DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING, MIT Manipal

M.Tech. POWER ELECTRONICS AND DRIVES

Program Structure (Applicable to 2019 admission onwards)

Year	FIRST SEMESTER						SECOND SEMESTER					
	Sub Code	**Subject Name**	**L**	**T**	**P**	**C**	**Sub Code**	**Subject Name**	**L**	**T**	**P**	**C**
I	MAT 5163	Computational Methods and Applied Linear Algebra	4	0	0	4	ELE 5271	Advanced Power Electronic Converters	4	0	2	5
	HUM 5151	Research Methodology and Technical Communication	1	0	3	2	ELE 5272	Application of Power Electronics in Power Systems	4	0	2	5
	ELE 5152	Design of Control Systems	3	1	0	4	ELE ****	Elective I	4	0	0	4
	ELE 5171	Embedded System Design	4	0	2	5	ELE ****	Elective II	4	0	0	4
	ELE 5172	Modeling and Analysis of Electrical Machines	4	0	2	5	ELE ****	Elective III	4	0	0	4
	ELE 5173	Power Semiconductor Controlled Drives	4	0	0	4	*** ****	Open Elective	3	0	0	3
	ELE 5161	Electric Drives Lab	0	0	3	1						
		Total	**20**	**1**	**10**	**25**		**Total**	**23**	**0**	**4**	**25**
II	**THIRD AND FOURTH SEMESTER**											
	ELE 6098	Project Work							0	0	0	25
								Total	0	0	0	**25**

PROGRAM ELECTIVES			
ELE 5001	Digital Signal Processing and Applications	ELE 5008	Instrumentation in Electrical Systems
ELE 5002	Digital System Design using FPGA	ELE 5009	Lighting Controls: Technology and Applications
ELE 5003	Distributed Energy Systems	ELE 5010	Power Quality Issues and Mitigation
ELE 5004	Electric Vehicles	ELE 5011	Time Frequency Analysis
ELE 5005	Embedded System Design	ELE 5012	Wind Energy Conversion Systems
ELE 5006	Energy Analytics		
ELE 5007	Energy Storage Devices		

OPEN ELECTIVES			
ELE 5051	Intelligent Control Systems	ELE 5052	Photovoltaic Systems

SEMESTER I

MAT 5163 COMPUTATIONAL METHODS & APPLIED LINEAR ALGEBRA [4 01 0 4]

Numerical differentiation and integration, ODE, PDE, Optimization techniques – linear programming, dynamic programming, genetic algorithm, PSO, Linear Algebra - vector space, matrix algebra, simultaneous equations, LU decomposition and matrix inversion, special matrices and Gauss Siedel methods applied in engineering problems, eigen values, characteristic vectors, Cayley-Hamilton theorem, minimal polynomial, polynomial matrices

References:

1. Steven. C. Chapra and Raymond P. Canale, "Numerical Methods for Engineers", Tata McGraw Hill Edition, 2006
2. S. S. Sastry, "Numerical Analysis for Engineers" Tata McGraw Hill Edition, 2002
3. Hoffman K and Kunze R, "Linear Algebra", Prentice Hall of India, 2011.

HUM 5151 RESEARCH METHODOLOGY AND TECHNICAL PRESENTATION [1 0 3 2]

Mechanics of Research Methodology - Basic concepts, Types of research, Significance of research, Research framework, Case study method, Experimental method, Sources of data, Data collection using questionnaire, Interviewing, and experimentation, Research formulation - Components, selection and formulation of a research problem, Objectives of formulation, and Criteria of a good research problem. Research hypothesis - Criterion for hypothesis construction, Nature of hypothesis, need for having a working hypothesis, Characteristics and Types of hypothesis, Procedure for hypothesis testing, Sampling methods- Introduction to various sampling methods and their applications, Data Analysis - Sources of data, Collection of data, Measurement and scaling technique, Data analysis techniques, Thesis Writing and Journal Publication - thesis writing, journal and conference papers writing, IEEE and Harvard styles of referencing, Effective Presentation, Copyrights, and avoiding plagiarism.

