SEMESTER VIII

Sl. No	Code	Title	L	T	P	C	Category
1	ME4104	Principles of Management	3	-	-	3	PT
2	EE4002	Instrumentation Systems	3	-	-	3	PT
3		Elective - 7	3	-	-	3	PT
4		Elective - 8	3	-	-	3	FE
5	EE4093	Seminar	-	-	2	1	PT
6	EE4094	Control Systems Lab	-	-	3	2	PT
7	EE4095	Project	-	-	6	4	PT
			12	**-**	**11**	**19**	

LIST OF ELECTIVES – VIIITH SEMESTER

Sl. No	Code	Title	Credits
1	EE4031	Advanced Digital Signal Processing	3
2	EE4032	Static VAr Compensation and Harmonic Filtering	3
3	EE4033	Optimal and Adaptive Control	3
4	EE4034	Power System Stability and Control	3
5	EE4035	Flexible AC Transmission	3
6	EE4036	Non-linear System Analysis	3
7	EE4037	Energy Auditing, Conservation and Management	3
8	EE4038	Data Acquisition and Signal Conditioning	3
9	EE4039	Advanced DC – AC Power Conversion	3
10	EE4040	System Identification and Parameter Estimation	3
11	EE4041	Power Quality	3
12	EE4042	Digital Protective Relaying	3

BRIEF SYLLABI

ME4104 PRINCIPLES OF MANAGEMENT

L	T	P	C
3	0	0	3

Prerequisite: Nil

Introduction to management theory, Characteristics, Systems approach, Task responsibilities and skill required, Process of management, Planning, Organizing, Directing, Controlling, Decision making process, Project management, Overview of operations management, Human resources management, Marketing management, Financial management.

Total Hours: 42 hours

EE4002: INSTRUMENTATION SYSTEMS

Prerequisites: EE2001 Signals and Systems,
EE2008 Analog Electronic Circuit and systems

L	T	P	C
3	0	0	3

Measurement, Instrumentation and Calibration– Errors in measurement - Calibration and Standards - Signals and their representation. - Electrical Measuring systems – Dynamics of Instrument systems – generalized performance of systems – electrical Networks – Mechanical systems - Electromechanical systems –Thermal systems – Fluidic systems – Filtering and Dynamic Compensation - Basics of Temperature, pressure, Force, Torque, Density, Liquid level, Viscosity, Flow, Displacement, measurement. Passive Electrical Transducers – Digital Transducer, Feed back Transducers Systems –Signal processing Circuits –

Total Hours: 42 Hours

EE4031 ADVANCED DIGITAL SIGNAL PROCESSING

Pre-requisite: **EE3005 Digital Signal Processing**

L	T	P	C
3	0	0	3

Optimization Methods for IIR and FIR filter Design both in frequency and time domain –Algorithms for design and algorithms for implementation; Speech signal processing- Speech production models – Analysis of speech signals - Different coding methods; Two dimensional signal processing (Image Processing)- Digital image representation- Image enhancement- color image processing- Image restoration- Fundamentals of image compression; Digital signal processors - Memory architecture- An example DSP architecture

Total Hours : 42 Hours

EE4032 STATIC VAR COMPENSATION AND HARMONIC FILTERING

Pre-requisites: None

L	T	P	C
3	0	0	3

Fundamentals of Load Compensation , Power Quality Issues - Sources of Harmonics in Distribution Systems and Ill Effects .Static Reactive Power Compensators and their control . Shunt Compensators, SVCs of Thyristor Switched and Thyristor Controlled types and their control, STATCOMs and their control, Series Compensators of Thyristor l, SSSC and its Control, Sub-Synchronous Resonance Transient and Dynamic Stability Improvement in Power Systems - Converters for Static Compensation . Standard Modulation Strategies -GTO Inverters (Multi-Level Inverters)-Passive Harmonic Filtering.

Total Hours: 42 Hours

EE4033 OPTIMAL AND ADAPTIVE CONTROL

Pre-requisites : None

L	T	P	C
3	0	0	3

Optimal control problem - performance measure for linear regulator problem - dynamic programming - discrete linear regulator problem - Hamilton-Jacobi-Bellman equation - continuous linear regulator problem.
Fundamental concepts and theorems of calculus of variations -
Open loop and closed loop form of optimal control - closed loop control for linear regulator problem - linear tracking problem – Pontryagin's minimum principle - state inequality constraints - minimum time problems - minimum control effort problems.
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 Liapunov function

Total Hours: 42 Hours

EE4034 POWER SYSTEM STABILITY AND CONTROL

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Generation Control Loops-Economic Dispatch and AGC-Modeling of power system components-Transient Stability Analysis-Low Frequency Oscillations-Sub Synchronous Resonance -Voltage Stability-Voltage Stability Improvement Methods.

Total Hours: 42 Hours

EE4035 FLEXIBLE AC TRANSMISSION SYSTEMS

Pre-requisites : None

L	T	P	C
3	0	0	3

FACTS Concept and General System Considerations - Converters for Static Compensation. Multi-Level Inverters - Current Control of Inverters. - Static Shunt Compensators. SVC and STATCOM - Static Series Compensation. GCSC, TSSC, TCSC and SSSC - UPFC and IPFC. Special Purpose FACTS Controllers.

