Indian Institute of Technology Patna
Electrical Engineering Department

B.Tech – Electrical and Electronics 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	EE200	Semiconductor Devices	3	0	0	6
4	EE201	Digital Circuits and Microprocessor	3	0	0	6
5	EE202	Digital Circuits and Microprocessor Lab	0	0	3	3
6	EE221	Signals and Systems	3	0	0	6
7	EE2nn	Electromagnetic Theory	3	0	0	6
		Total	**18**	**1**	**3**	**41**

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	EE203	Analog Circuits	3	0	0	6
5	EE204	Analog Circuits Lab	0	0	3	3
6	EE205	Network Analysis and Synthesis	3	0	0	6
7	EE280	Electrical Machines	3	0	0	6
8	EE281	Electric Machines 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	EE330	Communication Systems	3	0	0	6
3	EE331	Communication Laboratory	0	0	3	3
4	EE381	Power Systems	3	0	0	6
5	EE350	Control Systems	3	0	0	6
6	EE370	Electronic Instrumentation	3	0	0	6
7	EE372	Control and Instrumentation Lab	0	0	3	3
8	EE3nn	Computer Architecture	3	0	0	6
		Total	**18**	**0**	**6**	**42**

Semester 6

Sl. No	Course Code	Course name	Credit Structure			
			L	**T**	**P**	**C**
1	HS3nn	HSS Elective	3	0	0	6
2	EE320	DSP	3	0	0	6
3	EE321	DSP Lab	0	0	3	3
4	EE382	Power Electronics	3	0	0	6
5	EE309	VLSI Design	3	0	0	6
6	EE311	VLSI Lab	0	0	3	3
7	EE3nn	Power Electronics Lab	0	0	3	3
8	EE305	Design Lab	0	0	3	3
		Total	**12**	**0**	**12**	**36**

Semester 7

Sl. No	Course Code	Course name	Credit Structure			
			L	**T**	**P**	**C**
1	XX4nn	Open Elective	3	0	0	6
2	EEnnn	Departmental Elective – I	3	0	0	6
3	EEnnn	Departmental Elective - II	3	0	0	6
4	EE493	BTP – I/One Course	0	0	6	6
		Total	**9**	**0**	**6**	**24**

Semester 8

Sl. No	Course Code	Course name	Credit Structure			
			L	**T**	**P**	**C**
1	EEnnn	Departmental Elective – III	3	0	0	6
2	EEnnn	Departmental Elective – IV	3	0	0	6
3	EE496	BTP – II / Two Courses	0	0	12	12
		Total	**6**	**0**	**12**	**24**
		Grand Total	**108**	**8.5**	**64**	**297**

XX – Department Code

nnn – Course Number

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.

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.

Semester 3

EE200 Semiconductor Devices and Circuits (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.

EE201 Digital Circuits and Microprocessor (3-0-0-6) Pre-requisites: Nil

Introduction to digital circuits: Logic families (TTL and MOS), Number systems, Integer and floating point representation.

Logic gates representation and combinational circuit realization, Boolean functions and simplification. Karnaugh Maps and logic optimization. Macro level combinational circuits and their realization: Multiplexers, Code converters, Decoders, parity Generators, 7-segment display decoder; Digital Arithmetic Circuits: Adders, Subtractors, BCD adders.

Introduction to sequential elements (Latches and Flip-flops) and sequential circuit design, State machines. Finite state machines and examples: counters and shift registers.

Introduction to memory circuits.

Introduction to programmable and reconfigurable devices. Digital logic realization using programmable Logic devices.

Introduction to Microprocessor, Architecture, programming model and interfacings

Text/reference Books

1. D. P. Leach, A. P. Malvino and G. saha, Digital Principal and Applications, 2/e, McGraw-Hill, 2006.
2. J. F. Wakerly, Digital design principles and practices, 4/e, Pearson Education, 2006.
3. Morris mano and Michael D. Ciliettі, “Digital design”, 4th Ed., Pearson Education, 2008.
4. C. H. Roth, Fundamentals of logic design, 5th Ed., Cengage learning, 2004.

5. David J. Corner, Digital logic and state machine design, Oxford university, 3rd Reprint, Indian Edition, 2012.
6. R. K. Gaonkar, “Microprocessor Architecture, Programming and Applications with the 8085”, Penram International Publishing (India), 2000.
7. D. V. Hall, “Microprocessors and Interfacing: programming and hardware”, TMH, 1995.

EE221 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.

EE202 Digital Circuits Laboratory (0-0-3-3) Pre-requisites: Nil

To setup circuits for Bipolar (RTL, DTL, TTL) and Unipolar (MOS, CMOS) Logic families, Logic Gate verification and introduction to Combinational circuits, Realization of Decoder, Design and realisation of a Multiplexer and Magnitude Comparator, Verification of basic Flip Flops using 74XXICS, Implementation of basic Latches, Asynchronous Counters, Synchronous Counters, Introduction to 8085 Kit, The 8085 Assembly Language Programming.

Texts/References:

1. Niklaus Wirth, Digital Circuit Design: An Introductory Textbook, Springer, 1995.
2. D. P Leach, A. P. Malvino and G. Saha, Digital Principles and Applications, 2/e, Tata McGraw-Hill, 2006
3. R. S. Gaonkar, “Microprocessor Architecture, Programming and Applications with the 8085”, Penram International Publishing (India), 2000.
4. TTL IC Data Sheets (www.datasheetarchive.com/).

