Jan-May 2026 Semester Courses

Course No: EE1100

Course Name: Basic Electrical Engineering

Course Type: Theory

Description:

This course provides a comprehensive understanding and applications of DC and AC circuits used in electrical and electronic devices, parameters of electrical circuits, single phase, three phase circuits, diodes and operational amplifiers circuits, transformers, induction and DC machines.

Course Content:

1. Properties of resistance, Ohms law, KVL, KCL, mesh and nodal analysis, Network theorems: Superposition, Thevenin, Norton and maximum power transfer.

2. Properties of inductance and capacitance, DC transients: Series RL, RC, RLC and parallel RLC.

3. Single phase AC, voltage and current phasors, impedance, network theorems application to AC, frequency response of ac circuits, resonance, filters, active power, reactive power, apparent power, power factor.

4. Balanced Three phase AC, three phase power, star and delta connection.

5. Single phase transformer: Principle of operation, equivalent circuit, OC and SC test, voltage regulation, efficiency.

6. Three phase Induction motor: Construction, rotating magnetic field, principle of operation, slip, torque, equivalent circuit, efficiency.

7. DC machines: Principle of operation, excitation, equivalent circuit, emf, speed and torque characteristics.

8. Diodes and applications: Diode characteristics, voltage and current relationship, diode circuits-rectifiers, peak and envelop detectors, solar cell.

9. Operational amplifiers: Description of amplifiers as a black box and definition of gain, effect of feedback on gain, Operational amplifier circuits: Non-inverting, inverting, summing, differential, integrators, differentiators, buffers.

Text Books:

Electrical Engineering Fundamentals, Vincent Del Toro, Prentice Hall, 2006.

Reference Books:

[1] Electrical Circuit Theory and Technology, John Bird, Elsevier, 2011.

[2] Essentials of Electrical and Computer Engineering, Kerns & Irwin, Pearson, 2004

[3] Electrical Engineering Concepts and Applications, Carlson and Gisser, Addison Wesley, 1990.

Course

Course No: EE1101

Course Name: Signals and Systems

Course Type: Theory

Description:

At the end of this course, the student should be able to:

1. Understand and apply the concepts about linear time-invariant (LTI) systems

2. Understand and apply Fourier Series representation of periodic continuous-time

signals

3. Understand and apply Fourier Transform representation of periodic and aperiodic continuous-time

Signals

4. Apply Laplace transforms to analyze LTI Systems

Course Content:

1. Signals (continuous-time): Signal classification (analog-digital, energy-power, even-odd, periodic-aperiodic,deterministic-random etc.), standard signals (unit step, unit impulse, ramp, exponential, sinusoids),transformations of the independent variable (4 classes)

2. Systems (continuous-time): System classification(memory, causal, stable, linear, time-invariant, invertible etc.), Impulse response of an LTI system, convolution integral, graphical convolution, system properties from impulse response, complex exponential as eigenfunction ofLTI systems, interconnection of LTI systems (6 classes)

3. Discrete-time signals and systems: Emphasizesimilarities and differences with continuous-time counterpart (3 classes)

4. Continuous-time Fourier series:

Periodic signals and their properties, exponential and trigonometric FS representation of periodic signals, convergence, FS of standard periodic signals, salient properties of Fourier series, FS and LTI systems, some applications of FS (eg. filtering) (6 classes)

5. Continuous-time Fourier transform: Development of Fourier representation of aperiodic signals, convergence, FT of standard signals, FT of periodic signals, properties of FT,

some applications of FT (eg. modulation) (6 classes)

6. Laplace Transform: Bilateral Laplace transform, region of convergence, properties of Laplace transform, standard Laplace transform pairs, transfer function of LTI system,

characterising LTI system properties from transfer function, algebra of transfer functions and block diagram representations, Unilateral Laplace transform – brief introduction and application to simple initial value problems (8classes)

7. Sampling (Bridge continuous and discrete): Sampling theorem and signal reconstruction, notion of aliasing with examples, Sampling in frequency domain (5 classes)

Text Books:

Signals and Systems: Oppenheim, Willsky and Nawab (2nd Edn).

Reference Books:

Principles of Linear Systems and Signals: B.P. Lathi (2nd Edn)

Course No: EE2002

Course Name: Digital Systems

Course Type: Theory

Description:

The learning objectives of the course are as follows:

1. Apply Boolean Algebra to minimize complexity of digital circuit
2. Systematically analyze combinational and sequential logic circuits
3. Design controller or finite state machine for digital system

Course Content:

The course is focused on teaching the students to adopt a systematic approach towards combinational and sequential logic circuit design and analysis. It consists of the following modules:

1. Introduction to Digital Systems and Boolean Algebra - Binary, decimal, and hexadecimal number systems and conversions. Truth table, basic logic operations and logic gates. Basic postulates and fundamental theorems of Boolean algebra; Canonical (SOP and POS) forms

2. Logic Minimization and Implementation - Minterm and Maxterm expansions; Karnaugh-maps, essential prime implicants, incompletely specified functions, NAND and NOR implementation. Ex-OR functions.

3. Combinational Logic - Multi level gate circuits, Decoders, encoders, multiplexers, demultiplexers and their applications; Parity circuits and comparators; Representation of signed numbers; Adders, Ripple carry.

4. Sequential Logic - Latches and flip-flops - SR-latch, D-latch, D flip-flop, JK flip-flop, T flip-flop; Setup and Hold parameters, timing analysis; Registers and counters; Shift register; Ripple counter, Synchronous counter design using D, T, and JK flip flops.

5. State Machine Design - State machine as a sequential controller; Moore and Mealy state machines; Derivation of state graph and tables; Sequence detector; state table reduction and state assignment, logic realization; equivalent state machines.

6. Advanced Topics - Asynchronous sequential machines, static and dynamic hazards; race free design.

Text Books:

Morris M. Mano & Michael D. Ciletti (6th edition). Digital Design. Pearson Educación.

Reference Books:

Charles. H. Roth, Jr., Fundamentals of Logic Design, Fifth Edition, Thomson Brooks /Cole, 2005

Course Details

Course No: EE2004

Course Name: Digital Signal Processing

Course Type: Theory

Description:

To teach the fundamentals of Digital Signal Processing

Course Content:

Review of Signals and Systems: Discrete time complex exponentials and other basic signals—scaling of the independent axis and differences from its continuous-time counterpart—system properties (linearity,time-invariance, memory, causality, BIBO stability)—LTI systems described by linear constant coefficient difference equations (LCCDE)—impulse response and convolution.Discrete-Time Fourier Transform (DTFT): Complex exponentials as eigensignals of LTI systems—DTFT definition—inversion formula—properties—relationship to continuous-time Fourier series (CTFS).Z-Transform: Generalized complex exponentials as eigensignals of LTI systems—z-transform definition—region of convergence (RoC)—properties of RoC—properties of the z-transform—inverse z-transform methods (partial fraction expansion, power series method, contour integral approach)—pole-zero plots—time-domain responses of simple pole-zero plots—RoC implications of causality andstability.Frequency

Domain Analysis of LTI Systems: Frequency response of systems with rational transfer function—definitions of magnitude and phase response—geometric method of frequency response evaluation frompole-zero plot—frequency response of single complex zero/pole—frequency response of simple configurations (second order resonator, notch filter, averaging filter, comb filter, allpass systems)—phase response—definition of principal phase—zero-phase response—group delay—phase response of single complex zero/pole—extension to higher order systems—effect of a unit circle zero on the phase response—zero-phase response representation of systems with rational transfer function—minimum phase and allpass systems—constant group delay and its consequences—generalized linear phase—conditions that have to be met for a filter to have generalized linear phase—four types of linear phase FIR filters—on the zero locations of a linear phase FIR filter—constrained zeros at $z = 1$ and at $z = -1$ and their implications on choice of filters Type I through Type IV when designing filters—frequency response expressions for Type I through Type IV filters. Sampling: Impulse train sampling—relationship between impulse trained sampled continuous-time signal spectrum and the DTFT of its discrete-time counterpart—scaling of the frequency axis—relationship between true frequency and digital frequency—reconstruction through sinc interpolation—aliasing—effect of sampling at a discontinuous point—relationship between analog and digital sinc—effects of oversampling—discrete-time processing of continuous-time signals. Discrete Fourier Transform (DFT): Definition of the DFT and inverse DFT—relationship to discrete-time Fourier series—matrix representation—DFT as the samples of the DTFT and the implied periodicity of the time-domain signal—recovering the DTFT from the DFT—circular shift of signal and the "index mod N" concept—properties of the DFT—circular convolution and its relationship with linear convolution—effect of zero padding—introduction to the Fast Fourier Transform (FFT) algorithm—decimation-in-time and decimation-in-frequency algorithms.

Text Books:

Discrete-Time Signal Processing by Alan V. Oppenheim and Ronald W. Schafer, 3rd edition, 2010, Prentice Hall,

Upper Saddle River, NJ.

Reference Books:

(1) Digital Signal Processing by John G. Proakis and Dimitris K. Manolakis, 4th edition, 2007, Prentice Hall, Upper

Saddle River, NJ.(2) Digital Signal Processing by Sanjit Mitra, 4th edition, 2011, McGraw-Hill, New York, NY.

Prerequisite: **EE1101 Signals and Systems**

Course No: EE2006

Course Name: Electrical Machines

Course Type: Theory

Description:

The student should be familiar with the basics of construction, theory and operation of electrical machines and transformers.

Learning Outcomes: At the end of the course, the student is expected to be able to (a) understand and differentiate between the basic varieties of machines / transformers and their relevance in applications

(b)Understand the basic nameplate specifications of a machine / transformer (c) Analyze and quantify the performance of machines / transformers in simple applications and arrive at performance metrics

(d)Understand the principles of control and operation of machines and transformers

Course Content:

Review of magnetic circuits; Transformers: construction, equivalent circuit, parameter estimation – no-load andshort circuit tests, regulation, parallel operation, per-unit notation, three-phase transformers: construction andoperation. Autotransformers. DC Machines: construction and principles of operation, equivalent circuit,performance equations, generator and motor operation, series/shunt connections, speed-torque curves, principles of speed control as motor. Induction machines: construction and principles of operation, equivalent circuit, parameter estimation – no-load and blocked rotor tests, speed-torque curves, principles of speed control, elements of generator operation, performance assessment. Synchronous machines: construction and principles of operation, equivalent circuit, parameter estimation, armature reaction, performance assessment, regulation, synchronization and grid connected operation of cylindrical rotor machines

Text Books:

1. Fitzgerald, Kingsley and Umans, Electric Machinery, sixth edition, Tata McGraw Hill, New Delhi, 2002.

2. Nagrath and Kothari, Electric Machines, Fourth edition, Tata McGraw Hill, New Delhi, 2010.

3. Stephen J Chapman, Electric Machinery Fundamentals, Fourth Edition, McGraw Hill, Singapore 2005.

4. John Hindmarsh, Electric Machines and their Applications, Pergamon Press, London, 1977.

Reference Books:

None

Prerequisite: EE2015 - Electric Circuits and Networks

Course No: EE2007

Course Name: Analog Systems

Course Type:

Theory

Description:

Learning various fundamental concepts of analog systems such as open loop system, Op-amp based building blocks, negative feedback loop, stability of a closed loop system, compensation, voltage and current regulation, Active-RC Analog Filters, Gm-C based filters, Op-amp based oscillators, non-linear circuits with positive feedback, etc. Applying the above concepts in an analog system prototype.

Course Content:

Basics of operational amplifier, op-amp based building blocks, linear and non-linear system, feedback theory,negative/positive feedback, stability criterion, Bode plot with gain and phase margin, compensation, passive and active-RC analog filters, RLC filters, voltage and current regulators, pulse width modulation, AC coupling input and output and oscillators, basics of ADCs/DACs.

Text Books:

Microelectronic Circuits: Theory and Applications (International Version) Paperback – 11 Mar 2013 by A. Sedra, K.

Smith, A. Chandorkar Publisher: Oxford; Sixth edition (11 March 2013)ISBN-13: 978-0198089131

Reference Books:

Class notes

Course No: EE2702

Course Name: Digital Systems Lab

Course Type:

Lab

Description:

The learning objectives of the lab are

1. Characterize the noise margin of a digital gate
2. Measure the critical path delay of a circuit
3. Design simple drivers for displays

Course Content:

The lab will introduce students to the practical aspects of building digital circuits, including

1. Understanding electronic specifications
2. A/D and D/A conversion.
3. Noise margin of digital circuits
4. Fan-in and fan-out limitations
5. Propagation delay and critical paths
6. Output current limitations and open collector gates
7. Tristate gates
8. Driving displays and/ or motors

Text Books:

Mano, M. Morris & Ciletti, Michael D. (2002). Digital Design. Pearson Educación.

Reference Books:

Data sheets of ICs

Course No: EE2706

Course Name: Electrical Machines Lab

Course Type:

Lab

Description:

To be able to perform, analyze and debug experiments to relate the theory and practice dealing with transformers, DC Machines, Induction Machines and Synchronous Machines

Course Content:

Experiments to relate the theory and practice dealing with transformers, DC Machines, Induction Machines and Synchronous Machines.

Text Books:

1. Fitzgerald, Kingsley and Umans, Electric Machinery, sixth edition, Tata McGraw Hill, New Delhi, 2002.

2. Nagrath and Kothari, Electric Machines, Fourth edition, Tata McGraw Hill, New Delhi, 2010.

3. Stephen J Chapman, Electric Machinery Fundamentals, Fourth Edition, McGraw Hill, Singapore 2005.

4. John Hindmarsh, Electric Machines and their Applications, Pergamon Press, London, 1977.

Reference Books:

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Course No: EE2707

Course Name: Analog Systems Lab

Course Type:

Lab

Description:

Build an analog system prototype while applying the various fundamental concepts such as Op-amp based building blocks, negative feedback loop, stability of a closed loop system, compensation, voltage and current regulation, Active-RC Analog Filters, Op-amp based oscillators, non-linear circuits with positive feedback, etc.

Course Content:

Basics of operational amplifier, op-amp based building blocks, linear and non-linear system, feedback theory, negative/positive feedback, stability criterion, Bode plot with gain and phase margin, compensation, passive and active-RC analog filters, RLC filters, voltage and current regulators, pulse width modulation, AC coupling input and output and oscillators.