Total Hours: 42 Hours

EE4036 NONLINEAR CONTROL THEORY

Pre-requisites: EE3002 Control Systems I , EE4001 Control Systems II

L	T	P	C
3	0	0	3

Classical techniques- Characteristics-types of nonilearities phase plane analysis . perturbation techniques-periodic orbits - stability of periodic solutions - singular perturbation model - slow and fast manifolds. Stability of Nonlinear Systems - Lyapunov stability Centre manifold theorem - region of attraction - Invariance theorems - Input output stability - L stability - L stability of state models - L2 stability- Robust stabilization-.Harmonic Linearisation and Describing Function Method-Harmonic linearization - SIDF- Dual Input Describing function - study of sub-harmonic oscillations. Jump response.-Feedback Control and Feedback Stabilisation- Analysis of feedback systems- Circle Criterion - Popov Criterion– Concepts of Inverse control- - Exact Feedback Linearization - Input state linearization - input output linearization - state feedback control - stabilization - tracking - integral control.

Total Hours: 42 Hours

EE4037 ENERGY AUDITING, CONSERVATION & MANAGEMENT

Pre-requisites : None

L	T	P	C
3	0	0	3

Electrical Systems-Supply & Demand Side-Economic operation, Electric motors-Energy efficient controls and Load Analysis, Variable speed drives-Efficient Control strategies-Optimal operation, Transformer Loading-Efficiency analysis, Feeder and cable loss evaluation, Reactive Power management, Peak Demand controls, Optimal Load scheduling, Energy conservation in Lighting Schemes, Power quality issues, Cogeneration-Types and Schemes, Electric loads of Air conditioning & Refrigeration, case studies

Total Hours: 42 Hours

EE4038 DATA ACQUISITION & SIGNAL CONDITIONING

Pre-requisite: None

L	T	P	C
3	0	0	3

Transducers & Signal Conditioning Data Acquisition Systems(DAS)- Fundamentals of signals acquisition, conditioning and processing. DC Amplifiers. Filtering and Sampling-Sample and Hold Amplifiers Signal Conversion -Data transmission systems,

Total Hours: 42 Hours

EE4039 ADVANCED DC-AC POWER CONVERSION

Pre-requisite: EE3007 Power Electronics

L	T	P	C
3	0	0	3

Two-Level Voltage Source Inverter - Introduction - Sinusoidal PWM - Space Vector Modulation - Cascaded H-Bridge Multilevel Inverters - H-Bridge Inverter - Bipolar Pulse-Width Modulation - Unipolar Pulse-Width Modulation –Multilevel Inverter Topologies - Carrier Based PWM Schemes -Diode-Clamped Multilevel Inverters - Three-Level Inverter - Neutral-Point Voltage Control - Other Space Vector Modulation Algorithms - High-Level Diode-Clamped Inverters - Other Multilevel Voltage Source Inverters –NPC/H-Bridge Inverter - Multilevel Flying-Capacitor Inverters - PWM Current Source Inverters - Parallel Current Source Inverters

Total Hours: 42 Hours

EE4040 SYSTEM IDENTIFICATION AND PARAMETER ESTIMATION

Pre-requisites : None

L	T	P	C
3	0	0	3

Principles of Modelling and Identification of transfer function- System Identification and Stochastic Modeling-.State Space Models- Distributed parameter models- model structures . identifiability of model structures. -Transfer function from frequency response. Fourier Analysis and Spectral analysis- Pseudo random binary signals . maximum length sequences . Parameter Estimation Methods :linear regression and least squares methods - Recursive methods . RLS Algorithm, Recursive IV Method- Recursive Prediction Error Method - Identification of Multivariable Systems and Closed Loop Systems- reduction of higher order systems aggregation method. Experiment Design and Choice of Identification Criterion: Optimal Input design.

Persistently exciting condition .Choices of Identification criterion- choice of norm - variance: optimal instruments

Total Hours: 42 Hours

EE4041 POWER QUALITY

Pre-requisites: None

L	T	P	C
3	0	0	3

Power Quality – overview of power quality phenomena - Voltage sags – Harmonics - Power factor improvement- Passive Compensation - Passive Filtering- Methods for Single Phase APFC - Three Phase APFC and Control Techniques- Active Harmonic Filtering- Grounding and wiring-introduction - NEC grounding requirements

Total Hours: 42 Hours

EE4042 DIGITAL PROTECTIVE RELAYING

Pre-requisites : None

L	T	P	C
3	0	0	3

Protective Relaying-Standards-Classification, Design–zones and degree of protection, Instrument transformers. Basic elements of digital protection – Relay Schematics and Analysis, Protection of Power System Equipment - Generator, Transformer, Transmission Systems, Busbars, Motors, System grounding – ground faults and protection, algorithms for Numerical relays, Integrated and multifunction protection schemes - SCADA based protection systems, Testing of relays

Total Hours: 42 Hours

EE4094 CONTROL SYSTEMS LABORATORY

Prerequisite: None

L	T	P	C
0	0	3	2

DC Motor Transfer Function-.Amplidyne transfer function & characteristics-FEEDBACK® MS150 DC Modular Servo System-Compensator design and simulation using MATLAB®- PI and PID controllers-Inverted pendulum- Level Process Control Station- Closed loop voltage regulation for a dc separately excited generator using amplidyne and to obtain its characteristics - FEEDBACK® MS150 AC Modular Servo System.(10/12 experiments administered in two cycles).

