National Institute of Technology Sikkim
Department of Electrical and Electronics Engineering
M.Tech. in Electrical Engineering (Control, Power and Electric Drives)

(Effective from 2017 Admitted Batch onwards)

First Semester: 22 Credits

Sl. No.	Subject Code	Subject	L-T-P	Credits
1	EE21101	Power System Analysis and Operation	3-1-0	4
2	EE21102	Power Electronics	3-1-0	4
3	EE21103	Control Systems - I	3-1-0	4
4		Elective I	3-0-0	3
5		Elective II	3-0-0	3
6	EE21201	Power and Energy Systems Laboratory	0-0-3	2
7	EE21202	Intelligent Control Systems Laboratory	0-0-3	2

Second Semester: 22 Credits

Sl. No.	Subject Code	Subject	L-T-P	Credits
1	EE22101	Power System Stability and Control	3-1-0	4
2	EE22102	Electric Drives	3-1-0	4
3	EE22103	Control Systems - II	3-1-0	4
4		Elective III	3-0-0	3
5		Elective IV	3-0-0	3
6	EE22201	Power Electronics and Power Quality Laboratory	0-0-3	2
7	EE22202	Term Paper		2

Third Semester: 22 Credits

Sl. No.	Subject Code	Subject	L-T-P	Credits
1	EE23201	Dissertation Phase 1		20
2	EE23401	Seminar 1		2

Fourth Semester: 22 Credits

Sl. No.	Subject Code	Subject	L-T-P	Credits
1	EE24201	Dissertation Phase 2		20
2	EE24401	Seminar 2		2

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List of Electives:

Semester	Subject Code	L-T-P	Subject	Credits
Elective I and Elective II	EE21301	3-0-0	Optimization Techniques and Algorithms	3
	EE21302	3-0-0	Renewable Energy Systems and Applications	3
	EE21303	3-0-0	High Voltage Direct Current Transmission	3
	EE21304	3-0-0	Switchgear and Protection	3
	EE21305	3-0-0	Artificial Neural Networks and Genetic Algorithms	3
	EE21306	3-0-0	Power System Reliability and Deregulation	3
	EE21307	3-0-0	Switched Mode Power Supplies	3
	EE21308	3-0-0	Analysis of Machine	3
	EE21309	3-0-0	Computer Control of Industrial Processes	3
	EE21310	3-0-0	Machine Learning and Robotics	3
Elective III and Elective IV	EE22301	3-0-0	Biomedical Instrumentation	3
	EE22302	3-0-0	Advanced DC-AC Power Conversion	3
	EE22303	3-0-0	Optimal and Adaptive Control	3
	EE22304	3-0-0	Power Quality	3
	EE22305	3-0-0	Flexible AC Transmission Systems	3
	EE22306	3-0-0	Digital Control Systems	3
	EE22307	3-0-0	Linear System Theory	3
	EE22308	3-0-0	Fuzzy Logic Systems	3

L	T	P	C
3	1	0	4

EE21101 POWER SYSTEM ANALYSIS AND OPERATION
Total hours: 56 hours (including tutorial)

Module 1: (11 Hours)
Power system load flow – Load flow analysis; static load flow equation for a low-bus system, characteristics of a load flow equation, generalization to n-bus system, Gauss-Seidel and Newton-Raphson and FDLF methods of solution of load flow equations up to 30 bus system.

Module 2: (11 Hours)
Optimal power flow analysis: Static state estimation – method of least square and weighted least square; Dynamic state estimation- development of basic model, filtering techniques - Kalman Filter and Extended Kalman Filter.

Module 3: (10 Hours)
Generation operation - Load forecasting, importance of load forecasting, different methods of load forecasting, economic operation: economic dispatch of thermal units and methods of solution.

Module 4: (10 Hours)
Unit commitment: Solution methods - hydrothermal coordination, scheduling problems - short term hydrothermal scheduling problem - short term hydro scheduling-load model - prime mover model - governor model - tie-line model - generation control.

Text and Reference Book:

1. A. J. Wood and B. F. Wollenberg, "Power Generation Operation and Control", John Wiley & Sons, ICN, 2nd edition.
2. A. K. Mahalanabis, "Computer Aided Power system analysis and control", Tata McGraw-Hill 1991.
3. O. I. Elgerd, "Electric Energy Systems Theory", McGraw-Hill, 2nd edition, 1982.
4. Antonio Gomez-Exposito, Antonio Jconejo and Claudio Canizares, "Electric Energy systems analysis and operation", CRC press, 2009.
5. D. P. Kothari and I. J. Nagrath, "Modern Power System Analysis", Tata McGraw-Hill, 2007.

EE21102 POWER ELECTRONICS
Total hours: 56 hours (including tutorial)

L	T	P	C
3	1	0	4

Module 1: Power Semiconductor Devices (8 Hours)
Solid-state devices: Review of SCR, review on modern semiconductor devices: MOSFET, GTO, IGBT, SIT, SITH, MCT, their operating characteristics; general driver circuits and protection; power loss in semiconductors; principle of soft switching (ZVS & ZCS).

Module 2: Phase Controlled Converters (14 Hours)
Review of single-phase controlled converters, effect of load and source impedances, effect of freewheeling diode; three-phase converters, fully controlled and half controlled converters, multi-pulse converters using transformer connections; dual converter; improved quality converters; power factor improvement techniques, PWM converter.

Module 3: DC – DC Converters (10 Hours)
Principle of operation choppers; Buck converter, boost converter, buck-boost converter, forward converter, push-pull converter, fly-back converter, Cúk converter, resonant converter.

Module 4: AC-AC Converters (10 Hours)
Three-phase ac regulators, operation with resistive load; single-phase cyclo-converters; matrix converters, output voltage control techniques, commutation methods.

Module 5: Inverters (14 Hours)

Review of three-phase voltage source inverters, voltage and frequency control; harmonic reduction techniques, PWM inverters, space vector modulation; multi-level inverters configurations: diode clamped, flying capacitor and cascade multilevel inverters, applications; current source inverter, commutation circuits, DC link resonant inverters, operation and control.

Text/Reference Books:

1. Ned Mohan, Power Electronics, John Wiley and Sons, 2nd edition, 1995.
2. Rashid, Power Electronics, Circuits Devices and Applications, Pearson Education, 3rd edition, 2004.
3. G. K. Dubey, Thyristorised Power Controllers, Wiley Eastern Ltd, 1993.
4. Dewan and Straughen, Power Semiconductor Circuits, John Wiley & Sons, 1975.
5. Cyril W Lander, Power Electronics, McGraw-Hill, 3rd edition, 1993.
6. Electrical Motor Drives: Modeling, Analysis and control: R Krishnan, 1st edition, 2007, Pearson Education.
7. G. K. Dubey and C. R. Kasaravada, "Power Electronics & Drives", Tata McGraw-Hill, 1993.
8. Dubey, Power Electronics Drives, Wiley Eastern, 1993.
9. dré Veltman, Duco W. J. Pulle and Rik W. De Doncker: Fundamentals of Electrical Drives, 1st edition 2007, Springer.

EE21103 CONTROL SYSTEMS – I
Total hours: 56 hours (including tutorial)

L	T	P	C
3	1	0	4

Module 1: (14 Hours)

State space representation, solution of state equation, state transition matrix, canonical forms – controllable canonical form, observable canonical form, Jordan canonical form, controllability and observability, principle of duality, controllability and observability form Jordan canonical form and other canonical forms.

Module 2: (10 Hours)

Introduction to nonlinear systems, types of nonlinearities, describing functions, describing function analysis of nonlinear control systems. Introduction to phase-plane analysis, method of isoclines for constructing trajectories, singular points, phase-plane analysis of nonlinear control systems.