EE2nn Electromagnetic Theory and Applications (3-0-0-6) Pre-requisite: Nil

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 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.

Radiation: retarded potentials, hertzian dipole, short loop, different antenna types, antenna parameters, antenna measurement techniques.

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

Texts:

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. David M. Pozar, Microwave Engineering, Wiley India Private Limited; Fourth edition (14 May 2013)
5. C. A. Balanis: Antenna Theory: Analysis and Design, John Wiley, 2005, 3/e.
6. R. E. Collin, Foundations for Microwave Engineering, Wiley-Blackwell; 2nd Edition

References:

1. K. E. Lonngren & S. V. Savov: Fundamentals Electromagnetics with MATLAB, PHI, 2005, 1/e.
2. D. K. Cheng: Field and Wave Electromagnetics; Pearson, 2001, 2/e.
3. N. Ida, Engineering Electromagnetics, Springer, 2000, 1/e.
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

Semester 4

EE203 Analog Integrated Circuits 3 0 0 6 Pre-requisites: Nil

CMOS realizations: current source, sink and mirrors, differential amplifiers, multistage amplifiers;

Differential amplifiers: DC and small signal analysis, CMRR, current mirrors, active load and cascode configurations;

Frequency response of amplifiers: high frequency device models, frequency responses of various amplifiers, GBW, methods of short circuit and open circuit time constants, dominant pole approximation;

Analog subsystems: analog switches, voltage comparator, voltage regulator, switching regulator, bandgap reference voltage source, analog multiplier,

Filter approximations: Butterworth, Chebyshev, first order and second order passive/active filter realizations of LPF, HPF, BPF.

Signal generation and waveform shaping: Schmitt trigger, relaxation oscillators, sinusoidal oscillators – RC, LC, and crystal oscillator;

Feedback amplifiers: basic feedback topologies and their properties, analysis of practical feedback amplifiers, stability;

Power amplifiers: efficiency of class A, B, AB, C, D stages, output stages, short circuit protection, power transistors and thermal design considerations;

Case study: 741 op-amp - DC and small signal analysis, frequency response, frequency compensation, GBW, phase margin, slew rate, offsets;

Texts:

- S. Smith, "Microelectronics Circuits", 5/e, Oxford, 2005
- P. Gray, P. Hurst, S. Lewis, and R. Meyer, "Analysis & Design of Analog Integrated Circuits," 4/e, Wiley, 2001.
- B. Razavi, Fundamental of Microelectronics, Wiley 2009

References:

- B. Razavi, Design of Analog CMOS Integrated Circuits, McGraw Hill 2001.
- Bruce Carter and Ron Mancini – Opamaps for Everyone, Ch 20, Texas Instruments, 3/e
- D. Johns, K. Martin, "Analog Integrated Circuit Design," Wiley, 1997.

- R. A. Gayakwad, Op-Amps and Linear Integrated Circuit, Prentice Hall of India, 2002.
- P. E. Allen and D. R. Holberg, CMOS Analog Circuit Design, 2/e, Oxford University Press, 1997.

EE204 Analog Circuits Laboratory (0-0-3-3) 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:

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

EE205 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)

EE280 Electrical Machines (3-0-0-6) Pre-requisites: Nil

Magnetic circuits and transformer including 3-phase transformers; Fundamentals of D.C. machines; phasor diagram of cylindrical rotor and salient pole machines- electromagnetic and reluctance torque, response under short circuit conditions; Fundamentals of induction machines- derivation of equivalent circuits, dynamics under load change, speed reversal and braking, unbalanced and asymmetrical operation; Fundamentals of synchronous machines – equivalent circuit, d-q transformations, short circuit studies in synchronous machines

Texts:

1. Stephen Chapman, Electric Machinery Fundamentals, McGraw-Hill, 4/e, 2003.
2. B. S. Guru and H. R. Hiziroglu, Electrical Machinery and Transformers, 3/e, Oxford University Press, 2003.

References:

1. I. L. Kosow, Electrical Machinery and Transformers, 2/e, Prentice- Hall of India Pvt. Ltd., 2003.
2. R. K. Rajput, Electrical Machines, 3/e, Laxmi Publications (P) Ltd., 2003.

EE281 Electrical Machines Laboratory (0-0-3-3) Pre-requisites: Nil

Open circuit and short circuit tests of single phase transformer, three phase transformer connections, open circuit test and load characteristics of DC generator, speed control and output characteristics of DC motor, no load, blocked rotor and load tests on induction motor, open circuit and short circuit tests of an alternator.

Text/References:

1. Stephen Chapman, Electric Machinery Fundamentals, 4/e, McGraw-Hill, 2003.
2. C. S. Indulkar, Laboratory Experiments in Electrical Power Engineering, Khanna Publishers, 2003.

Semester 5

EE350 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)

EE370 Electronic 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:

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

References:

1. B. E. Jones, Instrumentation, measurement, and Feedback, Tata McGraw-Hill, 2000.
2. R. P. Areny and T. G. Webster, Sensors and Signal Conditioning, John Wiley, 1991.
3. B. M. Oliver and J. M. Cage, Electronic Measurements and Instrumentation, McGraw-Hill, 1975.

