## M.Tech (IPC & D) Syllabus for Admission Batch 2016-17

### 2nd Semester

**BRANCH-INDUSTRIAL POWER CONTROL & DRIVES**

**Specialization: Industrial Power Control & Drives**

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<td><strong>Course Name</strong></td>
<td><strong>Theory</strong></td>
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<td><strong>Hours/Week L/T</strong></td>
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<tr>
<td><strong>Specialization Core-1</strong></td>
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<tr>
<td>Load Flow &amp; Optimal Power Control</td>
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<td><strong>Specialization Core-2</strong></td>
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<td>Advanced Electric Drives</td>
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<td><strong>Elective -I(Specialization related)</strong></td>
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<td>1. HVDC Transmission &amp; FACTS</td>
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<td>2. Digital Relaying</td>
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<td>3. Solid State Control of Electric Drive</td>
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<td>4. Power System Reliability</td>
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<tr>
<td><strong>Elective-II (Departmental related)</strong></td>
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<tr>
<td>1. Advance Control System</td>
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<td>2. Design &amp; Synthesis of Control System</td>
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<td>3. Power Quality Improvement Techniques</td>
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<td>4. Power System Control &amp; Instrumentation</td>
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<td><strong>Elective -III(from any department)</strong></td>
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<td>1. Electric Drives In Hybrid Vehicle</td>
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<td>2. Green Energy Resources &amp; Technology</td>
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<td>3. Transducer &amp; Instrumentation</td>
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<td>4. Advanced Digital Signal Processing</td>
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<td><strong>Lab-2 (Specialization lab to be decided by the department)</strong></td>
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<td><strong>Seminar/Project</strong></td>
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<td><strong>Total</strong></td>
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<td><strong>Total Marks:</strong></td>
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<td><strong>Total Credits:</strong></td>
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LOAD FLOW AND OPTIMAL POWER CONTROL

Module-I : (10 Hours)
The energy system in steady state. System modeling and load flow analysis, A demonstration example, system model. The static load flow equation(SLFE), important characteristic of SLFE, classification of system variable, solution of system variable, solution of SLFE a basic diagram, modified specification, its solution generalization of N-bus system, practical state variable, constrains, practical control variable constrains , practical variable specification procedure, bus classification on basis of specification type, sensitivity analysis and the problem of control perturbation sensitivity matrices.

Module-II : (15 Hours)
Definition of load flow problem, Network formulation, a demonstration example, SLFE in general form, Network graph, choice of linearly independent network variable, Network variable in loop frame/bus frame of reference network variable. A load flow sample study, Computational aspect of the load flow problem. Iterative computation of the load flow equation. Effect of regulating transformer

The energy system in steady state optimum operating strategies.
The general programming problems, Optimum generation allocation. Line losses neglected, cost criterion, constrain relation, optimum dispatch strategy for a two bus system, optimum dispatch of N-bus system, Computational consideration, optimum generation allocation including the effect of transmission loss.
Derivation of optimum dispatch formula, optimum dispatch strategy for two bus system, optimum dispatch strategy for N-bus system, Computational consideration. The general optimum operational problem formulation. Necessary condition for optimum computational procedures.

Module-II : (15 Hours)
Control Problems:
Control system structure, Dynamic incremental state variable, coherency: power factor versus QV control: dynamic interaction between Pf Vs Qv loops megawatt frequency control problem. Fundamental characteristic of power control mechanism of an individual generator division of the power system into control area, pf. Control of single control area economic dispatch controller, pf control of multicontrol problems, control strategy: Fundamental characteristic of typical excitation system. Newer aspect of the megavar voltage control problem, Optimum system control, static versus dynamic stability, development of dynamic state variable, model for two area system, optimum control criterion ,optimum control strategy. Introduction of damping into the pf loop through voltage control

Reference:
1. Electrical Energy System Theory by O.I Elgard : TMH publisher
2. Power System Control and Stability by P.M Anderson and FOUD, A.A Iowa state university press
3. Current literature
ADVANCED ELECTRICAL DRIVES

Module-1 (15 hours)
Sensorless Introduction to AC Machines for Drives: Dynamic d-q model of Induction Motor and Salient Pole Synchronous machine. Study of Permanent Magnet (PM) machines and Variable reluctance Machine (VRM). [Ch- 2.2.12, 2.3.1-3, 2.4]

Control and Estimation of Induction Motor Drives: Small-Signal Equations of Induction Machines, Principle of vector control, Direct vector control, Indirect Vector Control, Stator flux oriented Vector control. [Ch- 8.2, 8.3, 8.4]

Module-2 (15 hours)
Sensorless Vector Control: Speed Estimation Methods, Direct vector control without speed signal, Direct Torque and Flux control. [Ch- 8.5, 8.6]


Module-3 (10 hours)

Neural Network Principles and Application: Introduction, The Structure of a Neuron, Artificial Neural Network, Application (PWM Controller, Vector-controlled Drive Feedback Signal estimation) [Ch- 12.1, 12.2, 12.3, 12.7.1-3]

Textbook:

References:
HVDC TRANSMISSION & FACTS

Module-I (10 hours)
Introduction: Comparison of AC-DC Transmission, Description and application of HVDC transmission, DC System components and their functions
Analysis of HVDC Converters: Pulse number, Converter configuration, Analysis of Graetz circuit, Bridge characteristics, 12 pulse converter.