Text Books:

Microelectronic Circuits: Theory and Applications (International Version) Paperback – 11 Mar 2013by A. Sedra, K.

Smith, A. Chandorkar Publisher: Oxford; Sixth edition (11 March 2013)ISBN-13: 978-0198089131

Reference Books:

Class notes (EE2007) and lab manual

Course No: EE3001

Course Name: Solid State Devices

Course Type:

Theory

Description:

1. Understand and explain how basic material properties affect the operation of semiconductor devices.

2. Understand how simple models can be developed and used to explain the impact of a device on circuit behavior.

3. Develop a thorough understanding of the ubiquitous semiconductor devices like pn junction diode and MOSFET

Course Content:

1) Solid state devices – History and its relevance in modern world

2) Recapitulation of concepts like energy bands, electrons and holes, effective mass, Density of states and Fermi

level in Solids.

3) Intrinsic and extrinsic semiconductors; Equilibrium Carrier concentration; Direct and indirect semiconductors;

4) Recombination and Generation of carriers; Carrier transport – Drift and Diffusion; Continuity and Poisson

equation

5) PN junction – energy band diagram, characteristics and modeling; LEDs, Solar cells

6) Metal Semiconductor junction - energy band diagram, characteristics

7) MOS capacitor; MOSFET – energy band diagram, characteristics and modeling; Scaled MOSFETs, CMOS inverter

8) Bipolar junction transistors – energy band diagram and characteristics

Text Books:

1) Donald A. Neamen, “Semiconductor Physics and Devices- Basic Principles,” McGraw Hill, 2021

2) Robert Pierret, “Semiconductor Device Fundamentals,” Pearson Education, 2006

3) Jesús A. del Alamo, “Integrated Microelectronic Devices: Physics and Modeling,” Pearson, 2017

Reference Books:

1) Robert Pierret, “Advanced Semiconductor Fundamentals,” Pearson, 2003

2) C.T. Sah, “Fundamentals of Solid State Electronics”, World Scientific Publishing, 1991

3) Amitava DasGupta and Nandita DasGupta, “Semiconductor Devices: Modelling And Technology”, Prentice Hall

India, 2004

4) S. Karmalkar, “Solid state devices”, NPTEL video lectures available on youtube

Course No: EE3005

Course Name: Communication Systems

Course Type:

Theory

Description:

Objectives: (i) an understanding of baseband and passband signals and channels, modulation formats appropriate for these channels, (ii) random processes and noise, (iii) a systematic framework for optimum demodulation based on signal space concepts, performance analysis and power-bandwidth tradeoffs for common modulation schemes

Course Content:

(1) Review of Signals and Systems -- Linear time-invariant systems, Fourier series, Fourier transform, Bandwidth, Baseband and passband signals, complex baseband representation of passband signals

(2) Amplitude Modulation (AM) -- Double Sideband - Suppressed carrier AM, Conventional AM, Single sideband AM, Vestigial sideband AM, Quadrature AM

(3) Angle Modulation -- Phase modulation (PM), Frequency modulation (FM), FM spectrum, Phase-locked loops

(4) Signal space representation -- Gram-Schmidt orthogonalization, orthogonal expansion of signals and approximation, vector representation, vector representation of channels

(5) Review of Probability -- Probability basics, Random variables, Random vectors, Independence of random variables, Moments, correlation matrix, covariance matrixGaussian random vectors -- Scaling and translation, Standard Gaussian, Joint Gaussianity, linear transformation of jointly Gaussian random vectors

(6) Random processes -- Basic definitions, Second-order statistics, Wide-sense stationarity and stationarity, Power spectral density, Gaussian random processes, Noise modeling, Filtering, Projection of Gaussian noise onto a signal space

(7) Binary modulation on the additive white Gaussian noise channel, Reduction to binary hypothesis testing

Text Books:

U. Madhow, "Introduction to Communication Systems," Cambridge University Press, 2014. Chapters 1-6

Reference Books:

S. Haykin, Communication Systems, Wiley, 2006.

Prerequisite

EE1101 Signals and Systems

Course No: EE3007

Course Name: RF and Optical Communication

Course Type:

Theory

Description:

To introduce Physical Layer link design, both in microwave and optical communication links

Course Content:

Basic requirements of Communication Link: Modulation, Power, Transmitter and Receiver Gain, Noise, SNR.Noise in channel vs Noise in Receiver RF Link Design Receivers and Transmitters: Radiation patterns, power,bandwidth, noise The RF channel: multipath, curvature of earth Near Field RF link. Inductive coupling with RFID antennas, readers

Short Range communications Zigbee, Bluetooth, Bluetooth Low Energy (BLE): Link design Long range communications Wireless links: Multipath, fading, attenuation, link design, case study Satellite links: Effect of ionosphere, atmosphere. Link design, case studies Ultra long links: Communicating across the solar system - link design for the deep space probes sent out by NASA. Optical communication: Sources: Modulation, power, beam spreading, beam wander Receivers: Sensitivity, noise, bandwidth Channel: Bandwidth, Fibre or free space, Channel noise, Turbulence, Fog Optical link design basics Free Space link design, case studies. Fog and free space optical links Optical Fibre Communication basics. Link design of a fibre link. Cost per bit for Copper, RF and Optical links vs distance and Bitrate RF over Optical links: Microwave Photonics Transporting analog RF over Optical links

Text Books:

Telecommunication Transmission Systems by Robert G. Winch (McGraw Hill, 1993/1998)

Reference Books:

Principles of LED Light Communications: Towards Networked LiFi by Svilen Dimitrov, Harald Hass

Fundamentals of Microwave Photonics by V.J. Urick, Keith J. Williams, Jason D. McKinney (Wiley)

Course No: EE3110

Course Name: Probability Foundations for Electrical Engineers

ourse Type:

Theory

Description:

To introduce probabilistic reasoning at advanced UG level, with examples of applications

Course Content:

Introduction to Probability: Sets, Events, Axioms of Probability, Conditional Probability and Independence, BayesTheorem. Random Variables: Definitions, Cumulative Distribution Functions, mass and density functions, joint and conditional distributions, Functions of Random Variables, Special distributions Expectations: Mean, Variance, Moments, Correlation, Markov and Chebychev Inequalities, Moment-generating functions, Conditional Expectations Random Vectors: Jointly Gaussian random variables, Covariance Matrices, Linear Transformations, Diagonalization of Covariance Matrices Law of Large Numbers, Central Limit Theorem

Text Books:

Probability and Statistics, Morris DeGroot and Mark Schervish, Fourth Edition, Pearson

Reference Books:

Stark and Woods: Probability and Random Processes with Applications to Signal Processing, 3rd ed 2002,

Pearson Education

Bertsekas and Tsitsiklis: Introduction to Probability, 2nd Ed, 2008, Athena Scientific

Course No: EE3111

Course Name: Statistics for Electrical Engineers

Course Type:

Theory

Description:

To introduce the basic ideas of data analysis and statistics.

Course Content:

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Text Books:

1. Probability and Statistics, DeGroot and Schervish, Fourth Edition, Pearson
2. Mathematical Statistics and Data Analysis, John Rice, Third Edition, Cengage Learning

Reference Books:

1. Statistical Inference, Casella and Berger, Second Edition, Cengage Learning

Course No: EE3203

Course Name: Power Electronics

Course Type:

Theory

Description:

To introduce B.Tech and DD students to basics of Power Electronics. The student will learn about the devices used for power electronic applications and the circuit topologies used for rectification (ac to dc), conversion (dc to dc), inversion (dc to ac) and cyclo-conversion (ac to ac). This course is a pre-requisite for advanced courses related to power electronics.

Course Content:

Introduction

Features of Power Processing Systems: Ideal DC and AC waveforms; DC figures of merit – ripple factor and average value; AC figures of merit – harmonic factor, distortion factor, THD, power factor, crest factor. Semiconductor Devices: SCR – static V-I characteristics, dynamic characteristics, commutation, turn-on methods; Power Diode; Power MOSFET; IGBT.

Simple Power Electronic Circuits: SCR circuits with R load, RL load, RL load and freewheeling diode – continuousand discontinuous modes of operation.

Rectifiers: Single phase diode bridge – R load, constant dc-side current, effect of source inductance, constant

dc-side voltage; Three phase diode full-bridge with constant dc-side current – ideal circuit, effect of source

inductance; Single phase full-controlled thyristor bridge – constant dc-side current, effect of source inductance,inverter mode of operation; Three phase full-controlled thyristor bridge – constant dc-side current, effect of source inductance; Higher pulse rectifiers.

Converters: Basic non-isolated topologies: Buck, boost, buck-boost and cuk converters – steady state analysis under continuous and discontinuous modes of operation; Steady state analysis of a few isolated topologies.

Inverters: Pulse-width-modulated inverters – sine-triangle modulation, single phase half-bridge inverter, single phase full-bridge inverter – unipolar and bipolar schemes, three phase inverters; Square wave inverters – single phase and three phase (180 degree mode of operation); Effect of blanking time; Other inverter control techniques – single phase output control by voltage cancellation, Selective Harmonic Elimination (SHE), hysteresis control; AC Voltage Controllers: Configuration and basic operation, application.

Text Books:

1. Mohan N, Undeland TM. Power electronics: converters, applications, and design. John Wiley & Sons; 2007.

2. Erickson RW, Maksimovic D. Fundamentals of power electronics. Springer Science & Business Media; 2007.

Reference Books:

1. Rashid MH. Power electronics: circuits, devices, and applications. Pearson Education India; 2009.

2. Bimbhra PS, Kaur S. Power electronics. Khanna publishers; 2012.

Course No: EE3500

Course Name: Industrial Training (summer)

Course Type:

Others

Description:

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Course Content:

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Text Books:

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Reference Books:

Course No: EE4371

Course Name: Introduction to Data Structures and Algorithms

Course Type:

Theory

Description:

This is an introductory course on data structures and algorithms meant for students of electrical engineering, especially those interested in computer aided design and design automation. The course covers basic algorithmic complexity theory; data structures and algorithms for list-like structures, graphs, matrices; Algorithm Design Paradigms - greedy, divide and conquer, dynamic programming, backtracking.

Course Content:

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Text Books:

Aho, Hopcroft and Ullmann, "Data structures and Algorithm", Addison Welsey, 1984

Reference Books:

T. Cormen, C. Leiserson, R. Rivest and C. Stein, Introduction to Algorithms, 3rd Ed., MIT Press, 2009. E.

Horowitz, S. Sahni and S. Rajsekaran, Fundamentals of Computer Algorithms, Galgotia Publications, 2012

Course No: EE4502

Course Name: Optics for Engineers

Course Type:

Theory

Description:

Optics is used in many applications today. In fact, the field of optics has quietly gone from the research table to being used in numerous applications ranging from devices to metrology. Opto-electronics and metrology are already well-developed fields merging the areas of optics and electronics in many advanced and commonly used devices. For an electrical engineering student to be able to understand and design optics or electronics for such applications, it is important to understand some basic optics. This course will introduce these concepts at a level relevant for an engineer. The course will also study specific engineering examples with a detailed look at the optics and electronics of these systems.

Course Content:

1. Basic Optics

Geometric Optics

Gaussian Optics

2. Advanced topics in optical engineering

Diffractive Optics and holography

Interferometry

3. Opto-electronic applications with details of working. For example,

Barcode readers

Finger print sensors

Pick-up heads used in DVD/CD players

Biomedical instrumentation

Interferometers for metrology (Optical coherence tomography)

Sensors

Holographic data storage

4. Lab Content

Optical System Design using OSLO® or Zemax

Simulation lab/Experiments with interferometry, diffractive optics, etc

Text Books:

Introduction to Ray, Wave, and Beam Optics, IOP, Shanti Bhattacharya

Reference Books:

Optics by Ghatak, Tata McGrawHill, 2008

Prerequisite

Electromagnetics

Course No: EE4900

Course Name: B.Tech Project

Course Type:

Project

Description:

This course can be taken by B.Tech students, and by Dual Degree students towards B.Tech credit requirement.

Course Content:

Project Work

Text Books:

Not Applicable

Reference Books:

Not Applicable

Course No: EE4901

Course Name: Mini Project 1

Course Type:

Project

Description:

This course can be taken by B.Tech students, and by Dual Degree students towards B.Tech credit requirement.

Course Content:

Mini project 1

Text Books:

Not applicable

Reference Books:

Not applicable

Course No: EE4902

Course Name: Mini Project 2

Course Type:

Project

Description:

This course can be taken by B.Tech students, and by Dual Degree students towards B.Tech credit requirement.

Course Content:

Mini project 2

Text Books:

Not applicable

Reference Books:

Not applicable

Course No: EE4903

Course Name: Mini Project 3

Course Type:

Project

Description:

This course can be taken by B.Tech students, and by Dual Degree students towards B.Tech credit requirement.

Course Content:

Mini project 3

Text Books:

Not applicable

Reference Books:

Not applicable

Course No: EE5002

Course Name: Analysis of Networks & Systems

Course Type:

Theory

Description:

PG level second course on Networks and systems.

Course Content:

Introduction, Network theorems, Fourier and Laplace transforms,positive real functions, passive network synthesis, passive and activefilter basics, S-parameters and transmission lines, adjoint networks and sensitivity analysis, numerical analysis of Non-linear circuits andtransients, discrete-time systems and z-transforms, digital filterbasics, graph theory and state-variable analysis.

Text Books:

1) Introduction to circuit synthesis and designGabor C. Temes and Jack W. LaPatra,McGraw-Hill.

Reference Books:

Electrical network theoryNorman Balabanian, Theodore A. BickartWiley, 19693) Computer-aided Network

DesignD. A. CalahanMcGraw Hill, 19684) Network AnalysisM. Van ValkenburgPearson Education, 20065)

Introduction to Modern Network SynthesisM. Van ValkenburgJohn Wiley & Sons.

Prerequisite

UG courses on Electrical Circuits and Networks and systems

Course No: EE5004

Course Name: Seminar on the history of Electrical Engineering

Course Type:

Seminar

Description:

Students are expected to give a seminar on the life of an important person, history of a product, patent, concept, company or industry which is related to Electrical Engineering.