Total Hours: 42 Hours

DETAILED SYLLABI

ME4104 PRINCIPLES OF MANAGEMENT

Prerequisite: Nil

L	T	P	C
3	0	0	3

Total Hours: 42 hours

Module 1 (9 Hours)
Introduction to management theory, Characteristics of management, Management as an art – profession, Systems approach to management, Task and responsibilities of a professional manager, Levels of managers and skill required. Management process – planning – mission – objectives – goals – strategy – policies – programmes – procedures.

Module 2 (9 Hours)
Organizing – principles of organizing – organization structures, Directing – delegation – span of control – leadership – motivation – communication, Controlling.

Module 3 (12 Hours)
Decision making process – decision making under certainty – risk – uncertainty – models of decision making, Project management – critical path method – programme evaluation and review technique – crashing.

Module 4 (12 Hours)
Introduction to functional areas of management, Operations management, Human resources management, Marketing management, Financial management.

References

1. Koontz, H., and Weihrich, H., *Essentials of Management: An International Perspective*, 8th ed., McGraw Hill, 2009.
2. Hicks, *Management: Concepts and Applications*, Cengage Learning, 2007.
3. Mahadevan, B., *Operations Management, Theory and Practice*, Pearson Education Asia, 2009.
4. Kotler, P., Keller, K.L, Koshy, A., and Jha, M., *Marketing Management*, 13th ed., 2009.
5. Khan, M.Y., and Jain, P.K., *Financial Management*, Tata-Mcgraw Hill, 2008.

EE4002: INSTRUMENTATION SYSTEMS

Prerequisites: **EE2001 Signals and Systems,**
EE2008 Analog Electronic Circuit and systems

L	T	P	C
3	0	0	3

Total Hours: 42 Hours

Module 1: **(10 Hrs)**
Measurement, Instrumentation and Calibration - Introduction to Instrumentation systems - Classification of transducers – performance characteristics, static and dynamic characteristics – Errors in measurement - gross Errors, systematic Errors – statistical Analysis of Random Errors – Calibration and Standards -Process of calibration, classification of standards, standards for calibration.
Signals and their representation.

Module 2: **(10 Hrs)**
Electrical Measuring systems –Measurement of Current, Voltage, Resistance, Impedance. Electronic Amplifiers- difference or Balanced Amplifiers, Electrometer Amplifier, operational Amplifiers, feed back amplifiers, Isolation Amplifiers, charge Amplifiers, power Amplifiers. Measurement of phase Angle- Frequency Measurement – Time – Interval measurement - Dynamics of Instrument systems – generalized performance of systems – electrical Networks – Mechanical systems - Electromechanical systems –Thermal systems – Fluidic systems – Filtering and Dynamic Compensation.

Module 3: **(12 Hrs)**
Basics of Temperature, pressure, Force, Torque, Density, Liquid level, Viscosity, Flow, Displacement, measurement. Passive Electrical Transducers – resistive, Inductive and capacitive Transducers and ,measurement of various physical variables, Active Electrical Transducers – Thermoelectric , piezoelectric , magnetostrictive, Hall – Effect, Electromechanical, Electro Chemical Photoelectric and Ionization Transducers, Digital Transducer, Feed back Transducers Systems –

Module 4: **(10 Hrs)**
Signal processing Circuits – Data Display and recording systems – Data Transmission and Telemetry – Developments in sensor Technology –

Text/Reference Books:

1. D.V.S Murty, Transducers & Instrumentation, prentia Hall of India (pvt ltd), Edition 2, 2008
2. 2. Ernest O. Deobine, Measurement System Application & design, Mcgraw Hill International, Edition 5, 2004.
3. K.B Kalasen, Electronic Measurement & Instrumentation, Cambridge University Press, 1996.
4. Cooper W.D, Modern Electronics Instrumentation, Prentia Hall of India,1996.

EE4031 ADVANCED DIGITAL SIGNAL PROCESSING

Pre-requisite: **EE3005 Digital Signal Processing**

L	T	P	C
3	0	0	3

Total Hours : 42 Hours

Module 1: **(10 Hrs)**
Optimisation Methods for IIR and FIR filter Design:
Deczky's method for IIR filter design in the frequency domain, Pade approximation method , Least- squares design method in time domain; Frequency sampling method for FIR filters, Parksand McClellan Algorithm for design, Remez exchange algorithm for implementation.

Module 2: **(12 Hrs)**
Speech signal processing:
Digital models for speech signal, Mechanism of speech production, Acoustic theory, Lossless tube models , Formulation of LPC equation, Solution of LPC equation, Levinson Durbin algorithm, Schur algorithm, Spectral analysis of speech, Short time fourier analysis, Speech coding, subband coding, Transform coding, Channel vocoder,Formant vocoder, Cepstral vocoder, Vector quantisation coder.

