# MIDC 201: ADVANCED CONTROL OF AC DRIVES

***Course Objective:*** *To provide the fundamental concepts in modeling and control schemes used in advanced AC drives systems*

***Syllabus:***

## Modeling

Dynamic d-q modeling of induction machines - stator, rotor and synchronously rotating reference frame models, state space equations and dynamic simulation, Space Phasor model - control principle of the induction motor

## Vector Control

Vector controlled induction motor drive - Basic principle-Direct Rotor flux oriented vector control - Estimation of rotor flux and torque - Implementation with current source and voltage source inverters

Stator flux oriented vector control - Indirect rotor flux oriented vector control scheme-implementation – tuning - Dynamic simulation.

Parameter sensitivity and compensation of vector controlled induction motors-Selection of Flux level - Flux weakening operation - Speed controller design -Vector control strategies for Synchronous motor.

## Sensor less Control

Principles for speed sensor less control **-** Sensor less methods for scalar control, Sensor less methods for vector control, Introduction to observer based techniques, Basic principle of DTFC.

## REFERENCES


1. R Krishnan, *Electric Motor Drives*, PHI-2001.
2. D W Novotny and T A Lipo, *Vector Control and Dynamics of AC Drives*, Oxford University Press, 1996.
3. B K Bose, *Modern Power Electronics and AC Drives,* Pearson-2002.
4. Leonhard, *Control of Electric Drives*, Springer-2001.
5. Kazmierkowski, Krishnan, Blaabjerg, *Control in Power Electronics-Selected Problems*, Academic Press, 2002.
6. John Chiasson, *Modeling and High Performance Control of Electric Machines*, Wiley-IEEE Press, 2005.
7. I Boldea, S A Nasar, *Electric Drives, 2$^{nd}$edition*, CRC Press, 2006.
8. K Rajashekara, *Sensorless Control of AC motors*, IEEE Press, 1996.
9. I Boldea, S A Nasar, *Vector Control of AC Drives,* CRC Press, 1992.
10. J Holtz, *Sensorless Control of Induction Motor Drives,* Proceedings of the IEEE, August 2002, PP 1359-1394.

# MIDC 202: ADAPTIVE CONTROL

***Course Objective:*** *To provide the fundamental concepts of parameter estimation and adaptive control theory*

***Syllabus:***

**Introduction**
Adaptive Control-effects of process variation-Adaptive schemes-Adaptive Control problem-Applications

**Real-Time Parameter Estimation**
Introduction-Least Squares and Regression Models-Estimating-Parameters in Dynamical Systems

**Model-Reference Adaptive Systems**
Introduction-The MIT Rule-Determination of the Adaptation Gain-Lyapunov Theory-Design of MRAS Using Lyapunov Theory-Bounded-Input-Bounded-Output Stability-Applications to Adaptive control

**Self-Tuning Regulators**
Introduction-Pole Placement Design-Indirect Self-tuning Regulators-Continuous Time Self-tuners-Direct Self-tuning Regulators-Disturbances with Known Characteristics-Relations between MRAS and STR

**Robust Adaptive Laws**
Introduction-Plant Uncertainties and Robust Control-Instability Phenomena in Adaptive Systems-Simple Examples-Robust Adaptive Laws

**Gain Scheduling**
Introduction-Principle and Design of Gain Scheduling controllers-Nonlinear Transformations-applications of Gain Scheduling

**Case Studies**

**REFERENCES**


1. Karl Jhon Astrom & Bjom Wittenmark, *Adaptive Control*, Addison Wesley, 1994.
2. Shankar Sastry, *Adaptive Control*, PHI (Eastern Economy Edition), 1989.
3. Karl Jhon Astrom, *Adaptive Control,* Pearson Education, 2001.
4. Petros A Ioannou, Jing, *Robust Adaptive Control*, Prentice-Hall, 1995.
5. Eykhoff P, *System Identification: Parameter and State Estimation*, 1974.
6. Ljung, *System Identification Theory for the User*, Prentice-Hall, 1987.


