tranter, "Principles of Communication-Systems, Modulation and Noise", 7th Edition, John Wiley & Sons, 2015.
3 S. Haykin and M. Moher, Introduction to Analog & Digital Communications, 2nd Edition, John Wiley & Sons, Inc., 2007.

ECE301: Control Systems

1. **Introduction and Mathematical Modeling of Physical Systems:** Classification of control systems: Open-loop and Closed-loop systems, Effect of feedback, Mathematical modeling of physical systems, Transfer Function, Block diagrams of control systems, Block diagram manipulations.
2. **Time-Domain Analysis:** Standard test signals for the time response of control systems, Time-response of 1st order and 2nd order systems, Transient and steady-state responses, Steady-state errors, Static error constants, Type-0, Type-1, and Type-2 systems, Effects of adding poles and zeros to transfer functions, Dominant poles.
3. **Stability of Linear Control Systems:** Bounded-Input Bounded-Output (BIBO) stability, Absolute and relative Stability, Routh-Hurwitz stability criterion.
4. **Root Locus Technique:** Defining root locus, properties and sketching of root locus for negative and positive feedback systems, Design via root locus; Improving steady-state and transient

response using cascade compensation, PI, PD, and PID controllers, Lag, lead, and lag-lead compensators.

5. **Frequency-Domain Analysis:** Correlation between time-domain and frequency-domain analysis, Polar plot and Bode plots, Introduction to Nyquist stability criterion, Nyquist plot, Gain margin and phase margin, Constant M and N circles; Nichols Chart, Design of feedback control systems using frequency response techniques.
6. **State-Variable Analysis:** Concept of state-space representation, converting a transfer function to state-space, converting state-space to transfer function, state-transition matrix and its properties, linearization, Laplace transform and time-domain solution of state equations, observability and controllability of linear Systems.
7. Introduction to digital control systems.

RECOMMENDED BOOK(S)

- **Textbooks:**

1. M. Gopal, *Control Systems: Principles and Design*. McGraw-Hill, 4th edition, 2012.
2. N. Nise, *Control Systems Engineering*. Wiley India, 7th edition, 2011.

- **Reference Books:**

1. B. C. Kuo and F. Golnaraghi, *Automatic Control Systems*. Wiley India, 4th edition, 2009.
2. K. Ogata, *Modern Control Engineering*. Prentice Hall India Learning Private Limited, 5th edition, 2015.

ECE303: Computer Organization and Design

1. **Internal operation of computers**: Layers of a computer system, operating systems, compiler/assembler/linker/loader, number systems/representations, binary arithmetic, memory types/management, limits imposed by VLSI manufacturing process such as limitations of Moore's Law, power and yield/cost
2. **RISC-V Instruction Set Architecture**: Assembly language, execution, function calls, branches
3. **Datapath design with single-cycle non-pipelined control:** Adding support for instructions one by one
4. **Pipelined datapath and control:** Performance and energy "Iron Laws" of CPU design, pipelined datapath and control, hazards
5. **Memory hierarchy and caches:** Memory hierarchies, cache hits, misses, write policies, replacement policies, multi-processor caches and coherency, virtual memory
6. **Interrupts and pipelined datapaths**
7. **Parallelism:** Amdahl's Law, data-level parallelism, vector instructions, loop-unrolling, thread-level parallelism, hardware threads versus software threads
8. **Miscellaneous:** Benchmarks, design process, architecture simulators for functionality and performance

RECOMMENDED BOOK(S)

1 **Computer Organization and Design RISC-V Edition: The Hardware Software Interface**, D. A. Patterson and J. L. Hennessy; Morgan Kaufmann Publishers

ECE304: Artificial Intelligence and Machine Learning

1. **Types of Learning:** Supervised, Unsupervised and Reinforcement; Regression and Classification Problems.
2. **Concepts:** Bias and Variance, Generalization, Overfitting, Training and Test Datasets, Cross-validation, Accuracy Measures for Regression and Classification, Imbalanced Datasets.
3. **Statistical Learning:** Naïve Bayes Classifier, k-NN Classifier, Linear Regression, Logistic Regression, Softmax function.
4. **Support Vector Machines:** Optimum Margin Classifier, Constrained Optimization, Lagrange Multipliers, Primal/Dual Problems, KKT Conditions, Kernels, Quadratic Programming.
5. **Neural Networks:** Multilayer Perceptron Networks, Backpropagation, Nonlinear Regression, Multiclass Discrimination, Training Procedures

6. **Decision Trees:** Concepts, C4.5 and CART Decision Trees
7. **Unsupervised Learning:** K-means Clustering, Gaussian Mixture Models
8. **Dimensionality Reduction:** Feature Selection, Principal Component Analysis, Linear Discriminant Analysis.

RECOMMENDED BOOK(S)

1. M. Gopal, "Applied Machine Learning", 2nd Edition McGraw-Hill, 2022.
2. E. Alpaydin, "Introduction to Machine Learning", 3rd Edition, The MIT Press, 2014.
3. T. Hastie, R. Tibshirani and J. Friedman, "The Elements of Statistical Learning: Data Mining, Inference and Prediction", 2nd Edition, Springer, 2009.