Module 3: **(12 Hrs)**
Two dimensional signal processing(Image Processing)
Digital image representation; 2-D DFT . properties; DCT; Image enhancement ,Spatial and frequency domain filtering methods; colour image processing; Image restoration- Degradation model, Inverse filtering; Fundamentals of image compression.

Module 4: **(8 Hrs)**
Digital signal processors
Introduction to DSP processors- common features, fixed point versus floating point; Memory architecture- Harvard architectures, multiple access memories, multi processor support, addressing modes; instruction set; An example DSP architecture- Analog Devices/Motorola/Texas Instruments

Text/Reference Books:

1. Alan V . Oppenheim, Ronald W. Schafer, .Discrete-Time Signal Processing., Prentice-Hall of India Pvt. Ltd., New Delhi, 1997
2. John G. Proakis, and Dimitris G. Manolakis, Digital Signal Processing. (third edition), Prentice-Hall of India Pvt. Ltd, New Delhi, 1997
3. L.R. Rabiner and R.W Schafer, Digital processing of speech signals, Prentice Hall, New Jersey , 1978.
4. R. C. Gonzalez and R.E. Woods , Digital Image processing, Addison Wesley, 1992
5. Jae S. Lim, Two Dimensional signal and image processing, Prentice Hall Inc., Englewood Cliffs, New Jersey,1990.
6. Lapsley P, Jeff Bier, Amit Shoham and Lee E. A., DSP Processor Fundamentals ,Architectures and features, IEEE Press.

EE4032 STATIC VAR COMPENSATION AND HARMONIC FILTERING

Pre-requisites: None

L	T	P	C
3	0	0	3

Total Hours: 42 Hours

Module 1: **(10 Hrs)**
Fundamentals of Load Compensation , Steady-State Reactive Power Control in Electric Transmission Systems , Reactive Power Compensation and Dynamic Performance of Transmission Systems .
Power Qulity Issues . Sags, Sweels, Unbalance, Flicker , Distortion , Current Harmonics - Sources of Harmonics in DistributionSystems and Ill Effects .

Module 2: **(10 Hrs)**
Static Reactive Power Compensators and their control . Shunt Compensators, SVCs of Thyristor Switched and Thyristor Controlled types and their control, STATCOMs and their control, Series Compensators of Thyristor Switched and Controlled Type and their Control, SSSC and its Control, Sub-Synchronous Resonance and damping, Use of STATCOMs and SSSCs for Transient and Dynamic Stability Improvement in Power Systems

Module 3: **(11 Hrs)**
Converters for Static Compensation . Single Phase and Three Phase Converters and Standard Modulation Strategies (Programmed Harmonic Elimination and SPWM) . GTO Inverters . Multi-Pulse Converters and Interface Magnetics . Multi-Level Inverters of Diode Clamped Type and Flying Capacitor Type and suitable modulation strategies (includes SVM) . Multi-level inverters of Cascade Type and their modulation . Current Control of Inverters.

Module 4: **(11 Hrs)**
Passive Harmonic Filtering . Single Phase Shunt Current Injection Type Filter and its Control, Three Phase Three-wire Shunt Active Filtering and their control using p-q theory and d-q modelling . Three-phase four-wire shunt active filters . Hybrid Filtering using Shunt Active Filters . Series Active Filtering in Harmonic Cancellation Mode . Series Active Filtering in Harmonic Isolation Mode . Dynamic Voltage Restorer and its control . Power Quality Conditioner

Text/Reference Books:

1. T.J.E Miller, “Reactive Power Control in Electric Systems”, John Wiley & Sons,1982.
2. N.G. Hingorani & L. Gyugyi, “Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems”, IEEE Press, 2000.
3. Ned Mohan et.al, “Power Electronics”, John Wiley and Sons 2006
4. R. Sastry Vedam & Mulukutla S. Sarma, “Power quality VAR compensation in power systems”, CRC press, 2009.
5. Hirofumi akagi, Edson hirokazu watanabe, Mauricio aredes, “Instantaneous power theory and applications to power conditioning” Wiley Inter Science,2007.
6. K.R. Padiyar, “FACTS controllers in power transmission and distribution”, New age international publications, 2008.

EE4033 OPTIMAL AND ADAPTIVE CONTROL

Pre-requisites : None

L	T	P	C
3	0	0	3

Total Hours: 42 Hours

Module 1: (10 Hrs)
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 Hrs)
Fundamental concepts and theorems of calculus of variations - Euler - Legrange 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 Hrs)
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 Hrs)
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 Liapunov 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.

EE4034 POWER SYSTEM STABILITY AND CONTROL

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total Hours: 42 Hours

Module 1: (11 Hrs)
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 Hrs)
Transient Stability Problem. Modeling Of Synchronous Machine, Loads, Network, Excitation And Systems, Turbine And Governing Systems. Trapezoidal Rule Of Numerical Integration Technique For Transient Stability Analysis. Data For Transient Stability Studies. Transient Stability Enhancement Methods.