4. C. F. Coombs, Electronic Instruments Handbook, McGraw-Hill, 1995.
5. R. A. Witte, Electronic Test Instruments, Pearson Education, 1995.
6. B. G. Liptak, Instrument Engineers' Handbook: Process Measurement and Analysis, Chilton Book, 1995.

EE3nn Computer Architecture (3-0-0-6) Pre-requisites: Nil

Introduction: Evolution of computing systems and applications, Introduction to computing system, top level view of computer function and interconnection, computing performances and measures, Number and data representation of Digital Computer, Register transfer and micro-operations, Basic Computer Arithmetic architectures.

Basic CPU architecture: Data Path and Control Path, hardwired and microprogrammed control architecture, Timing of control units, Basic CPU Design using HDL.

General purpose CPU organization and architecture: CISC features, Processor structure and function, CISC Instruction Set Architecture, Addressing Mode, RTL representation of Instructions, Assembly Language and Programming, Introduction to Assembler.

Memory Organization and Architecture: Types of memory and interfacing, paging, Cache Memory,

I/O and peripheral organization and architecture: programmable I/O architecture, Programmable Timers, Interrupts and exception handling, Priority Interrupt Controller, DMA Controller

Evolution of RISC Architecture: RISC features, pipeline and vector processor architecture and their performance studies.

Embedded and reconfigurable computing architecture: Embedded CPU organization and architecture, RISC ISA, Embedded CPU programming, Assembly Language, Embedded Bus protocol and architecture, FPGA Architecture, FPGA programming, Implementation and prototype methods: Case studies, IP and its reuse,

Introduction to Operating System: Embedded Operating System and RTOS.

Text/Reference Books:

1. Computer System Architecture by M Morris Mano, Prentice Hall of India, Latest Edition.
2. Computer Architecture and Organization by John P Hayes, McGraw Hill, Latest Edition.
3. Computer Architecture and Organization by William Stallings, PHI Pvt. Ltd., Eastern Economy Edition, Latest Edition.
4. Microprocessor and Interfacing, by Dauglas V. Hall, Tata McGraw Hill Publication, Latest Edition.
5. Embedded Systems: Architecture, Programming and Design, by Raj Kamal, McGraw Hill Publication, Latest Edition.
6. PIC Microcontroller and Embedded Systems by Muhammad Ali Mazidi, Rolind D. Mckinlay and Danny Causey, Pearson Publication, Latest Edition.

7. VerilogHDL by S. Palnitkar, Pearson Publication, Latest Edition.
8. FPGA Programming for Beginners by Frank Bruno, Packt Publishing, Latest Edition.
9. FPGA Prototyping by VerilogHDL examples, by Pong P. Chu, Wiley Publication, Latest Edition.

EE330 Communication Systems (3-0-0-6) Pre-requisites: Nil

Basic blocks in a communication system: transmitter, channel and receiver; baseband and passband signals and their representations; concept of modulation and demodulation. Power spectral density, Correlation between waveforms. Signal Space Concepts, Orthogonal representation of signals, Gram-Schmidt procedure.

Amplitude modulation (AM), double sideband suppressed carrier (DSBSC), single sideband suppressed carrier (SSBSC) and vestigial sideband (VSB) modulation. Angle modulation - phase modulation (PM) & frequency modulation (FM); narrow and wideband FM. Pulse Modulation: sampling process; pulse amplitude modulation (PAM); pulse width modulation (PWM); pulse position modulation (PPM) ; pulse code modulation (PCM). Noise in AM, FM and PAM.

Elements of digital communication systems: Concepts of Source coding and Entropy. Optimum Linear Receiver. Digital Modulation Schemes and their comparison: ASK, FSK, PSK, and QAM; Error Analysis. Introduction to Pseudo-Noise Sequences and Spread Spectrum.

Texts:

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. B. P. Lathi, Modern Analog and Digital Communication systems, 3/e, Oxford University Press, 1998.
4. R. G. Gallager, Principles of Digital Communication, Cambridge University Press, 2009.
5. U. Madhow, Fundamentals of Digital Communication, Cambridge University Press, 2008.
6. S. Haykin, Digital Communications, Wiley-India, 2011.

References:

1. A. B. Carlson, Communication Systems,3/e, McGraw Hill, 1986.
2. P. B Crilly, A. B. Carlson, Communication Systems, Tata McGraw-Hill Education, 5th Edition, 2011.
3. J.M Wozencraft, I.M. Jacobs, Principles of Communication Engineering, John Wiley, 1965.
4. I. A. Glover, P. M. Grant, Digital Communications, Pearson, 5th Impression, 2012.
5. P. Z. Peeples, Digital Communication Systems, Prentice Hall International, 1987.
6. K.S. Shanmugam, Digital and Analog Communication Systems, Wiley Int. Pub. 1980.
7. M. Schwartz, Information Transmission, Modulation and Noise, McGraw Hill Int. Student Edition, 1980.
8. S.S. Haykin, An Introduction to Analog and Digital Communication Systems, Wiley Eastern 1989

EE 381 Power Systems (3-0-0-6) Pre-requisites: Nil

Architecture of a power system: Components, network organization, breaker arrangement, voltage levels. Line parameter calculation: Calculation of series inductance and shunt capacitance, matrix representation of a line section, sequence transformation, transposition.

Performance analysis of an AC transmission line: Representation of short, medium-length and long transmission lines, wave propagation, surge impedance, Ferranti effect.