Module 3: (10 Hours)

Effect of state feedback on controllability and observability, design of state feedback control through pole placement, full order observer, reduced order observer, Lyapunov's stability and instability theorems, application of Lyapunov theorems.

Module 4: (22 Hours)

Application of soft-computing methods, system design through neural network, fuzzy system.

Relevant topics in research and class projects/assignments (for this course).

Reference:

1. Modern Control System Theory – M. Gopal, New Age International Publishers
2. Modern Control Engineering – K. Ogata, Prentice Hall of India
3. Control Systems Engineering - I. J. Nagarath and M.Gopal, New Age International (P) Ltd
4. Digital Control and State Variable Methods – M. Gopal, Tata Mc Graw-Hill Companies
5. Systems and Control - Stainslaw H. Zak , Oxford Press

EE21301 OPTIMIZATION TECHNIQUES AND ALOGORITHMS
Total hours: 42 Hours

L	T	P	C
3	0	0	3

Module 1: (11 Hours)
Concepts of optimization: Engineering applications-statement of optimization problem; classification - type and size of the problem; classical optimization techniques: single and multi-variable problems; types of constraints semi definite case saddle point.
Linear programming: Standard form-geometry of LP problems - theorem of LP-relation to convexity - formulation of LP problems - simplex method and algorithm - matrix form- two phase method; duality- dual simplex method- LU decomposition; sensitivity analysis; artificial variables and complementary solutions - QP engineering applications: minimum cost flow problem, network problems - transportation, assignment and allocation, scheduling; Karmarkar method - unbalanced and routing problems.

Module 2: (11 Hours)
Nonlinear programming: non linearity concepts - convex and concave functions; non-linear programming - gradient and Hessian; unconstrained optimization - first and second order necessary conditions -minimization and maximization; local and global convergence - speed of convergence; basic decent methods - Fibonacci and Golden section search; gradient methods - Newton method - Lagrange multiplier method - Kuhn-tucker conditions; Quasi-Newton method - separable convex programming – Frank and Wolfe method, engineering applications.

Module 3: (10 Hours)
Nonlinear programming - constrained optimization; characteristics of constraints - direct methods - SLP, SQP indirect methods - transformation techniques - penalty function; Lagrange multiplier methods; checking convergence; engineering applications.

Module 4: (10 Hours)
Dynamic programming: multistage decision process; concept of sub optimization and principle of optimality; computational procedure; engineering applications.
Genetic algorithms - simulated annealing methods optimization programming, tools and software- MATLAB, SIMULINK, FSQP, SOLVER, LINDO etc.

Text/Reference Books:

1. David G Luenberger, “Linear and Non Linear Programming”, 2nd Ed, Addison-Wesley Pub. Co., Massachusetts, 1973.
2. W. L. Winston, “Operation Research-Applications & Algorithms”, Thomson publications, 2003.
3. S. S. Rao, “Engineering Optimization”, 3rd Ed., New Age International (P) Ltd, New Delhi, 2004.
4. W. F. Stoecker, “Design of Thermal Systems”, 3rd Ed., McGraw-Hill, 1989.
5. G. B. Dantzig, “Linear Programming and Extensions”, Princeton University Press, 1963.
6. L. C. W. Dixton, “Non Linear Optimization: theory and algorithms”, Birkhauser, Boston, 1980.
7. Bazarra M.S, Sherali H.D. and Shetty C.M., “Nonlinear Programming Theory and Algorithms”, John Wiley, New York, 1979.
8. Kalyanmoy Deb, “Optimization for Engineering Design-Algorithms and Examples”, Prentice Hall India, 1998.

EE21302 RENEWABLE ENERGY SYSTEMS AND APPLICATIONS
Total hours: 42 Hours

L	T	P	C
3	0	0	3

Module 1: (12 Hours)
Introduction to renewable energy various aspects of energy conversion, principle of renewable energy systems environment and social implications, solar energy - solar radiation components, measurements-estimation; solar collectors, solar water heaters, calculation; types-analysis-economics; applications solar thermal power generation solar photovoltaics; energy conversion principle; classifications, equivalent circuit, characteristics, cell efficiency, limitations, PV modules, MPPT algorithms.

Module 2: (9 Hours)
Wind energy - basics of wind turbines, power and energy from wind turbine, characteristics, types of electric generators for wind power generation, dynamics matching, performance of wind generators, applications, economics of wind power.

Module 3: (10 Hours)
Storage devices - super capacitor, SMES, battery storage, flywheel storage, compressed air storage, fuel cells, types and applications; MHD generators, backup system design, industrial and domestic applications.

Module 4: (11 Hours)
Bioenergy - bio fuels, classification, biomass conversion technologies, applications; ocean energy, tidal energy, wave energy, ocean thermal energy conversion systems, applications; mini, micro and pico hydel power.

Text/Reference Books:

1. Godfrey Boyle, "Renewable Energy: Power for a sustainable future", Oxford University Press, 2nd edition.
2. Rai G. D., "Solar Energy Utilization", Khanna Publishers, 1997.
3. B. H. Khan, "Non-Conventional Energy Resources", McGraw-Hill Companies, Second Edition.
4. Sukhatme, S. P*, "*Solar Energy -Principles of Thermal Collection and Storage", Tata McGraw-Hill, 2nd Ed., 1997.
5. Sammes, Nige, "Fuel Cell Technologies-State and Perspectives", Springer publication, 2005.
6. Kreith, F. and Kreider, J. F., "Principles of Solar Engineering", McGraw-Hill Book Co, 1978.
7. S. L. Soo, "Direct Energy Conversion", Prentice Hall Publication, 1968.
8. James Larminie, Andrew Dicks, **"**Fuel Cell Systems", Wiley & Sons Ltd, 2nd ed., 2003.
9. E. J. Womack*,* "MHD power generation engineering aspects", Chapman, Hall publication, 1969.

EE21303 HIGH VOLTAGE DIRECT CURRENT TRANSMISSION
Total hours: 42 Hours

L	T	P	C
3	0	0	3

Module 1: (9 hours)
D.C. Power Transmission Technology: Introduction, Comparison of AC and DC Transmission, Application of DC Transmission, Description of DC Transmission System, Planning for HVDC transmission. Modern Trends in DC transmission.

Module 2: (9 hours)
Thyristor Valve: Introduction, Thyristor devices, Thyristor valve, valve test, recent trends; analysis of HVDC converters; pulse number, choice of converter configuration, simplified analysis of Graetz circuit, convertor bridge characteristics, characteristics of a twelve pulse converters, detailed analysis of converters.

Module 3: (14 hours)
Converter and HVDC system control: general, principles of DC link control, converter control characteristics, system control hierarchy firing angle control, current and extinction angle control, starting and stopping of DC link, power control, higher level controllers, telecommunication requirements; converter faults and protection: introduction, converter faults, protection against over currents over voltages in a converter station, surge arrests, protection against over voltages; smoothing reactor and DC line; introduction, smoothing reactors, DC line, transient over voltages in DC line, protection of DC line, DC breakers, Mono-polar operation, Effects of proximity of AC and DC transmission lines; reactive power control; introduction, reactive power requirements in steady state, sources of reactive power, static VAR systems, reactive power control during transients.

Module 4: (10 hours)
Harmonics and filters; introduction, generation of harmonics, design of AC filters, DC filters, carrier frequency and RI noise. Multi-terminal DC systems; introduction, potential applications of MTDC systems, types of MTDC systems, control and protection of MTDC systems, control and protection of MTDC systems study of MTDC systems.