Module-II : (11 hours)
HVDC Control: Principles of DC Link control-Converter control characteristics- System control, Firing angle control- Current and extinction angle control, DC link power control, Reactive power control and VAR sources, MTDC system- types- control and protection- DC circuit breakers

Module-III: (15 hours)
FACTS Concept and General System:
Transmission interconnections, Flow of power in AC system, Power flow and dynamic stability considerations of a transmission interconnection, Relative importance of controllable parameters, Basic types of FACTS controllers, Benefits from FACTS Technology, In-perspective: HVDC or FACTS

Module-IV: (15 hours)
Compensators: Objective of series and shunt compensation, SVC and STATCOM, GCSC, TSSC, TCSC, and SSSC, UPFC, IPFC, Generalized and Multifunctional FACTS Controllers

Text/References:
DIGITAL RELAYING

Module1-(10 hours)
Evolution in Protection systems, characteristic of protective relay, introduction to computer relaying, Functional block diagram of digital relay, software tools for digital simulation of relaying signal, Performance issue of Current and Voltage Transformer and its improvement

Module2-(10 hours)

Module3-(10 hours)
Signal conditioning, Sampling and Analogue to Digital Conversion, relaying algorithm, sample and derivative technique, Fourier full cycle and half cycle algorithm and its frequency response, differential equation algorithm, selective integration technique, digital algorithm for power system frequency measurement

Module4- (10 hours)
Digital protection scheme for Transformer, Generator, Transmission lines, Adaptive relaying, Basic concept of Artificial Neural Network[ANN] and Fuzzy logic. ANN approach and fuzzy logic method for fault detection and fault location. Testing of protecting relay

Books and Journals:-
2. Computer Relaying for power system, Arun G Phadke and James Throp, John Wiley, Inc
3. IEEE tutorial courses on Microprocessor Relay and protection Systems, Power research Group, University of Saskatchewan, 1979 and 1987
4. IEEE tutorial courses on Advancement in Microprocessor based protection and communication
5. Technical Papers from IEEE Transaction, CIGRE, IEE journals
SOLID STATE CONTROL OF ELECTRICAL DRIVES

Module -I: (8 hours)
**Speed control of dc motors:** Industrial motor drive requirements - typical load torque speed curves – energy savings - variable speed drives - load dynamics and modeling - load type and duty ratio - motor choice - speed control principles - constant torque - constant power - multi quadrant operations.


Module -II: (8 hours)

Module -III: (8 hours)
**Speed control of induction motor - Stator side:** Comparison of different ac power controllers - principles of speed control - variable voltage - variable frequency operation - constant flux operation - constant power operation - speed control of VSI and CSI fed drives - design examples. Closed loop control schemes - dynamic and regenerative braking - speed reversal. Tracing of critical waveforms - effect of non-sinusoidal supply.

Module -IV: (8 hours)
**Speed control of induction motor - Rotor side:** Torque slip characteristics - speed control through slip - rotor resistance control - chopper controlled resistance - equivalent resistance - TRC strategy - characteristic relation between slip and chopper duty ratio - combined stator voltage control and rotor resistance control - design solutions - closed loop control scheme.

Slip power recovery - torque slip characteristics - power factor considerations - sub and super synchronous operation - design solutions - closed loop control scheme.

Module - V: (8 hours)
**Speed control of synchronous motor drives:** Need for leading PF operation - open loop VSI fed drive - group drive applications. Self control - margin angle control - torque angle control - power factor control - simple design examples Closed loop speed control scheme with various power controllers - starting methods. Brush less excitation systems.

TEXT BOOKS
POWER SYSTEM RELIABILITY

Module-I (10 Hours)
Generating Capacity Frequency & Duration Method: The generation model, System risk indices.

Module-II (12 Hours)
Interconnected Systems: Probability error method in two interconnected systems, Equivalent assisting unit approach to two interconnected systems, Factors affecting the emergency assistance available through the interconnections, Variable reserve versus maximum peak load reserve, Reliability evaluation in three interconnected system, multiconnected system, Frequency & duration approach.
Operating Reserve: General concepts, PJM method, Extension to PJM method, Modified PJM method, Postponable outages, Security function approach, Response risk, Interconnected systems.