***Prerequisite*:** *Basic knowledge in sampled data systems, feedback control systems and automatic control*

# MIDC 203: ANALYSIS OF POWER ELECTRONIC SYSTEMS - II

***Course Objective:*** To provide a strong foundation on advanced converter techniques and their control in modern Power Electronic Systems.
***Syllabus:***

**PWM Strategies for Inverters**
Sinusoidal PWM - Regular Sampled PWM- Space Vector Modulation - modulation strategies for multilevel inverters of Diode Clamped Type and Flying Capacitor Type, Microcomputer implementation of PWM inverters.
**Current Regulated PWM Voltage Source Inverters**
Methods of Current Control, Hysteresis Control, Variable Band Hysteresis Control, Fixed Switching Frequency Current Control Methods.
**PWM Rectifier**s
Single phase and three phase- Basic topologies - Control Principles.
**DC-DC Switch Mode Converters**
Buck, Boost, Buck-Boost SMPS Topologies. Basic Operation-Waveforms-modes of operation – Output voltage ripple-State space modeling-Simulation and closed loop control system design. Push-Pull and Forward Converter Topologies-Basic Operation. Waveforms-Voltage Mode Control. Half and Full Bridge Converters. Basic Operation and Waveforms - Fly back Converter, Discontinuous mode operation, Waveforms, Control - Continuous Mode Operation, Waveforms
**Resonant Converters**
Classification of Resonant Converters, Basic Resonant Circuit Concepts, Load Resonant Converter, Resonant Switch Converter, Zero Voltage Switching - Zero current switching - ZVS Clamped Voltage Topologies, Resonant dc-link inverters
**Introduction to Matrix Converters**
Matrix converter switches and circuit-control strategies-Venturini control method.

**REFERENCES**


1. B W Williams, *Principles and Elements of Power Electronics,* University of Strathclyde Glasgow, 2006.
2. Mohan, Undeland, Robbins, *Power Electronics -3rd edition*, John Wiley and Sons, 2003.
3. William Shepherd, Li Zhang, *Power Converter Circuits*, Marcel Decker, 2004.
4. Prof. Ramnarayanan, *Course Material on Switch Mode Power Conversion*, Electrical Department, IISc, Bangalore, 2006.
5. Philip T Krein, *Elements of Power Electronics,* Oxford, 1998.
6. B K Bose, *Modern Power Electronics and AC Drives*, Pearson Education, 2002.
7. Kazmierkowski, Krishnan, Blaabjerg, *Control in Power Electronics*, Academic Press, 02
8. Issa Batarseh, *Power Electronic Circuits*, John Wiley, 2004.
9. Bin WU, *High Power Converters and AC drives*, John Wiley, 2006.
10. D Grahame Holmes, Thomas A Lipo, *Pulse Width Modulation for Power Converters: Principles and Practice*, IEEE Press, 2003.
11. M H Rashid (Ed), *Power Electronics Handbook,* Academic Press, 2001.

# MIDC 204: SPECIAL ELECTRICAL MACHINES AND DRIVES

***Course Objective:*** *To introduce special types of electric machines and their controls for special applications.*

***Syllabus:***

**Stepping Motors**
Constructional features, principle of operation, modes of excitation, single phase stepping motors, torque production in variable Reluctance (VR) stepping motor, Dynamic characteristics, Drive systems and circuit for open loop control, Closed loop control of stepping motor, microprocessor based controller

**Switched Reluctance Motors**
Constructional features, principle of operation. Torque equation, Power controllers, Characteristics and control. Microprocessor based controller. Sensor less control.

**Synchronous Reluctance Motors**
Constructional features: axial and radial air gap Motors. Operating principle, reluctance torque – Phasor diagram, motor characteristics.

**Permanent Magnet Brushless DC Motors**
Commutation in DC motors, Difference between mechanical and electronic commutators, Hall sensors, Optical sensors, Multiphase Brushless motor, Square wave permanent magnet brushless motor drives, Torque and emf equation, Torque-speed characteristics, Controllers-Microprocessor based controller. Sensorless control.

