M.TECH. (FULL TIME) - POWER SYSTEMS
CURRICULUM & SYLLABUS
2013 – 2014
## DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
## FACULTY OF ENGINEERING AND TECHNOLOGY
## SRM UNIVERSITY
## SRM NAGAR, KATTANKULATHUR – 603 203

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Category</th>
<th>I Semester</th>
<th>II Semester</th>
<th>III Semester</th>
<th>IV Semester</th>
<th>Category Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Core courses</td>
<td>12 (3 courses)</td>
<td>12 (3 courses)</td>
<td>---</td>
<td>---</td>
<td>24</td>
</tr>
<tr>
<td>2</td>
<td>Program Elective courses</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>18</td>
</tr>
<tr>
<td>3</td>
<td>Interdisciplinary elective courses – mandatory</td>
<td>3 (in I or II or III semester)</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Supportive courses – mandatory</td>
<td>3 (in I or II or III semester)</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>Seminar</td>
<td>1</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>Industrial Training (during summer vacation between II and III semesters)</td>
<td>---</td>
<td>---</td>
<td>1</td>
<td>---</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>Project work</td>
<td>---</td>
<td>---</td>
<td>06</td>
<td>16</td>
<td>22</td>
</tr>
</tbody>
</table>

**Total credits to be earned for the award of M.Tech degree – 72**
### PROGRAM CORE COURSES

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Name of the Course</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS2001</td>
<td>Modern Power System Analysis</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>PS2002</td>
<td>Power System Operation and Control</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>PS2003</td>
<td>Power System Protection</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>PS2004</td>
<td>Power System Dynamics</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>PS2005</td>
<td>Flexible AC Transmission Systems</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>PS2006</td>
<td>Deregulation of Power System</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>PS2046</td>
<td>Seminar</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>PS2048</td>
<td>Industrial Training</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>PS2049</td>
<td>Project Work Phase I</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>PS2050</td>
<td>Project Work Phase II</td>
<td>0</td>
<td>0</td>
<td>32</td>
<td>16</td>
</tr>
</tbody>
</table>

### PROGRAM ELECTIVE COURSES

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Name of the course</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS2101</td>
<td>High Voltage Direct Current Transmission System</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PS2102</td>
<td>Power Distribution Systems</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PS2103</td>
<td>Electrical Transients in Power Systems</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PS2104</td>
<td>Smart Grid Design and Analysis</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PS2105</td>
<td>Modern Optimization Techniques in Power Systems</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PS2106</td>
<td>Power System State Estimation</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PS2107</td>
<td>Advanced Power System Dynamics</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PS2108</td>
<td>Wind and Solar Energy Systems</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PS2109</td>
<td>Power quality</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PS2110</td>
<td>Industrial Power System Analysis and Design</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PS2111</td>
<td>Power System Planning and Reliability</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PS2112</td>
<td>Energy Management and Auditing</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PS2113</td>
<td>Distributed Generation and Micro Grid</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PS2114</td>
<td>Design of Controllers in Power Application</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PS2115</td>
<td>Analysis of Electrical Machines</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PS2116</td>
<td>Special Machines and their Controllers</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PS2117</td>
<td>System Theory</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Course Code</td>
<td>Name of the course</td>
<td>L</td>
<td>T</td>
<td>P</td>
<td>C</td>
</tr>
<tr>
<td>-------------</td>
<td>---------------------------------------------------</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>PS2118</td>
<td>Artificial Neural Networks Applied to Power Systems</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PS2119</td>
<td>Digital Signal Processing</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PS2120</td>
<td>Intelligent Controllers</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

**PROGRAM SUPPORTIVE COURSES**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Name of the course</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA2008</td>
<td>Applied Mathematics for Electrical Engineers</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PS2201</td>
<td>Object Oriented Programming</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PS2202</td>
<td>Computer Networks</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

**CONTACT HOUR/CREDIT:**

L: Lecture Hours per week  
T: Tutorial Hours per week  
P: Practical Hours per week  
C: Credit
PROGRAM CORE COURSES

<table>
<thead>
<tr>
<th></th>
<th>MODERN POWER SYSTEM ANALYSIS</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS2001</td>
<td></td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total Contact Hours</strong></td>
<td>-75</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**PURPOSE**

To enable the students to develop the understanding of the steady state analysis of power system.