Course Content:

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Text Books:

None

Reference Books:

None

Course No: EE5110

Course Name: Probability Foundations for Electrical Engineers

Course Type:

Theory

Description:

PG-level introduction to Probability

Course Content:

Various definitions of probability, axioms of probability, basic properties derived from the axioms, conditional probability, total probability, Bayes' rule, Independence of events, combined experiments and independence, binary communication channel example (MAP and ML decoding).Random variables: Definition, cumulative distribution function (cdf), continuous, discrete and mixed random variables, probability density function (pdf),

examples of random variables, physical interpretation of pdf's (histograms), multiple random variables, joint distribution – definition and properties, joint density – definition and properties, marginal distribution and density, conditional distribution and density, independence of random variables, expectations, moments, central moments,

properties of expectation operator, mean, variance, Markov inequality, Chebyshev inequality, Chernoff bound, effect of linear transformations on mean and variance, autocorrelation, crosscorrelation, covariance, Cauchy-Schwartz inequality, conditional expectation, characteristic function, central limit theorem, transformations of single and multiple random variables, random vectors, properties of Gaussian random vectors.Random processes: Definition, stationarity, mean, correlation and covariance, wide-sensestationary random processes, examples of random processes, cross-correlation functions, joint wide-sense stationarity, time averages andergodicity, measurement of mean and autocorrelation function, transmission of random process through a linear filter relationship between input and output processes, power spectral density (PSD) – definition and properties,examples, relationship between input and output processes PSD for a linearfilter, periodograms, cross spectral

densities, Gaussian process – properties, white noise, noise equivalent bandwidth, narrowband noise, bandpass processes – representation, sampling.

Text Books:

1. Henry Stark and John W. Woods, Probability and Random Processes with Applications to Signal Processing,

Pearson Education, 2001.2. Robert M. Gray and Lee D. Davisson, An Introduction to Statistical Signal Processing,

Cambridge University Press, 2010.

Reference Books:

1. Athanasios Papoulis and S. Unnikrishna Pillai, Probability, Random Variables and Stochastic Processes,

McGraw Hill Higher Education, 2002.2. Geoffrey R. Grimmett and David R. Stirzaker, Probability and Random

Processes, Oxford University Press, 2001.

Course No: EE5111

Course Name: Estimation Theory

Course Type:

Theory

Description:

To teach the fundamentals of parameter estimation; To introduce topics of current research interest in Estimation

Theory

Course Content:

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Text Books:

S. M. Kay, "Fundamentals of Statistical Signal Processing: Estimation Theory," Prentice Hall, 1993.

Reference Books:

1. H. L. Van Trees, "Detection, Estimation, and Modulation Theory, Part I," John Wiley, 1968.

2. H. V. Poor, "An Introduction to Signal Detection and Estimation," Springer, Second Edition, 1998.

Course No: EE5112

Course Name: Detection Theory

Course Type:

Theory

Description:

To teach the fundamentals of hypothesis testing and signal detection; To introduce topics of current research

interest in detection theory

Course Content:

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Text Books:

H. V. Poor, "An Introduction to Signal Detection and Estimation," Springer, Second Edition, 1998.

Reference Books:

[1] S. M. Kay, "Fundamentals of Statistical Signal Processing: Detection Theory," Prentice Hall, 1998.

[2] H. L. Van Trees, "Detection, Estimation, and Modulation Theory, Part I," John Wiley, 1968.

Course No: EE5141

Course Name: Introduction to Wireless and Cellular Communication

Course Type:

Theory

Description:

Fundamentals of the wireless channel – analytical methods, modeling, computer simulation, and propagationeffects. Its impact on BER performance and system design. Overview of cellular systems 2G/3G/4G/5G – design,and technical aspects. A good foundation in diversity, capacity and MIMO aspects. In depth coverage of CDMAand OFDM systems

Course Content:

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Text Books:

T. S. Rappaport, "Wireless Communications – Principles and Practice" (2nd edition) Pearson, 2010, ISBN

9788131731864A. Molisch, "Wireless Communications," Wiley, 2005

Reference Books:

. Goldsmith, "Wireless Communications," Cambridge Univ Press, 2005Haykin & Moher, "Modern Wireless

Communications" Indian Edition, Pearson, 2011, ISBN 9788131704431D. Tse and P. Viswanath, "Fundamentals

of Wireless Communications," Cambridge Univ Press, 2005J. G. Proakis, "Digital Communications," McGraw Hill,

New York, 1989

Course No: EE5143

Course Name: Information Theory

Course Type:

Theory

Description:

Provide an introduction to information theory.

Course Content:

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Text Books:

Elements of Information Theory, by T. M. Cover and J. A. Thomas, 2nd Edition, John Wiley & Sons.

Reference Books:

A First Course in Information Theory by Raymond Yeung, Springer, 2002

Course No: EE5150

Course Name: Communication Networks

Course Type:

Theory

Description:

The course seeks to provide an analytical introduction to communication networking. The course will identifyimportant protocols and algorithms that are part of standard communication networks and motivate their designbased on simple performance analysis and evaluation. An exercise with network simulator, ns-3, will permit us to evaluate performance of complex network systems as well.

Course Content:

1) Introduction to common networks such as the Internet, WiFi, Cellular networks, Ad hoc and Sensor networks;

Introduction to ISO/OSI Layers; Deterministic and Stochastic Network Calculus, Introduction to NetworkSimulators;

2) Medium Access Control Layer: ARQ protocols; Random access; Backoff algorithms; WFQ implementations; Introduction to Queueing theory; Mesh networks;

3) Routing Layer: Routing algorithms for wired,

wireless and mobile networks; Multihop networks; Flow management and Rate region; Buffer management;

4) Transport Layer: TCP; UDP

5) Applications: Cross-layer Design; Network Monitoring; Performance Measures;

Notions of fairness; QoS;

Text Books:

1) Communication Networking: An Analytical Approach, Anurag Kumar, D Manjunath and Joy Kuri, Morgan

Kauffmann, 2004.2) Data Networks, 2nd Edition, Dimitri P Bertsekas and R Gallager, Pearson, 1992.

Reference Books:

1) Wireless Networking, Anurag Kumar, D Manjunath and Joy Kuri, Morgan Kauffmann, 2004.2) Resource

Allocation and Cross-Layer Control in Wireless Networks, Leonidas Georgiadis, Michael J. Neely and Leandros

Tassiulas, NOW Publishers, 2006.3) Computer Networks, A Tanenbaum, Pearson Education India, 5th Edition,

2013.4) Computer Networking: A top-down approach, James F Kurose, Pearson Education, 5th Edition, 2012.5)

Various research publications.

Course No: EE5160

Course Name: Error Control Coding

Course Type:

Theory

Description:

The course aims to give a detailed introduction to classical theory of block codes and convolutional codes with an emphasis on algebraic codes. It also introduces students to modern codes such as LDPC codes and turbo codes. A basic knowledge of linear algebra and probability is assumed.

Course Content:

1. Mathematical Preliminaries: Groups, rings, fields, vector spaces, linear algebra review, Finite fields:construction, structure of fields, polynomials over finite fields, minimal polynomials, factorization of polynomials

2. Linear block codes: Generator and parity check matrices, dual code, distance of a code.Decoding linear codes: MAP decoder, ML decoder, standard array and syndrome decoding, bounded distance decoder.Bounds on codes: Singleton, Hamming, Plotkin, Gilbert-Varshamov bounds and asymptotic bounds, Weight enumerators, MacWilliams relation for binary block codes, Code constructions: puncturing, extending, shortening, direct sum,

product construction, interleaving, concatenation, Performance of block codes

3. Important algebraic block codes: Cyclic codes, BCH codes, Reed-Solomon codes, Reed-Muller codes and Hamming codes, Berlekamp-Massey algorithm for decoding BCH and Reed-Solomon codes

4. Convolutional codes, Various formulations of convolutional codes using shift registers, generator sequences,polynomials, and matrices, recursive and non recursive encoders, Code parameters: constraint length, memory, free distance, Structural properties of convolutional codes: state diagram, trellis diagram, non-catastrophic encoders, weight enumerators, Decoding convolutional codes: Viterbi and BCJR algorithms, hard decision and soft decision decoding, Performance of convolutional codes

5. Capacity achieving codes: LDPC codes: Tanner graphs, Low density parity check (LDPC) codes, iterative decoding, bit flipping and sum product algorithmsIntroduction to turbo codes

Text Books:

Error control coding, 2nd ed. Shu Lin and Daniel Costello Jr., Pearson, 2004.Channel codes: Classical and

Modern by William E. Ryan and Shu Lin, Cambridge University Press, 2009.

Reference Books:

Error Correction Coding: Mathematical Methods and Algorithms by Todd K. Moon, Wiley 2006.Iterative Error

Correction by Sarah Johnson, Cambridge University Press, 2009.

Prerequisite:

Basic linear algebra and probability

Course No: EE5175

Course Name: Image Signal Processing

Course Type:

Theory

Description:

Image basics, geometric transformation of images, understanding image formation principles in pin-hole and real aperture cameras, image homography, image registration, image mosaicing, recovering 3D from 2D using different image cues, unitary image transforms and their relationship to 1D transforms, image enhancement techniques,image restoration methods, image superresolution

Course Content:

Basics: Applications of image processing. notion of pixel, resolution, quantization, photon noise, Geometric transformations, source-to-target and target-to-source mapping, planar and rotational homography, RANSAC for homography estimation, image registration, change detection, and image mosaicing.Motion blur: Exposure time,

weighted frame integration, depth aware warping, spatio-temporal averaging, dynamic scenes.Image Formation in Lens:Pin-hole versus real aperture lens model, lens as a 2D LSI system, blur circle, Doubly block circulant system matrix, pill box and Gaussian blur models, space invariant and space variant blurring.3D Shape from Focus:Depth of field, focal stack, focus operators, focus measure curve, Gaussian interpolation, 3D recovery, focused image recovery.Image Transforms:Data dependent and independent transforms, 1D Orthogonal transforms, Kronecker product, 2D orthogonal transforms from 1D, 2D DFT, 2D DFT for image matching, 2D DCT, Walsh-Hadamard transform, Karhunen-Loeve transform, eigenfilters, PCA for face recognition, singular value decomposition, image denoising using SVD.Photometric stereo: Normal estimation, depth reconstruction, uncalibrated PS, Generalized bas relief ambiguity. Image Enhancement:Thresholding methods (peak-valley, Otsu, Chow-Kaneko), histogram equalization and modification, Noise models, mean, weighted mean, median, weighted median, non-local means filter, BM3D, frequency domain filtering, illumination compensation by homomorphic filtering, segmentation by k-means clustering, higher-order statistics based clustering. Image Restoration:Well-posed and ill-posed problems, Fredholm-integral equation, condition number of matrix, conditional mean, Inverse filter, Wiener filter, ML and MAP restoration, image super-resolution.Edge Detection:Gradient operators, Prewitt, Sobel, Roberts, compass

operators, LOG, DOG, Canny edge detectors, non-maxima suppression, hysteresis thresholding.

Text Books:

Digital Image Processing by Gonzalez and Woods.

Reference Books:

The essential guide to image processing by Alan Bovik

Course No: EE5178

Course Name: Modern Computer Vision

Course Type:

Theory

Description:

In this course, we will cover both traditional and modern aspects of computer vision. The overarching goal of computer vision is to enable machines/computers to infer the visual world as we humans do. The input to a computer vision system is an image or video and the goal is to infer high level information about the visual scene . This task is usually achieved by low-level processing such as feature extraction from image/video, followed by mid-level processing such as grouping/segmentation, and ultimately by high level inference such as object and scene recognition. Inferring 3D geometry from an image or video is another important aspect of computer vision. We will cover both traditional and modern (deep learning) techniques for low, mid and high level vision and 3D geometry.

Course Content:

?Quick review of Deep Learning

Multilayer perceptron (MLP), Convolutional Neural Network (CNN), Recurrent Neural Network (RNN)

?Low level vision

Edge, line and corner detections; Image filtering; Features

?Geometry

Single-view geometry; Stereo geometry; Multi-view geometry; Photometric stereo

?Mid-level vision

Optical flow, Image segmentation; Tracking; CB Image Retrieval

?High-level vision

Viola-Jones detector; Bag of words model; Deformable parts model; Object recognition and detection; Image

captioning

Text Books:

1. Szeliski, Computer Vision: Algorithms and Applications, Springer, 2010 (online draft)

2. Hartley and Zisserman, Multiple View Geometry in Computer Vision, Cambridge University Press, 2004

Reference Books:

Forsyth and Ponce, Computer Vision: A Modern Approach, Prentice Hall, 2002

Prerequisite:

1. A formal course on linear algebra and probability 2. Familiarity with image processing

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Course No: EE5180

Course Name: Introduction to Machine Learning

Course Type:

Theory

Description:

In this course, students will be exposed to some of the widely used machine learning ideas/techniques which have applications in electrical engineering and related areas. In addition, they will shown the strong connections that machine learning has with the traditional EE areas like information theory, detection and estimation theory, signal processing, and control.

Course Content:

1. An introduction to machine learning: why and what. A comparison of artificial intelligence, machine learning, and widely adored deep neural networks.

2. The most fundamental problem of electrical engineering: decision making under uncertainty (elaborated with examples from communication and signal processing). Detection and estimation theory & machine learning: similarities and differences.

3. Supervised learning (discrete labels): signal detection without the knowledge of path loss and noise distribution, image recognition, etc. Linear classifier, support vector machine and kernel method. Logistic regression.

4. Supervised learning (continuous labels a.k.a. function learning): LTI system and channel estimation. Linear regression, support vector regression.

5. A brief tour of neural networks. Why function representation? Why NN? Why deep NN? Some architectures: convolutional neural networks (image processing), recurrent neural networks (communication and control). Training, backpropagation and SGD.

6. Unsupervised learning: vector quantization and clustering, k-means algorithm, spectral clustering

7. Sparse recovery: applications in signal processing. LASSO, ISTA.

8. Low dimensional structure in high dimensional data: PCA

9. Graphical model: a statistical model for error correction codes, social networks, etc. Markov random field (MRF), inference on MRF, learning MRF structure from data.

10. Reinforcement learning: applications in robotics and wireless scheduling. A brief introduction to Markov decision processes, TD(?) and Q-learning.

Text Books:

The course will follow different parts from different books and lecture notes. Here is a brief list of references.