References:

1. Dr Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, SAGE, 2005.
2. Geoffrey R. Marczyk, David DeMatteo & David Festinger, Essentials of Research Design and Methodology, John Wiley & Sons, 2004.
3. John W. Creswel , Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, SAGE, 2004
4. Suresh C. Sinha and Anil K. Dhiman, Research Methodology (2 Vols-Set), Vedam Books, 2006.
5. C. R. Kothari, Research Methodology: Methods and Techniques, New Age International Publisher, 2008.
6. Donald R Cooper & Pamela S Schindler, Business Research Methods, McGraw Hill International, 2007.
7. R. Pannershelvam, Research Methodology, Prentice Hall, India, 2006
8. Manfred Max Bergman, Mixed Methods Research, SAGE Books, 2006.
9. Paul S. Gray, John B. Williamson, David A. Karp, John R. Dalphin, The Research Imagination, Cambridge University press, 2007.
10. Cochrain & Cox, Experimental Designs, II Edn. Wiley Publishers, 2006

ELE 5152 DESIGN OF CONTROL SYSTEMS [3 1 0 4]

Review of mathematical modeling of mechanical / electrical / electromechanical systems – transfer function and state space approach, System Identification, Lyapunov Stability, Input-Output Stability, Stabilization via state feedback, Absolute stability, Controllability, Observability, Design and realization of active industrial controllers / compensators, Output Feedback Control, Pole Placement Control, Linear Quadratic Regulator, Linear Quadratic Gaussian control, Sliding Mode Control, Optimal Control Theory, Adaptive control theory, Case study

References:

1. Norman S. Nise, Control Systems Engineering, John Wiley & Sons, Inc, 2010
2. Ogata K, Modern Control Engineering, Englewood Cliffs, NJ: Prentice Hall, 2010
3. Richard C. Dorf, Robert H. Bishop., Modern Control Systems, Pearson, 2011
4. Hassan K. Khalil, Nonlinear Systems, Macmillan, 1992
5. Martin Enqvist, Linear Models of Nonlinear Systems, Department of Electrical Engineering Linköpings universitet, Sweden, elibrary.matf.bg.ac.rs
6. Kemin Zhou, John C. Doyle, Essentials of Robust Control, Prentice Hall, 1999
7. Geir E. Dullerud, Fernando G. Paganini, A Course in Robust Control Theory - a convex approach, Springer 2005
8. William Brogan, Modern Control Theory, Pearson, 1990

ELE 5171 EMBEDDED SYSTEM DESIGN [4 0 2 5]

Embedded Systems - Introduction, Processor and memory architecture, Embedded hardware, Processor for embedded applications, Processing power and benchmarks, PIC microcontroller, Instruction set, on chip peripherals, ARM processor, ARM instruction set, ARM exceptions, ARM '3' stage pipeline, ARM processor based microcontroller, Memory organization, Cache memory, Virtual memory management, Input and output device interfacing - Parallel and serial interfaces and communication protocols, Wireless communication protocols, Embedded system design - Issues and challenges, Current trends in embedded system design, Introduction to RTOS and Task Scheduling.

Laboratory exercises and application case studies on power factor improvement, power quality measurement, control of electric drives, solar power MPPT.

References:

1. Frank Vahid and Tony Givargis, Embedded system design, Wiley India, 2012.
2. Shibu K V, Introduction to Embedded Systems, TMH, 2012
3. Steve Furber, ARM System on chip architecture, Pearson, 2012
4. Bose B. K., Microcomputer Control of Power Electronics and Drives, IEEE Press, 1999.
5. Ajay V Deshmukh, Microcontrollers, TMH, 2007

ELE 5172 MODELLING AND ANALYSIS OF ELECTRICAL MACHINES [4 0 2 5]

Basics of magnetic circuits, Analysis of magnetic circuits with air gap and permanent magnets, Analysis of singly excited electromechanical system with linear magnetics, nonlinear magnetics using energy and co-energy principles. Inductances of distributed windings - salient pole, cylindrical rotor, Analysis of the doubly excited two-phase rotational system, Reference frames power invariance and non-power invariance, Derivation of dc machine systems from the generalized machine,

Analysis of induction machine - synchronous reference frame - with currents as variables - with rotor flux as variables. Basis for vector control - small signal modelling of induction machine, Analysis of the alternator - synchronous reference frame, Derivation of salient and cylindrical rotor machine phasor diagrams. Three phase short circuit of alternator and various time constants.