ECE351: VLSI Design

1. Introduction to VLSI, MOSFET basics, short channel MOS issues, CMOS basic flow, Design of digital and combinational blocks, emerging device technologies trends as per ITRS.
2. **CAD and Computer Tools Used**: Cadence Virtuoso
3. **Models for Digital Design (5)**: Miller Capacitance, the Digital MOSFET Model, and Effective Switching Resistance of Long Channel MOSFET, Short-Channel MOSFET Effective Switching Resistance, Capacitive Effects.
4. **CMOS Technology (6)**: Static CMOS inverter, DC Characteristics, Noise Margins, Inverter Switching Point, Ideal Inverter VTC. Dynamic Characteristics of CMOS inverter: Computing the capacitance-propagation delay sizing inverter for performance optimization. Combinational MOS logic circuits (Parallel Connection of MOSFETs, Series Connection of MOSFETs, NAND Gate, Quick Estimate of Delays, Number of Inputs, and Complex CMOS Logic Gates.
5. **Other Design Styles (5)**: MOSFET Pass Gate, Delay through a Pass Gate, Transmission Gate, Sizing in Pass transistor. Applications of the Transmission Gate as Path Selector and Static Circuits. Differential Cascode Voltage Switch Logic, Pseudo NMOS, and other logic design styles
6. **Delay Analysis (6)**: Delay analysis using Elmore Delay, Delay analysis using Logical and electrical effort. Designing the circuits for large capacitive loads. Analysis of Super buffer. Delay calculation in datapath.
7. **Designing logic for reduced supply voltages (3):** Introduction, Overview of Power Consumption, and Low-Power Design through Voltage Scaling, Estimation and Optimization of Switching Activity, Reduction of Switched Capacitance.
8. **Dynamic CMOS design (4)**: Fundamentals of Dynamic Logic, Charge Leakage, Dynamic Circuits, Domino logic, Optimization of Domino logic, and NORA logic.
9. **Design of sequential Circuit (4):** Bistability Principle, Timing metric, Edge Triggered Register Design, TSPC Design
10. **Memory Design (6):** Array Subsystem, Design of NAND ROM, NOR ROM, Decoders Design for ROM, Introduction to NVM. Design of Programmable Logic: Pseudo NMOS PLA, 6T SRAM Design, Read, Write and Hold operations of 6T-SRAM, SRAM peripheral Design, Introduction to DRAMs.

RECOMMENDED BOOK(S)

- **Text Books**

1. Principles of CMOS VLSI Design. A Systems Perspective, 3rd Edition, by Neil H. E. Weste, Karman Eshraghian, Addison-Wesley, 2004
2. CMOS Digital Integrated Circuits: Analysis and Design, S.-M. Kang and Y. Leblebici, 2nd Edition, McGraw-Hill, Inc., 1999

- **Reference Books**

1. Circuit design layout and simulation, R. Jacob Baker,3rd Edition, Wiley Publication,2010
2. Digital Integrated Circuits: A Design Perspective, Jan M. Rabaey, Prentice Hall, Inc., 1996

ECE352: Photovoltaic Power Generation

1. Introduction of Solar Cell: Renewable energy sources, Current status of PV power generation in India, Advantages and challenges of solar energy, Solar cell technology, P-N junction diode, Introduction to P-N junction in equilibrium and non-equilibrium conditions, P-N junction under illumination: solar cell, Generation of a photo voltage, Photo generated current, Current-voltage (I-V) equation of solar cell, I-V characteristics of solar cell.

2. Design of PV Cell, Module and Array: Short circuit current, Open circuit voltage, Fill factor, Efficiency, modelling of a PV cell, Effect of series and shunt resistances on efficiency, Effect of solar radiation and temperature on efficiency, modelling of a PV module and array
3. Solar Radiation: Extra-terrestrial solar radiation, Solar spectrum at the Earth's surface, Declination angle, Apparent motion of the sun and solar altitude, Angle of sunrays on solar collector, Sun tracking, Estimation of solar radiation empirically
4. Identification of Solar PV Module: PV parameters estimation of a single diode model (SDM) and double diode model (DDM) PV module, Conversion of PV module parameters to array parameters, Temperature and solar irradiation dependence PV parameters, Study of I-V and power-voltage (P-V) characteristics of a PV array under different environmental conditions using Matlab simulation
5. Maximum Power Point Tracking (MPPT) Methods of a PV Source: Fractional short-circuit current (FSCI) technique, Fractional open circuit voltage (FOCV) technique, Hill Climbing/ Perturb & Observed (PO), Incremental conductance, One cycle control (OCC) technique, Differention technique, Feedback voltage and current technique, Load current/Load voltage maximization technique, Fuzzy logic based MPPT technique, Artificial neural network based MPPT technique, Particle swarm optimization based MPPT technique, Gauss-Newton, Steepest-Decent, Levenberg-Marquardt
6. Partial Shading of a PV Array: Shading effect of a PV array, Mismatch loss, Different types of PV configuration to reduce mismatch loss, Effect of bypass diode in a PV array under shading conditions, Extraction of maximum power from a PV array under partial shading conditions
7. Power Electronics Application in PV System: DC to DC converters, Control of DC to DC converter, Input side reflected impedance of DC to DC converters, DC to AC converter (Inverter), Grid integrated PV system: Single phase grid connection, Three phase grid connection.
8. PV System with Storage: Cells and batteries, Lead acid cell, Nickel cadmium storage cell, Nickel metal hydride (NiMH) Cells, Lithium cells, Stand-alone PV system, Design of PV water pumping system
9. Impact of DG integration on power quality and reliability: Power quality distrubances: Transients, Voltage sags and swells, Over-voltages and under-voltages, Outage, Harmonic distortion, Voltage notching, Flicker, Electrical noise, Impact of DG integration: Simple standby generation scheme, Secondary DG system with power quality support, Primary DG system with power quality support to priority loads, Soft grid-connected DG with power quality support to priority loads, DG with intermittent solar PV within power quality environment

RECOMMENDED BOOK(S)