Load flow analysis: Numerical techniques for solving algebraic equations, matrix representation of the power system, load flow equations, application of Gauss-Seidel method for solving load flow equations, application of Newton-Raphson method for solving load flow equations, fast decoupled solution for load flow equations.
Short circuit analysis: System representation for short circuit analysis, balanced short circuit analysis, sequence modelling of transformers, unbalanced short circuit analysis.
Stability analysis: Basic concept of stability, numerical techniques for solving differential equations, swing equation, equal-area criterion, critical clearing time.
Economic load dispatch: Introduction to constrained optimization, optimal scheduling of generators, network loss modeling.
Introduction to the protection system: Components of the protection system, different kinds of protection, functional characteristics of a protective relay,distance protection, power swing, arc interruption in circuit breakers
Text/References:

1. C. L. Wadhwa, Electrical Power Systems. New Delhi: New Age International Publishers.
2. J. J. Grainger and W. D. Stevenson, Jr., Power System Analysis. New Delhi: Tata McGraw-Hill.
3. H. Saddat, Power System Analysis. New Delhi: Tata McGraw-Hill.

EE331 Communication Laboratory (0-0-3-3) Pre-requisites: Nil

Amplitude modulation and demodulation (AM with carrier & DSBSC AM); frequency modulation and demodulation (using VCO & PLL); automatic gain control (AGC); pulse amplitude modulation (PAM); pulse code modulation (PCM); pseudo-random (PN) sequence generation; Amplitude shift keying (ASK), frequency shift keying (FSK), binary phase shift keying (BPSK); binary frequency shift keying (BFSK), Quadrature phase shift keying (QPSK), Code division multiple access (CDMA), 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.

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.

Semester 6

EE320 Digital Signal Processing (3-0-0-6) Pre-requisites: Nil

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.

EE309 VLSI Design (3-0-0-6) Pre-requisites: Digital Circuits 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.

EE382 Power Electronics (3 0 0 6) Pre-requisites: Nil

Power semiconductor devices: structure and characteristics; snubber circuits, switching loss. Controlled
rectifiers: full/half controlled converters, dual converters, sequence control. AC regulator circuits, reactive power compensators. de-de converters, switching dc power supplies. Inverters: square wave and pwm types, filters, inverters for induction heating and UPS.

Texts:

1. N. Mohan: Power Electronics- Converters, Applications and Design, 3/e, John Wiley & Sons, 2003.
2. G. K. Dubey, Fundamentals of Electrical Drives, Narosa Publishing House, 2003

References:

1. Muhammad Rashid, Power Electronics- Circuits, Devices and Applications, 3/e, Prentice Hall, 2004.
2. B. K. Bose, Modern Power Electronics and AC Drives, Pearson Education, 2003.
3. Andrzej M. Trzynadlowski, Introduction to Modern Power Electronics, John Wiley & Sons, 1998.
4. Muhammad Rashid, Power Electronics Handbook, Academic Press-Elsevier, 2001.

EE321 DSP 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)

EE311 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.

EE305 Design Laboratory (0-0-3-3) Pre-requisites: Nil

A student has to do an electronic hardware mini-project in broad areas like communication, electronic systems design, control and instrumentation, computer, power systems and signal processing. The project involves laying down the specifications, design, prototyping and testing. The project must have major hardware modules involving active discrete components and integrated circuits.

Texts/References:

1. P. Horowitz and W. Hill, Art of Electronics, Cambridge University Press, 2nd Edition, 1989.
2. M. M. Mano, Digital Design, Pearson Education, 2002.
3. The ARRL Handbook for Radio Communications- American Radio Relay League, 2008.
4. C. F. Coombs, Electronic Instruments Handbook. McGraw-Hill, 2000.
5. T. Williams, The Circuit Designer's Companion, Newnes, 2005.
6. R. Pease, Troubleshooting Analog Circuits, Newnes, 1991.

EE3nn Power Electronics Laboratory (0-0-0-3) Pre-requisites: Nil

Rectifiers and applications, DC-DC Converters and applications, DC-AC Converters and applications, AC regulator circuits, Design of PWM generators and projects.

Texts:

1. P Arora: *Power Electronics* Laboratory: Theory, Practice & Organization.Narosa Publishing House, 2003
2. N. Mohan: Power Electronics- Converters, Applications and Design, 3/e, John Wiley & Sons, 2003.

Semester 7

Departmental Electives I & II:

EE 540 Radio Frequency Integrated Circuits 3-0-0-6

Introduction to RF and Wireless technology; Basic concepts in RF & Wireless Integrated Circuits Design; Receiver and Transmitter Architectures.

Low Noise RF Amplifiers – Electrical Noises, Two port Noise theory, LNA characteristic parameters and basic topologies, Input impedance and Noise Figure of amplifiers, Differential and Broadband Amplifier, Stability;

Mixers – Mixer Operation and linearity, Passive and Active Mixers, Single & Double-Balanced Mixers, Conversion Gain and Port-to-Port Feedthrough (or leakage), Image Reject and Single Sideband Mixers, Noise in Mixers;

Oscillators – Oscillator as a Feedback System, Negative Resistance Oscillator, Colpitts, Hartley, Clapp, Pierce crystal Oscillators, Quadrature Oscillators, Voltage Controlled-Oscillator, Phase Noise in Oscillators;

Frequency Synthesizers – Phase Locked Loop (PLL), Analysis of PLL Synthesizers, Phase Noise in PLL Synthesis, PLL Frequency Synthesizers, Integer-*N* and Fractional-*N* PLL Synthesizers, PLL System Frequency Response and Bandwidth;

RF Power Amplifiers – Efficiency, Analysis of Basic Classes – A, AB, B, C, Class B Push-Pull Arrangements, Switch mode Classes – D, E, F Amplifiers, Doherty Power Amplifier, Linearization Techniques.