Lab (Simulation) Exercises on startup transient in DC motor, transients in Induction motor, small signal model of DC and Induction machine, inverter fed Induction motor, slip test of salient pole alternator.

References:

1. Fitzgerald and Kingsley, Electric Machinery (7 ed) McGraw-Hill Higher Education, 2013
2. O'Simmons and Kelly, Introduction to Generalized Machine Theory. McGraw-Hill Higher Education
3. Hancock, Matrix Analysis of Electric Machinery (2 ed) Pergamon Press, 2016
4. Dr. Krishna Vasudevan,IIT, Madras, Modelling and Analysis of Electric Machines https://nptel.ac.in/courses/108106023/

ELE 5173 POWER SEMICONDUCTOR CONTROLLED DRIVES [4 0 0 4]

Components of electric drive system - Types of loads, load characteristics, choice of power modulators, choice of motors, open & closed loop operation of drives, Analysis of converter fed DC motor Drives (single & three phases), Controlled Freewheeling, Analysis of Chopper fed DC motor Drives - single, two and four quadrant operations, AC Drives - Induction motor drives - Stator voltage control, Slip power recovery scheme, Frequency control (Scalar control), Field-oriented control (Vector control), Direct & Indirect, Direct Torque Control (DTC), Synchronous motor drive - Types of synchronous motors, Scalar & Vector control schemes for different types of synchronous motors. Modern trends in industrial drives and control, Case studies relating to steel mills, paper mills, textile mills, machine tools etc, A.C. motor drives in transportation system and traction.

References:

1. Dubey G.K., Fundamentals of Electric Drives, Narosa, 2010.
2. Murphy J.M.D.& F.G.Turnbull, Power Electronic Control of AC motors Pergamon 1989
3. Dubey G.K., Power Semiconductor Controlled Drives, PH, 1989.
4. Dewan S.B., G.R.Slemon & A.Straughen, Power Semiconductor Drives. Wiley, 1984
5. Bose B.K., Modern Power Electronics and AC Drives, Pearson, 2010
6. Krishnan R., Electric Motor Drives: Modeling, Analysis, and Control, Pearson, 2011.
7. Prof. K R Rajagopal, IIT Delhi, Industrial Drives, http://www.nptel.iitm.ac.in/courses
8. Prof K Gopakumar, IISC Bangalore, Industrial Drives-Power electronics, http://www.nptel.iitm.ac.in/courses

ELE 5161 ELECTRIC DRIVES LAB [0 0 3 1]

Simulation Exercises on DC and AC drives, Implementation of PWM controllers on analog / digital controllers, Hardware exercises on DC and AC drives.

SEMESTER II

ELE 5271 ADVANCED POWER ELECTRONIC CONVERTERS [4 0 2 5]

Linear and switched mode power supply – comparison, Design and analysis of non-isolated dc-dc converters - Buck, Boost, Buck-Boost, Cuk, SEPIC, Effect of non-idealities on the performance of converters, Isolated dc-dc converter topologies - Design and analysis of Fly-back, Forward, Push-Pull, Half-bridge and full-bridge configurations, Design of Magnetics - Inductor and transformer design for high frequency applications, Resonant Converters – Loaded resonant converters, SLRs and PLRs – analysis and design issues, ZCS, ZVS, ZCT, ZVT, Converter dynamics and control, converter transfer functions, regulator design, current mode control, slope compensation technique, unity power factor converter, Applications – MPPT, Solid State lighting

Lab Exercise:

Simulation exercise on isolated and non-isolated converter topologies, Design of high frequency inductor, Simulation exercise on soft switched converters, hardware realization of non-isolated / isolated converter.