**Permanent Magnet Synchronous Motors**
Principle of operation, EMF, power input and torque expressions, Phasor diagram, Power controllers, Torque speed characteristics, Self control, Vector control, Current control schemes. Sensor less control.

**REFERENCES**


1. Kenjo T, Sugawara A, *Stepping Motors and Their Microprocessor Control*, Clarendon Press, Oxford, 1994.
2. Miller T J E, *Switched Reluctance Motor and Their Control*, Clarendon Press, Oxford, 1993.
3. Miller T J E, *Brushless Permanent Magnet and Reluctance Motor Drives*, Clarendon Press, Oxford, 1989.
4. B K Bose, *Modern Power Electronics & AC drives*, Pearson, 2002.
5. Kenjo T, *Power Electronics for the Microprocessor Age*, Oxford University Press, 1990.
6. Ali Emadi (Ed), *Handbook of Automotive Power Electronics and Motor Drives*, CRC Press, 2005.
7. R Krishnan, *Electric Motor Drives – Modeling, Analysis and Control*, PHI, 2003.
8. H A Toliyat, S Campbell, *DSP Based Electro Mechanical Motion Control*, CRC Press, 2004.

# MIDC 205(1): DIGITAL SIMULATION OF POWER ELECTRONIC SYSTEMS

***Course Objective:*** *To focus on different approaches to modeling of power electronics systems and the use of software tools for analysis*

***Syllabus:***

## Modeling

Principles of Modeling Power Semiconductor Devices - Macro models versus Micro models - Thyristor model - Semiconductor Device modeled as Resistance, Resistance-Inductance and Inductance-Resistance-Capacitance combination - Modeling of Electrical Machines - Modeling of Control Circuits for Power Electronic Switches. Computer Formulation of Equations for Power Electronic Systems –Review of graph theory as applied to Electric networks- Systematic method of Formulating State Equations - Computer Solution of State Equations - Explicit Integration method - Implicit Integration method.
AC equivalent circuit modeling: Basic AC modeling approach-State space averaging-circuit averaging and averaged switch modeling-Modeling the PWM.

**Analysis Using Software Tools**

Circuit Analysis Software ORCAD- PSpice - Simulation Overview - Creating and Preparing a Circuit for Simulation - Simulating a Circuit with PSpice - Simple Multi-run Analyses - Statistical Analyses - Simulation Examples of Power Electronic systems- Creating Symbols - Creating - Models - Analog Behavioral Modeling - Setting Up and Running analyses - Viewing Results - Examples of Power Electronic Systems.
Dynamic modeling and simulation of DC-DC converters using MATLAB-Simulation of State Space Models. Modeling and simulation of inverters using MATLAB

## REFERENCES


1. V Rajagopalan, *Computer Aided Analysis of Power Electronic Systems*, Marcel Dekker, Inc., 1987.
2. Erickson, Maksimovic, *Fundamentals of Power Electronics - 2nd edition*, Springer, 2001.
3. Randall Shaffer, *Fundamentals of Power Electronics with MATLAB*, Firewall Media, India, 2007.
4. Mohan, Undeland, Robbins, *Power Electronics*, *3rd edition*, John Wiley, 2003.
5. Jai P Agrawal, *Power Electronic Systems-Theory and Design*, Pearson- 2001.
6. ORCAD PSpice Basics: Circuit Analysis Software, User's Guide, ORCAD Corporation.

## MIDC 205(2): SOFT COMPUTING TECHNIQUES

***Course Objective:*** *To introduce advanced techniques like, Fuzzy-logic, Neural Network, Genetic Algorithms etc., and its engineering applications*

***Syllabus:***

**System Identification**

Least Square Method-LSE for non linear load- Validation of simulation model-computer simulation of continuous and discrete system.

**Neural Network**

Different architectures-supervised learning-perceptron- Adaline-Back Propagation- Unsupervised learning-Competitive learning-Kohenon self organizing network-Hebbian learning- Hopfield network- ART network-NNW applications in control, identification and pattern recognition.