1. Understanding Machine Learning: From Theory to Algorithms

by Shai Shalev-Shwartz and Shai Ben-David

2. Machine Learning: A Probabilistic Perspective

by Kevin P. Murphy

3. Reinforcement Learning: An Introduction

by Richard S. Sutton and Andrew G. Barto

4. Deep Learning

by Ian Goodfellow, Yoshua Bengio, and Aaron Courville

Reference Books:

1. http://users.ece.utexas.edu/~sanghavi/courses/EE381V_spring2013.html

2. http://www.cs.cmu.edu/~ninamf/courses/601sp15/lectures.shtml

Prerequisite

EE3110 or equivalent AND basics of linear algebra (vector, matrix, norm, eigenvalue, SVD, etc.)

Course No: EE5203

Course Name: Switched Mode Power Conversion

Course Type:

Theory

Description:

To familiarise students with the techniques of modelling of converter topologies and their impact on the development of control strategies.

Course Content:

) Power Converters

• Introduction, DC-DC Converter: Linear regulators, switched mode converters: Topologies,

Non-isolated/isolated, constituent elements, operating principles, steady state analysis and

Steady state model in continuous and Discontinuous mode of operation. Steady-State

Equivalent Circuit Modelling, Losses, and Efficiency, Techniques of Design-Oriented

Analysis with application to switching converters.

2) Modelling of switching converters

• AC Equivalent circuit modelling of converters and simulation of converters operating in continuous mode, State Space averaged model, averaged switch modelling, canonical circuit model, transfer functions of switching converters.

3) Control Schemes and controller design

• Popular techniques for controlling switching converters: Voltage control, current programmed control: Average-current, peak-current-mode, Effects of current mode control on basic transfer functions, Frequency control techniques.

• Controller design in frequency Domain

• Concepts on application of non linear control techniques to power converters.

4) Soft Switching converters

ZVS/ZCS schemes, Topologies and control and analysis of various resonant / soft-switching dc-dc converters

Text Books:

1) R. W. Erickson and D. Maksimovic , "Fundamentals of Power Electronics", 2nd edition, Springer Science and Business Media Inc.

Reference Books:

1) Issa Batarseh, Power Electronic Circuits, John Wiley, 2004.

2) Philip T krein, Elements of Power Electronics, Oxford Press.

3) Marian P. Kazmierkowski, R. Krishnan and Frede Blaabjerg, "Control in Power Electronics", A volume in Academic Press Series in Engineering

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Course No: **EE5254**

Course Name: **High Voltage Technology**

Course Type:

Theory

Description:

To demonstrate and tell students the fundamental aspects of high voltage generations, measurements and testing of power apparatus.

Course Content:

Generation and measurement of high AC, DC and transient voltages. fundamental aspects of insulation engineering, Power apparatus testing and life estimation of power apparatus.

Text Books:

E. Kuffel, W.S. Zaengl and J. Kuffel, High voltage Engineering fundamentals, Newnes, 2000

Reference Books:

M.S. Naidu and Kamaraju, High voltage Engineering, Second Edition, McGraw-Hill, 1996.

Course No: EE5257

Course Name: Energy Management Systems and SCADA

Course Type:

Theory

Description:

This course provides an introduction various to Energy Management Systems (EMS) Applications in Power Systems, which includes various network analysis programs and methods which are executed in the load dispatch center. Introduction to the hardware and software components of SCADA (Supervisory Control and Data Acquisition), which is an interface between the Physical Power System and the EMS programs, will be discussed with latest developments and advancements. Integration of EMS and SCADA for various applications will be discussed and studied.

Learning Outcomes: The students will learn about the various Applications Programs (Aps) running in an Energy

Management Systems (EMS) and Their execution through SCADA. Development of some of the important

algorithms in an EMS and case studies SCADA will be considered.

Course Content:

1. Energy Management Systems

Introduction: Introduction and Evolution of EMS from Control Centers to Energy Control Centers to EMS.

Functions and Benefits of EMS; SEBs Monitoring and Control.

Architecture and Applications: Various Architecture of EMS, On / offline Functions of EMS, Real Time Modeling and Applications of EMS:

Energy Management Systems Control: Automatic Generation Control (AGC). Load Frequency Control (LFC), Voltage Reactive Power Control (VQC);

Case Studies of Energy Management Systems: Security Assessment; Dispatch, Contingency analysis. Study Mode Applications: Forecasting: Power Flow, Optimal Power Flow, State Estimation, Security Assessment.

2. SCADA (Supervisory Control and Data Acquisition)

Introduction and Evolution of SCADA, Functions and Benefits of SCADA, Various Architecture of SCADA. Modules

and Components of SCADA. SCADA Hardware RTU; IED SAS Architectures.

SCADA Software IEC618950; Protocol GOOSE; Configurations of SCADA, RTU (Remote Terminal Units) Connections. SCADA Communication requirements, protocols: Past Present and Future. Applications of SCADA

i) Power Systems; ii) Railways, iii) Renewal Energy and iv)Smart Grid; Power SCADA:

Automation; Protection; Relay Interoperability

Text Books:

1. E. Handschin . A. Petroian “Energy Management Systems Operation and Control of Electric Energy

Transmission Systems” Springer-Verlag, 1991

2. Gordon Clarke, Deon Reynders, Edwin Wright, Practical Modern SCADA Protocols: DNP3, 60870.5 and

Related Systems, Elsevier, 2004.

Reference Books:

3. Richard A. Panke , “Energy Management Systems And Direct Digital Control” , The Fairmont Press, 2003.

4. David Bailey,Edwin Wright, Practical SCADA for Industry, Elsevier, 2003.

5. R William Payne, John J. McGowan, Energy Management And Control Systems, Handbook, 1988.

Prerequisite: Power Systems

Course No: EE5262

Course Name: Distributed Generation and Microgrid Systems

Course Type:

Theory

Description:

The objectives of this course are to study the fundamentals of microgrid systems and their components, analyse the operation and control strategies employed in modern microgrids, evaluate the seamless integration of renewable energy sources into microgrid systems, and examine the challenges associated with grid interaction.From the acquired knowledge, students will gain the capability to proficiently design, simulate and develop modern microgrid systems.

Course Content:

1. Introduction: Overview of energy scenario of renewable and non-renewable energy sources, Distributed generation consisting of AC and DC type renewable energy sources (RES), architecture of microgrid and its components, photo voltaic system, wind energy systems, V2G, G2V operations, islanded and grid connected modes of microgrid operation, electrical storage and energy management

2. Solar Energy Systems: Photovoltaic power conversion, PV characteristics, efficiency, design and modelling of photovoltaic units, maximum power point operation

3. DC Interface: DC-DC converters for microgrid, topologies and control schemes for PV fed DC-DC converters, design and analysis of bidirectional converters, DC bus formation architecture

4. Energy Storage Systems: Types of storage systems, modelling and analysis of battery, supercapacitor storage

system, design of storage system for reliable operation of microgrid

5. Wind Energy Systems: Wind turbines, structure, dynamics and arrangements, Review of squirrel cage, wound rotor induction generator, operation of doubly fed induction generator, permanent magnet synchronous generator connected microgrid

6. AC Interface: DC-AC voltage source converters for microgrid, control of active, reactive power flow based on renewable power and local reactive power, parallel operation on converters

7. Grid Interaction: Grid-connected operation, synchronization, grid following and grid forming modes, vehicle to grid to vehicle operation, power quality aspects and islanding operation, power management schemes

Text Books:

1. Design of Smart Power Grid Renewable Energy Systems, Ali Keyhani, IEEE Press, Wiley, 2011.

2. Grid Converters for Photovoltaic and Wind Power Systems, Remus Teodorescu, Marco Liserre and Pedro

Rodriguez, IEEE Press, Wiley, 2011.

Reference Books:

1. Control of Power Electronic Converters and Systems, Frede Blaabjerg, Academic Press, Elsevier, 2016.

2. Advanced Control of Doubly Fed Induction Generator for Wind Power Systems, Dehong Xu, Frede Blaabjerg,

Wenjie Chen and Nan Zhu, IEEE Press, Wiley, 2018.

3. Voltage Sourced Converters in Power Systems, Amirnaser Yazdani and Reza Iravani, IEEE Press, Wiley, 2010.

4. Wind and Solar Power Systems, by Mukund R. Patel and Omid Beik, CRC Press, Taylor and Francis Group,

2021.

Prerequisite: B. Tech./DD with power electronics (EE3203)

Course No: EE5314

Course Name: Microelectronics Lab

Course Type:

Lab

Description:

Objectives:

a) To get hands-on experience in the process integration of simple semiconductor device like MOS capacitor or

Silicon solar cell which involves at least two lithography levels

b) To perform semiconductor process and device simulation

c) To do Electrical characterization and model parameter extraction

Course Content:

Course Contents:

1) Fabrication of MOS Capacitor and/or Silicon solar cell or any other simple semiconductor/MEMS device which

involves at least two lithography levels

2) Semiconductor process and device simulation

3) Electrical characterization and model parameter extraction

Text Books:

Integrated Circuit Fabrication: Science and Technology by James D. Plummer and Peter B. Griffin, Cambridge

University Press, 2023

Reference Books:

Introduction to Microfabrication 2/e by Sami Franssila, John Wiley & Sons Inc

Prerequisite: Fundamentals of Microfabrication and Semiconductor devices

Course No: EE5320

Course Name: Analog IC Design

Course Type:

Theory

Description:

To teach students advanced concepts in analog circuit and IC design, and their analysis and simulation.

Course Content:

1. Introduction to IC design and concepts2. Noise and mismatch in analog design3. Advanced concepts in Negative Feedback4. One-stage opamps5. Two-stage op-amps, compensation6. Fully differential opamps7. Advanced topics in analog IC design such as PLLs, bandgap references

Text Books:

Design of Analog CMOS Integrated Circuits by Behzad Razavi; Tata McGraw-Hill, 2006 (ISBN: 0070529035)

Reference Books:

NIL

Course No: EE5323

Course Name: Advanced Electrical Networks

Course Type:

Theory

Description:

To teach students advanced concepts in electrical network analysis and simulation.

Course Content:

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Text Books:

None.

Reference Books:

Selected papers from the IEEE Trans. On Circuits and Systems, IEEE Trans. On Microwave Theory and Techniques, the IEEE Journal of Solid State Circuits and the Proceedings of the IEEE.

Course No: EE5325

Course Name: Power Management Integrated Circuits

Course Type:

Theory

Description:

To develop understanding of why power management circuits are needed in a VLSI system. What are different components of a power management system with focus on dc-dc converters. How to design a chip level dc-dc converter from a given system level specifications.By the end of this course, students should be able to understand the concept behind power management circuits and be able to design a dc-dc converter for a specific system using behavioral and circuit level simulators such as

MATALB/Simulink and Cadence. Students should be able select various parameters such as switching frequency, inductor and capacitor values for best performance and efficiency.

Course Content:

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Text Books:

Switch-Mode Power Supplies: SPICE Simulations and Practical Designsby Christophe P. BassoIndian

Edition:Publisher: BPB Publications (1 December 2010)Language: EnglishISBN-10: 8183332919ISBN-13:

978-8183332910International Edition:Publisher: McGraw-Hill Professional, (1 February 2008)Language:

EnglishISBN-10: 0071508589ISBN-13: 978-0071508582

Reference Books:

1. Fundamentals of Power Electronics, 2nd editionby Robert W. Erickson, Dragan MaksimovicIndian

Edition:Publisher: Springer (India) Pvt. Ltd. (2005)ISBN-10: 8181283635ISBN-13: 978-8181283634International

Edition:Publisher: Springer; 2nd edition (January 2001)Language: EnglishISBN-10: 0792372700ISBN-13:

978-0792372707 2. Power Management Techniques for Integrated Circuit DesignBy Ke-Horng ChenPublisher:

Wiley-Blackwell (29 July 2016)ISBN-10: 1118896815ISBN-13: 978-1118896815

Course No: EE5332

Course Name: Mapping Signal Processing Algorithms to DSP Architectures

Course Type:

Theory

Description:

To understand properties of digital signal processing algorithms that are relevant to their hardware implementation, and use these insights to design appropriate hardware/software architectures for such systems.

Course Content:

Course topics: - Architectures for VLSI implementation of signal processing systems - Multi-core, many-core, hardware accelerators - Metrics for analysis and comparison of architectures - DSP algorithms, properties relevant to hardware realizations - Modifications to algorithms to improve hardware realizability - Models such as dataflow graphs and their use in architecture exploration - Communication architectures, networks on chip – Specialized architectures for DSP functions The course also has a lab component that could include C/C++ coding, Verilog etc., but is not intended to teach these languages in detail.

Text Books:

K. K. Parhi, VLSI Digital Signal Processing, Wiley 1999

Reference Books:

DSP Integrated Circuits, L. Wanhammar; papers and online reference material.

Prerequisite: **UG DSP required, Digital IC design recommended**

Course No: **EE5333**

Course Name: **Introduction to Physical Design Automation**

Course Type:

Theory

Description:

Understand the complexity of automating industrial-scale integrated circuit layouts and the various sub-problems involved. Learn relevant algorithms and appreciate the effort involved in building practical solutions.

Course Content:

1) Introduction: Motivating examples, basics of graph theory (Revise/introduce internals of transistor level layouts, Steps involved in the physical design flow, demo complexity of layout generation using industrial layouts, netlists as graphs/hypergraphs; Assignment: parse netlist and represent as graphs/hypergraphs.)