**INSTRUCTIONAL OBJECTIVES**

1. To introduce the mathematical representation of power system components and solution techniques.
2. To impart in-depth knowledge on different methods of power flow solutions.
3. To perform symmetrical and unsymmetrical short circuit analysis to understand the effects of different types of faults.
4. To get insight of contingency analysis problem and the solution methods.
5. To gain knowledge on transient stability analysis and the associated solution techniques.

**UNIT I - PRELIMINARIES FOR POWER SYSTEM PROBLEMS**

(9 hours)

Per unit quantities - Modeling of generators, transformers, off nominal tap setting and phase shifting transformers, transmission lines and loads. Primitive parameters - Bus admittance matrix - bus impedance matrix - reduction due to zero bus currents and zero bus voltages - Solution through factored matrices - Solution of non-linear algebraic equation and non-linear differential equations.

**UNIT II - POWER FLOW ANALYSIS**

(9 hours)


**UNIT III - SHORT CIRCUIT ANALYSIS**

(9 hours)

Sub-transient, transient and steady state reactances of synchronous machine - symmetrical fault analysis using bus impedance matrix - symmetrical components and sequence networks - analysis of unsymmetrical fault at generator terminals - analyzing unsymmetrical faults occurring at any point in a power system.

**UNIT IV - CONTINGENCIES ANALYSIS**

(9 hours)
Importance of contingency analysis - addition / removal of one line -
construction of a column of bus impedance matrix from the bus admittance
matrix - calculation of new bus voltages due to addition / removal of one line
- calculation of new bus voltages due to addition / removal of two lines.

UNIT V - TRANSIENT STABILITY ANALYSIS (9 hours)
Swing equation - equal area criterion - critical clearing angle - critical
clearing time - multi-machine transient stability studies by classical
representation - step-by-step solution of swing curve and algorithms for
multi-machine transient stability studies.

LABORATORY WORK (30 hours)
Computer programs for construction of $Y_{bus}$, $Z_{bus}$,
Power flow studies,
Short circuit analysis,
contingency analysis and transient stability analysis.
Solving power system problems using simulation software.

REFERENCES

2. J J Grainger and W D Stevenson, “Power System Analysis”, McGraw-
5. M A Pai,” Computer Techniques in Power System Analysis”, Tata
PURPOSE
To enable the students acquire a comprehensive idea on various aspects of power system operation and control.

INSTRUCTIONAL OBJECTIVES
1. To gain knowledge on economic operation of power system and its solution techniques.
2. To understand hydrothermal scheduling techniques and maintenance scheduling.
3. To get the insight of load frequency control and its modeling.
4. To study the concept of voltage control using compensation devices.
5. To understand the role of energy control centre, SCADA, EMS functions and power system security states.

UNIT I - ECONOMIC OPERATION OF POWER SYSTEM (9 hours)
Review of economic dispatch problem – Co-ordination equations without and with loss, Solution by direct and Lambda iteration method - Base point and participation factors - Review of Unit commitment problem - constraints - solution by priority list, dynamic programming and Lagrangian Relaxation methods - Formulation of combined active and reactive power dispatch - Security constrained optimal power flow.

UNIT II - HYDROTHERMAL SCHEDULING AND MAINTENANCE SCHEDULING (9 hours)

UNIT III - LOAD FREQUENCY CONTROL (9 hours)
Need for frequency and voltage control - Plant and system level control - modeling of LFC of single area system - static and dynamic analysis - LFC of two area system - static and dynamic analysis - Tie line bias control - development of state variable model of single and two area system.
UNIT IV - VOLTAGE CONTROL  
(9 hours)

UNIT V - COMPUTER CONTROL OF POWER SYSTEM  
(9 hours)

LABORATORY WORK  
(30 hours)
1. Study of Economic dispatch without and with losses using MATLAB coding
2. Study of Economic Dispatch using Mipower Software.
3. Priority order method of unit commitment using MATLAB coding
4. Study of OPF methods using Mipower/Power world simulator softwares
5. Simulation of single area and multi area LFC using MATLAB/SIMULINK.
6. Modeling of AVR using MATLAB/SIMULINK.