Module 3: (11 Hrs)
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: (9 Hrs)
Voltage Stability Problem. Real And Reactive Power Flow In Long Transmission Lines . Effect Of ULTC And Load Characteristics On 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. J. Arrilaga, C.P. Arnold, B.J. Harker, .Computer Modeling Of Electrical Power Systems., Wiley, New York, 1983.
4. I.J. Nagrath, O.P. Kothari, .Power System Engineering., Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1994.
5. Yao-Nan-Yu, .Electric Power System Dynamics..
6. P. Kundur, .Power System Stability And Control., McGraw Hill, New York, 1994.
7. K.R. Padiyar, .Power System Dynamics . Stability And Control., Interline Publishing (P) Ltd., Bangalore, 1999.
8. C. Van Custem, T. Vournas, .Voltage Stability Of Electric Power Systems., Rlever Academic Press (U.K.), 1999.
9. .B.R. Gupta, .Power System Analysis And Design., III Edition, A.H. Wheeler & Co. Ltd., New Delhi, 1998.
10. T.J.E. Miller, .Reactive Power Control In Electric Power Systems., John Wiley and Sons, New York, 1982.

EE4035 FLEXIBLE AC TRANSMISSION SYSTEMS

Pre-requisites : None

L	T	P	C
3	0	0	3

Total Hours: 42 Hours

Module 1: (11 Hrs)

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 Hrs)

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 Hrs)

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 Hrs)

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. 2.T.J.E Miller, “Reactive Power Control in Electric Systems “,John Wiley & Sons
3. 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.

EE4036 NONLINEAR CONTROL THEORY

Pre-requisites: EE3002 Control Systems I , EE4001 Control Systems II

L	T	P	C
3	0	0	3

Total Hours: 42 Hours

Module 1: **(11 Hrs)**
Introduction and classical techniques- Characteristics of nonlinear systems – Types of nonilearities and their occurrences- classification of equilibrium points - limit cycles - analysis of systems with piecewise constant inputs using phase plane analysis . perturbation techniques- periodic orbits - stability of periodic solutions - singular perturbation model - slow and fast manifolds.

Module 2: **(10 Hrs)**
Stability of Nonlinear Systems - Lyapunov stability - local stability - local linearization and stability in the small- Direct method of Lyapunov - generation of Lyapunov function for linear and nonlinear systems - variable gradient method - Centre manifold theorem - region of attraction - Invariance theorems - Input output stability - L stability - L stability of state models - L2 stability- Robust stabilization.

Module 3: **(10 Hrs)**
Harmonic Linearisation and Describing Function Method-Harmonic linearization - filter hypothesis - Sine Input describing function of standard nonlinearities- study of limit cycles (amplitude and frequency) using SIDF- Dual Input Describing function - study of sub-harmonic oscillations. Jump response.

Module 4: **(11 Hrs)**
Feedback Control and Feedback Stabilisation- Analysis of feedback systems- Circle Criterion - Popov Criterion– Concepts of Inverse control-Feedback linearization-Model predictive control-Simultaneous Feedback control-Design via linearization- stabilization - regulation via intgral control- gain scheduling - Exact Feedback Linearization - Input state linearization - input output linearization - state feedback control - stabilization - tracking - integral control.

Text/Reference Books:

1. Hassan K Khalil, *Nonlinear Systems*, Prentice - Hall International (UK), 1996
2. JJE Slotine & W.LI .Applied Nonlinear Control. Prentice Hall, Englewood Clifs, New Jersey 1991
3. Alberto Isidori, *Nonlinear Control Systems*, Springer Verlag, 1995

EE4037 ENERGY AUDITING, CONSERVATION & MANAGEMENT

Pre-requisites : None

Total Hours: 42 Hours

L	T	P	C
3	0	0	3

Module 1: **(9 Hrs)**
Electrical Systems: Supply & Demand Side, Economic operation, Input-Output curves, Load profiling,Electricity tariff types; Energy auditing: Types and objectives-audit instruments- ECO assessment and Economic methods-specific energy analysis

Module 2: **(11 Hrs)**
Electric motors-Energy efficient controls and starting efficiency-Motor Efficiency and Load Analysis- Energy efficient /high efficient Motors-Case study; Load Matching and selection of motors.
Variable speed drives; Pumps and Fans-Efficient Control strategies- Optimal selection and sizing -Optimal operation and Storage; Case study

Module 3: **(11 Hrs)**
Transformer Loading/Efficiency analysis, Feeder/cable loss evaluation, case study.
Reactive Power management-Capacitor Sizing-Degree of Compensation, Peak Demand controls-Methodologies-Types of Industrial loads-Optimal Load scheduling-case study;
Lighting- Energy efficient light sources-Energy conservation in Lighting Schemes- Electronic ballast-Power quality issues-Luminaries, case study;

Module 4: **(11 Hrs)**
Cogeneration-Types and Schemes;
Electric loads of Air conditioning & Refrigeration-Energy conservation measures- Cool storage .Types-Optimal operation-case study; Electric water heating-Gysers-Solar Water Heaters- Power Consumption in Compressors, Energy conservation measures; Electrolytic Process; Computer Controls- softwares-EMS