Prerequisite: Basic Electronics and Basic Electromagnetic Engineering.

Text:

1. Thomas H Lee, *The Design of CMOS Radio Frequency Integrated Circuits*, Cambridge University Press

2. Behzad Razavi, *RF MicroElectronics,* 2/e, Pearson India.

3. David M Pozar, *Microwave and RF Design of Wireless Systems,* John Wiley and Sons

4. Steven Cripps, *RF Power amplifier for wireless communications,* Artech House

5. Herbert Krauss, Charles Bostian, and Frederick Raab, *Solide state radio engineering*, John Wiley and Sons

References:

1. Guillermo Gonzalez, *Microwave Transistor Amplifier- Analysis and Design,* Prentice Hall, New Jersey.

2. Richard C-H Li, *RF Circuits Design*, John Wiley

3. John W M Rogers and Calvin Plett, *Radio Frequency Circuit Design*, Artech House, Boston.

4. Les Besser and Rowan Gilmore, *Practical RF Circuit Design for Modern Wireless Systems, vol. 2,* Artech House, Boston

EE 571 Computer Aided Power System Analysis 3-0-0-6

Load Flow for AC systems, fast decoupled load flow, optimal power flow.;Z - matrix for short circuit studies.;State estimation, LO algorithm, fast decoupled state estimation.;Security and contingency studies. Unit Commitment. Load frequency control.;Optimal hydro-thermal scheduling. AI applications

Texts/References

1. O.I.Elgerd, Electric Energy Systems Theory, McGraw Hill, 1971

2. G.W.Stagg and A.H.El-Abiad, Computer Methods in Power System Analysis, McGraw Hill 1968.

3. G.L.Kusic, Computer Aided Power Systems Analysis, Prentice Hall, 1986.

4. I.J.Nagrath and D.P.Kothari, Modern Power Systems Analysis, Tata McGraw Hill, 1980.

5. A.J.Wood and B.F.Wollenberg, Power Generation, Operation and Control, John Wiley, 1984

EE 561 Basics of Power Electronics Converters 3-0-0-6

Power semiconductor devices, BJT, MOSFET, IGBT, GTO and MCT: AC-DC Converters; Forced communication; synchronous link converters, DC-AC converters, buck, boost, buck-boost, cuk, flyback configuration, resonant converters, PWM inverters; active filters.

Text/References

1. Ned Mohan, Power Electronics: Converters, Applications, and Design, Wiley, 3rd Edition, 2002.

2. Robert W. Erickson, Dragan Maksimovic, “Fundamentals of Power Electronics” Springer Science & Business Media, 2007

3. Muhammad H. Rashid, Power Electronics Devices, Circuits, and Applications, Pearson, 4th Edition, 2014.

EE 577 Digital Control 3-0-0-6

Discrete-time system representations: modeling discrete-time systems by linear difference equations and pulse transfer functions, time responses of discrete systems; discrete state-space models, stability of discrete-time systems. Finite settling-time control design: deadbeat systems, inter sample behavior, time-domain approach to ripple-free controllers, limitations and extensions of the deadbeat controller. State-feedback design techniques: linear system properties, state feedback using Ackermann's formula, tracking of known reference inputs. Output-feedback design techniques: observer design , observer-based output feedback design.

Texts / References:

1. B. C. Kuo, Digital Control Systems; Oxford University Press, 2/e, Indian Edition, 2007.
2. K. Ogata, Discrete Time Control Systems; Prentice Hall, 2/e, 1995.
3. M. Gopal, Digital Control and State Variable Methods; Tata Mcgraw Hill, 2/e, 2003.
4. G. F. Franklin, J. D. Powell and M. L. Workman; Digital Control of Dynamic Systems; Addison Wesley, 1998, Pearson Education, Asia, 3/e, 2000.
5. K. J. Astroms and B. Wittenmark, Computer Controlled Systems - Theory and Design; Prentice Hall, 3/e, 1997.

EE 589 Generalized Theory of Electrical Machines 3-0-0-6

Reference Frame: Commonly used reference frames, Transformation between reference frames; Transformations in Machines: Power invariance, 3-phase to 2-phase transformation, Park’s Transformation; DC Machines: Voltage and torque equations, transfer function of DC Machines, Steady State Analysis of DC Machines; Polyphase Induction Machines: D-Q model, axes transformation, Steady state analysis from different frames of references; Polyphase Synchronous Machines: Equivalent circuit, Park’s Model, Shot Circuit Analysis, Steady State Analysis; Permanent Magnet Machines: Basic operation principle, Park’s model, Steady State analysis for various PWM techniques.

Texts:

1. A. K. Mukhopadhyay, Matrix Analysis of Electrical Machines, New Age, 1996.
2. P. Vas, *Electrical Machines and Drives: A Space-Vector Theory Approach* (Monographs in Electrical and Electronic Engineering), Oxford University Press, 1993.
3. W. Leonhard, *Control of Electrical Drives*. Springer, Berlin, 1985.