Reference:

1. K. R. Padiyar, HVDC Power transmission System, New age International, 1996.

2. Prabha Kundur, Power System Stability and Control

3. Research papers in relevant area

EE21304 SWITCHGEAR AND PROTECTION
Total hours: 42 Hours

L	T	P	C
3	0	0	3

Module 1: (10 Hours)
Circuit breakers-principles of operation–RRRV-current chopping; constructional features and selection of LT breakers (MCB/MCCB/ELCB) and HT breakers (ABCB - OCB – SF6CB– VCB); circuit breaker ratings-testing of circuit breakers.

Module 2: (10 Hours)
Over voltages – surges and travelling waves – wave propagation on transmission lines - reflection and attenuation- Lightning strokes- protection against lightning - earth wires- lightning diverters - surge absorbers - arcing ground - neutral earthing - basic concepts of insulation levels and their selection - BIL – co-ordination of insulation.

Module 3: (12 Hours)
Protective relays - protective zones - requirement of protective relaying- definitions-codes-standards - types – over current relays - earth fault relays- directional relays- differential relays- distance relays-under voltage/frequency relays; static, digital and numerical relays-PC based relays-construction-characteristic functions-converter elements-comparators-relay schematics, analysis.

Module 4: (10 Hours)
Protection scheme for generators-power station and DG sets, power and distribution transformers, transmission lines and busbars, motors. NEC and importance of relevant IS/IEC specifications related to switchgear and protection.

Text/Reference Books:

1. Sunil S Rao, "Switch Gear Protections", Khanna Publications, Delhi 1999.
2. Allen Greenwood, "Electrical Transients in Power Systems", 1991.
3. Van. C. Warrington A.R., "Protective Relays", Vol. 1 & 2, Chapman & Hall, 1998.
4. T S Madhav Rao, "Power system protection static relays with microprocessor Applications", Tata McGraw-Hill Publication, 1998.
5. Badri Ram, D N Vishwakarma, "Power System Protection and Switchgear', Tata McGraw-Hill, 2005.
6. Anderson P M, "Power System Protection", IEEE publication, 1999.
7. Walter -Marcel Dekker, "Protective relaying theory and applications", 2^{nd} ed., Elmore, 2004.

EE21305 ARTIFICIAL NEURAL NETWORKS AND GENETIC ALGORITHMS
Total hours: 42 Hours

L	T	P	C
3	0	0	3

Module 1: (11 Hours)
Introduction to Artificial Neural Networks - Biological neurons .Computational models of neuron-McCulloch -Pitts model - types of activation function .Introduction to network architectures - knowledge representation -Learning process .Learning algorithms- - error-correction learning .Boltzmann learning-Hebbian learning, competitive learning- Learning paradigms- supervised learning - unsupervised learning - method of steepest descent - least mean square algorithms - Adaline/medaline units perceptrons-derivation of the backpropagation algorithm- Advances in Learning strategies-Computer based simulation of simple Network Structures.

Module 2: (11 Hours)
Neural Network Architectures-MLFFN-Recurrent NN- RBF Network structure - separability of patterns – RBF learning strategies - comparison of RBF, RNN and MLP networks- Hopfield networks- associative memory energy function - spurious states - error performance - simulated annealing - applications of neural networks . Forecasting-the XOR problem - traveling salesman problem - image compression using MLPs – character retrieval using Hopfield networks-Advances in ANN Theory- Computer based simulation.

Module 3: (11 Hours)
Genetic Algorithm-Introduction to Genetic Algorithms. The GA computation process-natural evolution-parent selection-crossover-mutation-properties - classification – Advances in the theory GA- Application to Engineering problems.

Module 4: (9 Hours)
Hybrid systems and Soft Computing- Limitations of ANN and GA- Concept of neuro-fuzzy and neuro-genetic systems- GA as an optimization tool for ANN-Application of ANN in forecasting-Signal characterization-Fault diagnosis-Neuro-Fuzzy-Genetic Systems- Case Studies in solving Engineering problems of control, signal/image processing etc.

Text/Reference Books:

1. Simon Haykin, *Neural Network – A Comprehensive Foundation*, 2nd Ed, Pearson Education, 2002.
2. Zurada J.M., *Introduction to Artificial Neural Systems*, Jaico Publishers, 2003.
3. Bart Kosko, *Neural Network and Fuzzy Systems*, Prentice Hall of India, 2002.
4. Goldberg D.E., .*Genetic Algorithms in Search Optimization and Machine Learning*, Addison Wesley, 1989.
5. Suran Goonatilake and Sukhdev Khebbal (Eds.), *Intelligent Hybrid Systems*, John Wiley, 1995.
6. Hassoun Mohammed H, *Fundamentals of Artificial Neural Networks*, Prentice Hall of India, 2002.

EE21306 POWER SYSTEM RELIABILITY AND DEREGULATION
Total hours: 42 Hours

L	T	P	C
3	0	0	3

Module 1: (10 Hours)
Generator System Models- State Load Model- Probability Methods- Unit Unavailability- Outage Probability- Generating Capacity Limits- Recursive Techniques- Capacity Expansion Analysis - Scheduled Outages - Reliability Indices- Frequency Duration Method. Power quality issues.

Module 2: (11 Hours)
Interconnected Systems - Two Systems with Tie- Probability Array Methods- Reliability Indices- Variable Reserve And Maximum Peak Load Reserve- Multi Connected Systems.
Distribution System- Interruption Indices- System Performance- risk prediction- Radial Systems- Effect of Load Transfer- Line Failures- Parallel and Mesh Networks- Industrial Systems.

Module 3: (10 Hours)
Deregulated Systems: Need and conditions for deregulation-Introduction of Market structure-Market Architecture-Spot market-forward markets and settlements. Review of Concepts- marginal cost of generation least- cost operation-incremental cost of generation.

Module 4: (11 Hours)
Reconfiguring Power systems- Unbundling of Electric Utilities- Competition and Direct access. Transmission network and market power - Power wheeling transactions and marginal costing - transmission costing. Framework and methods for the analysis of Bilateral and pool markets.

Text/Reference Books:

1. Dong**,** Z**.,** Zhang**,** P**.** Ma**,** J**.,** Zhao, J., Ali**,** Meng**,** K**.,** Yin, "Emerging Techniques in Power System Analysis" Springer, 1st edition, 2010.
2. S.C. Savulescu, "Real-Time Stability assessment in modern power system control centres", John Wiley & Sons, 2009.
3. Eric Monmasson, "Static Converters", John Wiley & Sons, 2009.
4. Bo Bergman, Jacques de Mare, Thomas Svensson, Sara Loren, "Robust Design methodology for reliability", John Wiley & Sons, 2009.
5. Ali A. Chowdhury, Don O. Koval, "Power distribution system reliability-Practical methods and applications" John Wiley & sons Inc., *IEEE Press* 2009.
6. Richard E. Brown, "Electric power distribution reliability" Taylor & Francis Group, LLC, 2009.
7. Elmakias, David (Ed.) "New Computational Methods in Power System Reliability" Studies in Computational Intelligence, Springer, 2008.
8. Leveque, Francois, "Transport Pricing of Electricity Networks", Springer, 2003.
9. Steven Stoft, "Power System Economics-Designing markets for electricity", *IEEE Pres*, 2002.
10. M. Shahidehpour, H. Yamin and Zuyi Li, "Market operations in electric power systems-Forecasting, scheduling and risk management", John Wiley & sons Inc., 2002.

EE21307 SWITCHED MODE POWER SUPPLIES
Total hours: 42 Hours

L	T	P	C
3	0	0	3

Module 1: Introduction (8 Hours)
Linear regulator vs switching regulator – topologies of SMPS – isolated and non-isolated topologies – buck – boost – buck boost – Cuk – polarity inverting topologies – push pull and forward converters half bridge and full bridge – fly back converters voltage fed and current fed topologies, EMI issues.