References:

1. Robert W. Erickson, Dragan Maksimovic; Fundamentals of Power Electronics, (2 ed), Springer, 2005
2. Mohan, Undeland & Robbins; Power Electronics, Converters, Applications and Design, Wiley-2001
3. Daniel.W. Hart, Introduction to Power Electronics by, PHI-1997 edition
4. Umanand L, Bhat S.R, “Design of magnetic components for switched mode power converters”, New age International limited, 2001.
5. P. Krein, Elements of Power electronics, OUP, 1998
6. Prof. Umanand and Prof. Ramanarayanan, IISc Bangalore, Switched Mode Power Conversion: http://nptel.ac.in/courses/108108036/

ELE 5272 APPLICATION OF POWER ELECTRONICS IN POWER SYSTEMS [4 0 2 5]

Introduction to FACTS controllers - configuration and working principle of SVC, STATCOM, TCSC, SSSC, SPS and UPF Steady state characteristics, effect of FACTS devices on transient stability, power flow, power oscillation damping and voltage stability. Definition of Power Quality, issues, fundamentals of load compensation, control theories for load compensation, harmonic filters, DSTATCOM, DVR and UPQC circuit, operation, control modes. HVDC transmission system, merits and demerits, application and schemes of HVDC, equivalent circuit diagram of a two terminal HVDC link, HVDC control, grid firing units for converters.

Laboratory exercises on performance of uncompensated and compensated transmission line, stability analysis of the system with FACTS controllers, mitigation of harmonics by passive and active filters, performance analysis of custom power devices, modelling of HVDC systems.

References:

1. N.G. Hingorani & Laszlo Gyugyi, 'Understanding FACTS', IEEE press, Wiley Interscience, 2000.
2. K.R. Padiyar 'FACTS controllers in power transmission and distribution', New Age International Publisher, 2008.
3. R. Mohan Mathur and Rajiv K Varma, 'Thyristor based FACTS controllers for Electrical Transmission systems', IEEE press, Wiley Interscience, 2002.
4. Ewald F. Fuchs & Mohammad A.S. Masoum, 'Power Quality in Power

Systems and Electrical Machines', Elsevier Academic Press 2008.
5. Vijay K Sood, 'HVDC and FACTS controllers', Kluwer Academic Publishers, 2004.
6. J. Arrillaga, N. R. Watson, S. Chen, 'Power System Quality Assessment', John Wiley & Sons, England, 2000.

SECOND YEAR

ELE 6098 PROJECT WORK [0 0 0 25]

Students are required to undertake innovative and research oriented projects, which not only reflect their knowledge gained in the previous two semesters but also reflects additional knowledge gained from their own effort. The project work can be carried out in the institution/ industry/ research laboratory or any other competent institutions. The duration of project work should be a minimum of 36 weeks. There will be a mid-term evaluation of the project work done after about 18 weeks. An interim project report is to be submitted to the department during the mid-term evaluation. Each student has to submit to the department a project report in prescribed format after completing the work. The final evaluation and viva-voice will be after submission of the report. Each student has to make a presentation on the work carried out, before the departmental committee for project evaluation. The mid-term & end semester evaluation will be done by the departmental committee including the guides.

PROGRAM ELECTIVES

ELE 5001 DIGITAL SIGNAL PROCESSING AND APPLICATIONS [4 0 0 4]

Introduction to Signal Processing, Review of DFS and DTFT, Computation of DFT and FFT, Introduction to linear filtering using DFT, Digital Filter Structures - direct form I and II, Cascade, Parallel, Lattice, Linear phase, Digital Filter Design - FIR filter using window function technique and frequency sampling technique, finite word length, IIR filter design with bilinear transformation technique and impulse invariant technique, Architecture of Digital Signal Processors, Application of DSP in Power Electronics Converters and Drives.