- **Text Books:**
  1. Chetan Singh Solanki, "Solar Photovoltaics: Fundamentals, Technologies and Applications", PHI learning publication, 2015.
  2. Remus Teodorescu, Pedro Rodriguez, Dezso Sera, Sergiu Spataru, Laszlo Mathe, Sergiu Spataru, "Grid Connected Photovoltaic Power Systems", John Wiley & Sons Inc, 2019
  3. S. Chowdhury, S.P. Chowdhury and P. Crossley, "Microgrids and Active Distribution Networks", IET, First Edition, 2009.
- **Reference Books**
  1. A. K. Mukerjee and Nivedita Thakur, "Photovoltaic Systems: Analysis and Design", PHI learning publication, 2011.
  2. Garg & Prakash and H. P. Garg, "Solar Energy Fundamentals and Applications", Tata McGraw-Hill Education, 2017.
  3. Ali Keyhani, "Design of Smart Power Grid Renewable Energy Systems", Wiley- IEEE Press, 2011.
  4. Mukund R. Patel, "Wind and Solar Power Systems: Design, Analysis, and Operation", Taylor & Francis, 2006.

ECE355: Scientific Computing using MATLAB

1. **Fundamental Concepts:** Variables and constants, basic statement structure, input/output, algebraic operations, logic operations, loop control, conditional control, switch, graphical output 2D and 3D.
2. **Matrices and Eigenvalues:** Basic operation and properties of matrices, matrix inversion, generalized matrix inversion, matrix transformation, solving matrix equations, eigenvalues and vector, transformation and diagonalization, power method, Jacobi method,

3. **Linear and Non-**linear equations: Gauss and Gauss-Jordan eliminations, Matrix factorization, iterative method, bisection method, Newton-Raphson method, Secant method.
4. **Calculus Problems:** Solution to limit problems, solution to derivative problems, partial derivatives, partial derivatives of implicit functions, derivative of parametric equations, gradient, divergence and curl, solution to indefinite, definite and improper integral problems, multiple integrals, Taylor and Fourier series expansion, path and line integrals, scalar and vector surface integrals, numerical differentiation, numerical integration.
5. **Differential equations:** Numerical solution of ordinary differential equations, solution of special ordinary differential equations, solution of boundary value problems, Partial differential equation (PDE), Elliptical PDE, Parabolic PDE, Hyperbolic PDE.
6. **Transforms and Complex valued functions:** Laplace transform and their inverse, Fourier transform and their inverse, z transform and their inverse, complex matrices, computation of poles and residues, solution of difference equations.
7. **Data Interpolation:** Interpolation and data fitting of 1D, 2D and higher order, spline interpolation, fitting mathematical models, signal analysis and digital signal processing.
8. **Probability and Statistics:** Probability density function (PDF) and cumulative distribution function (CDF), probability computation of continuous functions, Monte-Carlo solution, random walk problems, mean and variance of stochastic processes, moments of stochastic processes, covariance of multivariate stochastic processes, joint PDFs and CDFs, statistical estimation.

RECOMMENDED BOOK(S)

1. Otto, Stephen Robert, and James P. Denier, "An introduction to programming and numerical methods in MATLAB", Springer, 2005.
2. Bashier, Eihab BM., "Practical Numerical and Scientific Computing with MATLAB and Python", CRC Press, 2020.
3. Yang, Won Y., Wenwu Cao, Jaekwon Kim, Kyung W. Park, Ho-Hyun Park, Jingon Joung, Jong-Suk Ro, Han L. Lee, Cheol-Ho Hong, and Taeho Im, "Applied numerical methods using MATLAB", John Wiley & Sons, 2020.
4. Palm, William John, "Introduction to MATLAB for Engineers", McGraw-Hill, 2011.

ECE356: RF and Microwave Circuit Design

1. **Introduction:** Frequency spectrum, frequency behaviour of passive components & chip components.
2. **Transmission Line:** Transmission lines, electrical equivalent circuit analysis, sending port impedance, input impedance, voltage standing wave, transmission line matching, smith chart, impedance and admittance transformations, impedance matching networks.
3. **Two-port Networks:** Series and parallel networks, Z-parameter, Y-parameter and h-parameter, S-parameters, X-parameter, ABCD parameters, conversion of different network parameters.
4. **RF Filter Design:** Basics of filter configurations, Butterworth and Chebyshev type filters, Filter design by the Image Parameter method and Insertion Loss method, Implementation of microwave filters.
5. **RF Transistor Amplifier Design:** Amplifier characteristics, Amplifier parameters, stability criteria, Amplifier design for maximum gain, constant gain, noise figure and VSWR circles, Introduction to Doherty amplifier.
6. **RF Oscillators:** Basic oscillator model, negative resistance and feedback oscillator designs, quartz oscillators, electronic tuning of oscillator, phase locked loop.
7. **RF Mixers:** Basic characteristics of mixers, single ended mixers, single balanced

RECOMMENDED BOOK(S)

- **Text Books**

1 Ludwig, R. and Bretchko, P., "RF Circuit Design", Pearson Education, 2000.
2 Misra, D.K., "Radio-frequency and Microwave Communication Circuits", John Wiley & Sons, 2001.

- **Reference Books**

1. Fooks, E.H. and Zakarevicius, R.A., "Microwave Engineering Using Microstrip Circuits," Prentice-Hall, 1990
2. Franco di Paolo, "Networks and Devices using Planar Transmission Lines," CRC Press, 2000.

3. Pozar, D.M., "Microwave Engineering", 3rd Ed., John Wiley & Sons, 2004.
4. Roberto Sorrentino and Giovanni Bianchi, "Microwave and RF Engineering" John Wiley & Sons, 2010.
5. B.Bhat and S.K.Koul, Stripline Like Transmission Lines For Microwave Integrated Circuits New Age Intl. Pvt Ltd., 2007.