2) Partitioning: Kernighan-Lin, Fiduccia-Mattheyses algorithms, and multilevel partitioning (Introduce divide-and-conquer paradigm, partitioning as a follow-through, complexity of partitioning; various classes of algorithms to partition; Assignment: Implement the partitioning algorithms and compare results for benchmark circuits)

3) Floorplanning: Representations, constraint graphs, slicing, non-slicing, sequence-pairs, simulated annealing and pin assigment. (Floorplanning objective, various abstract representations of floorplans, transforming representations to constraint graphs, solving constraint graphs to realize concrete floorplans, optimization of floorplans for estimated area and wire length using simulated annealing; Assignment: generate floorplans for previously partitioned circuits and assign ports)

4) Placement: Digital and AMS placement; Integer Linear Program (ILP) and simulated annealing placers, min-cut and analytic (quadratic and force-directed) global placement, legalization and detailed placement; (Complexity of placement, Need for global and detailed placement, various placement algorithms; Assignment: Place cells in each of the blocks in previous floorplan)

5) Routing: Single-net routing: spanning trees, shortest path routing using Dijkstra and A*, ILP routing; handling multi-net routing, channel routing, clock-tree synthesis, symmetric, length-constrained and octilinear routing (Problems in routing, Introduce nets, wires, and constituent routing shapes; algorithms to connect pins using shortest path routes; handling conflicts in routing multiple nets; introduce routing of special nets; Assignment: implement shortest path and global routing)

6) Design rule checks: Commonly encountered DRCs, Boolean operations on polygons and region query. (Complexity in physical design arising from advanced manufacturing; design rules from foundries and their sources; boolean operations on polygons to verify design rule compliance; region query for faster verification; Assignment: Implement a DRC checker for a given set of rules)Programming assignments will be in Python/C/C++.Prerequisite: Rudimentary programming experience in either Python/C/C++

Text Books:

VLSI Physical Design: From Graph Partitioning to Timing Closure, A. B. Kahng, J. Lienig, I. L. Markov, and J. Hu.

Reference Books:

VLSI Physical Design Automation, S. M. Sait and H. Youssef.Handbook of Algorithms for Physical Design

Automation, C. J. Alpert, D. P. Mehta, S. S. Sapatnekar.

Course No: EE5340

Course Name: Micro Electro Mechanical Systems

Course Type:

Theory

Description:

To study the design, fabrication and functioning of Micro Electro Mechanical Systems

Course Content:

Introduction to MEMSSurface micromachining, Oxide anchored Cantilever beam, poly anchored beamsLPCVD poly silicon deposition, doping, oxidationTransport in PolySi, 2 and 3 terminal beamsBulk micromachining; Wet etching –isotropic and anisotropic; Etch stop – Electrochemical etching; Dry etching; BondingComparison of bulk and Surface micromachining: LIGA; SU-8; Moulding processes;Stiction: process, in-use, Measuring stictionPull-in parallel plate capacitorPressure Sensor: piezo-resisitivity, Diffused Si, Poly, porous SiBeams: Structure; force, etcAccelerometer. Quasi-static, capacitive, equivalent circuit; Analog; Tunnel; Thermal accelerometerRate GyroscopeBiosensor and BioMEMS; Microfluidics; Digital Microfluidics; Ink jet printerOptical MEMS: Displays -DMDs, LGVs, active and passive componentsRF MEMS: switches, active and passive componentsPackaging; ReliabilityScalingOther materials/ actuatorsBy TAsMEMS software training: COMSOL & IntellisuiteSome process technology (Litho, oxidation, etc)

Text Books:

Microsystems design, Senturia

Reference Books:

Microfabrication, MadouPolycrystalline Si, Ted Kamins

Prerequisite: COT

Course No: EE5342

Course Name: Compound Semiconductors - Properties and Applications

Course Type:

Theory

Description:

To discuss and understand the merits and challenges of compound semiconductor based electronic and

opto-electronic devices

Course Content:

1. Introduction to Compound Semiconductors

2. Band structure and crystal structure of most widely used compound semiconductors e.g. GaAs, InP, GaN, SiC

and comparison with silicon.

3. Technology of Compound Semiconductor devices with emphasis on bulk crystal growth, epitaxy (MOCVD,

MBE), Ion-implantation, etching and metallization.

4. Electronic Devices on compound semiconductor platforms: MOSFET, MESFET, HEMT, HBT

a. MOS devices on GaAs and the problems

b. MESFET

c. Heterojunctions and heterojunction based devices (HEMT and HBT) on different material systems

d. GaN and GaAs RF devices

e. GaN and SiC Power electronic devices

5. Optoelectronic devices on compound semiconductor platforms: Solar cells, Photodetectors, LEDs and LASERs

Text Books:

1. VLSI Fabrication Principles by S.K.Ghandhi, Wiley

2. High-Speed Semiconductor Devices ed S.M.Sze, Wiley

3. Physics of Semiconductor Devices by Michael Shur, PHI

4. Optoelectronics and Photonics by S.O. Kasap, Pearson

5. Silicon Carbide Power Devices by B. Jayant Baliga, World Scientific

Reference Books:

1. Nitride Semiconductor Devices ed J.Piprek, Wiley-VCH

2. Fundamentals of Power Semiconductor Devices by B. Jayant Baliga, Springer

Prerequisite: EE5313 (Semiconductor Device Modelling) for EE M.Tech, MS and Ph.D; EE 3001 (Solid State Devices) for EE B.Tech/DD and EE3301 (Introduction to Semiconductor Devices) for non-EE B.Tech/DD students

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Course No: EE5343

Course Name: Solar Cell Device Physics and Materials Technology

Course Type:

Theory

Description:

Solar photovoltaic (PV) technology is making rapid strides worldwide, and major efforts are underway in India at present to take the lead in PV manufacturing. It is hence essential to expose and educate engineering graduates in this important field of renewable energy, and prepare them for industrial and academic R & D.

Course Content:

Motivation - Energy, Environment. Limits in Efficiency Semiconductor materials, Energy gap, Doping. Electrical conductivity, Transport equation, Application of transport equations

Optical properties of semiconductors, Excess carriers, Recombination dynamics, Lifetime, Diffusion lengths. p-n junctions, dc IV characteristics and Photocurrent in Solar cell configurations, Efficiencies (solar cell parameters) and spectral response, Losses in solar cells, Equivalent circuits, Measurement Techniques Crystalline Si solar cells, Polycrystalline and amorphous silicon solar cells, Heterojunctions - interfaces and cells, GaAs/AlGaAs solar cells, InP/CdS/CIGS/CdTe solar cells, Growth and fabrication techniques, Organic solar cells, 3rd generation solar cells - technology, ideas, designs

PV Systems: Introduction to PV System, Construction, Solar Irradiation and Panels, Effect of Insolation and Temperature on V-I Curve, Shading and Tilt angle In Solar Energy, Charge Controller in Solar Energy System, Maximum Power Point Tracking (MPPT) Charge Controllers Off-Grid and on-grid Solar Systems. Protection of PV Systems. Batteries in PV System Lab and hands on experience (CEC)

I-V Curve, Series & Parallel of PV Modules, Series type Charge Controller, Shunt type Charge Controller, MPPT and Current booster, Diodes in PV System (Bypass and Blocking diodes), Charge and Discharge of PV batteries, PV Inverter, PV Water pumping system, Off Grid Solar Energy System, On Grid Solar Energy System.

Text Books:

1. Fundamentals of solar cells: A. L. Fahrenbruch and R. H. Bube. (Textbook)

2. Solar Cells Materials, Manufacture and Operation, 2nd Edition, Augustin McEvoy, L. Castaner, Tom Markvart

Reference Books:

1. Semiconductor physics and devices, D. A. Neamen.

2. Physics of semiconductor devices (2nd Ed.): S. M. Sze

3. Review papers and other referred materials will be distributed in class.

Prerequisite: Basics of semiconductor devices

Course No: EE5351

Course Name: Linear Algebra Techniques for data analysis and modelling

Course Type:

Theory

Description:

1. Linear algebra tools required for data analysis and dimensionality reduction2. Reduced order modelling: Subspace projection methods for efficient analysis of dynamical systems, in particular for circuit simulation.

Course Content:

Vector spaces, spaces associated with a matrix, linear transformations, similarity transformations.Solution of linear system of equations, LU and QR decomposition, orthogonal and oblique projections, pseudo-inverse,singular value decomposition.Applications to data analysis: Regression, Principal component analysis, factor analysis, linear discriminant analysis, compressed sensing.Application to modelling: System identification, dimensionality reduction of a system of differential equations, Krylov subspace techniques, data-driven modelling.

Text Books:

1. A.C.Antoulas, Approximation of large-scale dynamical systems, SIAM2. Dan A. Simovici, Linear Algebra tools

for data mining, World Scientific3. Nathan Kutz, Data driven modelling and scientific computation, Oxford Universit

press.4. G.Strang, Linear Algebra and its applications.

Reference Books:

None

Course No: EE5402

Course Name: Industrial Internet-of-Things (IoT)

Course Type:

Theory

Description:

• To comprehend the principles, components, and technologies of Industrial IoT and how to incorporate them into

an ecosystem to optimize the business value of the IoT.

• To develop skills in designing and implementing sensors, network architectures, communication protocols and

data analytics techniques for Industrial IoT applications.

• To explore methods of data aggregation and analysis using machine learning, edge and cloud computing

paradigms and their utilization for different business objectives.

• To learn how to drive digital transformation of industries through the Industrial IoT to gain business insights and

significant traction in the IoT space and claim market opportunities.

Course Content:

Course Contents:

1. General Introduction to the IoT and applications in the Industry

- IoT evolution, vision, tools, concepts and the role of humans in the loop

- Digital transformation and redefining industry boundaries, IoT markets and technologies, Technical and business challenges

- IoT standardization and implementation considering things-centric, data-centric, service-oriented applications.

2. Sensors and Data Communication

- Sensors as IoT data sources: Smart devices, Sensor data formats, Wireless sensor nodes, Sensor swarms, MEMS, Sensor nano/microfabrication, Performance parameters of sensors, Energy harvesting architectures, Batteryless/Self-powered devices

- Network architectures and communication protocols for IoT: Overview and comparison, in the application context, of PAN, LAN, MAN, WAN, LPWAN, USB, Ethernet, Bluetooth/Bluetooth Low Energy, ZigBee, NFC, RFID, Wi-Fi, WiMax, LoRaWAN, 4G, 5G, LTE, UDP, TCP, IPv6, 6LoWPAN, RPL

- Data ingestion and aggregation: Data integrity, Data validation, Data refinement, IoT supported Microprocessors, Microcontrollers and SoCs

3. Machine Learning and Analytics – with focus on Industrial Applications

- Machine Learning and Deep Learning: Regression, Support Vector Machines, Decision trees, Neural Networks, Long Short Term Memory networks, Data mining, Artificial Intelligence

- Storage, analytics and insights: SQL and NoSQL databases, Time series databases, Encryption/Decryption, Edge intelligence, Cloud computing, Big data analytics, Real-time analytics frameworks, Data visualization, HTTP, HTTPS, MQTT, AMQP, XMPP, CoAP, RESTful, JSON, Predictive analysis, Prescriptive analysis

Text Books:

Hanes, D., Salgueiro, G., Grossetete, P., Barton, R., & Henry, J. (2017). IoT fundamentals: Networking

technologies, protocols, and use cases for the internet of things. Cisco Press

Reference Books:

1. Dian, F. J. (2023). Fundamentals of Internet of Things: For Students and Professionals. John Wiley & Sons.

2. Kranz, M. (2016). Building the internet of things: Implement new business models, disrupt competitors,

transform your

industry. John Wiley & Sons.

3. James, A., Seth, A., & Mukhopadhyay, S. C. (2022). IoT System Design—

A Project Based Approach (pp. 9-33). Springer International Publishing.

4. V., Karnouskos, S., Holler, J., Boyle, D., & Mulligan, C. (2018). Internet of Things: technologies and applications

for a

new age of intelligence. Academic Press.

5. Bahga, A., & Madisetti, V. (2014). Internet of Things: A hands-on approach. Vpt.

6. Chou, T. (2016). Precision: principles, practices and solutions for the internet of things. Lulu Press, Inc.

Prerequisite: EE3006, for B. Tech., BS and DD

Course No: EE5410

Course Name: Introduction to Digital Signal Processing

Course Type:

Theory

Description:

To introduce the fundamentals of Digital Signal Processing

Course Content:

Discrete-Time Signals and Systems: Basic discrete time signals (unit impulse, unit step, etc.)—complex exponentials and differences between their continuous-time counterparts—scaling of the independent axis—system properties (linearity, time-invariance, memory, causality, BIBO stability)—LTI systems described by linear constant coefficient difference equations (LCCDE).Discrete-Time Fourier Transform (DTFT): Complex exponentials as eigensignals of LTI systems—DTFT definition—inversion formula—properties—relationship to continuous-time Fourier series (CTFS).Z-Transform: Generalized complex exponentials as eigensignals of LTI systems—z-transform definition—region of convergence (RoC)—properties of RoC—properties of the z-transform—inverse z-transform methods (partial fraction expansion, power series method, contour integral approach)—pole-zero plots—time-domain responses of simple pole-zero plots—RoC implications of causality and stability. Frequency Domain Analysis of LTI Systems: Frequency response of systems with rational transfer function—definitions of magnitude and phase response—geometric method of frequency response evaluation from pole-zero plot—frequency response of single complex zero/pole—frequency response of simple configurations (second order resonator, notch filter, averaging filter, comb filter, allpass systems)—phase response—definition of principal phase—zero-phase response—group delay—phase response of single complex zero/pole—extension to higher order systems—effect of a unit circle zero on the phase response—zero-phase response representation of systems with rational transfer function—minimum phase and allpass systems—constant group delay and itsconsequences— generalized linear phase—conditions that have to be met for a filter to have generalized linear phase—

four types of linear phase FIR filters—on the zero locations of a linear phase FIR filter—constrained zeros at z = 1 and at z = -1 and their implications on choice of filters Type I through Type IV when designing filters—frequency response expressions for Type I through Type IV filters.Sampling: Impulse train sampling—relationship between impulse trained sampled continuous-time signal spectrum and the DTFT of its discrete-time counterpart—scaling of the frequency axis—relationship between true frequency and digital frequency—reconstruction through sinc interpolation—aliasing—effects of oversampling—discrete-time processing of continuous-time signals.Introduction to the DFT—FFT: Decimation in Time (DIT) algorithm.

Text Books:

Discrete-Time Signal Processing by Alan V. Oppenheim and Ronald W. Schafer, 3rd edition, 2010, Prentice Hall,

Upper Saddle River, NJ.