References:

1. D. O'Kelly and S. Simmons, *Introduction to Generalized Electrical Machine Theory*, McGraw-Hill Education, 1968.

EE 587 A first course in Optimization 3-0-0-6

Motivation. mathematical review , matrix factorizations, sets and sequences, convex sets and functions, linear programming and simplex method, Weierstrass' theorem, Karush Kuhn Tucker optimality conditions, algorithms, convergence, unconstrained optimization, Line search methods, method of multidimensional search, steepest descent methods, Newton's method, modifications to Newton's method , trust region methods, conjugate gradient methods, quasi-Newton's methods. constrained optimization, penalty and barrier function methods, augmented Lagrangian methods, polynomial time algorithm for linear programming, successive linear programming, successive quadratic programming.

Text/References

1. R. Fletcher Practical Optimization (2nd Edition) John Wiley & Sons, New York, 1987.
2. M.S.Bazaraa , H.D.Sherali and C.Shetty , Nonlinear Programming, Theory and Algorithms, John Wiley and Sons, New York, 1993.

EE 593 Power System Deregulation 3-0-0-6

Fundamentals of deregulation: Privatization and deregulation, Motivations for Restructuring the Power industry; Restructuring models and Trading Arrangements: Components of restructured systems, Independent System Operator (ISO): Functions and responsibilities, Trading arrangements (Pool, bilateral & multilateral), Open Access Transmission Systems; Different models of deregulation: U K Model, California model, Australian and New Zealand models, Deregulation in Asia including India, Bidding strategies, Forward and Future market; Operation and control: Old vs New, Available Transfer Capability, Congestion management, Ancillary services; Wheeling charges and pricing: Wheeling methodologies, pricing strategies

Text/Reference

1. Operation of restructured power systems. Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen, Kluwer Academic Pub., 2001.

2. Restructured electrical power systems: operation, trading and volatility Mohammad Shahidehpour, Muwaffaq Alomoush, Marcel Dekker Pub., 2001

EE 591 Advanced Electric Drives 3-0-0-6

Motors with continuous rotation, Electromagnetic Stepping Drives, Drives with limited motion, Piezoelectric drives, Open loop and closed loop control of fractional horse power motors, Magnetic bearings and their control, Integration and Control of Mechanical transfer units such as gears, pulleys, flexible drives etc., Project design of drive systems, Application of Artificial Intelligence in Electric Drives, AI based steady state and transient analysis of Induction Machines, AI based Switch Reluctance Machine performance estimation and Control.

Texts/References:

1. B. Wu, *High-Power Converters and AC Drives.* Wiley-IEEE Press, New Jersey, 2006
2. W. Leonhard, *Control of Electrical Drives*. Springer, Berlin, 1985.
3. N. Mohan, *Advanced Electric Drives: Analysis, Control and Modeling using Simulink*. MNPERE, 2001.
4. Hans Dieter Stoelting, *Handbook of fractional Horsepower Drives*, Springer, 1st edition, 2009
5. Ion Boldea, Syed A. Nasar, *Electric Drives*, CRC Press, 2nd Edition, 2005
6. Peter Vas, *Artificial Intelligence Based Electrical Machines and Drives: Application of Fuzzy, Neural and Genetic Algorithm Based Techniques*, Oxford University Press, 1999.

EE579 Advanced Control Theory 3-0-0-6

Frequency response design: Design of lag, lead, lag-lead and PID controllers, the Nyquist criterion, analysis and design, relative stability and the Bode diagram, closed-loop response, sensitivity, time delays; Root locus design: construction of root loci, phase-lead and phase-lag design, PID controller design; Modern design: controllability and observability, state feedback with integral control, reduced order observer; Optimal control design: Solution-time criterion, Control-area criterion, Performance indices, Zero steady state step error systems; Modern control performance index: Quadratic performance index, Ricatti equation; Digital controllers: Use of z-transform for closed loop transient response, stability analysis using bilinear transform and Jury method, deadbeat control, Digital control design using state feedback; On-line identification and control: On-line estimation of model and controller parameters.

Texts/References

1. G. F. Franklin, J. D. Powel and A. E. Emami-Naeini: Feedback Control of Dynamic Systems, Prentice Hall Inc. 2002.

2. M. Gopal: Control Systems, 3/e, Tata McGraw Hill, 2008.

3. M. Gopal: Digital Control and State Variable Methods, Tata McGraw Hill, 2003.

4. K. J. Astrom and T. Hagglund: Advanced PID Control, ISA, Research Triangle Park, NC 27709, 2005

EE 585 Advanced Power System Protection 3-0-0-6

Protective Devices: Philosophy of protection, Methods of earthing and their effect on fault conditions. Different types of relays: attracted armature type, balanced beam type, induction type. Static relays: Generalised theory of phase and magnitude, comparator, realization of different relay characteristics of static devices. Evolution of Power System Protection and the Emergence of Digital Relaying, Digital Signal Processing Basics and Architecture of Numerical Relay: Introduction to Digital Signal Processing, The DSP Signal Processing Chain, Analog to Digital Converters, Anti-aliasing Filter, Algorithms Based on Undistorted Single Frequency Sine Wave, Algorithms Based on Solution of Differential Equation, Algorithms Based on Least Squared Error, Discrete Fourier Transform, FFT and Goertzel Algorithm, Introduction to Digital Filtering, Synchrophasors, Introduction to computer relaying, Relaying applications of traveling waves, Wide area measurement applications

References:

1) Arun G. Phadke and James S. Thorp, "Computer Relaying for Power Systems," 2nd Edition, Wiley, 2009.
S. R. Bhide, "Digital Power System Protection," PHI Learning Private Limited, 2014.