Module 2: Design Concepts (10 Hours)
Magnetic circuits and design – transformer design - core selection – winding wire selection – temperature rise calculations - inductor design; Core loss – copper loss – skin effect - proximity effect. Power semiconductor selection and its drive circuit design – snubber circuits; closing the feedback loop – control design – stability considerations.

Module 3: Control Modes (12 Hours)
Voltage mode control of SMPS transfer function and frequency response of error amp; Transconductance error amps. PWM Control ICs (SG 3525, TL 494, MC34060 etc.)
Current mode control and its advantages; current mode vs voltage mode; current mode PWM control IC (e.g. UC3842).

Module 4: (12 Hours)
Applications of SMPS - active front end – power factor correction – high frequency power source for fluorescent lamps - power supplies for portable electronic gadgets.
Resonant converters
Principle of operation – modes of operation – quasi resonant operation- advantages.

Text/Reference Books:

1. Abraham I Pressman - Switching power supply design – 2nd edition 1998 McGraw-hill Publishing Company.
2. Keith H Billings - Switch mode power supply handbook – 1st edition 1989 McGraw-hill Publishing Company.
3. Sanjaya Maniktala - Switching power supplies A to Z. – 1st edition 2006, Elsevier Inc.
4. Daniel M Mitchell: DC-DC Switching Regulator Analysis. McGraw-Hill Publishing Company
5. Ned Mohan et.al: Power Electronics. John Wiley and Sons.
6. Otmar Kilgenstein: Switched Mode Power Supplies in Practice. John Wiley and Sons.
7. Mark J Nave, Power Line Filter Design for Switched-Mode Power Supplies. Van Nostrand Reinhold, New York.

EE21308 ANALYSIS OF MACHINE
Total hours: 42 Hours

L	T	P	C
3	0	0	3

Module 1: DC machines (11 Hours)
Output equation - main dimensions - choice of specific electric and magnetic loadings - choice of speed and number of poles - design of armature conductors, slots and winding - design of air-gap, field system, commutator, interpoles, compensating winding and brushes - Carter's coefficient - real and apparent flux density - design examples.

Module 2: Transformers (10 Hours)
Output equation of single phase and three phase power transformers - main dimensions - choice of specific electric and magnetic loadings - design of core, LV winding, HV winding, tank and cooling tubes - prediction of no load current, forces on winding during short circuit, leakage reactance and equivalent circuit based on design data - design examples.

Module 3: Alternators (10 Hours)
Output equation of salient pole and turbo alternators - main dimensions - choice of specific electric and magnetic loadings - choice of speed and number of poles - design of armature conductors, slots and winding - design of air-gap, field system and damper winding - prediction of open circuit characteristics and regulation of the alternator based on design data - design examples.

Module 4: Induction machines (11 Hours)
Output equation - main dimensions - choice of specific electric and magnetic loadings - design of stator and rotor windings, stator and rotor slots and air-gap of slip ring and squirrel cage motors - calculation of rotor bar and end ring currents in cage rotor - calculation of equivalent circuit parameters and prediction of magnetizing current based on design data - design examples

Text/Reference Books:
1. Clayton and Hancock, Performance & Design of DC Machines, CBS, 3rd edition, 2001
2. Sawhney, Electrical Machine Design, Educational Publishers and Distributors, 1998.
3. Say M. G, Performance and Design of AC Machines, Pitman, ELBS.3rd edition, 1983.

EE21309 COMPUTER CONTROL OF INDUSTRIAL PROCESSES
Total hours: 42 Hours

L	T	P	C
3	0	0	3

Module 1: Multivariable Control (12 Hours)
Multivariable control- Basic expressions for MIMO systems- Singular values- Stability norms- Calculation of system norms- Robustness- Robust stability- H2/ H Theory- Solution for design using H2/ H - Case studies .Interaction and decoupling- Relative gain analysis- Effects of interaction- Response to disturbances-Decoupling- Introduction to batch process control.

Module 2: Programmable Logic Controllers (10 Hours)
Programmable logic controllers Organization- Hardware details- I/O- Power supply- CPU- Standards- Programming aspects- Ladder programming- Sequential function charts- Man- machine interface- Detailed study of one model- Case studies.

Module 3: Large Scale Control System (12 Hours)
SCADA: Introduction, SCADA Architecture, Different Communication Protocols, Common System Components, Supervision and Control, HMI, RTU and Supervisory Stations, Trends in SCADA, Security Issues DCS: Introduction, DCS Architecture, Local Control (LCU) architecture, LCU languages, LCU – Process interfacing issues, communication facilities, configuration of DCS, displays, redundancy concept - case studies in DCS.

Module 4: Real Time Systems (8 Hours)
Real time systems- Real time specifications and design techniques- Real time kernels- Inter task communication and synchronization- Real time memory management- Supervisory control- direct digital control- Distributed control- PC based automation.

Text/Reference Books:

1. Shinskey F. G., Process control systems: application, Design and Tuning, McGraw-Hill International Edition, Singapore, 1988.
2. Belanger P.R., Control Engineering: A Modern Approach, Saunders College Publishing, USA, 1995.
3. Dorf, R.C. and Bishop R. T., Modern Control Systems , Addison Wesley Longman Inc., 1999.
4. Laplante P.A., Real Time Systems: An Engineer’s Handbook, Prentice Hall of India Pvt. Ltd., New Delhi, 2002.
5. Constantin H. Houpis and Gary B. Lamont, Digital Control systems, McGraw Hill Book Company, Singapore, 1985.
6. Stuart A. Boyer: SCADA-Supervisory Control and Data Acquisition, Instrument Society of America Publications, USA, 1999.
7. Gordon Clarke, Deon Reynders: Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems, Newnes Publications, Oxford, UK, 2004.
8. Efim Rosenwasser, Bernhard P. Lampe, Multivariable computer-controlled systems: a transfer function approach, Springer, 2006.

EE21310 MACHINE LEARNING AND ROBOTICS
Total Hours: 42 Hours

L	T	P	C
3	0	0	3

Module 1: (8 Hours)

Overview and preliminaries, generation of data set, manipulation on data set, storage and representation of data, dynamic system modelling – rotational, translational systems.

Interchange of system modelling – differential, state Space, transfer function

Time response of dynamic systems – LTI, nonlinear systems

Module 2: (10 Hours)

Introduction to neural networks, SLP, MLP, RBFN, recurrent network, SOM, fuzzy systems

Module 3: (8 Hours)

Sensors and actuators, mobile robots, position and orientation, equations of motion, transformations, path Planning and trajectories, introduction to robotic arm/manipulator, forward kinematics, inverse kinematics, redundancy and redundancy resolution

Module 4: (16 Hours)

Case study of applications of neural network on mobile robot, case study of applications of neural network on robot manipulator, case study of applications of fuzzy logic on mobile robot, case study of applications of fuzzy logic on robot manipulator

Text/Reference:

1. Robot Analysis and Control, H. Asada, J. J. Slotine, Wiley
2. Robot Modeling and Control, Spong, Hutchinson, and Vidyasagar, Wiley
3. A Mathematical Introduction to Robotic Manipulation, Murray, Li, and Sastry, CRC
4. Introduction to Robotics: Mechanics and Control, Craig, Addison-Wesley
5. Robotics Technology and Flexible Automation, S. R. Deb, S. Deb, McGraw Hill
6. Research Papers from IEEE, Elsevier, Springer

EE21201 POWER AND ENERGY SYSTEMS LABORATORY

L	T	P	C
0	0	3	2

Name of the experiments:

1. Study of the effect of load angle δ on the stability of synchronous machines.
2. Study of Short, Medium & Long transmission line.
3. Study of the bus admittance/ impedance matrix of a 5 bus system.
4. Study of power flow using Gauss-Seidel Method IEEE 14-bus system.
5. Study of power flow using Newton Raphson Method IEEE 14-bus system.
6. Study of power flow using FDLF Method IEEE 14-bus system.
7. Study of AGC in single area: Static and Dynamic response.
8. Study of AGC of two interconnected areas by tie-line: Dynamic response.
9. Study of UPFC and study of improvement in power system stability using UPFC.
10. Study of STATCOM and study of improvement in power system stability using STATCOM.
11. Study of TCSC and study of improvement in power system stability using TCSC.
12. Additional experiments in form of group project in relevant field.