ECE360: IoT - Architecture, Communication Technology, and Applications

1. **Introduction**: Introduction of IoT, Architectural Overview, Design principles and needed capabilities, IoT applications, Sensing, Actuation, Basics of networking, Wireless sensor networks, M2M and IoT technology, Fundamentals - Devices gateways, Data management, Business processes in IoT, Role of Cloud in IoT, Security aspects in IoT.
2. **Elements of IoT**:-->
3. **Hardware components**- Computing (Arduino/Raspberry Pi), Communication, Sensing, Actuation, I/O interfaces.
4. **Communication Protocols** ZigBee, Bluetooth, Wi-Fi-IEEE802.11a,n,ac,ax,ah,af,p, LPWAN-LoRa, Sigfox, NB-IoT, LTE-M
5. **Software Components**- Programming API's (using Python/Node.js/Arduino) for communication protocols- MQTT, COAP, UDP, TCP
6. **IoT Application Development**: Solution framework for IoT applications:-> Implementation of device integration, Data acquisition and integration, Device data storage- Unstructured data storage on cloud/local server, Authentication, authorization of devices
7. **Cloud, edge, and fog computing** architectures for IoT applications. The OpenFog reference architecture. Case studies from various domains (details TBD).
8. **IoT Case Studies**: IoT case studies and mini projects based on Industrial automation, Transportation, Agriculture, Healthcare, Smart Home, Smart building, Smart City

ECE361: Power System Analysis

1. Per unit system representation. Primitive network, single phase and of three phase.
2. Formation of network A and B matrices and Ybus and Zbus . Building algorithm for the formation of Zbus with coupling.
3. Power system load flow studies, necessity, data requirements, network flow equations both in Polar and rectangular co-ordinates, line flow and line losses; types of busses for load flow; numerical methods of load flow solution- Gauss, Gauss Seidel, Newton Raphson methods in polar and rectangular co-ordinates without and with PV buses; Decoupled , fast decoupled and DC load flows. Their comparisons.
4. Short-circuit analysis of power system; introduction to symmetrical component transformation and obtaining sequence components Generator, Transformer and transmission line impedances; sequence impedance diagrams of network and flow of currents in transformers. Computer methods for the solution of balance and unbalance faults in three phase networks.
5. Power System stability, definition, elementary ideas of steady state, dynamic stability. Surge impedance loading and problems of long transmission lines, series and shunt compensation.
6. Power System transient stability, determination of swing curve, Transient stability using equal area criteria, its limitations, calculation of swing curve by point by point method for single and multi- machine case . Methods to improve transient stability.

RECOMMENDED BOOK(S)

1. D.P. Kothari, I. j. Nagrath, " Power System Engineering", 2nd Edition, Sixteen reprint, 2013 McGraw Hill Education
2. T.N. Nagsarkar , M.S. Sukhija, "Power System Analysis"7th Impression,2012,Oxford Publication
3. M.A. Pai, Dheeman Chatterjee, Third Edition , 5th Reprint, 2017, Mc Graw Hill Education.

ECE362: Digital Communication

1. **Communications Signal and Systems:** Introduction to Digital Communication, Representations of Bandpass Signals and Systems, Inner Product Spaces and Subspaces, Orthonormal bases, Gram Schmidt orthogonalization procedure, Geometric representation of Signals, Signal Space Representation of M-ary Signal Sets.

2. **Review of Random processes and random variables:** Random variables, Some useful probability distributions: Uniform, Exponential, Gaussian, Rayleigh, Transformation of Random variables, expectation, variance. White Gaussian noise process: autocorrelation function and power spectral density, LTI filtering.
3. **Baseband and Passband Digital Data communication:** Baseband digital data transmission in white Gaussian noise: Matched filter and correlation. Passband digital data transmission in noise: Transmission and reception (correlation-based) model. Hierarchy of digital modulation techniques and their constellations: BPSK, QPSK, M-ary QAM, M-ary PSK, Minimum Shift Keying (MSK), Frequency Shift Keying (FSK). Coherent detection of signals: Probability of error and performance comparison. Non-coherent reception and their performance. Intersymbol interference (ISI) and Equalization.
4. **Carrier and Symbol Synchronization:** Importance in signal demodulation, carrier frequency and phase estimation– decision directed and power of N methods, symbol timing estimation– spectral-line, MMSE, and ML methods. Joint carrier and symbol synchronization.
5. **Fundamental Limits of Communication systems:** Channel capacity, Coding and Decoding, Source Coding, Information Measure, Introduction to Error control: Linear Block codes, Convolution Codes, Hamming, and Turbo codes.
6. **Advanced Communication Techniques:** Multichannel communications, Spread spectrum communications, OFDM.

RECOMMENDED BOOK(S)

- Text Books

1 John G Proakis and Salehi, Digital Communication, 5th Edition, McGraw-Hill, 2008.
2 Simon Haykin, "Communication Systems", 4th Edition, John Wiley & Sons, 2001.
3 Rodger E. Ziemer and William H. Tranter, "Principles of Communication-Systems, Modulation and Noise", 7th Edition, John Wiley & Sons, 2015.
4 B. P. Lathi, "Modern Digital and Analog Communication Systems", 3rd Edition, Oxford University Press, 1998.

- **Reference Books**

1. John M. Wozencraft and Irwin Mark Jacobs, "Principles of Communication Engineering," Wiley, 1965.
2. John R. Barry, Edward A. Lee, David G. Messerschmitt, Digital Communications, Springer, 3rd Edition, 2004.