Module-III (10 Hours)
Composite Generation & Transmission Systems: Radial configurations, Conditional probability approach, Network configurations, State selection, System & load point indices, Application to practical systems, Data requirements for composite system reliability.
Plant & Station Availability: Generating plant availability, Derated states & auxiliary systems, Allocation & effect of spares, Protection systems, HVDC systems.

Module-IV (11 Hours)

Text Books
ADVANCED CONTROL SYSTEMS

Module-I : (10 Hours)


Module -II : (12 Hours)


Module - III : (11 Hours)

Non linear Systems : The Aizerman and Kalman Conjectures : Popov’s stability criterion, the generalized circle criteria, simplified circle criteria. Simple variable structure systems, sliding mode control, feedback linearization, Model reference adaptive control, (MRAC), Self Tuning Regulator (STR).

Module - IV : (10 Hours)

Fuzzy Logic Control : Fuzzy sets and crispsets, Fuzzy Relations and composition of Fuzzy Relations, Introduction to Fuzzy Logic Controllers.

Books :
DESIGN AND SYNTHESIS OF CONTROL SYSTEM

Module-1 (15 hours)

Module-2 (15 hours)

Module-3 (10 hours)

References:
POWER QUALITY IMPROVEMENT TECHNIQUES

Module-I: (15 Hours)
Concept of Power Quality: Frequency variations, voltage variations- sag and swell, waveform distortion – dc offset, harmonics, inter-harmonics, notching and noise. Fundamentals of Harmonics: Representation of harmonics, waveform, harmonic power, measures of harmonic distortion; Current and voltage limits of harmonic distortions: IEEE, IEC, EN, NORSOK. Causes of Harmonics: 2-pulse, 6-pulse and 12-pulse converter configurations, input current waveforms and their harmonic spectrum; Input supply harmonics of AC regulator, integral cycle control, cycloconverter, transformer, rotating machines, ARC furnace, TV and battery charger.

Module-II: (14 Hours)
Effect of Harmonics: Parallel and series resonance, effect of harmonics on static power plant – transmission lines, transformers, capacitor banks, rotating machines, harmonic interference with ripple control systems, power system protection, consumer equipments and communication systems, power measurement. Elimination/ Suppression of Harmonics: High power factor converter, multi-pulse converters using transformer connections (delta, polygon).

Module-III: (15 Hours)
Passive Filters: Types of passive filters, single tuned and high pass filters, filter design criteria, double tuned filters, damped filters and their design. Active Power Filters: Compensation principle, classification of active filters by objective, system configuration, power circuit and control strategy. PWM Inverter: Voltage sourced active filter, current sourced active filter, constant frequency control, constant tolerance band control, variable tolerance band control.

Module-IV: (15 Hours)

Text/Reference Books:
POWER SYSTEM CONTROL AND INSTRUMENTATION

Module-I
Control of voltage, frequency and tie-line power flows, Q-V and P-f control loops. Mechanism of real and reactive power control.

Module-II
Net interchange tie line bias control. Optimal, sub-optimal and decentralised controllers. AGC in isolated and interconnected power systems, AGC with economic dispatch. Discrete mode AGC.

Module-III

Module-IV
SCADA, supervisory control, supervisory master stations, remote terminal units, communication links, SCADA systems applications in power networks. System measurements using SCADA and computer Control.

Reference Books:
7. Ronald L. Krutz “Securing SCADA system” johnwilly publication.
9. AtifS. Debs, “Modern power systems control and operation”, Kluwer academic publishers
ELECTRIC DRIVES IN HYBRID VEHICLE

Module-I: (11 Hours)
Introduction: History of hybrid vehicles, architectures of HEVs, series and parallel HEVs, complex HEVs. Hybridization of Automobile: Fundamentals of vehicle, components of conventional vehicle and propulsion load; Drive cycles and drive terrain; Concept of electric vehicle and hybrid electric vehicle; Plug-in hybrid vehicle, constituents of PHEV, comparison of HEV and PHEV; Fuel Cell Vehicles and its constituents.

Module-II: (10 Hours)
Plug-in Hybrid Electric Vehicle: PHEVs and EREVs, blended PHEVs, PHEV architectures, equivalent electric range of blended PHEVs; Fuel economy of PHEVs, power management of PHEVs, end-of-life battery for electric power grid support, vehicle to grid technology, PHEV battery charging.

Module-III: (10 Hours)
Power Electronics in HEVs: Rectifiers used in HEVs, voltage ripples; Buck converter used in HEVs, non-isolated bidirectional DC-DC converter, regenerative braking, voltage source inverter, current source inverter, isolated bidirectional DC-DC converter, PWM rectifier in HEVs, EV and PHEV battery chargers.