Reference Books:

(1) Digital Signal Processing by John G. Proakis and Dimitris K. Manolakis, 4th edition, 2007, Prentice Hall, Upper

Saddle River, NJ.(2) Digital Signal Processing by Sanjit Mitra, 4th edition, 2011, McGraw-Hill, New York, NY.(3)

Essentials of Digital Signal Processing by B.P. Lathi and R.A. Green, 2014, Cambridge University Press, New

York, NY

Prerequisite: **EE1101 Signals and Systems or equivalent**

Course No: **EE5419**

Course Name: **Advanced Control Laboratory**

Course Type:

Lab

Description:

At the end of the course the students will be able to

* Model, design and simulate controllers for electro-mechanical systems

* To interface sensors and actuators to implement the control laws on digital platform

* Have practical knowledge of control systems

Course Content:

Some experiments from the following list will be offered:

1. Position control of inertia disk
2. Stabilization of an inverted pendulum on a cart
3. Position control of flexible-link manipulator
4. Way-point and trajectory tracking of mobile robots
5. IMU-based hovering control of quadrotor
6. Pitch and yaw stabilization of twin-rotor system
7. Experiments involving ARM programming, Lego kits and use of Matlab toolboxes in ML/RL

Text Books:

Lecture notes from the following courses

1. Synthesis of Control Systems (EE5411)
2. Linear Dynamical Systems (EE5413)
3. Non-linear Control Systems (EE6415)

Reference Books:

Lab Manual

Course No: EE5502

Course Name: Optical Engineering

Course Type:

Theory

Description:

Optics is used in many applications today. Opto-electronics and metrology are already well-developed fields merging the areas of optics and electronics in many advanced and commonly used devices. For an electrical engineering student to be able to understand and design optics or electronics for such applications, it is important to understand some basic optics. This course will introduce these concepts at a level relevant for an engineer. The

course will also study specific engineering examples.

Course Content:

1. Basic Optics Geometric Optics Gaussian Optics Fourier Optics2. Interferometry Diffractive Optics and holography Advanced topics in optical engineering3. Opto-electronic applications with details of working. Barcode readers Finger print sensors Pick-up heads used in DVD/CD players Biomedical instrumentation Interferometers for metrology Sensors Holographic data storage4. Lab Content Optical System Design using OSLO® Experiments with interferometry, diffractive optics, CD pick-ups

Text Books:

Introduction to Ray, Wave, and Beam Optics, IOP, Shanti Bhattacharya

Reference Books:

Optics by Ghatak, Tata McGrawHill, 2008

Prerequisite: **UG Electromagnetics course**

Course No: **EE5504**

Course Name: **Fiber Optic Communication Technology**

Course Type:

Theory

Description:

Understand the fundamental principles of fiber optic communications

Develop the ability to design fiber optic communication links according to specific requirements

Course Content:

I. Single Hop Optical Communication Links

Motivation for optical communication links

Optical fiber characteristics – concept of modes, origin of attenuation/dispersion

Semiconductor light sources and detectors – double hetero-structures, LI and modulation characteristics, responsivity and bandwidth of PIN/APDs

Noise in optical receivers – shot/thermal noise limitations, BER measurements

Design of single-hop communication links - power/rise-time budget, power penalty

External light modulators – modulation bandwidth, extinction ratio, modulation formats

II. Multi-Hop Optical Communication Links

Concept of Wavelength Division Multiplexing (WDM), WDM components

Optical Amplifiers – Erbium Doped Fiber Amplifiers (EDFA), gain saturation, ASE noise, noise figure

Design of WDM links – power/rise-time budget, power penalty

Influence of nonlinearities in WDM links

III. Optical Fiber Networks

Introduction to Optical Networking

Design of SDH networks

Text Books:

G.P. Agrawal, Fiber Optic Communication Systems, John Wiley, 2003

Reference Books:

Gerd Keiser, Optical Fiber Communications, 3/e, McGraw Hill, 1999.

Rajiv Ramaswamy, Kumar N. Sivarajan and Galen Sasaki, “Optical Networks - A Practical Perspective”, 3/e,

Morgan and Kaufmann, 2008

Prerequisite: **Undergraduate-level course in electro-magnetics or optics**

Course No: EE5507

Course Name: RF Systems Laboratory

Course Type:

Lab

Description:

To introduce students to experiments with RF devices for radars, communication and imaging. At the end of this course, students would be able to understand the working of a Vector Network Analyser, measure the S parameters of some commonly used RF components, measure the radiation pattern of different types of antennas, demonstrate generation and detection of commonly used modulations, configure transmitters and receivers for mm wave communication, demonstrate sensing using mm waves and demonstrate the commonly used signal processing tasks in radar systems.

Course Content:

The laboratory will comprise of experiments that include characterisation of a microwave source, assembling a network analyzer, measurement of S-parameters of devices, microstrip and patch antenna fabrication and characterisation, radiation pattern measurement - single antenna and antenna arrays, modulation, detection and signal processing, THz imaging. Experiments will be supported with design and simulation exercises as applicable.

Text Books:

Michael Steer, Fundamentals of Microwave and RF Design, Third Edition, NC State University Press (Open

Access), 2019

Reference Books:

Application notes and other online r

Course Name: Power Laboratory

Course Type:

Lab

Description:

At the end of the course the students will be able to

* Perform power flow and short circuit analysis

* Analyze power quality of a three-phase balanced/unbalanced linear/Non-linear system

* Analyze a dc and an ac drive system and experimentally validate the same in the hardware

* Generate and measure high voltage ac, dc and lightning impulse

Course Content:

List of experiments

1. Power flow and short circuit analysis of a power system
2. Analysis of three-phase four wire balanced/unbalanced system
3. Compensation of unbalanced delta connected linear loads
4. Compensation of unbalanced Non-linear loads
5. Demonstration of DSTATCOM
6. Familiarization of Lab View
7. DC Drive
8. AC Drive
9. Generation and measurement of high ac and dc voltages
10. Generation and measurement of lightning impulse voltage

Text Books:

None

Reference Books:

1. John J Grainger and William D Stevenson Jr., Power System Analysis, Tata McGraw Hill, 1994

2. Arindam ghosh and G. Ledwich, Power Quality Enhancement using Custom Power Devices, Kluwer Academic,

2002.

3. Mohan, Ned, Tore M. Undeland, and William P. Robbins. Power electronics: converters, applications, and

design. John Wiley & Sons, 2003.

4. B. K. Bose, Power Electronics and AC Drives, Prentice Hall, 1986

5. E. Kuffel, W.S. Zaengl and J. Kuffel, High voltage Engineering fundamentals, Newnes, 2000

Prerequisite: COT

Course No: Data Analytics Laboratory - EE5708

Description

Offered by Department of Electrical Engg. Covers basics of python or R. Simple analytics tasks - regression, classification, clustering, associations, etc. Emphasis will be on choice of models, evaluation of results, significance analysis, visualization and interpretation of results.

Course Content

1.Introduction to various Python toolkits: Numpy for handling arrays and matrices; SciPy for scientific computing; Matplotlib for data visualization; Pandas for data manipulation; SciKit Learn library for machine learning.2.Linear models for regression: Ordinary least squares; Ridge regression (l2 regularization); Lasso (l1 regularization); Elastic Net (l2-l1 regularization).3.Linear classification: Linear Discriminant Analysis (LDA); Logistics regression; Linear Support Vector Machine (SVM); l2 and l1 regularized versions of these algorithms.4.Non-linear algorithms: Kernel SVM, Random forrest. Neural network.5.Unsupervised learning: Dimensionality reduction technique such as Principal Component Analysis (PCA), Clustering techniques such as k-Means clustering and Agglomerative clustering

TextBooks

1.Sarah Guido, Andreas C. Müller, Introduction to Machine Learning with Python, O'Reilly Media, Inc., 2016.2.Jerome H. Friedman, Robert Tibshirani, and Trevor Hastie, The Elements of Statistical Learning, Second Edition (Springer Series in Statistics)

Reference Books

1.Edouard Duchesnay, Tommy Löfstedt, Statistics and Machine Learning in Python, Draft by the authors, available online.

Prerequisite

CH5019

Course No: EE6000

Course Name: Seminar

Course Type:

Seminar

Description:

To enable students to read technical papers and present seminars

Invite technical experts from industry / academia to provide overviews of current technology

Course Content:

Technical seminars

Topics to be decided by Course Coordinator and students

Text Books:

Not applicable

Reference Books:

Not applicable

Course No: EE6150

Course Name: Stochastic Modeling and the Theory of Queues

Course Type:

Theory

Description:

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Course Content:

1. A short tour through basics (not very measure theoretic) of axiomatic probability theory, convergence, and lawsof large numbers.

2. Discrete time Markov chains: class properties, stationary distribution, hitting and mixing times, coupling, and applications to queues and social networks.

3. Renewal theory: elementary renewal theorem, Wald's lemma, renewal reward theorem, and batch biasing (brief discussion on Key and Blackwell's renewal theorem).

4.Poisson process.

5. Continuous time Markov chains: stationarity, time reversal, Kelly's lemma, reversibility, and applications to social networks and queues. 6. (If time permits) Chernoff bound and introduction to large deviations; Martingales and concentration. ?

Text Books:

NIL

Reference Books:

NIL

Course No: EE6255

Course Name: Power System Protection

Course Type:

Theory

Description:

1. To understand the fundamentals and basics of protection of power systems.

2. To understand the protective relaying of various components in a power system.

3. To understand the relay characteristics of various protective equipment .

4. To be able to perform simple calculations in power systems protection.

Course Content:

Introduction to Protective Relays: Basics and fundamentals of protection and protective relaying in power systems, Classification and Types of relays, overcurrent, differential, distance, directional, Relay characteristics, etc.

Equipment Protection: Equipment Protection functions and their applications: Overcurrent Protection, Ground fault Protection, Bus bar Protection, Generator Protection, Motor Protection, Transformer Protection, Transmission Line Protection, Pilot Protection, Overcurrent protection, Distance protection, Directional over current relays, Protection schemes, relay coordination,

Modern Protective Relaying: Concepts of Digital Signal Processing, Fourier and Laplace Transforms, Z transform,

Filter responses; Fundamentals of Digital/Numeric Relays, Various Relay Algorithms used in Digital Relays,

Introduction to Phasor Measurement Units and, Load shedding and Frequency Relaying, Multifunction Relays,

Digital Protection: IEC 61850 Communication Structure and Relay interoperability, architecture and protocols for

protection; Distributed Network Topologies and Protocols, IEC6185 Object Models, GOOSE Messaging, Data

models, Intelligent Electronic Devices (IEDs), Control and Protection by IEDs; IEC 61850 Substation and

Automation Protocols, Digital Protection of Electrical Apparatus; Wide Area Measurements (WAMs), Synchronous

Phase Measurement Units (SPMU), fault location and identification and protection using SPMU.

Text Books:

1. Paul M. Anderson “Power System Protection”, Wiley- IEEE Press, 1999

2. J. C. Das, “Power System Protective Relaying”, , CRC Press, 2018.

3. Y. G. Pathiankar, S. R. Bhide “Fundamentals of Power System Protection”, Prentice Hall of India,

Pvt. Ltd,

2004,

Reference Books:

1. Leslie Hewirson, Marl Brown, Ramesn Balakrishnan, “Practical Power Systems Protection”, Newnesm 2005

2. Stanley H Horowitz and Arun G Phadke, James K Niemira, “Power System Relaying”, Wiley Research Studies

Press, 2014.

3. J. lewis Blackburn, Thomas J Domin, “Protective relaying: Principles and Applications”, CRC Press, 2014.

4. Christopher Preve, “Protection of Electrical networks”, Wiley-ISTE, 2006

Prerequisite: EE3003 Electrical Power Systems

Course No: EE6262

Course Name: Advanced Motor Control

Course Type:

Theory

Description:

This course is an advanced level graduate course for Electrical Engineering students. This course introduces the students to advanced control techniques of modern ac motor drives that include induction motor drives, BLDC motor drives, PMSM drives and switched reluctance motor drives.

Course Content:

Induction Motor Drives

Vector Control: Machine equations – indirect vector, direct vector control, estimation of flux vectors, current and voltage methods. DTC/DSC and their triggering strategies – with and without sector identification.

Sensorless control of Induction Machines – methods of speed identification. Position estimation by signal injection

Rotor Controlled induction machines – theory of power flow and control of rotor side converters

BLDC drives

Theory of operation of machine and bridge – triggering based on hall sensors – Control loop – sensorless control

Method

PMSM drives

Modelling of PMSM machines. Vector control of PMSM drives – performance characteristics – flux weakening for extending speed range. Sensorless control of PMSM drives Switched Reluctance Motor drives

Introduction to the machine and controller structure – determination of inductance variations and torque performance.

Text Books:

1. P.C. Krause, O. Wasynczuk, and S. D. Sudhoff, "Analysis of Electric Machinery", McGraw-Hill Book Company.

2. R. Krishnan, "Electric Motor Drives: Modeling, Analysis and Control", Prentice Hall.

3. W. Leonhard, Control of Electrical Drives, Springer, 3rd ed. 2001.

4. R. Krishnan, Electric Motor Drives: Modeling, Analysis, and Control, Prentice Hall, 2001.

Reference Books:

5. P. Vas, Sensorless Vector and Direct Torque Control, Oxford University Press, 1998.

6. B. K. Bose, Power Electronics and Ac Drives, Prentice Hall, 1986.

7. I. Boldea and S.A Nasar, Electric Drives, CRC Press, 2nd ed. 2006.

Prerequisite: Power Electronic Control of Electrical Machines

Course No: EE6320

Course Name: RF Integrated Circuits

Course Type:

Theory

Description:

The goal of this course is to teach students who have some knowledge of basic analog circuits and IC design to analyze and design RF integrated circuits that are used in modern wireless communication systems. The course will include design projects on RF building blocks such as LNA, Mixer and VCO.