ECE363: Computer Communication Networks

1. **Introduction** to communication and networks.
2. **Transmission Medium**: Copper cable, Shielded twisted pair(STP), UTP, Coaxial cable, Optical fibre cable.
3. Data Communication. Serial/parallel comm. Asynchronous/Synchronous Communication, SDLC, HDLC
4. **OSI layers**
5. **Data Link layer**: Multiple Access Control: ALOHA, Polling, CSMA/CD, Token passing.
6. **LAN**: **Ethernet**: Standard, Fast, Gigabit, Terabit Ethernet, IEEE802.3.x **Wireless LAN**: CSMA/CA, IEEE802.11a, b, g, n, ad, ay, Advance Wi-Fi6, 6E, 7
7. **Switching**: Circuit switching, Packet switching, Message switching, Cell switching, Permanent virtual circuit switching, Virtual circuit switching.
8. **Interconnected Devices**: Repeater, Hub, Bridge, Router, and Gateway.
9. **WAN**: X.25, Frame relay, ATM. Broadband Access Technology: ISDN, xDSL
10. **Internet Protocol**: IPv4, IPv6
11. **Transport Protocol**: TCP/IP, UDP
12. Wireless Personal Area Network (WPAN): Bluetooth, ZigBee,
13. Midrange wireless Local Area network: IEEE802.11ah HaLow, IEEE802.11af White-Fi.

RECOMMENDED BOOK(S)

1. Introduction to Data Communication and Networking, W. Tomasi, 5th Edition, 2012, Pearson Publication.
2. Data Communication and Networking, B.A Forouzan, 5th Ed., 2017, Pub. McGrawHill.
3. Wireless Communication and Networks, Willium Stallings, 2006, Pub. PHI.

ECE364: Wireless and Mobile Communication

1. **Introduction**: Evolution of mobile radio communication.
2. **Cellular Concept and Engineering**: Cellular concept, frequency reuse, channel assignment strategies, handoff strategies, channel capacity, cell splitting, cell sectoring.
3. **Mobile radio propagation**: Path loss, multipath propagation – Reflection, scattering, diffraction, fading, Doppler spread.
4. **Multiple Access Techniques:** FDMA, TDMA, CDMA, OFDMA,
5. **Spread spectrum** – FHSS, DSSS, PN codes, Walsh codes.
6. **Digital Modulation**: ASK, FSK, PSK, QPSK, M-ary Modulation – MASK, MFSK, GMSK, QPSK, n-QAM.
7. **Voice/audio/image/video Compression:** Waveform Coding, Source Coding
8. **Mobile phone system and Network Architecture**:
9. **1G** –AMPS architecture, signal processing, services, handoff,
10. **2G** – GSM, D-AMPS, CDMA, GSM service and features, GSM system architecture, GSM radio subsystem- frame structure, signal processing, SMS, D-AMPS architecture, frame structure, IS-95 CDMA network architecture, services and features, Power control, Near-far problem, soft handoff.
11. **3G**: UMTS network, architecture, services and features, WCDMA, CDMA2000, TD-CDMA, TD-SCDMA, 3.5G-HSPA, 3.9G-HSPA+
12. **4G**: LTE, OFDMA, PAPR, SC-FDMA, VoLTE, LTE-A, MIMO, SU-MIMO, MU-MIMO, Software Defined Radio (SDR), Cognitive Radio.
13. **Beam** forming, and Beam tracking at mm Wave and sub-mm Wave frequency band. Massive MIMO
14. **5G**: Enhanced mobile broadband (eMBB) for wideband, Massive machine type communication (mMTC) for IoT, Ultra reliable low latency com (uRLLC) for remote surgery and V2X communication, Low Power Wide Area Network (LPWAN)**:** LTE-M, NB-IoT. Open-RAN: RRH, BBU, RU, DU, CU
15. **5G and Beyond (6G):** Augmented Reality, Virtual Reality, Holography, Non-Terrestrial Communication through Leo satellite

RECOMMENDED BOOK(S)

1. J. Schiller, Mobile communications, 2nd Ed., Pearson, 2009
2. T.L. Singal, Wireless Communication, Mc GrawHill, 2016
3. B.A. Forozoun, Data Communication &Networking, McGraw Hill, 2013
4. W. Stallings, Wireless communications and Networks, Prentice-Hall,

ECE365: Object Oriented Programming

For the C++ variant:

1. **Object oriented analysis and design:** Encapsulation, inheritance, polymorphism, operator overloading
2. **Preprocessor**: Namespaces, macros, conditional compilation, name mangling and interoperability with C
3. **Functions and variables**: Data types, local versus global variables, pointers and references, non-member functions, passing arguments by value versus reference, function overloading, default arguments, inline functions
4. **Structures**: Structures, pointers to structures, poor man's encapsulation using opaque structures
5. **Classes**: Encapsulation, member functions, constructors and destructors, initializers, default constructor, static class members, nested classes, local classes
6. **Inheritance**: **Is-A** relation between base and derived classes, access control and public/protected/private inheritance, multiple inheritance
7. **Streams**: File/display/keyboard input/output
8. **Operator overloading**: Syntactic sugar versus real use
9. **Error handling**: Throwing, catching and propagating exceptions
10. **Templates and Generic programming**: Templates, template parameters
11. **The Standard Template Library (STL)**: Vectors, sets, maps, etc
12. **Program structure**: Introduction to the programming environment, header files, source files, compilation
13. **Debugging**: Breakpoints, stepping through, watch variables, trace variables, stack trace
14. **Miscellaneous**: Choosing a suitable development environment, coding standards, etc

For the Python variant:

1. **Getting started**
2. **Object types:** Python's core data types like numbers, strings, lists, tuple, dictionary
3. **Statements and Syntax:** Statements; assignments, expressions, and print; conditional statements; loops; iterations and comprehensions; the documentation interlude
4. **Functions and Generators:** Basic functions, scopes, arguments, advanced function topics, comprehensions & Generations, the benchmarking interlude
5. **Modules and Packages:** The big picture, module coding basics, module packages, advanced module topics
6. **Classes and OOP:** The big picture, class coding basics, class coding details, operator overloading, designing with classes, advanced class topics