EE21202 INTELLIGENT CONTROL SYSTEMS LABORATORY

L	T	P	C
0	0	3	2

Experiments:

1. Familiarization of programming environment (C++, MATLAB, Player-stage, ROS)
2. Data manipulation and storage
3. Solution for dynamic system response – linear time invariant systems, nonlinear Systems
4. Design of controllers using state feedback
5. Design of regulators – full order regulator, reduced order regulator
6. Design of linear quadratic regulators (LQR)
7. Design of linear quadratic Gaussian (LQG) controller
8. Design and implementation of controllers for an inverted pendulum
9. Additional experiments in form of group projects in relevant fields
10. Case study of applications of neural network on mobile robot
11. Case study of applications of neural network on robot manipulator
12. Case study of applications of fuzzy logic on mobile robot
13. Case study of applications of fuzzy logic on robot manipulator

EE22101 POWER SYSTEM STABILITY AND CONTROL
Total hours: 56 Hours (14 hours tutorial)

L	T	P	C
3	1	0	4

Module 1: (11 Hours)
Generation Control Loops: AVR Loop. Performance and Response. Automatic Generation Control of Single Area and Multi Area Systems. Static and Dynamic Response of AGC Loops. Economic Dispatch and AGC.
Module 2: (11 Hours)
Transient Stability: Modeling of Synchronous Machine, Loads, Network, Excitation, Turbine and Governing Systems. Trapezoidal Rule of Numerical Integration Technique for Transient Stability Analysis. Case Study of Transient Stability. Transient Stability Enhancement Methods.
Module 3: (10 Hours)
Low Frequency Oscillations: Power System Model for Low Frequency Oscillation Studies. Improvement of System Damping with Supplementary Excitation Control. Introduction to Sub Synchronous Resonance and Countermeasures.
Module 4: (10 Hours)
Voltage Stability Problem: Real and Reactive Power Flow in Long Transmission Lines. Effect Of Under Load Tap Changer on Load Characteristics and Voltage Stability. Voltage Stability Limit. Voltage Stability Assessment using PV Curves. Voltage Collapse Proximity Indices. Voltage Stability Improvement Methods.

Text/Reference Books:

1. O. I. Elgard, Electric Energy System Theory: An Introduction, II Edition, McGraw-Hill, New York, 1982.
2. A. J. Wood, B. F. Wollenberg, Power Generation, Operation and Control, John Wiley and Sons, New York, 1984, 2nd Edition: 1996.
3. P. Kundur, Power System Stability and Control, McGraw-Hill, New York, 1994.
4. J. Arrilaga, C. P. Arnold, B. J. Harker, Computer Modeling of Electrical Power Systems, Wiley, New York, 1983.
5. I. J. Nagrath, D. P. Kothari, Power System Engineering, Tata McGraw-Hill Publishing Co. Ltd., New Delhi, 1994.
6. Yao-Nan-Yu, Electric Power System Dynamics.
7. K. R. Padiyar, Power System Dynamics. Stability and Control, Interline Publishing (P) Ltd., Bangalore, 1999.
8. C. V. Custem, T. Vournas, Voltage Stability of Electric Power Systems, Rlever Academic Press (U.K.), 1999.
9. T. J. E. Miller, Reactive Power Control in Electric Power Systems, John Wiley and Sons, New York, 1982.

EE22102 ELECTRIC DRIVES

Pre-requisite: Knowledge of Power Electronics and Electric Drives (EE16103, EE17102)

Total: 56 Hours

L	T	P	C
3	1	0	4

Module 1: Review (6 Hours)

Review: Power electronic converters for ac drive control, voltage source and current source inverters

Module 2: LCI-IM Drive (10 Hours)

LCI-IM Drive: Drive configuration, commutation at different speeds, mathematical modeling, control structure, resonance problem and performance

Module 3: FOC-IM Drive (14 Hours)

Drive configuration, mathematical modelling, direct and indirect FOC, influence of parameters, VSI and CSI fed schemes, adaptive drive control and direct torque controlled IM drive

Module 4: (18 Hours)

Brushless DC Drive: Self-control, CSI with load commutation, low speed commutation, inverter control strategies, performance and sensors

Permanent Magnet SM Drive: Principle of operation, converter configuration, synchronization, trapezoidal and sinusoidal drive control structures, performance and sensors

Switched Reluctance Motor Drive: Principle of operation, converter circuits, sensors, speed control, performance and sensors

Module 5: (8 Hours)

Resonant-Link Converter fed Drive: Principle of soft switching in inverters and converters utilizing resonant circuits, modulation strategies and application in IM drives

Text/Reference Books:

1. Ned Mohan, Power Electronics., John Wiley and Sons, 2nd edition, 1995.
2. Rashid, Power Electronics, Circuits Devices and Applications, Pearson Education, 3rd edition, 2004.
3. Cyril W Lander, Power Electronics, McGraw-Hill, 3rd edition, 1993.
4. Electrical Motor Drives: Modeling, Analysis and control: R Krishnan, 1st edition, 2007, Pearson Education.
5. G. K. Dubey and C. R. Kasaravada, Power Electronics and Drives, Tata McGraw-Hill, 1993.
6. Dubey, Power Electronics Drives, Wiley Eastern, 1993.
7. André Veltman, Duco W.J. Pulle and Rik W. De Doncker: Fundamentals of Electrical Drives, 1st edition, 2007, Springer.
8. Dubey G. K., Power Semiconductor Controlled Drives, Prentice-Hall International Editions, 1989.
9. Bose B. K., Modern Power Electronics and AC Drives, Pearson Education, 2008.
10. Leonard W., Control of Electric Drives, Springer Press, 2010.

EE22103 CONTROL SYSTEMS - II
Total hours: 56 Hours (14 hours tutorial)

L	T	P	C
3	1	0	4

Module 1: (10 Hours)

Introduction and Background - introduction to nonlinear and time-varying systems; mathematical background including vector spaces and norms, induced norms for systems, existence and uniqueness of solutions of differential equations.

Module 2: (12 Hours)

Stability Analysis - techniques for the stability analysis of nonlinear and time-varying systems; internal stability of feedback systems; phase plane portraits. Lyapunov stability theorems; LaSalle’s theorem, Popov and circle criteria for nonlinear feedback systems, comparison functions, input-to-state stability, Input-output stability

Module 3: (12 Hours)
Design techniques - overview of design for nonlinear systems; Jacobian linearization and gain scheduling; introduction to feedback linearization and extensions of optimal control techniques.