Course Code: EE543 Internet of Things (IoT) 3-0-0-6 Pre-requisites: Engineering Mathematics, and Computer Programming

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.

Semester 8

Departmental Electives III & IV:

EE 549 Power System Dynamics and Control 3-0-0-6

Basic Concepts of dynamical systems and stability. Modelling of power system components for stability studies: generators, transmission lines, excitation and prime mover controllers, flexible AC transmission (FACTS) controllers.;Analysis of single machine and multi-machine systems. Small signal angle instability (low frequency oscillations): damping and synchronizing torque analysis, eigenvalue analysis.;Mitigation using power system stabilizers and supplementary modulation control of FACTS devices. Small signal angle instability (sub-synchronous frequency oscillations): analysis and counter-measures. Transient Instability: Analysis using digital simulation and energy function method. Transient stability controllers. Introduction to voltage Instability. Analysis of voltage Instability.

Texts/References:

1. P.Kundur, Power System Stability and Control, McGraw Hill Inc, New York, 1995.
2. P.Sauer & M.A.Pai, Power System Dynamics & Stability, Prentice Hall, 1997.

EE 574 Control of Electric Drives 3-0-0-6

Modelling of DC Machines, Phase Controlled DC Motor Drives, Chopper Controlled DC Motor Drives, Modeling of Polyphase Induction Machines, Phase Controlled Motor Drives, Frequency Controlled Induction Motor Drives, Vector Controlled Induction Motor Drives, Permanent Magnet Synchronous and Brushless DC Motor Drive Modeling and Control.

Texts / References:

1. R. Krishnan, *Electric Motor Drives: Modeling, Analysis and Control*, Prentice Hall, 2002.
2. Mohamed El-Sharkawi, *Fundamentals of Electric Drive*, CL- Engineering, 1st Edition, 2000

EE555 Random signals and systems 3-0-0-6

Probability and statistics of multivariable (a quick revision): Bayes theorem, multiple random variable, discrete random variable, probability mass function and probability density function, a few well known distributions, moments.

Random process: Concept of random process, ensemble, mathematical tools for studying random process, correlation function, stationarity, ergodicity, a few known stochastic processes: random walk, Poisson process, Gaussian random process, Markov chains, Brownian motion etc., pseudorandom process, nonlinear transformation of random process.

Random process in frequency domain: Periodogram and power spectral density, Weiner-Khintchine-Einstein Theorem, concept of bandwidth, spectral estimation.

Linear system: Discrete time and continuous time LTI system, concept of convolution, system described in frequency domain, state space description of the system.

Linear systems with random inputs: Linear system fundamentals, response of a linear system, convolution, mean, autocorrelation and cross correlation function in LTI system, power spectral density in LTI, cross power spectral density in LTI.

Processing of random signals: Noise in systems, noise bandwidth, SNR, bandlimited random process, noise reduction, matched filter, Wiener filter.

The Kalman filter: Mean square estimation, discrete Kalman filter, innovation, Kalman filter vs Wiener filter,properties of Kalman filter, Kalman Bucy filter, engineering examples.

Text book:

1. Miller, Scott, and Donald Childers, “probability and random processes: with applications to signal processing and communications”, Academic Press, 2012.

2. Wim C. van Etten, “Introduction to random signals and Noise”, Chichester, England: Wiley, 2005.

3. Peyton Z. Peebles, “Probability, random variables, and random signal principles”. McGraw Hill Book Company, 1987.

Reference:

1. Geoffrey R. Grimmett, and David Stirzaker, “Probability and random processes”, Oxford university press, 2001.

2. Alberto Leon-Garcia, “Probability, statistics, and random processes for Electrical engineering”, Upper Saddle River, NJ: Pearson/Prentice Hall, 2008.

3. Grewal, Mohinder, and Angus P. Andrews, “Kalman filtering: theory and practice with MATLAB”, John Wiley & Sons, 2014.

4. Alberto Leon-Garcia, “Probability, statistics, and random processes for Electrical engineering”, Upper Saddle River, NJ: Pearson/Prentice Hall, 2008.

5. Kay, Steven M, “Fundamentals of statistical signal processing”, Prentice Hall PTR, 1993.

6. H.L. Van Trees, “Detection, estimation, and modulation theory, part I”, New York, NY: John Wiley & Sons, Inc., 1971.

7. Brown, Robert Grover, and Patrick YC Hwang., “Introduction to random signals and applied Kalman filtering”, New York: Wiley, 1992.

8. Shovan Bhaumik, and Paresh Date, “Nonlinear estimation: methods and applications with deterministic Sample Points”, CRC Press, 2019.