**Fuzzy Logic**

Basic concepts- set theoretic operations-membership function-fuzzy rules-fuzzy reasoning-fuzzy inference systems-Mamdani and Sugeno type-defuzzification- fuzzy controllers-applications in electric drives.

**Neuro Fuzzy**

Modeling - Neuro fuzzy inference system-controllers-Back propagation through recurrent learning- Reinforced learning.

**Genetic Algorithms**

Basic concepts-design issues-modeling-hybrid models.

### REFERENCES


1. S Rajasekharan, Vijaya Lakhmi Pai, *Neural Network, Fuzzy logic and Genetic Algorithm*, PHI, 2002.
2. J S R Lang, C T Sun, Mizutani, *Neuro Fuzzy and Soft Computing.*
3. David E Goldberg, *Genetic Algorithms.*
4. C T Lin, C S G Lee, *Neural Fuzzy Systems.*
5. Bort Kosko, *Fuzzy Engineering.*
6. Simon Haykin, *Neural networks.*
7. M Ananda Rao, J Sreenivas, *Neural Network Algorithm and Applications.*
8. B K Bose, *Modern Power Electronics & AC drives,* Pearson, 2002.
9. Cirstea, Dinu, Mccormick, *Neural and Fuzzy Logic Control of Drives and Power Systems,* Elsevier, 2002.

# MIDC 205(3): ROBOTICS AND AUTOMATION

***Course Objective:*** *Deals with dynamics and various aspects of manipulation of robots*

***Syllabus:***

**Introduction**

Geometric configuration of robots – Manipulators – Drive systems – Internal and external sensors – End effectors – Control systems – Robot programming languages and applications – Introduction to robotic vision.

**Robot Arm Kinematics**

Direct and inverse kinematics – Rotation matrices – Composite rotation matrices – Euler angle representation – Homogenous transformation – Denavit Hattenberg representation and various arm configurations.

**Robot Arm Dynamics**

Lagrange – Euler formulation, joint velocities – Kinetic energy – Potential energy and motion equations – Generalized D'Alembert equations of motion.

**Planning of Manipulator Trajectories**

General consideration on trajectory planning joint interpolation & Cartesian path trajectories.

**Control of Robot Manipulators**

PID control computed, torque technique – Near minimum time control – Variable structure control – Non-linear decoupled feedback control – Resolved motion control and adaptive control.

**REFERENCES**

1. Fu K S, Gonazlez R C and Lee C S G, *Robotics (Control, Sensing, Vision and Intelligence)*, McGraw-Hill, 1987.
2. Wesley, E Sryda, *Industrial Robots: Computer Interfacing and Control*. PHI, 1985.
3. Asada and Slotine, *Robot Analysis and Control*, John Wiley and Sons, 1986.
4. Philippe Coiffet, *Robot Technology, Vol. II (Modeling and Control)*, Prentice Hall INC, 1981.
5. Saeed B Niku, *Introduction to Robotics, Analysis, Systems and Applications*, Pearson Education, 2002.
6. Groover M P, Mitchell Wesis, *Industrial Robotics Technology Programming and Applications*, Tata McGraw-Hill, 1986.
7. Sciavicco L, B Siciliano, *Modeling & Control of Robot Manipulators, 2nd Edition*, Springer Verlag, 2000.
8. Gray J O, D G Caldwell (Ed), *Advanced Robotics & Intelligent Machines*, The Institution of Electrical Engineers, UK, 1996.
9. Craig John J, *Introduction to Robotics: Mechanics and Control*, Pearson, 1989.