Module 4: (22 Hours)

Design of controller, system identification, formulation of optimal control problem, state regulator problem, output regulator problem, tracking problem, continuous-time linear regulators

Relevant topics in research and class projects/assignments (for this course)

Reference:

1. H. K. Khalil, Nonlinear Systems, Prentice Hall
2. Isidori, Nonlinear Control Systems, Communications and Control Engineering Series, Springer
3. S. S. Sastry, Nonlinear Systems: Analysis, Stability and Control
4. H. Nijmeijer and A. J. V. D. Schaft, Nonlinear Dynamical Control Systems, Springer
5. E. D. Sontag, Mathematical Control Theory: Deterministic Finite Dimensional Systems, volume 6 of TAM, Springer
6. M. Gopal, Modern Control System Theory, New Age International Publishers
7. K. Ogata, Modern Control Engineering, Prentice Hall of India
8. I. J. Nagarath and M. Gopal, Control Systems Engineering, New Age International (P) Ltd
9. M. Gopal, Digital Control and State Variable Methods, Tata Mc Graw-Hill Companies
10. S. H. Zak, Systems and Control, Oxford Press
11. M. Vidyasagar, Nonlinear Systems Analysis, Prentice Hall

EE22301 BIOMEDICAL INSTRUMENTATION
Total hours: 42 Hours

L	T	P	C
3	0	0	3

Module 1: (11 Hours)
Introduction to electrophysiology – action potential – transducers for biomedical applications - electrodes – mono polar and bipolar recording - heart and cardiovascular system –blood pressure measurement – characteristics of blood flow-electromagnetic and ultrasonic blood flow meters-indicator dilution technique - plethysmography - sounds of the heart – blood pumps – heart lung machine - ECG – Eindhoven's law - 12 lead system – cardiac pace maker –defibrillator -EMG – introduction to nervous system and brain -EEG

Module 2: (11 Hours)
Introduction to intensive care monitoring –patient monitoring instruments –organization of hospital for patient care monitoring – respiratory physiology – measurements in respiratory system –respiratory therapy equipment – instrumentation for sensory measurement and behavioral studies – ultrasonic in medicine

Module 3: (10 Hours)
Lasers in medicine - X ray and radio isotopes – radio therapy equipment -safety and dosage

Module 4: (10 Hours)
Renal physiology – membranes for hemodialysis – hemodialysis machines- lithotripters –
Measurement of pH, pCO_2 and pO_2.

Text/Reference Books:

1. Hand book of Biomedical instrumentation by RS Khandpur, Tata McGraw-Hill , 2007
2. Biomedical instrumentation and measurements by Leslie Cromwell, Fred J Weibell Erich A Pfeiffer, Pearson, 2008.
3. Principles of Applied biomedical instrumentation, Geddes & Baker, 3rd edition, John Wiley & Sons.

EE22302 ADVANCED DC-AC POWER CONVERSION
Total hours: 42 Hours

L	T	P	C
3	0	0	3

Module 1: Two-Level Voltage Source Inverter (10 Hours)
Introduction **- Sinusoidal PWM** - Modulation Scheme - Harmonic Content – Over-modulation – Third Harmonic Injection PWM - **Space Vector Modulation** - Switching States - Space Vectors - Dwell Time Calculation - Modulation Index - Switching Sequence - Spectrum Analysis - Even-Order Harmonic Elimination - Discontinuous Space Vector Modulation
Module 2: Cascaded H-Bridge (CHB) Multilevel Inverters (9 Hours)
Introduction **- H-Bridge Inverter** - Bipolar Pulse-Width Modulation - Unipolar Pulse-Width Modulation. **Multilevel Inverter Topologies -** CHB Inverter with Equal dc Voltage - H-Bridges with Unequal dc Voltages. **Carrier Based PWM Schemes** - Phase-Shifted Multicarrier Modulation - Level-Shifted Multicarrier Modulation - Comparison Between Phase and Level-Shifted PWM Schemes - Staircase Modulation.
Module 3: Diode-Clamped Multilevel Inverters (13 Hours)
Introduction **- Three-Level Inverter -** Converter Configuration - Switching State - Commutation - Space Vector Modulation - Stationary Space Vectors - Dwell Time Calculation - Relationship Between *Vref* Location and Dwell Times - Switching Sequence Design -Inverter Output Waveforms and Harmonic Content - Even-Order Harmonic Elimination - **Neutral-Point Voltage Control** - Causes of Neutral-Point Voltage Deviation – Effect of Motoring and Regenerative Operation - Feedback Control of Neutral-Point Voltage - **Other Space Vector Modulation Algorithms** - Discontinuous Space Vector Modulation - SVM Based on Two-level Algorithm; **High-Level Diode-Clamped Inverters** - Four- and Five-Level Diode-Clamped Inverters - Carrier-Based PWM. **Other Multilevel Voltage Source Inverters – Introduction - NPC/H-Bridge Inverter - Inverter** Topology - Modulation Scheme - Waveforms and Harmonic Content - **Multilevel Flying-Capacitor Inverters** – Inverter Configuration - Modulation Schemes
Module 4: PWM Current Source Inverters (10 Hours)
Introduction **-** PWM Current Source Inverter - Trapezoidal Modulation - Selective Harmonic Elimination. **Space Vector Modulation** - Switching States - Space Vectors - Dwell Time Calculation - Switching Sequence - Harmonic Content - SVM Versus TPWM and SHE - **Parallel Current Source Inverters** - Inverter Topology - Space Vector Modulation for Parallel Inverters - Effect of Medium Vectors on dc Currents - dc Current Balance Control - Load-Commutated Inverter (LCI)

Text/Reference Books:

1. B. Woo, “High Power Converters and AC Drives”, John Wiley & Sons, 2006
2. Ned Mohan et.al , “Power Electronics”, John Wiley and Sons, 2006
3. Rashid, “Power Electronics, Circuits Devices and Applications”, Pearson Education, 3rd edition, 2004.
4. G.K.Dubey, Thyristorised Power Controllers, Wiley Eastern Ltd, 1993.
5. Dewan and Straughen, Power Semiconductor Circuits, John Wiley & Sons, 1975.
6. Cyril W Lander, Power Electronics, McGraw-Hill, 3rd edition, 1993.

EE22303 OPTIMAL AND ADAPTIVE CONTROL
Total hours: 42 Hours

L	T	P	C
3	0	0	3

Module 1: (10 Hours)
Optimal control problem – formulation of performance measure - performance measure for linear regulator problem - dynamic programming - principle of optimality - application to multi stage decision making – application to optimal control problem – need for interpolation - recurrence relation of dynamic programming - curse of dimensionality - discrete linear regulator problem - Hamilton-Jacobi-Bellman equation – continuous linear regulator problem.

Module 2: (10 Hours)
Fundamental concepts and theorems of calculus of variations - Euler - Lagrange equation and solution – extremal of functionals of a single function - extremal of functionals of several independent functions - various boundary conditions - extremal of functionals with dependent functions - differential equation constraints – isoperimetric constraints.

Module 3: (12 Hours)
Open loop and closed loop form of optimal control - the variational approach to solving optimal control problems - necessary conditions and boundary conditions for optimal control using *Hamiltonian* – closed loop control for linear regulator problem - linear tracking problem – Pontryagin's minimum principle – state inequality constraints - minimum time problems - minimum control effort problems.

Module 4: (10 Hours)
Model following control – Model Reference Adaptive systems (MRAS) - an over view of adaptive control systems - mathematical description of MRAS - design hypothesis - equivalent representation of MRAS - introduction to design method based on the use of Lyapunov function.

Text / Reference Books:

1. Donald E. Kirk - Optimal Control Theory, An introduction, Prentice Hall Inc.
2. A.P. Sage - Optimum Systems Control, Prentice Hall.
3. Kwakernaak -Linear optimal control systems. Wiley.
4. HSU and Meyer - Modern Control. Principles and Applications, McGraw-Hill.
5. Yoan D. Landu - Adaptive Control - Model Reference Approach, Marcel Dekker.