RECOMMENDED BOOK(S)

1. ***C++ Primer***, Stanley Lippman, Josée Lajoie and Barbara Moo; Addison-Wesley, 5th edition
2. Online: https://www.cplusplus.com/

ECE366: Antenna Theory and Wave Propagation

1. **Fundamental Concepts:** Concept of Radiation (physical meaning), Potential functions & Electromagnetic field, Network Theorems, Radiation Pattern, near-field and far-field regions, basic parameters of antenna (directivity, gain, effective aperture, polarization, input impedance, and efficiency), Friis transmission equation, Methods of Excitation.
2. **Radiation from Wires, Loops, Aperture and Microstrip Antennas:** Infinitesimal dipole, finite-length dipole, dipoles for mobile communication, small circular loop. Huygens' principle, radiation from rectangular and circular apertures, design considerations, Babinet's principle, Radiation from sectoral and pyramidal horns, design concepts, Basic characteristics of microstrip antennas, feeding methods, methods of analysis, design of rectangular and circular patch antennas.
3. **Antenna Arrays:** N element linear array, Broadside and End fire array, pattern multiplication, Phased array, Adaptive array, Antenna synthesis- Binomial array.
4. **Special Antennas:** Log-periodic antennas, Spiral Antennas, Helical Antennas, Modern Antenna: Reconfigurable Antenna, Dielectric Resonator Antennas, Active Antennas, Electronic band Gap Structure, Terahertz Antennas.
5. **Radio Wave Propagation:** Modes of propagation, Structure of atmosphere, ground wave propagation, Tropospheric wave propagation, Duct propagation, Tropo-scatter propagation, Flat and curved earth concepts, Sky wave propagation, Virtual height, Critical frequency, Maximum usable frequency, Skip distance, Fading, Multi-hop propagation.

RECOMMENDED BOOK(S)

- **Text Books**

  1. Constantine A Balanis, "Antenna theory: Analysis and Design" John wiley & sons, 2015.
  2. Raju, G. S. N. "Antennas and wave propagation", Pearson Education India, 2006.

- **Reference Books**

  1. Kraus, John D., Ronald J. Marhefka, and Ahmad S. Khan. "Antennas and wave propagation", Tata McGraw-Hill Education, 2006.
  2. Edward C Jordan and Keith G Balmain, "Electromagnetic waves and radiating systems" Pearson Education; Second edition, 2015.

ECE367: Digital System Design with FPGAs

Familiarisation with Xilinx Vivado Suite: i) Installation guide and settings for Xilinx Vivado Suite, ii) Description of various tool boxes available with Xilinx Vivado Suite.

Verilog Concepts: i) Review of various design styles in Verilog, ii) Combinational and sequential logic iii) Finite state machine

FPGA Architecture: i) Introduction to various programmable links: PLA, PAL, SPLD, CPLD, FPGA ii) Various FPGA Technologies iii) Generic architecture of FPGA iv) Familiarization of Nexus-4 FPGA board

Introduction to Static Timing Analysis:

i) STA Basics: What is STA, Purpose of STA, How does STA fit into the Design Flow, What are Timing Libraries, Elements of Static Timing, Introduction to Timing Arcs, Timing Arc Characteristic (Unateness, Slew & Delay).
ii) Understanding Cell and Net Delays: Terminology for Cell and Net Delay, Different kind of Cell Delay, Cell Library Model, and Wire Load Model.
iii) Understanding Clocks: Ideal Clock, Duty Cycle, Clock Skew, Clock Propagation, Clock uncertainty, Latency, and Understanding of Launch and Capture Clock.
iv) Timing Paths & Timing Checks: Understanding Timing Paths: Start point, End Point, Timing Paths Types, Slack, Setup and Hold Time, Setup and Hold Violation, Recovery and Removal, Min Clock period, Path Exceptions: Multi-Cycle paths and false paths.
v) Xilinx Design Constraints (XDC): Design Constraints, Syntax, and Design Objects: Chip, Cell, Block, Pin, Port, Clock, Environmental Constraints, Design Rules, Timing Constraints, Exceptions.

Power Report and IP integration

Design Applications: i) General Design Issues, and ii) Implementation of Memory and FIFO iii) Design for Wireless Communication Systems.

RECOMMENDED BOOK(S)

1. Wayne and Wolf, "FPGA based system Design", 11th edition, Pearson Publishing Private Limited.
2. Samir Palnitkar, "Verilog HDL A guide to Digital Design and Synthesis", SunSoft Press.
3. Clive Maxfield, "The Design Warrior's Guide to FPGA", Elsevier Publishing.
4. Andrew Moore and Ron Wilson, "FPGA for dummies", 2nd special edition by INTEL, Wiley Publishing.