REFERENCES

<table>
<thead>
<tr>
<th>PS2003</th>
<th>POWER SYSTEM PROTECTION</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td><strong>Total Contact Hours - 60</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**PURPOSE**
To impart knowledge on various aspects of protective relaying for power system components

**INSTRUCTIONAL OBJECTIVES**
1. To illustrate concepts of transformer protection
2. To describe about the various schemes of Over current protection
3. To analyze distance and carrier protection
4. To familiarize the concepts of Busbar protection and Numerical protection

**UNIT I - EQUIPMENT PROTECTION** (12 hours)
Types of transformers – Phasor diagram for a three – Phase transformer- Equivalent circuit of transformer – Types of faults in transformers- Over – current protection Percentage Differential Protection of Transformers - Inrush phenomenon-High resistance Ground Faults in Transformers - Inter-turn faults in transformers - Incipient faults in transformers - Phenomenon of over-fluxing in transformers - Transformer protection application chart Electrical circuit of the generator –Various faults and abnormal operating conditions-rotor fault –Abnormal operating conditions; numerical examples for typical transformer and generator protection schemes.

**UNIT II - OVER CURRENT PROTECTION** (12 hours)
Time – Current characteristics-Current setting – Time setting-Over current protective schemes - Reverse power or directional relay - Protection of parallel feeders - Protection of ring feeders - Earth fault and phase fault protection - Combined Earth fault and phase fault protection scheme - Phase fault protective scheme directional earth fault relay - Static over current relays; numerical example for a radial feeder
UNIT III - DISTANCE AND CARRIER PROTECTION OF TRANSMISSION LINES (12 hours)
Drawback of over – Current protection – Introduction to distance relay – Simple impedance relay – Reactance relay – mho relays comparison of distance relay – Distance protection of a three – Phase line-reasons for inaccuracy of distance relay reach - Three stepped distance protection - Trip contact configuration for the three - Stepped distance protection - Three-stepped protection of three-phase line against all ten shunt faults - Impedance seen from relay side - Three-stepped protection of double end fed lines-need for carrier – Aided protection – Various options for a carrier –Coupling and trapping the carrier into the desired line section - Unit type carrier aided directional comparison relaying – Carrier aided distance schemes for acceleration of zone II.; numerical example for a typical distance protection scheme for a transmission line.

UNIT IV - BUSBAR PROTECTION (12 hours)
Introduction – Differential protection of busbars-external and internal fault - Actual behaviors of a protective CT - Circuit model of a saturated CT - External fault with one CT saturation :need for high impedance – Minimum internal fault that can be detected by the high – Stability ratio of high impedance busbar differential scheme - Supervisory relay-protection of three – Phase busbars-Numerical examples on design of high impedance busbar differential scheme.

UNIT V - NUMERICAL PROTECTION (12 hours)

REFERENCES
PURPOSE
To enable the students to develop understanding of power system components modelling and Small-Signal stability analysis in power system.

INSTRUCTIONAL OBJECTIVES
1. To impart knowledge on dynamic modelling of a synchronous machine in detail.
2. To describe the modelling of excitation and speed governing system in detail.
3. To understand the fundamental concepts of stability of dynamic systems and its classification.
4. To understand and enhance small signal stability problem of power systems.

UNIT I - SYNCHRONOUS MACHINE MODELLING (9 hours)
Schematic Diagram, Physical Description: armature and field structure, machines with multiple pole pairs, MMF waveforms, direct and quadrature axes, Mathematical Description of a Synchronous Machine: Basic equations of a synchronous machine: stator circuit equations, stator self, stator mutual and stator to rotor mutual inductances, dq0 Transformation: flux linkage and voltage equations for stator and rotor in dq0 coordinates, electrical power and torque, physical interpretation of dq0 transformation, Per Unit Representations: Lad-reciprocal per unit system and that from power-invariant form of Park’s transformation; Equivalent Circuits for direct and quadrature axes, Steady-state Analysis: Voltage, current and flux-linkage relationships, Phasor representation, Rotor angle, Steady-state equivalent circuit, Computation of steady-state values, Equations of Motion: Swing Equation, calculation of inertia constant, Representation in system studies, Synchronous Machine Representation in Stability Studies: Simplifications for large-scale studies: Neglect of stator \( p \Psi \) terms and speed variations, Simplified model with amortisseurs neglected: two-axis model with amortisseur windings neglected, classical model.