# MIDC 205(4): ESTIMATION THEORY

***Course Objective:*** *The purpose of this course is to give students a background in stochastic system approach and the analysis. Stochastic optimal linear filter, prediction, and smoothing algorithms for discrete-time systems are the main focus.*

***Syllabus:***

**Elements of Probability Theory**

Random variables-Gaussian distribution-stochastic processes-characterizations and properties-Gauss-Markov processes-Brownian motion process-Gauss-Markov models

**Optimal Estimation for Discrete-time Systems**

Fundamental theorem of estimation-optimal prediction

**Optimal Filtering**

Weiner approach-continuous time Kalman Filter-properties and implementation-steady-state Kalman Filter-discrete-time Kalman Filter-implementation-sub-optimal steady-state Kalman Filter-Extended Kalman Filter-practical applications

**Optimal Smoothing**

Optimal fixed-interval smoothing, optimal fixed-point smoothing, optimal fixed-lag smoothing-stability-performance evaluation

**REFERENCES**


1. James S Meditch, *Stochastic Optimal Linear Estimation and Control,* McGraw-Hill, New York, 1969.
2. Jerry M Mendel '*Lessons in Estimation Theory for Signal processing, Communication, and Control,* Prentice-Hall Inc, New Delhi, 1995.
3. Mohinder S Grewal, Angus P Andrews, *Kalman Filtering; Theory and Practice*, Prentice-Hall Inc, Englewood Cliffs, 1993.
4. Grimble M J, M A Johnson, *Optimal Control and Stochastic Estimation; Theory and Applications*, Wiley, New York, 1988.
5. Peter S Meybeck, *Stochastic Models, Estimation, and Control*, Volume 1 & 2, Academic Press, New York, 1982.
6. Papoulis Athanasios, *Probability, Random Variables, and Stochastic Process*, 2$^{nd}$ Edition, McGraw-Hill, New York, 1984.
7. Frank L Lewis, *Optimal Estimation*, Wiley, New York, 1986.
8. Mcgarty J P, *Stochastic Systems and State Estimation,* John Wiley, New York, 1974.


***Prerequisite:*** *Second level course in control systems*

## MIDC 205(5): ADVANCED POWER SEMICONDUCTOR DEVICES

***Course Objective:*** *The purpose is to make students aware of the device physics and operation of common power semiconductor devices and also those which are in the development stage*

***Syllabus:***

### Introduction

Power switching devices overview – Attributes of an ideal switch, application requirements, circuit symbols; Power handling capability – (SOA); Device selection strategy – On-state and switching losses – EMI due to switching - Power diodes - Types, forward and reverse characteristics, switching characteristics – rating. Shottky Diode

### Current Controlled Devices

BJT's – Construction, Device Physics, static characteristics, switching characteristics; Negative temperature co-efficient and secondary breakdown; Power Darlington - Thyristors – Physical and electrical principle underlying operation, Gate and switching characteristics; converter grade and inverter grade and other types; series and parallel operation; comparison of BJT and Thyristor – steady state and dynamic models of BJT & Thyristor.

### Voltage Controlled Devices

Power MOSFETs and IGBTs – Principle of voltage controlled devices, construction, types, Device physics, Static and Switching Characteristics- Steady state and dynamic models of MOSFET and IGBTs - Basics of GTO, MCT, FCT, RCT and IGCT.

### Firing and Protection Circuits

Necessity of isolation, pulse transformer, optocoupler – Gate drives circuit: SCR, MOSFET, IGBTs and base driving for power BJT. Over voltage, over current and gate protections; Design of snubbers.

### Thermal Protection

Heat transfer – conduction, convection and radiation; Cooling – liquid cooling, vapour – phase cooling; Guidance for hear sink selection – Thermal resistance and impedance -Electrical analogy of thermal components, heat sink types and design – Mounting types.

### REFERENCES


1. Kassakian J G et al, *Principles of Power Electronics*, Addison Wesley, 1991.
2. B W Williams, *Principles and Elements of Power Electronics*, University of Strathclyde, Glasgow, 2006.
3. Mohan, Undeland, Robins, *Power Electronics – Concepts, Applications and Design*, John Wiley and Sons, Singapore, 2000.
4. M D Singh, K B Khanchandani, *Power Electronics*, Tata McGraw Hill, 2001.