References:

1. Proakis J.G. and D.G. Manolakis, Introduction to Digital Signal Processing (4e), PHI, 2007
2. Mitra S. K., DSP: A computer based approach (2e), TMH, 2006
3. Douglas O'Shaghnessy, Speech communication – Human & Machines (2e), Wiley-IEEE Press 1999 Gonzalez R. C. & Woods R. E, Digital Image Processing, Pearson, 2005

ELE 5002 DIGITAL SYSTEM DESIGN USING FPGA [4 0 0 4]

Revision of basic Digital systems - Combinational Circuits, Sequential Circuits, Synchronous FSM and asynchronous design, Metastability, Clock distribution and issues, basic building blocks like PWM module, pre-fetch unit, pre-fetch unit, programmable counter, FIFO, Booth's multiplier, ALU, Barrel shifter etc, Digital system Design - Top down Approach to Design, Verilog Synthesis for FPGA Implementation - Verilog constructs and operators, interpretation of Verilog constructs, Examples of Verilog codes for combinational and sequential logic, Data Path and Control Path Design, Programmable Logic Devices - Introduction, Evolution - PROM, PLA, PAL, Architecture of PAL's, Applications, Programming PLD's, FPGA with technology, FPGA structures, Programmable Interconnections, Coarse grained reconfigurable devices, Case study - Applications of digital system design for power electronic converters and drives. IP and Prototyping - IP in various forms: RTL Source code, Encrypted Source code, Soft IP, Netlist, Physical IP, and Use of external hard IP during prototyping, Case studies, and Speed issues, Testing of logic circuits -Fault models, BIST, JTAG interface

References:

1. S. Palnitkar, Verilog HDL : A Guide to Digital Design and Synthesis, PH/Pearson, 2003
2. K. Coffman, Real World FPGA Design with Verilog, PH,1999
3. Peter Ashenden, Digital Design: An Embedded systems Approach using Verilog, Elsevier, 2007
4. Douglas Smith, “HDL Design: A Practical Guide for Designing, Synthesizing & Simulating ASICs & FPGAs Using VHDL or Verilog”, Doone publications 1998.

ELE 5003 DISTRIBUTED ENERGY SYSTEMS [4 0 0 4]

Energy scenario,Overview of electrical grid, introduction to distributed generation, sources of DG systems, advantages, sizing and siting of distributed generation and demand side management, power quality issues, voltage stability, storage technology for power smoothing, operation of hybrid DG systems, micro grids, types of grid integration, issues and challenges, principles of power injection, converting technologies for grid integration, AC-link integration, DC-link integration, HFAC-link integration, instantaneous active and reactive power control approach, standards and codes for interconnection, islanding operation, Life cycle costing.

References:

1. H. Lee Willia and W.G Scott, Distributed power Generation Planning and Evaluation, CRC Press,2007
2. Felix. A. Farret, M. Godoy Simoes, Integration of Alternative Sources of Energy, Wiley InterScience, 2008.
3. Extracts from current literature

ELE 5004 ELECTRIC VEHICLES [4 0 0 4]

Introduction to Electric Vehicles - History, social and environmental importance, Impact of modern drive-trains; Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, Electric Drive-trains - Basic concepts, power flow control, topologies; Electric Propulsion unit: Introduction, Configuration and control of DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, Switch Reluctance Motor drives, Energy Storage - Introduction, Charging technologies, Battery based energy storage, Fuel Cell based energy storage, Super Capacitor based energy storage and Flywheel based energy storage and analysis, Sizing the drive system - Sizing the propulsion motor, power electronics, energy storage technology, Communications, Supporting subsystems - Energy Management Strategies, Battery management systems, Fleet management systems, EV standards, Case Studies - Design of a Battery Electric Vehicle (BEV)

References:

1. Mehrdad Ehsani, Yimin Gao, Sebastien E .Gay, and Ali Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, CRC Press 2004. online access from computers on the colorado.edu network.
2. Evaluation of the 2004 Toyota Prius Hybrid Electric Drive System, Oak Ridge National Lab 2006 report
3. Evaluation of the 2010 Toyota Prius Hybrid Electric Drive System, Oak Ridge National Lab 2011 report
4. Davide Andrea, Battery Management Systems for Large Lithium-Ion Battery Packs, Artech House, 2010.
5. C.Mi, M.A.Masrur, D.W.Gao, Hybrid Electric Vehicles, Wiley 2011.