UNIT II - MODELLING OF EXCITATION AND SPEED GOVERNING SYSTEMS (9 hours)
Excitation System Requirements; Elements of an Excitation System; Types of Excitation System; Control and protective functions; IEEE (1992) block diagram for simulation of excitation systems. Turbine and Governing System

UNIT III - SMALL-SIGNAL STABILITY ANALYSIS WITHOUT CONTROLLERS (9 hours)

UNIT IV - SMALL-SIGNAL STABILITY ANALYSIS WITH CONTROLLERS (9 hours)
Effects Of Excitation System: Equations with definitions of appropriate K-constants and simple thyristor excitation system and AVR, block diagram with the excitation system, analysis of effect of AVR on synchronizing and damping components using a numerical example, Power System Stabiliser: Block diagram with AVR and PSS, Illustration of principle of PSS application with numerical example, Block diagram of PSS with description, system state matrix including PSS, analysis of stability with numerical a example. Multi-Machine Configuration: Equations in a common reference frame, equations in individual machine rotor coordinates, illustration of formation of system state matrix for a two-machine system with classical models for synchronous machines, illustration of stability analysis using a numerical example. Principle behind small-signal stability improvement methods: delta-omega and delta P-omega stabilizers.

UNIT V - ENHANCEMENT OF SMALL SIGNAL STABILITY (9 hours)

LABORATORY WORK (30 hours)
1. Simulation of IEEE excitation systems.
2. Simulation of turbine and governor modeling.
5. Small-signal stability analysis with excitation systems.
6. Small-signal stability enhancement using PSS.

REFERENCES
UNIT I - INTRODUCTION (9 hours)
Review of basics of power transmission networks-control of power flow in AC transmission line- Analysis of uncompensated AC Transmission line- Passive reactive power compensation: Effect of series and shunt compensation at the mid-point of the line on power transfer- Need for FACTS controllers- types of FACTS controllers.

UNIT II - STATIC VAR COMPENSATOR (SVC) (9 hours)
Configuration of SVC- voltage regulation by SVC- Modelling of SVC for load flow analysis- Modelling of SVC for stability studies-Design of SVC to regulate the mid-point voltage of a SMIB system- Applications: transient stability enhancement and power oscillation damping of SMIB system with SVC connected at the mid-point of the line.

UNIT III - THYRISTOR AND GTO THYRISTOR CONTROLLED SERIES CAPACITORS (TCSC and GCSC) (9 hours)
Concepts of Controlled Series Compensation – Operation of TCSC and GCSC- Analysis of TCSC-GCSC – Modelling of TCSC and GCSC for load flow studies- modeling TCSC and GCSC for stability studied- Applications of TCSC and GCSC.

UNIT IV - VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS (9 hours)

UNIT V - CONTROLLERS AND THEIR CO-ORDINATION (9 hours)

LABORATORY WORK (30 hours)
1. Simulation and Implementation of Voltage Source Inverter and Current source Inverter
2. Load flow studies using TCSC.
3. Load flow analysis with SVC.
5. Load flow analysis of two-bus system with SVC and STATCOM.
6. Transient analysis of two-bus system with SVC and STATCOM.
7. Transient stability analysis without FACTS controller.
8. Transient stability analysis with TCSC for damp the power oscillations.

REFERENCES


<table>
<thead>
<tr>
<th>PS2006</th>
<th>DEREGULATION OF POWER SYSTEM</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Contact Hours - 60</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>

PURPOSE
To enable the students to understand the process and operation of restructured power system

INSTRUCTIONAL OBJECTIVES

1. To Introduce the restructuring of power industry and market models.
To impart knowledge on fundamental concepts of congestion management.
To analyze the concepts of locational marginal pricing and financial transmission rights.
To Illustrate about various power sectors in India
UNIT I - INTRODUCTION TO RESTRUCTURING OF POWER INDUSTRY (12 hours)
Introduction: Deregulation of power industry, Restructuring process, Issues involved in deregulation, Deregulation of various power systems – Fundamentals of Economics: Consumer behavior, Supplier behavior, Market equilibrium, Short and long run costs, Various costs of production – Market models: Market models based on Contractual arrangements, Comparison of various market models, Electricity vis-à-vis other commodities, Market architecture, Case study.