EE22304 POWER QUALITY
Total hours: 42 Hours

L	T	P	C
3	0	0	3

Module 1: (9 Hours)
Power Quality –overview of power quality phenomena -Basic terminologies –Power Quality Issues – Causes for reduction in Power Quality –– Power Quality Standards and indices.
Module 2: (11 Hours)
Voltage sags, causes of voltage sags, magnitude & duration of voltage sags, effect on drives and peripherals, monitoring & mitigation of voltage sags. Interruptions -Origin of Long & Short interruptions – influence on various equipment – monitoring & mitigation of interruptions. Harmonics-important harmonic introducing devices-SMPS-Three phase power converters-arcing devices saturable devices-harmonic distortion of fluorescent lamps, effect of power system harmonics on power system equipment and loads.
Module 3: (11 Hours)
Power factor improvement- Passive Compensation- Passive Filtering- Harmonic Resonance - Impedance Scan Analysis- Active Power Factor Corrected Single Phase Front End-Control Methods for Single Phase APFC Three Phase APFC and Control Techniques- PFC Based on Bilateral Single Phase and Three Phase Converter staticvar compensators-SVC and STATCOM
Module 4: (11 Hours)
Active Harmonic Filtering-Shunt Injection Filter for single phase , three-phase three-wire and three-phase four wire systems-d-q domain control of three phase shunt active filters -UPS-constant voltage transformers- series active power filtering techniques for harmonic cancellation and isolation. Dynamic Voltage Restorers for sag, swell and flicker problems. Grounding and wiring-introduction-NEC grounding requirements-reasons for grounding-typical grounding and wiring problems-solutions to grounding and wiring problems.
Text/Reference Books:

1. G. T. Heydt, “Electric Power Quality”, Stars in a Circle Publications, 1991.
2. Math H. Bollen, “Understanding Power Quality Problems”, IEEE Press, 1st Edition, 2001.
3. J. Arrillaga, “Power System Quality Assessment”, John Wiley, 2000.
4. J. Arrillaga, B.C. Smith, N.R. Watson & A. R.Wood, Power system Harmonic Analysis, Wiley, 1997
5. Wilson E Kazibwe, Musoke H Sendaula, “Electic Power quality control techniques”, Van Nostrand Reinhold , NewYork, 1993.
6. J. Schlabbach, D. Blume, T. Stephanblome, “Voltage quality in Electrical Power Systems”, IEE, 2001.
7. Roger c. Dugan/ Mrak F. McGranaghan, Surya Santoso & H. Wayne Beaty, “Electrical power systems quality”, Tata McGraw-Hill, 2010.
8. George J. Walkilesh, “Power Systems Harmonics”, Springer, 2007.
9. R. Sastry Vedam & Mulukutla S. Sarma, “Power quality VAR compensation in power systems”, CRC press, 2009.
10. Angelo Baggini, “Handbook of power quality”, Wiley, 2008.

EE22305 FLEXIBLE AC TRANSMISSION SYSTEMS
Total hours: 42 Hours

L	T	P	C
3	0	0	3

Module 1: (11 Hours)
FACTS concepts and general system considerations: Power flow in AC systems - Definition of FACTS – Power flow control -Constraints of maximum transmission line loading - Benefits of FACTS Transmission line compensation- Uncompensated line -shunt compensation - Series compensation -Phase angle control.

Module 2: (11 Hours)
Static shunt compensators: SVC and STATCOM - Operation and control of TSC, TCR and STATCOM - Compensator control - Comparison between SVC and STATCOM.
Static series compensation: TSSC, SSSC -Static voltage and phase angle regulators - TCVR and TCPAR Operation and Control –Applications- Modeling and Simulation

Module 3: (10 Hours)
Unified Power Flow Controller: Circuit Arrangement, Operation and control of UPFC- Basic Principle of P and Q control- independent real and reactive power flow control- Applications - Introduction to interline power flow controller.

Module 4: (10 Hours)
Special purpose FACTS controllers - Thyristor controlled voltage limiter - Thyristor controlled voltage regulator-Thyristor controlled braking resistor - Thyristor controlled current limiter- Custom Power - Compensation Devices - STS - SSC - SVR -Backup energy supply devices, UPQC.

Text/Reference Books:
1. N.G. Hingorani & L. Gyugyi,"Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems", IEEE Press, 2000.
2. T.J.E Miller, "Reactive Power Control in Electric Systems", John Wiley & Sons
3. Ned Mohan et.al. "Power Electronics", John Wiley and Sons.
4. K. R. Padiyar, "FACTS controllers in power transmission and distribution", New Age International (P) Ltd, 2008.

EE22306 DIGITAL CONTROL SYSTEMS
Total hours: 42 Hours

L	T	P	C
3	0	0	3

Module 1: (**11 Hours**)
Basic digital control system- Examples - mathematical model-ZOH and FOH- choice of sampling rate principles of discretization-Mapping between s-domain and z-domain-Pulse transfer function- Different configurations for the design- Modified z-transform- Multi-rate discrete data systems.

Module 2: (11 Hours)
Time responses of discrete data systems**-** Correlation between time response and root locations in the z-plane- Steady state performance- Disturbance Rejection- Robustness and Sensitivity -Jury's stability test – Routh stability criterion on the r-plane -Root locus- Polar plots-Nyquist stability criterion- Bode plot-Bilinear transformation method .

Module 3: (10 Hours)
Cascade compensators using Root Locus- Design of PID controllers by using bilinear transformation-Digital controller design using bilinear transformation- Dead-beat response design- Deadbeat controller without and with prescribed manipulated variable-Choice of sample time for deadbeat controller-Realization of digital controllers- Computer based simulation.

Module 4: (10 Hours)
State variable model of discrete data systems with S/H devices- State transition equations- state diagrams-Transfer function- Transformation to Jordan canonical form and phase variable form-Computation of state transition matrix using Cayley-Hamilton theorem and z-transform method-Response between sampling instants-Controllability, Observability, stabilizability and reachability- Loss of controllability and observability due to sampling, pole placement design using state feedback for SISO systems.

Text/Reference Books:

1. M. Gopal, Digital control and State Variable methods, Tata McGraw –Hill , 1997
2. B.C. Kuo, Digital Control Systems, 2nd Ed., Oxford University Press, 1992.
3. Constantine H. Houpis and Gary B. Lamont, Digital control systems Theory, hardware software, Mc-Graw Hill Book Company, 1985.
4. R. Isermann, Digital control systems, Volume 1, Fundamentals, Deterministic control,(2nd revised edition),Springer Verlag, 1989.
5. R. G. Jacquot, Modern digital control systems, (second edition), Marcel Dekker, Inc., 1995.
6. Philips and Nagle, Digital control system analysis and design, Prentice Hall, 1984.
7. G. F. Franklin, J. D. Powell and M. Workman, Digital Control of Dynamic Systems, 3rd Ed., Addison Wesley, 2000.

EE22307 LINEAR SYSTEM THEORY
Total hours: 42 Hours

L	T	P	C
3	0	0	3

Module 1: (11 Hours)
Introduction to the concepts of dynamic systems modelling and analysis design and development-Definition of system–System Dynamics--Feedback-Classification of systems- static, dynamic, linear, non-linear, time varying, time invariant, distributed, lumped, continuous time, discrete time, discrete event, systems etc.- Modelling of electrical systems- passive networks- d c and a c motors linear models – Concept of transfer function – transfer functions for simple electrical and electromechanical systems. Impulse response and transfer function- convolution –block diagrams and signal flow graphs- Mason's gain formula.