# MIDC 206(1): FIELD THEORY

***Course Objective:*** *This course presents a unified macroscopic theory of electromagnetic waves in accordance with the principle of special relativity from the point of view of the form in invariance of Maxwell's equations and the constitutive relations. The topic includes the fundamental equations and boundary conditions, time harmonic fields, waves through space and media, reflection, transmission, guidance and resonance of electromagnetic waves, antenna theory and the various methods of flux plotting.*

***Syllabus:***

Time varying fields and electromagnetic waves-Solution of Maxwell's equations for charge free unbounded region – Uniform waves – Uniform plane waves – Characteristics – Wave impedance and propagation constant – Wave propagation in good dielectrics, conductors – Depth of penetration – Surface impedance of good conductor to sinusoidal currents – Polarization – Elliptic, Linear and Circular polarization.

Waves at boundary between two media – Wave incident normally on boundary between perfect dielectrics – Wave incident obliquely on boundary between perfect dielectrics – Wave polarized perpendicular to the plane of incidence – Parallel polarization – Wave incident normally on perfect conductor – Oblique incidence – Brewster angle, Snell's law.

Poynting Vector – Poynting Vector for a plane wave in a dielectric – Flow of direct current in cylindrical resistor – Co-axial cables – Instantaneous, Average and Complex poynting vector.

Guided waves – Essential conditions – Transverse electric waves – Transverse magnetic waves – Characteristics – TEM waves – Velocities of Propagation – TEM waves in co-axial cables and two wire transmission lines – Attenuation factor for TE, TM and TEM waves.

Propagation characteristics of Radio waves – Electro-magnetic wave spectrum – Transmission path from transmitter to receiver – Ionosphere - Ionospheric investigation – Virtual height and critical frequency – Maximum usable frequency.

Eddy current problems – Calculation of Eddy current loss – Effect of saturation Flux plotting – Two Dimensional field plotting methods – Method of images – Multiple images – Image of point charge in conducting sphere – Graphical method of field mapping – experimental methods.

## TEXT BOOKS

1. V V Sarwate, *Electromagnetic Field and Waves*, Wiley Eastern, Second Edition.
2. William H Hayt Jr., *Engineering Electromagnetics*, Tata McGraw Hill, Fifth Edition.

## REFERENCES

1. Kraus, Fleisch, *Electromagnetic with Applications*, McGraw Hill, Fifth Edition.
2. E C Jordan, *Electromagnetic Waves and Radiating Systems.*
3. P V Gupta, *Electromagnetic Fields.*

# MIDC 206(2): OPTIMIZATION TECHNIQUES

***Course Objective:*** *To identify different optimization problems in engineering and to introduce important techniques for the solution.*

***Syllabus:***

**Classification of Optimization Problems and Applications**
Basic concepts of design vectors-design constraints-constraint surface and objective function surfaces-Formulation and solution of linear programming problem-Simplex Method-Two phase simplex method- Duality theory, Duel Simplex method.

**Introduction to Integer Programming Methods**
Branch and bound method-Gomory's cutting plane method for integer and mixed integer programming-Integer polynomial programming

**Nonlinear Programming**
Properties of single and multivariable functions-Optimality criteria-Direct Search Methods-Gradient based methods-Newton's method- Conjugate Gradient Methods- Quasi - Newton Methods-DFP method-Broyden-Fletcher-Golfarb-Shanno method

**Constrained Optimality Criteria**
Lagrange Multipliers-KKT Conditions-interpretation of KKT Conditions, Second order optimality Conditions-Linearization methods for constrained problems-method of feasible directions-GRG methods-Quadratic approximation methods for constrained problems-Variable metric methods for constrained optimization

**REFERENCES**


1. G V Reklaitis, A Ravindran, K M Rajsdell, *Engineering Optimization, Methods and Applications*, John Wiley & Sons.
2. Singiresu S Rao, *Engineering Optimization Theory and Practices*, 3rd Edition, Wiley and Sons, 1998.
3. A Ravindran, Don T Philips, Jamer J Solberg, *Operations Research - Principles and Practice*, John Wiley & Sons.
4. P G Gill, W Murray, M H Wright, *Practical Optimization*, Academic Press, 1981.
5. Fredrick S Hiller, G J Liberman, *Introduction to Operations Research*, McGraw Hill, 1995.
6. Ashok D Belegundu, Tirupathi R Chandrapatla, *Optimization Concepts and Applications in Engineering*, Pearson Education, Delhi, 2002.
7. Kalyanmoy Deb, *Engineering Optimization*, PHI, 2001.