ELE 5005 EMBEDDED SYSTEM DESIGN [4 0 0 4)]

Embedded Systems - Introduction, Processor and memory architecture, Embedded hardware, Processor for embedded applications, Processing power and benchmarks, PIC microcontroller, Instruction set, on chip peripherals, ARM processor, ARM instruction set, ARM exceptions, ARM '3' stage pipeline, ARM processor based microcontroller, Memory organization, Cache memory, Virtual memory management, Input and output device interfacing - Parallel and serial interfaces and communication protocols, Wireless communication protocols, Embedded system design - Issues and challenges, Current trends in embedded system design.

References:

1. Frank Vahid and Tony Givargis, Embedded system design, Wiley India, 2012.
2. Shibu K V, Introduction to Embedded Systems, TMH, 2012
3. Steve Furber, ARM System on chip architecture, Pearson, 2012
4. Bose B. K., Microcomputer Control of Power Electronics and Drives, IEEE Press, 1999.
5. Ajay V Deshmukh, Microcontrollers, TMH, 2007.

ELE 5006 ENERGY ANALYTICS [4 0 0 4]

Introduction to Data science and Data analytics, Data Sets and relations, Data Preprocessing, Data Modeling and Visualization, Correlation Analysis, Regression Analysis, Forecasting techniques, Classification and clustering techniques, Electricity and Energy management, Industrial and household loads, working and maintenance techniques, Demand side management approaches, Applications of data analytics in energy sector.

References:

1. Thomas A. Runkler, "Data Analytics Models and Algorithms for Intelligent Data Analysis", 2nd Edition, Springer Publications, 2016.
2. John J. McGowan, "Energy and Analytics: Big data and building technology integration", Fairmont Press, 2015.
3. Seog-Chan Oh, Alfred J. Hildreth "Analytics for Smart Energy Management", Springer Series in Advanced Manufacturing, 2016.
4. Kornelis Blok, Evert Nieuwlaar, "Introduction to Energy Analysis", Routledge, 2016.
5. References from current literatures

ELE 5007 ENERGY STORAGE DEVICES [4 0 0 4]

Introduction to different energy forms-Need for Energy storage, performance indices. Mechanical energy storage, Electromagnetic energy storage. Electro-chemical storage- Electro-chemical cell, fuel cells, batteries, Battery Technologies, Fuel cells: History – principle - working - thermodynamics and kinetics of fuel cell process –performance evaluation of fuel cell – comparison on battery Vs fuel cell, Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC, Hydrogen storage: Physical and chemical properties, general storage methods, compressed storage-composite cylinders, glass micro sphere storage, zeolites, metal hydride storage, chemical hydride storage and cryogenic storage, carbon based materials for hydrogen storage, hydrogen as storage medium for renewable energy systems, Pumped hydrostorage, Energy Storage Systems & applications – utilities, transport, industry, house hold, total energy system – hybrid, combined, integrated.

References:

1. Johannes Jensen Bent Squrensen, Fundamentals of Energy Storage, John Wiley, NY, 1984.
2. P. Peregrinus, Electrochemical Power Sources: Primary and Secondary Batteries, M. Barak (Editor), IEE, 1980.
3. Baader, W. Dohne, E, Brenndorfer, Bio-gas in Theory and Practice, [Russian translation], Kolos, Moscow, 1982.
4. P.D.Dunn, Renewable Energies, Peter Peregrinus Ltd, London, United Kingdom , 1st Edition, 1986.
5. Sorenson B, Hydrogen and Fuel Cells: Emerging Technologies and Applications, Bent Sorenson, Academic Press (2005).
6. Hordeski MF, Hydrogen and Fuel Cells: Advances in Transportation and Power, The Fairmont Press, Inc. (2009)
7. Busby RL, Hydrogen and Fuel Cells: A Comprehensive Guide, PennWell Books (2005).