Text/Reference Books:

1. Rik DeGunther, "Alternative energy for dummies", John Wiley & Sons, May 2010.
2. Paul A. Lynn, "Electricity from sunlight", John Wiley & Sons, July 2010
3. Leon K. Kirchmayer, "Economic Operation of power system", Wiley India Pvt Ltd, July 2010.
4. Jean-Claude SabonnadiAre, "Low emission power generation technologies and energy management", John Wiley & Sons, August 2010
5. Ursula Eicker, "Low energy cooling for sustainable buildings", John Wiley & Sons, August 2010
6. Allen J. Wood, " Power generation Operation and Control", Wiley 2nd edition, August 2010.
7. Timothy J. E. Miller, "Reactive power control in electric systems", Wiley edition, August 2010
8. Paul C. Crause, Oleg Wasynczuk, Scott D.sudhoff, "Analysis of electric machinery and drive system" , Wiley 2nd Edition, August 2010.
9. Marion Pagliaro, Giovanni Palmisano Rosaria Ciriminna, "Flexible Solar Cells", John Wiley & Sons, November 2009.
10. Alexander Mitsos, Paul I.Barton, "Microfabricated Power Generation Devices", John Wiley & Sons, March 2009.
11. Albert Thumann, P.W,Plant Engineers and Managers Guide to Energy Conservation" TWI Press Inc, Terre Haute, 9th edition,2008
12. Roland Wengenmayr, "Renewable Energy", John Wiley & Sons, April 2004
13. Francois, Leveque, "Transport pricing of electricity networks", Springer 2003.
14. Parasiliti F., P. Bertoldi, "Energy Efficiency in motor driven systems", Springer, 2003.
15. Turner, Wayne C., "Energy Management Handbook", Lilburn, The Fairmont Press, 2001
16. Donald R. W., "Energy Efficiency Manual", Energy Institute Press,2000
17. Giovanni Petrecca, ".Industrial Energy Management:
    Principles and Applications", The Kluwer international series -207,1999
    Springer 2000.
18. Anthony J. Pansini, Kenneth D. Smalling, "Guide to Electric Load Management", Pennwell Pub,1998
19. Albert Thumann , "Handbook of Energy Audits", Fairmont Pr; 5th edition,1998

20. Howard E. Jordan, “Energy-Efficient Electric Motors and Their Applications”, Plenum Pub Corp; 2nd edition 1994
21. Petrecca, Giovanni, “Industrial Energy Management”, Springer 1993
22. IEEE Bronze Book- “Recommended Practice for Energy Conservation and cost effective planning in Industrial facilities”, IEEE Inc, USA.,1985
23. Partab H., “Art and Science of Utilisation of Electrical Energy”, Dhanpat Rai and Sons, New Delhi, 2nd edition,
24. Tripathy S.C, “Electric Energy Utilization And Conservation”, Tata McGraw Hill.
25. NESCAP-Guide Book on Promotion of Sustainable Energy Consumption

EE4038 DATA ACQUISITION & SIGNAL CONDITIONING

Pre-requisite: None

L	T	P	C
3	0	0	3

Total Hours: 42 Hours

Module 1: Transducers & Signal Conditioning **(10 Hrs)**
Data Acquisition Systems(DAS)- Introduction – Fundamentals of signals acquisition, conditioning and processing. -Objectives of DAS . Block Diagram Description of DAS- General configurations - Single and multichannel DAS-Transducers for the measurement of motion, force, pressure, flow, level, dc and ac voltages and currents (CTs, PTs for supply frequency as well as high frequency, Hall Effect Current Sensors, High Voltage Sensors) – Signal Conditioning: Requirements - Instrumentation amplifiers: Basic characteristics . Chopped and Modulated DC Amplifiers-Isolation amplifiers - Opto couplers - Buffer amplifiers .Noise Reduction Techniques in Signal Conditioning- Transmitters .Optical Fiber Based Signal Transmission-Piezoelectric Couplers- Intelligent transmitters.

Module 2: Filtering and Sampling **(12 Hrs)**
Review of Nyquist.s Sampling Theorem-Aliasing . Need for Prefiltering-First and second order filters - classification and types of filters - Low -pass, High-pass, Band-pass and Band-rejection and All Pass: Butterworth, Bessel, Chebyshev and Elliptic filters . Opamp RC Circuits for Second Order Sections-Design of Higher Order Filters using second order sections using Butterworth Approximation-Narrow Bandpass and Notch Filters and their application in DAS. Sample and Hold Amplifiers

Module 3: Signal Conversion **(12 Hrs)**
Analog-to-Digital Converters(ADC)-Multiplexers and demultiplexers - Digital multiplexer . A/D Conversion . Conversion Processes , Speed, Quantization Errors . Successive Approximation ADC . Dual Slope ADC . Flash ADC . Digital-to-Analog Conversion(DAC) . Techniques, Speed, Conversion Errors, Post Filtering- Weighted Resistor, R-2R, Weighted Current type of DACs- Multiplying Type DAC-Bipolar DACs

Module 4: Data Transmission **(8 Hrs)**
Data transmission systems- Analog transmission system, Digital transmission system,
Analog encoding of analog information, Analog encoding of digital Information, Digital encoding of analog information, Digital encoding of digital information, Schmitt Trigger-Pulse code formats- Modulation techniques and systems-Telemetry systems.