UNIT II - TRANSMISSION CONGESTION MANAGEMENT (12 hours)

UNIT III - LOCATIONAL MARGINAL PRICES AND FINANCIAL TRANSMISSION RIGHTS (12 hours)

UNIT IV - ANCILLARY SERVICE MANAGEMENT AND PRICING OF TRANSMISSION NETWORK (12 hours)
Introduction of ancillary services – Types of Ancillary services – Classification of Ancillary services – Load generation balancing related services – Voltage control and reactive power support devices – Black start capability service - ancillary service –Co-optimization of energy and reserve services - International comparison - Transmission pricing – Principles – Classification – Role in transmission pricing methods – Marginal transmission pricing paradigm – Composite pricing paradigm – Merits and demerits of different paradigm.
UNIT V - REFORMS IN INDIAN POWER SECTOR (12 hours)

REFERENCES


<table>
<thead>
<tr>
<th>PS2046</th>
<th>SEMINAR</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Contact Hours - 30</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

PURPOSE
To expose the communication of the students by conducting seminar

INSTRUCTIONAL OBJECTIVES
1. To motivate the students to attain the confidence and competence.

- The students are asked to give a seminar on the recent trends in the field of electrical engineering on an individual basis and evaluation will be done by a panel of faculty members. So this course has no credits and no end semester examination. It is only a pass/fail course. However this course is mandatory and the student has to pass the course to become eligible for the award of degree.

<table>
<thead>
<tr>
<th>PS2048</th>
<th>INDUSTRIAL TRAINING (Training to be undergone during II semester vacation)</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

PURPOSE
To provide hands-on experience at industry or a company where Power Engineering projects are carried out.
INSTRUCTIONAL OBJECTIVES

1. Students have to undergo one week practical training in Power Engineering related project at industry or a company so that they become aware of the practical application of theoretical concepts studied in the class rooms.

- Students have to undergo one week practical training in Power Engineering related project at industry or a company of their choice but with the approval of the department. At the end of the training student will submit a report as per the prescribed format to the department.

Assessment process
This is pass (P) / Fail (U) course and no grade point will be awarded. However this course is mandatory and the student has to pass the course to become eligible for the award of degree. The student shall make a presentation before a committee constituted by the department which will assess the student based on the report submitted and the presentation made and award either a P or U. The student with ‘U’ grade will redo the training.

<table>
<thead>
<tr>
<th>PS2049</th>
<th>PROJECT WORK PHASE I</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>6</td>
</tr>
</tbody>
</table>

INSTRUCTIONAL OBJECTIVES

1. To impart the practical knowledge to the students and also to make them to carry out the technical procedures in their project work. To provide an exposure to the students to refer, read and review the research articles, journals and conference proceedings relevant to their project work and placing this as their beginning stage for their final presentation.

- Every student has to identify the project supervisor (guide) based on their thrust area of research. He/She has to give the objectives of the project work and the detailed work plan. The project topic will be approved by the project evaluation committee. The committee will assess/review the work done by them by conducting periodical reviews. He/She has to submit a project report at the end of the semester. The grades will be awarded based on their performance in the internal reviews and the viva voce exam conducted at the end of the semester. The topic should be in the recent trends in the field of power system engineering.

•
### INSTRUCTIONAL OBJECTIVES

1. This enables and strengthens the students to carry out the project on their own and to implement their innovative ideas to forefront the risk issues and to retrieve the hazards by adopting suitable assessment methodologies and stating it to global.

- Usually the student has to continue the work carried out in Phase I. The student’s performance will be evaluated by conducting periodical reviews by the committee members nominated by the head of the department.
- The end semester examination/ viva voce will be conducted by the External/Internal Examiner nominated by the controller of examinations. Due weight age & considerations will be given in the internal marks for the project work presented in conferences/ Journals.
PROGRAM ELECTIVE COURSES

<table>
<thead>
<tr>
<th>COURSE CODE</th>
<th>COURSE TITLE</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
<th>CONTACT HOURS</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS2101</td>
<td>HIGH VOLTAGE DIRECT CURRENT TRANSMISSION SYSTEM</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>45</td>
</tr>
</tbody>
</table>

**PURPOSE**
To mould the students to acquire knowledge about HVDC Transmission systems.

**INSTRUCTIONAL OBJECTIVES**
1. This course gives idea about modern trends in HVDC Transmission and its application.
2. Complete analysis of harmonics and basis of protection for HVDC Systems.