ECE451: Design of Analog CMOS Circuits

1. **CMOS Fundamentals:** MOSFET physics, concept of threshold voltage, body-effect, DC models, small-signal models, MOSFET frequency response
2. **Single-transistor non-differential stages**: Common-source stage (with and without source degeneration), common-drain stage, common-gate stage
3. **Multi-transistor non-differential stages**: Cascode stage, active cascode, super source follower
4. **Differential pairs**: Basic differential pair, DC analysis, small signal analysis, common-mode and differential mode analysis, key metrics like CMRR/PSRR/Z_{in}/Z_{out},/V_{OS}, effect of mismatch on key metrics
5. **Current mirrors**: Simple current mirror, cascode current mirror, high-swing cascode current mirrors, Wilson current mirror
6. **Active loads**: Complementary load, depletion load, diode-connected load, usage in a differential-pair
7. **Current sources**: Widlar current source, Peaking current source, threshold-voltage-referenced current source, concept of sensitivity, supply-sensitivity of current sources, self-biasing and start-up circuits
8. **Bandgap voltage references**: Motivation, temperature sensitivity, general principle, MOS implementation
9. **Case study of a 2-stage single-ended MOS Operational Amplifier**: Schematic, discussion of metrics like input offset voltage, input bias current, input offset current, common-mode input range, CMRR, PSRR, frequency response and slew rate, and the desired design space parameters
10. **Feedback:** Benefits of feedback, canonical treatment of feedback, various feedback styles and their effect on key metrics, modelling the loading by feedback networks
11. **Frequency response theory**: Poles and zeros, Miller effect and its application to a common-source stage, OCTC and SCTC methods for calculating the dominant and most non-dominant pole, application of the OCTC method to a 2-transistor circuit
12. **Frequency response of feedback amplifiers, stability and compensation:** Bode plots, Nyquist criterion for stability, Phase margin, frequency compensation by narrowbanding, adding a pole versus moving a pole, pole-splitting and Miller multiplication, slew rate

RECOMMENDED BOOK(S)

1 **Analysis and Design of Analog Integrated Circuits**, Paul R. Gray, Paul J. Hurst, Stephen H. Lewis and Robert G. Meyer; John Wiley & Sons, 5th edition
2 **Design of Analog CMOS Integrated Circuits**, Behzad Razavi; McGraw Hill Education, 2nd edition

ECE452: Power System Operation and Control

1. **Economic Operation of Power System:** Fundamental of power flow solutions, Power factor correction, Distribution of load between units within a plant, Distribution of load between plants, The transmission-loss equation, An interpretation of transformation C, Classical economic dispatch with losses, Automatic generation control, Unit commitment, Solving the unit commitment problems.
2. **Load Frequency Control and Control Area Concept:** Automatic load-frequency control of single area systems: Speed-governing system, Hydraulic valve actuator, Turbine-generator response, Static performance of speed governor, Closing the ALFC loop, Concept of control area, ALFC of multi-control area systems (Pool operation): The two area systems, Modelling the Tie-Line, Block diagram representation of two area system, Dynamic response of two area system, Supervisory control and data acquisition (SCADA).
3. **Power System Stability Problems:** Basic concepts and definitions, Rotor angle stability, Synchronous machine characteristics, Power versus angle relationship, Stability phenomena, Voltage stability and voltage collapse, Mid-term and long-term stability, Classification of stability.
4. **Small Signal Stability:** State space concepts, Basic linearization technique, Participation factors, Eigen properties of state matrix, Small signal stability of a single machine infinite bus system, Studies of parametric effect: Effect of loading, Effect of KA, Effect of type of load, Stability improvement by power system stabilizers. Design of power system stabilizers.
5. **Transient Stability:** Time domain simulations and direct stability analysis techniques (extended equal area criterion) Energy function methods: Physical and mathematical aspects of the problem, Lyapunov's method, Modelling issues, Energy function formulation, Potential Energy Boundary Surface (PEBS): Energy function of a single machine infinite bus system, equal area criterion and the energy function, Multi-machine PEBS.
6. **Sub Synchronous Oscillations:** Turbine generator torsional characteristics, Shaft system model, Torsional natural frequencies and mode shapes, Torsional interaction with power system controls: interaction with generator excitation controls, interaction with speed governors, interaction with nearby DC converters, Sub Synchronous Resonance (SSR): Characteristics of series capacitor - compensated transmission systems, Self – excitation due to induction generator effect, Torsional interaction resulting in SSR, Analytical methods, Counter measures to SSR problems.

RECOMMENDED BOOK(S)

1. John. J. Grainger & W. D. Stevenson, "Power System Analysis", Mc Graw Hill Education, Fifteenth Reprint, 2003.
2. O. I. Elgerd, "An Introduction to Electric Energy System Theory",Mc Graw Hill Education, Second Edition, 2013.
3. Prabha Kundur, "Power System Stability and Control", Mc Graw Hill Education, Edition, Twentieth Reprient, 2016.

ECE3453: Foundations of Deep Learning

1. Review of Machine Learning Concepts required for the Course.
2. What is Deep Learning? Major architectures of deep neural networks. Applications in Computer Vision, Speech, and Natural Language Processing.
3. Training of Deep Learning Networks.
4. Convolutional Neural Networks (CNN) architecture and design, Backpropagation in convolutional layer, Transfer Learning, Building a CNN Model for CIFAR-10 Data.
5. Autoencoders, Convolutional Autoencoder (CAE) architecture and design. Unsupervised learning using CAE.
6. Sequence Analysis using Recurrent Neural Networks (RNN), LSTM based Recurrent Networks. Challenges in training Recurrent Networks and the Solutions, Back-Propagation Through Time (BPTT).
7. Word Embedding Models for Vector-space Representation of Words: Word2Vec Models. Sequence Analysis to examine Speech and Language. Building a Recurrent LSTM Model for Sentiment Analysis using Twitter Dataset.
8. Understanding the Fundamentals of Deep Reinforcement Learning.

RECOMMENDED BOOK(S)

1. M. Gopal, "Deep Learning: Core Concepts, Methods and Applications", McGraw-Hill, 2022.

2. I. Goodfellow, Y. Bengio and A. Courville, "Deep Learning", The MIT Press, 2016.
3. R. S. Sutton and A. G. Barto, "Reinforcement Learning: An Introduction", 2nd Edition, The MIT Press, 2018.

ECE3454: Optical Fiber Communication

Module 1: Optical Fibers

Overview optical communication, other forms of communication systems, Basic elements of optical fiber links, Introduction to vector nature of light, Propagation of light, Ray model and wave model. Optical fiber: Types, Structure and wave guiding fundamentals, Optical fiber modes and analysis, Step and Graded Index Fibers.