# MIDC 206(3): POWER QUALITY

***Course Objective:*** *To introduce different concepts associated with power quality and to discuss available methods for improving*

***Syllabus:***

### Introduction

Power quality-The mechanism of Harmonic generation-voltage quality-overview of power quality phenomena-classification of power quality issues-power quality measures and standards-THD-TIF-DIN-C-message weights-flicker factor-transient phenomena-occurrence of power quality problems-power acceptability curves-IEEE guides, standards and recommended practices.

### Harmonics

Individual and total harmonic distortion-RMS value of a harmonic waveform-triplen 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. Modeling of networks and components under non-sinusoidal conditions-transmission and distribution systems-shunt capacitors-transformers-electric machines-ground systems-loads that cause power quality problems-power quality problems created by drives and its impact on drives

### 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.

### 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 uninterruptible power supplies-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.

## REFERENCES


1. G T Heydt, *Electric Power Quality,* West LaFayette, Stars in a Circle Publications, 1991.
2. Math H Bollen, *Understanding Power Quality Problems,* IEEE Press-Standard Publishers, Delhi, 2001.
3. Jose Arillaga and Newille R Watson, *Power System Harmonics*, John Wiley, 2003.
4. Ali Emadi, Nasiri, Bekiarov, *Uninterruptible Power Supplies & Active Filters*, CRC Press, 2005.
5. J Arrillaga, *Power System Quality Assessment*, John Wiley, 2000.
6. J Arrillaga, B C Smith, N R Watson, A R Wood, .*Power System Harmonic Analys*is. Wiley, 1997.
7. Surya Santoso, H Wayne Beaty, Roger C Dugan, Mark F McGranaghan, *Electrical Power System Quality*, McGraw Hill, 2002.

# MIDC 206(4): POWER ELECTRONICS APPLICATIONS IN POWER SYSTEMS

***Course Objective:*** *The main focus is on the study and analysis of different compensators, employing power electronics, applied in power system*

***Syllabus:***

**Introduction**

Concept and General System Considerations. Power Flow in AC System. Definitions on FACTS . Basic Types of FACTS Controllers. Converters for Static Compensation. Multi-Pulse Converters and Interface Magnetics. Transformer Connections for 12, 24 and 48 pulse operation. Multi-Level Inverters - Diode Clamped Type, Flying Capacitor and cascade multilevel inverters.

**Static Shunt Compensators**

SVC and STATCOM, Operation and Control of TSC and TCR, direct and indirect control of STATCOM. Decoupled control strategy - Compensators- Comparison between SVC and STATCOM - transient and dynamic stability enhancement using STATCOM.

**Static Series Compensators**

TSSC, TCSC and SSSC, Operation and Control, External System Control for Series Compensators, SSR and its damping - Static Voltage and Phase Angle Regulators, TCVR and TCPAR, Operation and Control, The Unified Power Flow Controller. Operation, Comparison with other FACTS devices, control of P and Q, Dynamic Performance.

**Custom Power Devices**

Introduction - DSTATCOM, DVR, UPQC, Custom Power Park. Load compensation using DSTATCOM - Distributed generation and grid interconnection – standards -Power quality issues - islanding issues.

**Excitation Systems**

Need for AVR-brushless alternator - static excitation – Modeling – Stability - Applications of power electronics in modern excitation systems.