Module 2: (10 Hours)
Modelling of non-electrical systems- Examples of simple pneumatic, hydraulic and thermal and liquid level systems-control valves - Translational and rotational systems, D'Alembert's principle-Modelling of electromechanical systems, force-voltage and force-current analogy- Comparison of RLC Circuits and Mass-Spring-Damper system- Development of linearized models- Superposition principle-Linearized model for Inverted Pendulum. Introduction to Time delay systems.

Module 3: (11 Hours)
Fourier representation of aperiodic signals- Fourier transform and inverse Fourier transform pairs-Properties of Fourier transforms. Continuous amplitude and phase spectra-Relation between Laplace transforms and Fourier transforms. Concepts of attenuation, amplification and filtering of signals. Stability of linear systems – open loop and closed loop stability – bounded input bounded output stability –Routh Hurwitz criterion – limitations.

Module 4: (10 Hours)
Time domain and Frequency domain analysis of single input-single output linear time invariant systems-Determination of Impulse response-Analysis of response to other standard inputs- step, ramp ,acceleration and sinusoidal inputs- Time domain performance measures for first order and second order systems- under-damped and over-damped systems- Significance of damping factor. Definition of order and type of dynamical systems steady state and dynamic error-Determination of error constants from transfer functions- Analysis of response of higher order systems- Effect of poles and zeros. Frequency response – Bode plots – performance criteria in frequency domain – band width – cut off frequency – gain margin –phase margin. Computer simulation of systems.

Text/Reference Books:

1. David K Cheng: A*nalysis of Linear Systems*, Narosa Publishers, 1998.

2. Gene F Franklin, J David Powell, Abbas Emami Naeini, *Feedback Control of Dynamic Systems,* 4th Ed, Pearson Education Asia, 2002.
3. M. Gopal *Control Systems Engineering*, Tata McGraw-Hill, 2008.
4. John J D'Azzo, Constantine H Houpis, Stuart N. Sheldon, *Linear Control System Analysis & Design with MATLAB*, 5th Ed, Marcel Dekker, 2003.
5. Burton T.D., *Introduction to Dynamic Systems*, McGraw-Hill, 1994.
6. John Dorsey, *Continuous & Discrete Control Systems*, McGraw-Hill, 2002.
7. Wayne H Chen, *The Analysis of Linear Systems*, McGraw-Hill, 1963.
8. Benjamin Kuo, *Automatic Control Systems*, 7th Ed, Prentice Hall India, 1995.
9. Norman S. Nise, *Control Systems Engineering*, 4th Ed., John Wiley, 2004.
10. Chi-Tong Chen, *Linear System Theory and Design*, Oxford University Press, 1999.

EE22308 FUZZY LOGIC SYSTEMS
Total Hours: 42 Hours

L	T	P	C
3	0	0	3

Module 1: (12 Hours)
Theory of Fuzzy Sets and fuzzy relations: Fuzzy Reasoning-Fuzzy Rules-Fuzziness compared to randomness- Introduction - Classical sets and fuzzy sets-operations on both- properties of fuzzy sets-classical relations and fuzzy relations- cardinality of fuzzy relations-Fuzzy Cartesian product and composition–fuzzy tolerance and equivalence relations- value assignments - cosine amplitude-max-min method.

Module 2: (12 Hours)
Fuzzification and De-fuzzification : Formation of Fuzzy Rule Base-Membership functions - features – standard forms –fuzzification - membership value assignments - intuition – inference-rank ordering - angular fuzzy sets-inductive reasoning -fuzzy to crisp conversion – lambda/alpha cuts for fuzzy sets and fuzzy relations - defuzzification methods.

Module 3: (11 Hours)
Fuzzy Logic : Classical logic and fuzzy logic –fuzzy rule based systems - approximate reasoning – canonical rule forms - decomposition of compound rules - likelihood and truth classification - aggregation of fuzzy rules – fuzzy inference systems- Mamdani and Takagi-Sugeno fuzzy models- fuzzy control models-P-1-D like fuzzy control rules – implementation. Computer based simulation-Language based programming in C/C++-Use of Simulation Tools.

Module 4: (7 Hours)
Fuzzy nonlinear simulation- fuzzy classification - clustering – fuzzy pattern recognition - fuzzy control systems- fuzzy optimization - case studies – Fuzzy Logic combined with Neural Networks and Genetic Algorithms-Soft Computing Techniques- Fuzzy measures (brief introduction only).

Text/Reference Books:

1. Timothy J Ross, *Fuzzy Logic with Engineering Applications*, McGraw Hill, 2007.
2. Guanrong Chen & Trung Tat Pham Introduction to Fuzzy Systems, Chapman & hall /CRC, 2006.
3. Driankov D., Hellendoorn H., Reinfrank M, *An Introduction to Fuzzy Control*, Narosa Publications, 1993.
4. Robert Babuska, *Fuzzy Modeling for Control*, International Series in Intelligent Technologies, Kluwer Academic Publications, 1998.
5. Ronald R Yager and Dimitar P Filev, *Essentials of Fuzzy Modelling & Control*, John Wiley & Sons, Inc, 2002.
6. J.-S.R.Jang, C.-T.Sun,E.Mizutani, *Neuro-Fuzzy and Soft Computing*, Prentice Hall, 1997.
7. B.Kosko, *Fuzzy Engineering*, Prentice Hall, 1997.

EE22201 POWER ELECTRONICS AND POWER QUALITY LABORATORY
Prerequisite: Power Electronics EE21102

L	T	P	C
0	0	3	2

List of Experiments:

1. To study the V-I characteristics of Thyristor, IGBT, MOSFET.
2. To study the R, RC, and Cosine triggering scheme for Thyristor.
3. To study the performance of single-phase symmetrical and unsymmetrical semi-converter for R and RL loads.
4. To study the performance of Single Phase half wave and full-wave uncontrolled and controlled rectifier for R and RL loads.
5. To study the performance of Single Phase AC voltage controller.
6. To study the performance of a Single Phase square wave inverter and the effect of variation is DC Bus voltage and duty cycle.
7. To study the performance of voltage commutated chopper circuit.
8. To study the performance of current commutated chopper circuit.
9. Harmonic analysis and its compensation using passive filter for single phase controlled/uncontrolled rectifier with R and RL load
10. Harmonic analysis of single phase AC regulator with R and RL load.
11. Harmonic analysis of inrush current in single phase transformer
12. To study the performance of single phase active power filter.
13. Additional experiments in form of Group Projects in relevant fields

Text/Reference Books:

1. Ned Mohan et.al, "Power Electronics", John Wiley and Sons, 2006.
2. Rashid, Power Electronics, Circuits Devices and Applications, Pearson Education, 3rd edition, 2004.
3. G.K.Dubey, Thyristorised Power Controllers, Wiley Eastern Ltd, 1993.
4. H. Akagi et.al, "Instantaneous Power Theory and Applications to power conditioning", IEEE Press, 2007.
5. Dewan & Straughen, Power Semiconductor Circuits, John Wiley & Sons, 1975.
6. Cyril W Lander, Power Electronics, McGraw-Hill, 3rd edition, 1993.
7. Electrical Motor Drives: Modeling, Analysis and control: R Krishnan, 1st edition, 2007, Pearson Education.
8. G.K.Dubey & C.R.Kasaravada,"Power Electronics & Drives", Tata McGraw-Hill, 1993.
9. Dubey, Power Electronics Drives, Wiley Eastern, 1993.
10. André Veltman, Duco W.J. Pulle and Rik W. De Doncker: Fundamentals of Electrical Drives, 1st edition, 2007, Springer.