Course Content:

1. LC resonant circuits and RF impedance matching2. RF systems concepts – definitions of noise figure & IIP3;

cascaded systems3. Design of Low noise amplifiers4. Design of active and passive mixers5. Design of LC Oscillators6. Design of Power amplifiers7. Transmitter and receiver architectures

Text Books:

RF Microelectronics by Behzad Razavi, 2nd Edition (2013) (Publisher: Pearson), ISBN-10: 9789332518636,

ISBN-13: 978-9332518636

Reference Books:

The Design Of CMOS Radio-Frequency Integrated Circuits by Thomas H. Lee, 2nd Edition (2004) (Publisher:

Cambridge University Press), ISBN-10: 9780521613897, ISBN-13: 978-0521613897

Prerequisite: EE5310 or EE3002

Course No: EE6331

Course Name: Embedded Memory Design

Course Type:

Theory

Description:

Learning Objectives: Part 1-Static Random Access Memory (SRAM) DesignArticulate memory hierarchy and the value proposition of SRAMs in the memory chain + utilization in current processorsExplain SRAM building blocks

and peripheral operations and memory architecture (with physical arrangement)Articulate commonly used SRAM cells (6T vs 8T), their advantages and disadvantagesExplain the operation of a non-conventional SRAM cells, and their limitationsExplain commonly used assist methodsExplain how variations impact memory cells

Part 2-Embedded Dynamic Random Access Memory (eDRAM) DesignExplain the working of a (e)DRAM and whatEmbedded means? Explain the working of a feedback sense amplifier and modify existing designs to improve performanceCalculate the voltage levels of operation of various components for an eDRAMIntroduce stacked protect devices to reduce voltage stress of the WL driverExplain when an eDRAM can be faster than an SRAMPart 3: Embedded Non Volatile Memory(eNVM) DesignConstruct circuits to enable high voltage programming an eNVM elementDesign sense amplifiers to read in the eNVM elementExplain the design techniques to achieve optimal programming of an eNVM element

Course Content:

Contents:SRAM: Memory hierarchyMemory organizationFlip flop6T SRAM basics6T SRAM cellStatic/ Read and Write noise marginsRead/ Write/ Hold and Access failuresColumn interleavingAlternative Cell TypesImpact of Variation Redundancy Modes of failure Assist CircuitsBTI StressMemory TestingPowerVariation characterizationeDRAM:Basics of DRAMDefinition of Embedded Requirement for short BLs in DRAMsTransfer ratioRetention time/ Refresh rate analysisPower supplies required for eDRAMAdvantages of eDRAM over eSRAMWrite time calculationHierarchical sensing3T Micro Sense AmpMicro Sense Amp EvolutionRead time calculationSOI Technology - Floating body effects on eDRAMGated Feedback Sense AmplifierVariability studyThick Oxide Word-line driversThin Oxide Word-line driversRedundancy and TestingNon Volatile MemoriesCharge Trap Transistor

Text Books:

Course will be taught from current literature.

Reference Books:

Course will be taught from current literature.

Prerequisite: EE5311

Course No: EE6345

Course Name: Advanced Memory Technology

Course Type:

Theory

Description:

This course will provide a systematic exploration of various memory technologies since 1950s and its key concepts, device physics, essential properties for technology and challenges. This is followed by major focus on device/technology aspects of numerous emerging memory technologies including PCM, MRAM, FeRAM, RRAM and also its importance towards realizing universal memory for future high speed computing. A strong emphasize will be given throughout this course on the interdisciplinary nature of learning device physics, electrical, thermal and structural properties of various materials that are essentially governing technical specifications of memory devices.

Course Content:

Introduction to memory devices: Evolution and history; archival data storage; advances in optical memories.Non-volatile memory devices: Magnetic memories, HDDs; Silicon based thin film transistor non-volatile memories; Flash memories, classification and operation; challenges; advancements in vertically stackable arrays.

Volatile memory devices: Random access memories, classification and operation; SRAMs; DRAMs; history and challenges.Emerging memory technologies: Phase Change Memory (PCM); Magneto-resistive Random Access Memory (MRAM); Ferroelectric Random Access Memory (FeRAM), Resisitive Random Access Memory (RRAM); Comparison and future direction towards universal memory concepts.

Text Books:

Tseung-Yuen Tseng and Simon M. Sze, Nonvolatile memories-Materials, Devices and Applications, Volume 1

and 2, ISBN: 1-58883-250-32. Joe Brewer and Manzur Gill, Nonvolatile memory technologies with emphasis on

Flash, IEEE Press series on microelectronic systems, WILEY-INTERSCIENCE 2008, ISBN: 978-0471-77002-23.

Simone Raoux and Matthias Wuttig, Phase change materials-Science and Applications, Springer 2009, ISBN:

978-0-387-84873-0

Reference Books:

Seungbum Hong, Orlando Auciello, Dirk Wouters, Emerging Non-Volatile Memories, springer 2014, ISBN

978-1-4899-7537-92. Betty Prince, Vertical 3D Memory Technologies, Wiley 2014, ISBN: 978-1118760512

Prerequisite: **EE5313 Semiconductor device modeling or equivalent desired**

Course No: EE6346

Course Name: Advanced CMOS Devices and Technology

Course Type:

Theory

Description:

The learning objectives of the course are as follows:

1. To teach the basics of how modern CMOS devices are designed for better power-performance compared to

previous generations when simple geometric shrinking no longer works.

2. Technology has reached a stage where assumptions that allowed a total decoupling of circuit design from

process technology development are no longer valid. This course would be equally useful for those who plan to

have a career in IC design, compact modeling or technology development.

3. To enable students to understand and give seminars on advanced CMOS papers presented in the latest edition of flagship conferences like IEEE International Electron Devices Meeting (IEDM) and IEEE Symposium on VLSI Technology.

Course Content:

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Text Books:

No single textbook is available

Reference Books:

Jesús A. del Alamo, “Integrated Microelectronic Devices: Physics and Modeling,” Pearson, 2017

James D. Plummer and Peter B. Griffin, “Integrated Circuit Fabrication: Science and Technology,” Cambridge

University Press, 2023

J.-P. Colinge, “FinFETs and Other Multi-Gate Transistors,” Springer, 2010.

S. Deleonibus, “Electronic Device Architectures for the Nano-CMOS Era,” Pan Stanford 2009

B. Wong et al, “Nano-CMOS Circuit and Physical Design”, Wiley Inter-science 2004 Hei

Wong , “Nano-CMOS Gate Dielectric Engineering,” CRC, 2011.

B. Wong et al, “Nano-CMOS Design for Manufacturability”, Wiley 2009

Yongke Sun et al, "Strain Effect in Semiconductors: Theory and Device Applications”, Springer 2010

N. Collaret, “High mobility materials for CMOS applications”, Woodhead Publishing, 2018

Course No: EE6402

Course Name: Biomedical Electronic Systems

Course Type:

Theory

Description:

- To learn the origin and underlying mechanisms of biopotential recording and functional electrical stimulation

- To learn the electrical model of the physiological-electrical interface

- To understand the design parameters of the front-end electronics for recording and stimulation

- To understand electrical safety, noise and interference of recording and stimulation

- To understand the design principles of wireless power transmission in implantable devices

Course Content:

1. Biopotential recording

a. ECG, EMG, EEG, Action potentials

i. Physiological origin and characteristics

ii. Electrical characteristics

b. Biopotential amplifiers

i. Electrode-tissue-electronics interface

ii. Operation and design principles

c. Noise and interference

i. Sources and pathways

ii. System and circuit design for noise mitigation

2. Electrical stimulation of cells

a. Nerve and muscle stimulation

i. Basics of electrical stimulation of excitable cells

ii. Stimulation parameters

b. Safety

i. Electrochemical safety

ii. Tissue safety

c. Stimulation electronics

i. Electrode-tissue-electronics interface

ii. Operation and design principles

3. Implantable electronic devices

a. Wireless power and data transmission

i. Inductive, RF and optical links

ii. Design parameters and principles

b. Safety and compatibility

i. Regulations and standards

ii. Design for safety and compatibility

4. Cardiac electronic devices

a. Pacemakers

i. Cardiac pacing mechanisms

ii. Operation and design principles

b. Defibrillators

i. Fibrillation mechanisms

ii. Operation and design principles

5. Neural electronic implants

a. Cochlear implants

i. Deafness and Auditory nerve stimulation

ii. Operation and design principles

b. Brain stimulators

i. Deep brain and vagus nerve stimulation

ii. Operation and design principles

c. Retinal implants

i. Retinal blindness and Retinal stimulation

ii. Operation and design principles

Text Books:

"Medical Instrumentation: Application and Design", by John G. Webster

Reference Books:

Research papers will be shared

Course No: EE6403

Course Name: Transducers

Course Type:

Theory

Description:

To impart knowledge on transducers and train students to apply this knowledge and make measurements on

physical parameters such as displacement, velocity, temperature, torque and speed

Course Content:

Transducers and their characteristics: Definition of terminologies – Generalized performance characteristics – range – resolution – linearity – overload factor – accuracy – precision – static and dynamic – rise time – fall time – settling time– slew rate – frequency response – bandwidth – modelling – Classification – ingress protection – vibration isolation – passive – active.Resistive Transducers: Resistance potentiometer – noise – resolution – signal conditioning – strain gauges – associated electrical circuitry – temperature compensation – load cells – torque and pressure measurement using strain gauges –resistive temperature device (RTD) – three- lead arrangement – thermistors – linearization - hot-wire anemometers – time constant improvement – measurement of direction of flow – peizo resistive transducers.5 Experiments on signal conditioning applied to transducersInductive

Transducers: Self-inductance transducers – transverse armature and plunger type – sensitivity and linearity – signal conditioning circuits – choice of components – linear variable differential transducer (LVDT) – lead and lag compensation.Capacitive Transducers: Single – push-pull – angle transducer – humidity sensor – parasitic effects – solutions – signal conditioning circuits.Miscellaneous transducers: Peizo electric – signal conditioning – thermo couples – theory – mass-spring accelerometer – force-balance.Applications of transducers:

Measurement of displacement (linear and angular) – velocity – acceleration – force – torque – pressure – flow– temperature.

Text Books:

1. H. K. Neubert, ‘Instrument Transducers-An introduction to their performance and design’ Oxford University

press, Oxford, Second edition-2003.

Reference Books:

2. E. O. Doeblin ‘Measurement Systems – Application and Design’ McGraw - Hill Publications, Fifth Edition, 2004.

Course No: EE6408

Course Name: Non-invasive Sensing & Signal Processing for Human Health

Description

This course aims to provide a deep understanding of cutting-edge non-invasive methods for health assessment with emphasis on quantification of biological ageing, innovative ways of blood pressure measurement and recent advances in near field sensing methods for vitals tracking. By course completion, participants will be proficient in quantifying both structural and functional aspects of the cardiovascular system, novel methods for vitals detection & tracking, and have a strong grasp of the key aspects in design, development, and validation of such medical instrumentation systems.

Course Content

The course will discuss both hardware and signal processing aspects of multiple non-invasive sensing and instrumentation systems designed for quantification of structural and functional health. We will discuss recent advances such as ballisto cardiograph, impedance plethysmography, and camera-based sensing of vitals, and mobile phone-based health assessments. We will also perform a detailed dissection of selected instruments to understand system design and engineering constraints posed in medical device development, and explain the typical protocols needed in functional verification & clinical validation of such instruments.Module A: Essential physiology and bio-system modelsCardiovascular physiology and engineering system analogy - relation between blood flow, blood pressure and arterial wall dynamics. Vessel wall properties & modelling. Vascular ageing markers.Module B: Advanced Instrumentation systems & methods for health assessmentPulse Wave Velocity: Regional and Local PWV, Invasive reference methods. Non-invasive methods - ECG gating, Dual pulse waves.Tonometry, PPG, BCG, Applications of PWV. Clinical grade vs wellness devices.BP Measurement: Invasive catheters, A-line systems, Auscultation, Oscillometry, PAT & PTT derived BP, Calibration methods & issues, Calibration-free cuff less BP, AI methods, Challenges and opportunities in cuff less BP.Pulse Contour Analysis (PCA): Clinical significance, and methods of assessment, tools available. Use of mobile phones for health assessment beyond activity trackingUltrasound methods: Basic principles, Sensors, A-scan and its applications. Doppler & flow measurement, Echo processing methods, B-mode imaging, Wall tracking (Image processing vs RF tracking), intima-media thickness measurement.Echo cardiography: Introduction, protocol of measurement and key measures.Endothelial function: Clinical significance, Measurement Methods, Equipment & Challenges, Recent advances quantifying endothelial function non-invasively – FMD, PTT tracking, Z change based methodsModule C: System design of medical devices : Case examples illustrating hardware & signal processing elementsCase # 1 : Image free ultrasound for vascular assessmentCase #2: Oscillometry based BP deviceCase #3 : Impedance plethysmography / BallistoCardioGraphy / Camera based vitals

TextBooks

1.W. W. Nichols, M. F. O'Rourke, and C. Vlachopoulos, Mcdonald's blood flow in arteries: theoretical, experimental and clinicalprinciples, 6th ed. London: Hodder Arnold, 2011.2. J. Sola and

R. Delgado-Gonzalo, The Handbook of Cuffless Blood Pressure Monitoring, 1st ed. Switzerland AG: Springer Nature,2019.3. Wenjin Wang, Xuyu Wang, Contactless Vital Signs Monitoring, 1st Edition - September 20, 2021,Elsevier, ISBN: 9780128222829

Reference Books

1. J. A. Chirinos, Ed., Textbook of Arterial Stiffness and Pulsatile Hemodynamics in Health and Disease, 1st ed. London: AcademicPress, 2022.2. P. M. Nilsson, M. H. Olsen, and S. Laurent, Early vascular aging (EVA): New directions in cardiovascular protection, 1st ed.Oxford: Elsevier, 2015.3. M. E. Safar, M. F. O'Rourke, and Edward D. Frohlich, Blood Pressure and Arterial Wall Mechanics in Cardiovascular Diseases, 1sted. London: Springer-Verlag, 2014.4. T. L. Szabo, Diagnostic ultrasound imaging: inside out, 2nd ed. Boston: Academic Press, 2014.5. J. L. Zamorano et al., The ESC Textbook of Cardiovascular Imaging, 3rd ed. Oxford: Oxford University Press, 2021

Prerequisite

Undergraduate level skills in electronics, analog circuits, signal processing in Matlab/Lab VIEW • Exposure to biomedical instrumentation / engineering (preferred)

Course No: EE6412

Course Name: Optimal Control

Course Type:

Theory

Description:

To introduce optimal control theory using tools from calculus of variations for finding extremals thatminimize/maximize cost functionals, and derive optimal control using Pontryagin's maximum principle. The course will also introduce numerical methods for solving problems related to practical applications.