**REFERENCES**


1. N G Hingorani and L Gyugi, *Understanding FACTS*, IEEE Press, 2000.
2. Y H Song and A T Johns(Ed), *Flexible AC Transmission Systems*, IEE Press, 2001.
3. Mohan Mathur, Rajiv K Varma, *Thyristor Based FACTS Controllers for Electrical Transmission Systems*, IEEE Press, 2002.
4. Arindom Ghosh and Gerald Ledwich, *Power Quality Enhancement Using Custom Power Devices*, Kluwer Academic, 2002.
5. Bin W U, *High Power Converters and AC drives*, John Wiley, 2006.
6. Arriliga and Watson, *Computer Modeling of Electrical Power Systems*, Wiley, 2001.
7. Olle I Elgerd, *Energy Systems Theory*, TMH, 1986.
8. C Schauder and H Mehta, *Vector Analysis and Control of Advanced Static VAR Compensators*, IEE Proceedings-C, Vol.140, Issue 4, 1993.
9. Schaefer RC, *Applying static excitation systems*, Industry Applications Magazine, IEEE, Volume 4, Issue 6, Nov.-Dec., 1998.
10. N G Hingorani, *Introducing Custom Power, IEEE Spectrum*, Vol. 32, No.6, pp 41-48, June, 1995.

# MIDC 206(5): COMPUTER AIDED DESIGN OF ELECTRICAL MACHINES

***Course Objective:*** *To introduce the technique of Finite Element Methods in the area of electrical machines.*

***Syllabus:***

**Introduction**
Computer aided design of electrical machines - Conventional design procedures - Analysis and synthesis methods - Limitations - Need for field analysis based design.

**Mathematical Formulation of Field Problems**
Development of torque/force - Electromagnetic Field Equations - Magnetic Vector/Scalar potential - Electrical Vector/Scalar potential - Stored energy in field problems – Inductances - Laplace and Poisson's Equations - Energy functional - Principle of energy conversion.

**Philosophy of FEM**
Mathematical Models - Differential/Integral equations - Finite Difference method - Finite Element Method - Energy minimization - Variational method - 2D Field problems - Discretisation- Shape functions - Stiffness matrix - Solution techniques.

**CAD Packages**
Elements of a CAD System - Preprocessing - Modeling - Meshing -Material properties - Boundary Conditions - Setting up solution - Postprocessing.

**Design Applications**
Design of Solenoid Actuator - Induction Motor - Switched Reluctance Motor – Synchronous Machines.

**REFERENCES**


1. S J Salon, *Finite Element Analysis of Electrical Machines,* Kluwer Academic Publishers, London, 1995.
2. Chee-Mun Ong, *Dynamic Simulations of Electric Machinery: Using MATLAB/SIMULINK,* Prentice Hall, 1998.
3. Vlado Ostovic, *Computer Aided Analysis of Electric Machines*, Prentice Hall International (UK) Ltd, 1994.
4. Silvester and Ferrari, *Finite Elements for Electrical Engineer,* Cambridge University Press, 1983.
5. S R H Hoole, *Computer-Aided, Analysis and Design of Electromagnetic Devices*, Elsevier, New York, Amsterdam, London, 1989.
6. D A Lowther, P P Silvester, *Computer Aided Design in Magnetics*, Springer Verlag, New York.
7. M Ramamoorthy, Computer Aided Design of Electrical Equipments, Affiliated East West Press.
8. C W Trowbridge, *An Introduction to Computer Aided Electromagnetic Analysis,* Vector Field Ltd.
9. User Manuals of Software Packages like MAGNET, ANSOFT& ANSYS.

## MIDC 207: SEMINAR - II

It would be a perspective technical paper presentation related to the area in which the student intends to do the Masters Research Project. An approved copy of the seminar report should be submitted to the department.

## MIDC 208: ELECTRIC DRIVES LABORATORY

### Part (a): Experiments

1. Closed loop control of high frequency of DC – DC converters
2. Closed loop control of BLDC motors.
3. Closed loop control of Switched reluctance motors.
4. Vector control of three phase induction motors.
5. Vector control of three phase synchronous motors.
6. Closed loop control of PMSM.
7. Sensor less control of motors.
8. Use of Microcontrollers, DSP and FPGA for the control motors.

**(At least 5 experiments in the list are to be conducted in the laboratory. Additional experiments and simulation assignments can also be given by the department)**

### Part (b): Mini Project

**It should be an implemented prototype from Power Electronics and allied areas backed by analysis and simulation.**