Module 2: Losses in Optical Fibers

Signal degradation in Optical fiber due to dispersion and attenuation.

Module 3: Optical sources and detectors

Optical Sources: Basic light emission mechanism in semiconductors, LED and LASERs, Optical Detectors: Basic light absorption concepts in semiconductors, photodiodes, *p-i-n* detectors, detector responsivity, noise, Optical Receivers.

Module 4:

Optical Power Launching and Coupling: Lensing Scheme for coupling improvement, Fiber-to-Fiber Joints, Splicing Techniques, Optical fiber connectors. Design Considerations of Optical fiber Systems: Noise in detection process. Bit error rate. Optical receiver operation. Power Budget and Rise time Budget. WDM.

Module 5: Advanced topics in Optical Communication

Basics of Optical amplifiers, Optical amplifiers and soliton-based Communication, nonlinear effects in optical fiber links.

RECOMMENDED BOOK(S)

- **Textbooks**

1. G. Keiser, Optical Fiber Communications, TMH.
2. Ghatak & K. Thygarajan, Introduction to Fiber Optics, Cambridge.

- **Reference Books**

1. J. Gowar, Optical Communication Systems, PHI.
2. J.M. Senior, Optical Fibre Communications: Principles & Practice, PHI

ECE3456: High Voltage Engineering

1. Electric breakdown phenomenon in gases, liquid, and solid insulation materials, generation of high A.C. and D.C. voltages, generation of impulse voltages and currents, measurement of high voltages and currents, high voltage testing of electrical apparatuses, transients in power systems (lightning and switching induced transients), insulation coordination.
2. Numerical computation of the electric field intensity in homogenous and multi-dielectric isotropic materials by using finite element method (FEM).
3. Extra-high voltage (EHV) and ultra-high voltage (UHV) transmission systems, mitigation of audible noise, radio interference, corona loss, and high voltage gradients.

RECOMMENDED BOOK(S)

1. E. Kuffel, W. S. Zaengl, and J. Kuffel, *High Voltage Engineering Fundamentals*. Butterworth-Heinemann, Oxford, 2000.
2. M. S. Naidu and V. Kamaraju, *High Voltage Engineering*. TMH Publications, 2000.
3. R. K. Begumudre, *Extra High Voltage AC Transmission Engineering*. New Age Science Ltd., 2011.
4. C. L. Wadhwa, *High Voltage Engineering*. New Age International Publishers, New Delhi, Second Edition, 2007

ECE3459: Computational Electromagnetics

1. **Fundamental Concepts:** Review of EM theory, Electrostatic Fields, Magnetostatic Fields, Time varying Fields, Boundary conditions, Wave Equations, Vector Potentials, Network Theorems, Classical Differential Equations, Classical Boundary Conditions

2. **Analytical Methods:** Separation of Variables, Separation of variables in rectangular coordinate and related examples, Separation of variables in cylindrical coordinate and related examples, Separation of variables in spherical coordinate and related examples,
3. **Finite Difference Method**: Basics of Finite Difference Method, Finite-Difference-Time-Domain Method, Stability and Accuracy, Practical application examples, Absorbing boundary Conditions,
4. **Finite Element Method:** Introduction, Solution of Laplace's Equation, Solution of Poisson's Equation

RECOMMENDED BOOK(S)

1. Computation Electromagnetics with MATLAB by Matthew N. O. Sadiku, fourth edition, CRC press
2. The Finite Difference Time Domain Method for Electromagnetics by Karl S Kunz, CRC Press.
3. Theory and Computation of Electromagnetic fields by Jian-Ming Jin, John Wiley & Sons

ECE3461: HVDC Transmission

1. **Introduction to Line Commutated HVDC**: HVDC applications, Comparison of AC and DC Transmission, Line-commutated HVDC components, LCC HVDC Topologies.
2. **Thyristor Converters:** Three-phase uncontrolled bridge, three-phase Thyristor rectifier, Analysis of commutation overlap in Thyristor converter, Active and reactive power in a three phase Thyristor converter, Inverter operation, Analysis of 12-Pulse converter.
3. **Analysis of HVDC Converter:** Equivalent circuit of rectifier bridge, Equivalent circuit of Inverter bridge, HVDC equivalent circuit.
4. **Converter Control Characteristics:** HVDC V-I operating diagram, HVDC power reversal, Constant extinction angle (CEA) control, Constant current (CC) control, modification of inverter characteristics.
5. **HVDC Interaction with AC systems:** Influence of converter extinction angle, Influence of reactive power compensation, power transfer between two AC systems, Systems dynamics with low short circuit ratio.
6. **Fault Management and HVDC System Protection:** DC line faults, overvoltage protection, AC line faults.
7. **HVDC System Harmonics:** Thyristor converter harmonics, Harmonic filters.
8. **HVDC with Voltage Source Converters:** Voltage source converter (VSC) HVDC applications and topologies, performance and cost comparison with LCC HVDC, Introduction to multilevel VSC converters.
9. **Cables for HVDC Transmission:** Underground and undersea cable transmission, different HVDC cable types, HVDC cable insulation.

RECOMMENDED BOOK(S)

1. K. R. Padiyar, *HVDC Power Transmission Systems*. New Age International Publishers, New Delhi, Second Edition, 2012.
2. T. Gonen, *Electric Power Transmission System Engineering: Analysis and Design*. CRC Press, Taylor and Francis Group, New York, 2009.
3. D. Jovcic and K. Ahmed, *High Voltage Direct Current Transmission: Converters, Systems and DC Grid*. John Wiley Publishers, 2015.