9. Steven Key, “Intuitive probability and random processes using MATLAB®”, Springer Science & Business Media, 2006.

10. D. J. Gordana, “Random signals and processes primer with MATLAB”, Springer Science & Business Media, 2012

EE 580 Optimal Control Systems 3-0-0-6

Introduction. static and dynamic optimization. Parameter optimization.;Calculus of Variations : problems of Lagrange,. Mayer and Bolza. Euler-Language equation and transversality conditions, Lagrange multipliers.;Pontryagin’s maximum principle; theory; application to minimum time, energy and control effort problems, and terminal control problem. Dynamic programming : Belaman’s principle of optimality, multistage decision processes. application to optimal control.;Linear regulator problem : matrix Riccati equation and its solution, tracking problem.;Computational methods in optimal control. application of mathematical programming. singular perturbations, practical examples.

Text/References

1. D.E.Kirk, Optimal Control Theory, Prentice-Hall. 1970.
2. A.P.Sage and C.C.White II, Optimum Systems Control, 2nd ED., Prentice-Hall, 1977.
3. D.Tabak and B.C.Kuo, Optimal Control by Mathematical Programming, Prentice-Hall, 1971.
4. B.D.O. Anderson and J.B.Moore, Linear Optimal Control, Prentice-Hall, 1971.

EE 586 HVDC Transmission and FACTS 3-0-0-6

General aspects of DC transmission, converter circuits and their analysis, DC link controls, faults and abnormal operation and protection; Mechanism of active and reactive power flow control; Basic FACTS controllers: SVC, STATCOM, TCSC, TCPAR, UPFC; Modeling of FACTS Controllers; System static performance improvement with FACTS controllers; System dynamic performance improvement with FACTS controllers

1. K.R. Padiyar, HVDC Power Transmission Systems, Wiley eastern Ltd. 1990.

2. Hingorani N. G. “Understanding FACTS Concepts & Technology of FACTS Systems,” IEEE PRESS, 2000.

3. R. M. Mathur and R. K. Varma, Thyristor Based FACTS Controllers for Electric Power Transmission Systems, IEEE Press and Wiley Interscience, New York, 2002

EE 584 Multivariable Control Theory 3-0-0-6

Mathematical Fundamentals: Invariant subspaces, Similarity transformations, Quotienting and equivalence classes; Canonical Representations and Feedback Laws:, Multivariable Observer and controller canonical representations, multivariable pole placement problem, multivariable observer design problem; System decomposition: Controllability indices and system invariants, Controllability subspaces and Observability subspaces, stabilizability and detectability, Disturbance decoupling and Output stabilization problems; Binary Systems:Introduction to linear modular systems.

Texts/ References:

1. C. T. Chen, Linear System Theory and Design , 3 rd Edn., Oxford 1999.

2. O. Gasparyan, Linear and Nonlinear Multivariable Feedback Control: A Classical Approach , John Wiley and Sons, 2007.

3. W. M. Wonham, Linear Multivariable Control: A Geometric Approach , Springer, 1985.

EE 582 Control Techniques in Power Electronics 3-0-0-6

State space modeling and simulation of linear systems, Discrete time models, conventional controllers using small signal models, Hysteresis controllers, Output and state feedback switching controllers. Averaged - switch modeling, modeling of dynamics of converters operating in discontinuous conduction mode, input filter design.

Text/References:

1. Muhammad Rashid, Power Electronics Handbook, Academic Press-Elsevier, 2001.
2. B. Wu, *High-Power Converters and AC Drives.* Wiley-IEEE Press, New Jersey, 2006.
3. Erickson and Maksimovic, Fundamentals of Power Electronics, 2nd ed., Springer Science+Business (2000),

EE 588 Nonlinear Dynamical Systems 3-0-0-6

Introduction to nonlinear systems; analysis by phase plane and describing function methods. Lyapunov stability theory. The Lure problem: Popov's method, circle criterion. Hyperstability. Hamiltonian, Lagrangian and gradient systems: physical examples and analysis. Stability of Hamiltonian systems. Periodic systems: Floquet-Lyapunov theory, Krein's stability theorem.

Text/References

1. V. M. Popov : Hyperstability of control systems. Springer Grundleheren series, 1970.
2. M. Vidyasagar, Nonlinear systems analysis. 2nd Edition. Prentice Hall, 1993.
3. Y. A. Yakubovitch and V. M. Starzhinskii, Linear differential equations with periodic coefficients. Wiley, 1975

EE 561 Antenna Theory and Design 3-0-0-6

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;

Main 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.

EE XXX 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.

EE 573 VLSI Technology 3-0-0-6

Dept. Elective-2: EE573 VLSI Technology (3-0-0-6) Prerequisite: Semiconductor Devices and Circuits Integrated Circuit Technology–Basic classification and comparison. Monolithic Technology-wafer preparation, Oxidation, isolation, Diffusion, ion implantation and masking techniques, Design and fabrication of Bipolar, MOS active and passive devices. Thin –Film Technology-Different deposition techniques, Thinness measurement and monitoring, Design and fabrication of active and passive components, Thick-Film Technology-Material process, design and fabrication of thick film components. Hybrid Integrated Circuits. Applications: Advance and emerging micro-nanoelectronics devices and technology

S.M Sze, VLSI Technology, McGraw-Hill Science/Engineering/Math; 2 edition

·Texts/References: S. K. Gandhi, VLSI Fabrication Principles: Silicon and Gallium Arsenide, Wiely, 2

·Mark J. Madau, Fundamentals of Micro fabrication: The Science of Miniaturization