Course Content:

1.Review of state-space representation of systems

2. Introduction to Optimization-

Unconstrained and constrained optimization, Karush-Kuhn-Tucker (KKT) conditions

3. Calculus of variations-Examples of variational problems, Brachistochrone, Catenary etc., Cost functionals, extremals, Weak and strong extrema,

First-order necessary conditions for weak extrema--Euler-Lagrange equations, Hamiltonian formalism and mechanics, Variational problems with constraints, Second-order conditions-Legendre's condition, Weierstrass- Erdmann corner conditions, Weierstrass excess function

4. Optimal control problem formulations- Variational approach to the fixed-time, free-endpoint problem

5. Pontryagin maximum principle- Proof of the maximum principle,

Time-optimal control of double integrator, Bang-bang control

6. Hamiltonian-Jacobi Bellman (HJB) equation-principle of optimality,

Sufficient condition for optimality

7. Linear quadratic regulator (LQR) problem- candidate optimal feedback law,

Riccati differential equation, proof of sufficiency using HJB equation

8. Numerical methods for optimal control problems- Evaluation of parameter-dependent functionals and their gradients, Indirect methods, Direct methods,

9.Applications- Time-optimal control of linear systems, Singular control, Optimal control to target curves

Text Books:

1. Pinch Enid R., ``Optimal Control and the Calculus of Variations", Oxford University Press, 19952. Daniel

Liberzon, ``Calculus of Variations and Optimal Control Theory -- A concise introduction", Princeton University

Press, 2012

Reference Books:

1. Mike Mesterton- Gibbons, ``A Primer on The Calculus of Variations and Optimal Control Theory"--American

Mathematical Society, First Indian Edition 2012

Course No: EE6415

Course Name: Non-linear Systems Analysis

Course Type:

Theory

Description:

At the end of the course, the students will be able to analyze and design control laws for Non-linear systems using Lyapunov function based methods.

Course Content:

1. Mathematical preliminaries: Open and closed sets, compact set, dense set, Continuity of functions, Lipschitz

condition, Vector space, norm of a vector, normed linear space, inner product space.

2. Examples of Non-linear systems drawn from mechanical, electrical, biological and chemical systems. Notion of

equilibrium points and operating points, Jacobian linearization.

3. Second-order Non-linear systems , vector field, trajectories, flow, vector field plot, phase-plane portrait and

positively invariant sets. Classification of equilibrium points based on the eigenvalues of the linearized system.

Periodic solutions and the notion of limit cycles, Bendixson's theorem and Poincare- Bendixson criteria.

4. Stability notions such as Lagrange, Lyapunov, asymptotic, global asymptotic, exponential, input-to-state (ISS)

and instability. Lyapunov's direct and indirect method, La Salle's invariance principle and singular perturbations,

set stability and stability of center manifold. Sum-of-Squares based construction of Lyapunov functions.

5. Design methods: Control laws based on Lyapunov function and Sliding mode control on benchmark examples.

Text Books:

Non-linear Systems (3rd Ed.), Hassan K. Khalil, Pearson Education.

Reference Books:

1. Non-linear Systems: Analysis, Stability and Control, Shankar Sastry, Springer.

2. Non-linear System Analysis - M. Vidyasagar, Siam

Prerequisite: Basic Course in Control

Course No: EE6417

Course Name: Incentive-Cenetred Design (Advanced Topics in Control)

Course Type:

Theory

Description:

a. Introduce the fundamentals of incentive-centered design and, title notwithstanding, learning in games.

b. Provide the background necessary to access literature and conduct advanced research on engineering

Course Content:

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Text Books:

a. Lecture notes and/or slides will be provided.

b. Tim Roughgarden, Twenty Lectures on Algorithmic Game Theory (1st. ed.), Cambridge University Press, 2016.

Reference Books:

a. Nisan, Roughgarden, Tardos, Vazirani (eds), Algorithmic Game Theory, Cambridge University Press, 2007.

b. R. M. Starr, General Equilibrium Theory: An Introduction, 2nd ed., Cambridge University Press, 2011.

c. Y. Narahari, Game theory and mechanism design (Vol. 4). World Scientific, 2014.

d. Claude d'Aspremont, Louis-André Gérard-Varet, Incentives and incomplete information, Journal of Public

Economics, Volume 11, Issue 1, 1979.

e. B. Satchidanandan and M. A. Dahleh, "Incentive Compatibility in Two-Stage Repeated Stochastic Games," in

IEEE Transactions on Control of Network Systems, 2023.

Course No: EE6430

Course Name: Fundamentals of Linear Optimization

Course Type:

Theory

Description:

To teach the students the geometry of linear optimization. At the end of course the students would have a good understanding of polyhedral objects and perform computations on them.

Course Content:

1. Origins of Linear Optimization: Fourier-Motzkin Elimination

2. 2. Affine Spaces: Affine Hull, Affine Subspaces,

Affine Independence and Dimension

3. Convex Cones: Polyhedral Cones, Finitely Generated Cones, Carathoedery's Theorem Wely's Theorem, Farkas Lemma, Dual Cones and Minkowski's thorem .

4. Polyhedrons: Faces of Cones and Polyhedrons, Homogenization, Minkowski-Weyl Duality, V-H descriptions,Recession cone .

5. Linear Programming and Duality: Feasibility, Dual of an LP, Weak and Strong Duality theorems and Complementary Slackness theorem.6. Computations on a Polyhedron:

Dimension of a polyhedron

and Double description method and Simplex Algorithm

Text Books:

1. Undergraduate Convexity: From Fourier-Motzkin to Kuhn-Tucker, Niels Lauritzen, World Scientific

Press.2. Polyhedral Geometry and Linear Optimization: Andreas Paffenholtz (Lecture Notes Available in Web

2. Lectures on Modern Convex Optimization by Aharon Ben-Tal and Arkadi Nemirovski, MPS SIAM series

Reference Books:

Understanding and Using Linear Programming, Matousek and Gartner, Springer.

Prerequisite: Linear Algebra

Course No: EE6431

Course Name: Nonsmooth analysis in control and optimization

Course Type:

Theory

Description:

Course motivation: Nonsmooth problems arise naturally in many fields of applications such as rigid bodies subjected to set-valued force laws, nonsmooth harmonic oscillator and circuits with Non-linear elements. In feedback control, they occur by design while dealing with sliding-mode, optimal control, switched or hybrid systems and in continuous-time optimization algorithms by way of nonsmooth cost function and constraints. The resulting dynamics manifest as differential equations with discontinuous vector field. Analysis, optimization and stabilization of such systems require tools from nonsmooth analysis involving set-valued functions, generalized derivatives, convex analysis etc. Course Objective: Expose the students to various applications involving nonsmooth dynamics and equip them with various tools to perform nonsmooth analysis.

Course Content:

1. Applications: Nonsmooth harmonic oscillator, stick-slip system and systems involving discontinuous stabilizing control law

2. Semicontinuity, proper and improper convex functions, Lipschitz property of convex function, projection of a point onto a set, distance function, gradient of the distance function and the projection inequality, normal and tangent cones, properties of normal cones

3. Subdifferential of a convex function and its properties, connection to convex geometry, basic inequality, subgradient calculus and optimality conditions.

4. Directional derivatives, relation between subgradients and directional derivatives, existence of subgradient, subdifferential and gradient direction of steepest descent, examples involving the subgradient of a norm, distance function, indicator function, max function and maximum eigen value of a symmetric matrix.

5.Solution notions for discontinuous systems, Caratheodory, Fillipov, sample-and-hold solutions.6. Lyapunov-like stability theorems for nonsmooth systems and optimality conditions for nonsmooth optimization.

Text Books:

1. Non-linear Optimization by Andrzej Ruszczynski, Princeton University Press, 2006.2. Nonsmooth analysis and control theory: F. H. Clarke, Yu. S. Ledyaev, R. J. Stern and P.R. Wolenski, Springer, 1998.3. Hybrid dynamical systems: Modeling, stability and robustness by Rafal Goebel, Ricardo G. Sanfelice and Andrew Teel, Princeton University Press, 2012.

Reference Books:

1. Discontinuous dynamical systems: A tutorial on solutions, nonsmooth analysis and stability by Jorge Cortes,

IEEE Control System Magazine, June 2008.2. An easy path to convex analysis and applications by Boris S.

Mordukhovich and Nguyen Mau Nam, Morgan and Claypool Publisher, 2014.3. Nonsmooth analysis and control

theory: F. H. Clarke, Yu. S. Ledyaev, R. J. Stern and P.R. Wolenski, Springer, 1998.

Prerequisite: Control Engineering or equivalent

Course No: EE6500

Course Name: Integrated Optoelectronics Devices and Circuits

Course Type:

Theory

Description:

In this course, students will learn background theory, working principle, technology of various integrated optoelectronic devices and circuits for optical interconnect applications. It is mainly designed for postgraduate students studying in various streams like Microelectronics, Communication Systems, Photonics and Optical Engineering. However, undergraduate students can also take this course after completing basic courses coveringEM Fields and Semiconductor Devices.

Course Content:

(i) Introduction: Generic Optical Systems and Fundamental Building Blocks;

(ii) Basics of Semiconductor Optoelectronics: Elemental and Compound Semiconductors;

(iii) Electronic Properties and Optical Processes in Semiconductors;

(iv) P-N Junction Theory, LEDs and Photodetectors;

(v) Heterostructures, Confinement of Electron Waves, Optical Waveguides and Guided Modes;

(vi) Semiconductor Optical Amplifiers and Fabry-Perot Lasers;

(vii) Coupled Mode Theory, DBR and DFB Lasers;

(viii) Silicon Photonics: Integrated Optical Passive and Active Components;

(ix) Tunable Filters, Delay-Lines and Switching Circuits in SOI Platform;

(x) CMOS Technology: Electrical vs. Optical Interconnects

Text Books:

Photonics - Optical Electronics in Modern Communications

Author(s): A. Yariv and P. Yeh (Oxford University Press)

Reference Books:

1. Semiconductor Optoelectronic Devices

Author(s): Pallab Bhattacharya (Pearson Education Inc.)

2. Silicon Photonics - Fundamentals and Devices

Author(s): M. Jamal Deen and P.K. Basu (John Wiley & Sons Ltd.)

Course No: EE6501

Course Name: Optical Sensors

Course Type: Theory

Description:

Optical Sensors is intended as a graduate level course that introduces the different types of optical sensor technologies and their applications in metrology, navigation, structural health monitoring.

Course Content:

Introduction: Optics for differential sensing of temperature, humidity and pressure; detection of bio-molecules, gases and chemicals; measurements of displacement, vibration and thickness of transparent thin-films; inertial navigation – position, velocity, acceleration, and rotational sensing; structural health monitoring; scanning and infrared imaging, etc. Principle of Optical Sensing: Fluorescence & Absorption Spectroscopy, Polarization/Amplitude/Intensity Modulation, Cavity Resonances & Sagnac Effect, Distributed Scattering Effects (Bragg, Raman & Brillouin).

Integrated Optical Sensing Elements & Accessories: Dielectric and Plasmonic Waveguides, Microbridge / Suspended Waveguide and Waveguide cantilever, Passive and Active Phase Shifters, Quantum Dot Photodetectors, Dielectric Mirror & Antireflection Coating, Membrane / Diaphragm, Microfluidic Channels, and Micropumps.

Integrated Optical Multi-Functional Sensor Devices: Surface Plasmon Polariton Resonators, Vertical and In-Plane Fabry-Perot Interferometer, Mach-Zehnder Interferometers, Coupled Microring Resonator(s), Lab-on-Chip.

Application Specific Optical Sensor Systems: Integrated Fiber Optic Gyro (IFOG), Optical Time Domain

Reflectometer (OTDR), Light Detection and Ranging (LIDAR), Optical Scanners, IR Camera and Photodetector

Array.

Text Books:

John Dakin and Brain Culshaw, "Optical Fiber Sensors", Artech House, 1997.Joerg Haus, "Optical Sensors:

Basics & Applications", Wiley-VCH, 2010

Reference Books:

K.T.V. Grattan and B.T. Megitt, "Optical Fiber Sensor Technology", Kluwer Academic Publishers, 1999.Francis T.S.

Yu, Shizhou Yin, Paul B. Ruffin, "Fiber Optic Sensors", 2/e, CRC Press, 2008.Masood Tabib-Azar, "Integrated

Optics, Microstructures and Sensors", Kluwer Academic Publishers.

Course No: EE6502

Course Name: Optical Signal Processing and Quantum Communication

Course Type:

Theory

Description:

To introduce the basic principles required for the understanding of linear and Non-linear optical signal processing techniques. To apply these principles for specific optical signal processing applications, such as all-optical switching, wavelength conversion, and logic gates, for applications in optical communication systems. These ideas are then extended to quantum information processing with the introduction of entangled photons, qubits and cluster states and their use in photonic quantum computing and in quantum communications

Course Content:

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Text Books:

Photonics – Yariv, 2006

Optical Quantum Information Processing, P. Kok and B. W. Lovett, 2010

Reference Books:

Optical Electronics, Ghatak and Thyagarajan, 1990

Non-linear fiber optics; Applications of Non-linear fiber optics, GP Agrawal, 2012

Quantum Optics: M. Orszag, 2007

Relevant Journal Publications will be shared during the course

Course No: EE6904

Course Name: M.Tech Project 40

Course Type:

Project

Description:

EE6904 is for 3rd semester (M.Tech) or 9th (DD) semester students

Course Content:

Project work

Text Books:

None

Reference Books:

None

Course No: EE6999

Course Name: Special Topics in Electrical Engineering

Course Type:

Others

Description:

The course envisages to train research scholar in the preparation of a “critical review of literature”, present the same in the form of a written report and make as oral presentation before members of DC and invitees and take feedback.

Course Content:

Review of literature in the related area.

Text Books:

As prescribed by the guide.

Reference Books:

Relevant journal paper

Course No: EE7500

Course Name: Advanced Topics in RF and Photonics

Course Type:

Theory

Description:

To teach students recent research and technology advances in areas of current interest.

Course Content:

To be decided

Text Books:

To be decided

Reference Books:

To be decided

Prerequisite: COT

Course No: EE7999

Course Name: Special Topics in Electrical Engineering

Course Type:

Others

Description:

The course envisages to train research scholar in presenting simulation / preliminary experimental / analytical verification of prior art in the area of research, in the form of a report and an oral presentation to the DC and invitees and take feedback

Course Content:

To be suggested by the guide

Text Books:

To be suggested by the guide

Reference Books:

To be suggested by the guide