Module-IV: (11 Hours)
Electric Machines and Drives in HEVs: Induction motor drives, Field oriented control of induction machines; Permanent magnet motor drives; Switched reluctance motors; Doubly salient permanent magnet machines.

Suggested Books:
GREEN ENERGY RESOURCES & TECHNOLOGY

Module-I:


Module-II:

Wind energy: Wind energy conversion, power ~ speed and torque ~ speed characteristics of wind turbines, wind turbine control systems; conversion to electrical power: induction and synchronous generators, grid connected and self excited induction generator operation, constant voltage and constant frequency generation with power electronic control, single and double output systems, reactive power compensation;

Ocean Energy: Ocean energy resources-ocean energy routes - Principles of ocean thermal energy conversion systems- ocean thermal power plants- Principles of ocean wave energy conversion and tidal energy conversion.

Module-III:

Biomass Energy: Introduction, Biomass conversion technology, Biogas, Composition of Biogas, Properties of Biogas, Biogas production reaction, Factor affecting biogas production, Biogas plant site selection, Biogas plants, Types of Biogas plants, Biogas purification, Biogas storage, Biogas dispensing, Advantages and disadvantages of Biogas, Emission from Biogas engines, Digester Filling and Biogas plant operation, Biogas digester sizing.

Module-IV:


Energy Conservation, Management and Economics: Impact of renewable energy on environment, Principle and strategies of energy conservation, energy management, energy audit, energy planning, Total energy system concept, Power tariff, Cost of electricity production from renewable.

Text/Reference Books:

5. Duffic and Beckman - Solar Engineering of Thermal Processes, John wiley
7. Green Marketing and Management: A global Perspective by John F. Whaik, 2005
TRANSDUCERS AND INSTRUMENTATION

Module-1 (10 hours)
TRANSDUCER CLASSIFICATION
Introduction, Electrical Transducer, Classification, Basic requirements of a Transducer.

PERFORMANCE CHARACTERISTICS OF AN INSTRUMENTATION SYSTEM
Introduction, Generalized measurements, Zero-order system, First-order system, Second-order system, Dead-time element, Specification and testing of dynamic response.

MEASUREMENT OF DISPLACEMENT, FORCE AND PRESSURE

Module-2 (15 hours)
MEASUREMENT OF SPEED AND VELOCITY

MEASUREMENT OF TORQUE
Introduction, Torque sensing shafts, Strain gauge torque transducers, Magnetostrictive torque transducers, Angular-shift torque transducer

MEASUREMENT OF TEMPERATURE
Introduction, Thermal Expansion methods, Resistance thermometers, Thermocouple Thermometer.

Module-3 (15 hours)
DIGITAL TRANSDUCERS
Introduction, Digital encoders disc type, Linear displacement transducers, Digital tachometer, Frequency output type transducers.

DIGITAL SIGNAL TRANSMISSION AND TELEMETRY SYSTEMS
Introduction, Data transmission systems, Pulse code formats, Modulation techniques for Digital data transmission. Telemetry systems, Introduction, Fundamentals of telemetry system, Classification of Telemetry systems, Intensity or proximity telemetry systems, current telemetry systems, voltage telemetry systems, Analog systems of frequency and pulse types, Communication channels for telemetry system, Short-range radio-telemetry, comparison of various telemetry systems.

INPUT-OUTPUT DEVICES AND DISPLAYS
Introduction, Analog Displays and Recorders, Digital Input-Output devices, displays

POWER PLANT INSTRUMENTS
Introduction, The power plant scheme, pressure, temperature, flow and level, vibration and Expansion.

REFERENCES:
1. Principle of Industrial Instrumentation, 2nd Edition by D Patranabis, TMH Publication
ADVANCED DIGITAL SIGNAL PROCESSING

Module-I: (15 hours) Discrete time signals, systems and their representations: Discrete time signals-Linear shift invariant systems- Stability and causality- Sampling of continuous time signals- Discrete time Fourier transform- Discrete Fourier series- Discrete Fourier transform- Z- transform- Properties of different transforms- Linear convolution using DFT- Computation of DFT.

Module II: (15 hours) Digital filter design and realization structures Design of IIR digital filters from analog filters- Impulse invariance method and Bilinear transformation method- FIR filter design using window functions- Comparison of IIR and FIR digital filters- Basic IIR and FIR filter realization structures- Signal flow graph representations.

Module III (10 hours) Analysis of finite word-length effects Quantization process and errors- Coefficient quantisation effects in IIR and FIR filters A/D conversion noise- Arithmetic round-off errors- Dynamic range scaling- Overflow oscillations and zero input limit cycles in IIR filters.


Text/ References