ELE 5008 INSTRUMENTATION IN ELECTRICAL SYSTEMS [4 0 0 4]

Electrical instrumentation: Introduction & Overview, Modern transducers – Resistive, Inductive, Capacitive types, Smart Transducers and Non-Contact Transducers – Modeling and analysis, Analog Signal Conditioning: Active Amplifiers and Filters – Modeling and analysis, signal modulation & demodulation, A/D and D/A converters, Signal Transmission – wired and wireless, Programmable Logic Controllers – Overview of the architecture, Ladder design for typical industrial applications, Virtual Instrumentation – Overview of LabVIEW programming for various applications, Smart Metering, Internet of Things

References:

1. Clarence W. deSilva : Sensors & Actuators: Engineering System Instrumentation, 2nd Edition, CRC Press (Taylor & Francis Group)
2. Sergio Franco,"Design with Operational Amplifiers and Analog Integrated Circuits", McGraw Hill, 4th Edition - 2014
3. Jovitha Jerome, Virtual Instrumentation using LabVIEW, PHI
4. David A. Bell: Operational amplifiers & linear ICs, 2nd edition, PHI/Pearson 2004
5. Hank Zumbahlen, "Linear Circuit Design Handbook: Analog Devices" – Elsevier, 2008
6. JR Hackworth and F.D Hackworth Jr: Programmable logic controllers- Programming Method and applications, Pearson, 2004

ELE 5009 LIGHTING CONTROLS: TECHNOLOGY & APPLICATIONS [4 0 0 4]

Strategies and technologies - occupancy sensing, switching controls, daylight adaptation and photo sensors, Commissioning and energy codes, Controller and control algorithms - Integral reset, open-loop and closed loop control, adaptive control, predictive control , inverse control with online adaptive learning, Camera based measurement, virtual scenario based intelligent lighting control, Protocols and Networking - architecture, standard lighting protocols, wired and wireless, centralized and distributed, WSAN lighting control application, connected lighting system, SoC solutions for lighting control system, Low voltage dc systems, Power-over-Ethernet, Commissioning of smart lighting system.

References:

1. Simpson, Robert S. Lighting control: technology and applications. Taylor & Francis, 2003.
2. DiLouie, Craig. Lighting controls handbook. The Fairmont Press, Inc., 2008.
3. Cai, H. "Luminance gradient for evaluating lighting." Lighting Research & Technology 48.2 (2016): 155-175.
4. Serpanos, Dimitrios, and Marilyn Wolf. Internet-of-things (iot) Systems: Architectures, Algorithms, Methodologies. Springer, 2017.
5. Yang, Kun. "Wireless sensor networks." Principles, Design and Applications (2014)

ELE 5010 POWER QUALITY ISSUES & MITIGATION [4 0 0 4]

Power Quality Issues - Terminologies, classification, causes, effects, Power Quality Monitoring - Standards, measurement techniques, PQ monitoring system, Power Quality Mitigation - Analysis and design of passive compensators, PQ enhancement using custom power devices - DSTATCOMs, DVRs, UPQCs, control and design, Power Filters - passive, active and hybrid approaches, control and design, Performance analysis of simple systems through modeling and simulation studies, design of power filters, Power quality improvement in electrical system.

References:

1. Bhim Singh, Ambrish Chandra and Kamal Al Haddad, Power Quality: Problems and Mitigation Techniques, John Wiley & Sons Ltd., U. K, 2015
2. C. Shankaran, Power Quality, CRC Press, 2013.
3. Math H J Bollen, Understanding Power Quality Problems; Voltage Sags and Interruptions, Wiley India, 2011.
4. Roger C Dugan, et.al, Electrical Power Systems Quality, 3rd Edition, TMH, 2012.
5. Arindam Ghosh et.al, Power Quality Enhancement Using Custom Power Devices, Kluwer Academic Publishers, 2002

ELE 5011 TIME FREQUENCY ANALYSIS [4 0 0 4]

The time and frequency description of signals, bandwidth equation, AM and FM contributions to the bandwidth, Fourier transform of the time and frequency densities, non-additivity of spectral properties, uncertainty principle. Instantaneous frequency and the complex signal, analytic signal, quadrature approximation, instantaneous frequency, density of instantaneous frequency, one dimensional densities, two dimensional densities, local quantities, negative densities, Time-Frequency Distributions - global averages, local average, time and frequency shift invariance, linear scaling, weak and strong finite support, uncertainty principle and joint distributions, short-time Fourier transform and spectrogram, global quantities, local averages, optimal window. Wavelet bases for discrete and continuous variables, The Haar basis, Differentiable wavelet bases, Compact wavelet bases, Multiresolution analysis, Applications: Wide Area Measurement