Text/Reference Books:

1. Ernest O Doeblin., Measurement Systems: Application and Design, McGraw Hill (Int. edition) 1990
2. George C.Barney, Intelligent Instrumentation, Prentice Hall of India Pvt Ltd., New Delhi, 1988.
3. Ibrahim, K.E., Instruments and Automatic Test Equipment, Longman Scientific & Technical Group Ltd., UK, 1988.
4. G.B. Clayton, .Operational Amplifiers, Butterworth &Co, 1992
5. Oliver Cage, .Electronic Measurements and Instrumentation., McGraw-Hill, (Int. edition) 1975

EE4039 ADVANCED DC-AC POWER CONVERSION

Pre-requisite: EE3007 Power Electronics

L	T	P	C
3	0	0	3

Total Hours: 42 Hours

Module 1: Two-Level Voltage Source Inverter (10 Hrs)

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 Hrs)

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 Hrs)

Introduction **-Three-Level Inverter -** Converter Configuration - Switching State - Commutation - Space Vector Modulation - Stationary Space Vectors - Dwell Time Calculation - Relationship Between V_{ref} 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 Hrs)

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 & Straughen, Power Semiconductor Circuits, John Wiley & Sons, 1975.
6. Cyril W Lander, Power Electronics, Mc Graw Hill, 3rd edition, 1993.

EE4040 SYSTEM IDENTIFICATION AND PARAMETER ESTIMATION

Pre-requisites : None

L	T	P	C
3	0	0	3

Total Hours: 42 Hours

Module 1: **(14 Hrs)**
Principles of Modelling and Identification of transfer function
System Identification and Stochastic Modeling- Structure and parameter estimation . properties of estimates - validation of models-impulse Response. Step Response . Frequency response- transfer function from these.- disturbances and transfer function .State Space Models- Distributed parameter models- model structures . identifiability of model structures. signal spectra . single realization and ergodicity . multivariable systems.- Transfer function from frequency response. Fourier Analysis and Spectral analysis- Estimating Disturbance Spectrum . Correlation Identification . Practical Implementation . Pseudo random binary signals . maximum length sequences . generation using hardware . random number generation on digital computer

Module 2: **(10 Hrs)**
Parameter Estimation Methods
Guiding principles behind parameter estimation methods . minimizing prediction errors . linear regression and least squares methods . statistical framework for parameter estimation . maximum likelihood estimation . correlating prediction errors with past data . Instrumental variable method . consistency and identifiability- Recursive methods . RLS Algorithm, Recursive IV Method- Recursive Prediction Error Method . Recursive pseudo-linear regressions . choice of updating step

Module 3: **(10 Hrs)**
Identification of Multivariable Systems and Closed Loop Systems-Transfer function matrix representation of MVS- state space method input output difference equation method - canonical models for MVS . comparison of different models . identification of continuus MV systems from input output data.Identification of closed loop systems . reduction of higher order systems . aggregation method . aggregation with partial realization . singular perturbation method . optimum approximation . comparison of different methods of model reduction.

Module 4: **(8 Hours)**
Experiment Design and Choice of Identification Criterion
Optimal Input design . Persistently exciting condition . optimal input design for higher order black box models . choice of sampling interval and presampling filters .Choices of Identification criterion . choice of norm . variance: optimal instruments

Text/Reference Books:

1. System Identification Theory for The User : Lennart Ljung , Prentice Hall Information Systems Science Series (1987)
2. Sinha N K , Kuztsa : System Identification And Modeling of Systems(1983)
3. Harold W Sorensen : Parameter Estimation : Marcel Dekker Inc, New York. 1980, Advances in Control Systems series
4. Daniel Graupe :Identification of Systems : Van Nostrand

EE4041 POWER QUALITY

Pre-requisites: None

L	T	P	C
3	0	0	3

Total Hours: 42 Hours

Module 1: **(9 Hrs)**
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 Hrs)**
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 equipments – 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: **(11Hrs)**
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-static var compensators-SVC and STATCOM

Module 4: **(11Hrs)**
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 Mc Graw-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.

EE4042 DIGITAL PROTECTIVE RELAYING

Pre-requisites : None

Total Hours: 42 Hours

L	T	P	C
3	0	0	3

Module 1: (8 Hrs)

Protective Relaying - Qualities of relaying - Definitions - Codes- Standards; Characteristic Functions; Classification –analog-digital- numerical; schemes and design-factors affecting performance –zones and degree of protection; faults-types and evaluation; Instrument transformers for protection.