References:

1. L. Cohen, Time-Frequency Analysis. Prentice Hall, 1995.
2. S. Mallat, A Wavelet Tour of Signal Processing - The Sparse Way. Elsevier, Third Edition, 2009.
3. M. Vetterli, J. Kovacevic, and V. K. Goyal, Fourier and Wavelet Signal Processing. Book site: http://fourierandwavelets.org/terms.php

ELE 5012 WIND ENERGY CONVERSION SYSTEMS [4 0 0 4]

Wind source, wind statistics, energy in the wind, turbine power characteristics - aerodynamics, rotor types, parts of wind turbines, braking systems, tower - control and monitoring system, Types of generators, General characteristics of induction generators – grid-connected and self-excited systems steady state equivalent circuit, performance predetermination, permanent magnet alternator, steady-state performance, Power electronic converters for interfacing wind electric generators, power quality issues, hybrid systems -wind-diesel systems, wind-solar systems, wind-micro turbine systems, wind – fuel cell systems, Wind Energy Application, Wind pumps - Performance analysis, design concept and testing, Principle of Wind Energy Generators, Stand alone, grid connected and hybrid applications of WECS, Economics of wind energy utilization, Wind energy in India, Case studies.

References:

1. Adel, A Elbaset, Renewable Energy and Smart Grid Integration Through Advanced Power Electronics, Elminia University, Elminia, Egypt.
2. Nelon Vaughn, wind energy .CRC press Boca Raton 2009.
3. S.N Bhadra, D.Kastha, S. Banerjee, Wind Electrical system, Oxford university press 2005.

OPEN ELECTIVES

ELE 5051 INTELLIGENT CONTROL SYSTEMS [3 0 0 3]

Fundamentals of Artificial Neural Networks - Feed forward and feedback networks, learning rules, Single layer feed forward networks, Multilayer feed forward networks, Linearly non-separable pattern classification, generalized delta learning rule, error back propagation training algorithms, Single layer feedback network - Energy function, Application of neural networks, Introduction to Fuzzy control, Inference rules, Fuzzy knowledge based controllers, Fuzzification, membership function evaluation, Defuzzification methods, Application of fuzzy logic to control systems, fuzzy-neural systems, Introduction to Genetic Algorithms.

References:

1. J. S. T Jang, C.T Sun and E. Mitzutani, Neuro-Fuzzy and Soft Computing, Prentice Hall International, Inc, 2011.
2. Chin-Teng Lin, C.S.George Lee, Neural Fuzzy Systems, Prentice – Hall International, Inc.1996.
3. S. Haykin, Neural Networks - A Comprehensive Foundation - 2nd Edition, Prentice Hall, 2005.
4. T. J. Ross, Fuzzy Logic with Engineering Applications, McGraw-Hill, Inc., 2014
5. Jacek M. Zurada, Introduction to Artificial Neural Networks, Jaico, 2016

ELE 5052 PHOTOVOLTAIC SYSTEMS [3 0 0 3]

Prerequisites: Basics on solar systems, Electronic devices, Electrical machines and Power electronics.

Basic characteristics of sunlight, Solar PV cell, I-V characteristics, P-V characteristics, fill factor, Modeling of solar cell, maximum power point tracking, PV module, blocking diode and bypass diodes, composite characteristics of PV module, PV array, PV system design, Applications – PV powered fan, PV fan with battery backup and charge controllers, PV powered pumping system, PV powered lighting systems, grid connected PV systems, Simple payback period, life cycle costing.

References:

1. Chetan Singh Solanki, 'Solar Photovoltaic's: Fundamentals, Technologies and Applications' PHI Learning Publications, 2 Nd Edition, 2011.
2. Roger A. Messenger and Jerry Ventre, 'Photovoltaic systems engineering', Taylor and Francis Group Publications, 2nd Edition, 2003.