Module 2: (12 Hrs)

Basic relay units-sequence networks-fault sensing data processing units- FFT and Wavelet based algorithms - Phase& Amplitude Comparators-. Duality - Zero Crossing/Level Detectors; Relay Schematics and Analysis- Over Current Relay- Instantaneous/Inverse Time –IDMT Characteristics; Directional Relays; Differential Relays- Restraining Characteristics; Distance Relays: Types- Characteristics;

Module 3: (12 Hrs)

Protection of Power System Equipment - Generator, Transformer, Generator- Transformer Units, Transmission Systems, Busbars, Motors; Pilotwire and Carrier Current Schemes;
System grounding –ground faults and protection; Load shedding and frequency relaying; Out of step relaying ; Re-closing and synchronizing

Module 4: (10 Hrs)

Numerical relays - Characteristics -Functional Diagrams-architecture - algorithms -Microprocessor & DSP based relays- sampling –aliasing –filter principles;
Integrated and multifunction protection schemes -SCADA based protection systems- FTA; Testing of Relays.

Text/Reference Books:

1. C.R. Mason, The art and science of protective relaying, John Wiley &sons.
2. A.R.Warrington, Protective Relays, Vol .1&2, Chapman and Hall.
3. T.S.Madhav Rao, Power system protection static relays with microprocessor applications, Tata McGraw Hill Publication.
4. Power System Protection Vol. I, II , III&IV, The Institution Of Electrical Engineers, Electricity Association Services Ltd., 1995
5. Helmut Ungrad , Wilibald Winkler, Andrzej Wiszniewski, Protection techniques in electrical energy systems, Marcel Dekker, Inc.
6. Badri Ram , D.N. Vishwakarma, Power system protection and switch gear, Tata McGraw Hill.
7. Blackburn, J. Lewis ,Protective Relaying, Principles and Applications, Marcel Dekker, Inc., 1986.
8. Anderson, P.M, Power System Protection,. McGraw-Hill, 1999
9. Singh L.P ,Digital Protection, Protective Relaying from Electromechanical to Microprocessor, John Wiley & Sons, 1994
10. Wright, A. and Christopoulos, C, Electrical Power System Protection,. Chapman & Hall, 1993,
11. Walter A. Elmore, J. L. Blackburn, Protective Relaying Theory and Applications, ABB T&D Co. Marcel Dekker, Inc.
12. Arun G. Phadke, James S. Thorp, Computer Relaying for Power Systems, Marcel Dekker, Inc.

EE4094 CONTROL SYSTEMS LABORATORY

Prerequisite: None

Total Hours: 42 Hours

L	T	P	C
0	0	3	2

List of experiments:

1. To obtain the moment of inertia and develop the transfer function of the given DC Motor for (a) Armature controlled and (b) Field controlled cases. Draw the relevant block diagrams.
2. To conduct experiments on the given amplidyne for (a) To obtain the transfer function (b)To obtain the load characteristics under different levels of compensation (c) To obtain the characteristics of a metadyne.
3. To Study the FEEDBACK® MS150 DC Modular Servo System and to obtain the characteristics of the constituent components. Also to set up a closed loop position control system and study the system performance.
4. To design a Lead compensator and to obtain the characteristics by experiment and simulation using MATLAB®.
5. To design a Lag compensator and to obtain the characteristics by experiment and simulation using MATLAB®.
6. To design a Lag-Lead compensator and to obtain the characteristics by experiment and simulation using MATLAB®.
7. To set up a system for closed loop voltage regulation for a dc separately excited generator using amplidyne and to obtain its characteristics.
8. To obtain the model of the Inverted pendulum and study the closed loop performance using experiments on Bytronic® Inverted Pendulum
9. To obtain the characteristics of the synchro systems and to set up a synchro link position control system using FEEDBACK® MS150 AC Modular Servo.
10. To set up a closed loop feedback control system using the FEEDBACK® MS150 DC Modular Servo System-with velocity (rate) feed back.
11. To conduct experiments on the Level Process Control Station and to study the working of a level control loop.
12. To set up a closed loop feedback control system using the FEEDBACK® MS150 AC Modular Servo System-with velocity (rate) feed back.

[**Note**: Normally the practical classes are administered in two cycles. Depending on the availability of equipments and time, class coordinators may choose the experiments for each cycle.]

Text/Reference Books:

1. Gene F Franklin, J David Powell, Abbas Emami Naeini, *Feedback Control of Dynamic Systems,* 4th Ed, Pearson Education Asia, 2002
2. Graham C Goodwin, Stefan F Graebe, Mario E Salgado, *Control System Design*, Prentice Hall India, 2003.
3. John J D'Azzo, Constantine H Houpis, Stuart N. Sheldon, *Linear Control System Analysis & Design with MATLAB*, 5th Ed, Marcel Dekker, 2003
4. P.C. Sen, *Principles of Electrical Machines & Power Electronics*, John Wiley, 2003.
5. John E Gibson, Franz B. Tuteur, Control System Components, McGrawHill, 1958.
6. Ramesh S Gaonkar, Microprocessor architecture Programming and application with 8085/8080A 2E, New Age Publications, 1995.
7. Users' Manual for FEEDBACK® MS150 DC Modular Servo System
8. Users' Manual for FEEDBACK® MS150 AC Modular Servo System
9. Users' Manual for 8085n Microprocessor kit, ©Vi MicroSystems.
10. www.mathworks.com
11. Users' Manual for Bytronic® Inverted Pendulum.
12. Users' Manual for Level Process Station, ©Vi McroSystems