**UNIT I - DC POWER TRANSMISSION TECHNOLOGY** (9 hours)
Introduction - Comparison of AC and DC transmission – Application of DC transmission – Classification of DC transmission system - Planning for HVDC transmission – Modern trends in DC transmission – DC breakers – Cables, VSC based HVDC. Comparison of Line Commutated Converter (LCC) link and Voltage Source Converter (VSC) link.

**UNIT II - ANALYSIS OF HVDC CONVERTERS AND HVDC SYSTEM CONTROL** (9 hours)

**UNIT III - MULTITERMINAL DC SYSTEMS AND HARMONICS** (9 hours)
Introduction – Potential applications of MTDC systems - Types of MTDC systems - Control and protection of MTDC systems - Study of MTDC systems- parallel operation of AC and DC transmission. Harmonics on AC and DC sides – filters.

**UNIT IV - POWER FLOW ANALYSIS IN AC/DC SYSTEMS** (9 hours)
Per unit system for DC Quantities - Modeling of DC links - Solution of DC load flow - Solution of AC-DC power flow - Case studies.
1.

UNIT V STABILITY ANALYSIS OF HVDC SYSTEMS  (9 hours)
Introduction – System simulation tools – Modeling of HVDC systems for
digital dynamic simulation – Dynamic interaction between DC and AC
systems.– inclusion of HVDC model in Small Signal Stability (SSS)
algorithm – inclusion of HVDC model in transient stability algorithm and
voltage stability analysis.

REFERENCES
   International (P) Ltd., New Delhi, 2002.
2. J.Arrillaga, “High Voltage Direct Current Transmission”, Peter
4. Erich Uhlmann, “Power Transmission by Direct Current”, BS
5. V.K.Sood, “HVDC and FACTS controllers – Applications of Static

<table>
<thead>
<tr>
<th>PS2102</th>
<th>POWER DISTRIBUTION SYSTEMS</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Contact Hours - 45</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

PURPOSE
To enable the student acquire a comprehensive idea on various aspects of
power distribution systems.

INSTRUCTIONAL OBJECTIVES
1. To give an overview of the function of an electrical power distribution
   in an electric power system.
2. To derive the tools for distribution analysis.
3. To have the wider knowledge on planning and design of a distribution
   infrastructure.

UNIT I - DISTRIBUTION SYSTEM PLANNING AND DESIGN  (9 hours)
Distribution system planning Short term planning, Long term planning,
dynamic planning, Sub-transmission and substation design. Sub-transmission
networks configurations, Substation bus schemes, Distribution substations
ratings, Service areas calculations, Substation application curves.
UNIT II - DISTRIBUTED GENERATIONS SYSTEMS  (9 hours)
Distributed Generation Standards, DG potential, Definitions and terminologies; current status and future trends, Technical and economical impacts of DG Technologies, DG from renewable energy sources, DG from non-renewable energy sources.

UNIT III - DISTRIBUTED GENERATION EVALUATION  
(9 hours)
Distributed generation applications, Operating Modes, Base load; peaking; peak shaving and emergency power, Isolated, momentary parallel and grid connection.

UNIT IV - DISTRIBUTION SYSTEM RELIABILITY ANALYSIS  
(9 hours)
Primary and secondary system design considerations Primary circuit configurations, Primary feeder loading, secondary networks design Economic design of secondary’s, Unbalance loads and voltage considerations.

UNIT V - DISTRIBUTION SYSTEM AUTOMATION AND CONTROL  
(9 hours)
Distribution system performance and operation Distribution automation and control, Voltage drop calculation for distribution networks, Power loss Calculation, Application of capacitors to distribution systems, Application of voltage regulators to distribution systems.

REFERENCES

**PURPOSE**
To enable the student understand the various types of power system transients and its impact on power system stability.

**INSTRUCTIONAL OBJECTIVES**
1. To understand the various types of transients and its analysis in power system.
2. To learn about the various protective devices against transients.

**UNIT I - REVIEW OF TRAVELLING WAVE PHENOMENA**
(9 hours)
Lumped and Distributed Parameters – Wave Equation – Reflection, Refraction, Behaviour of Travelling waves at the line terminations – Lattice Diagrams – Attenuation and Distortion.

**UNIT II - LIGHTNING, SWITCHING AND TEMPORARY OVERVOLTAGES**
(9 hours)
Lightning overvoltages: interaction between lightning and power system-ground wire voltage and voltage across insulator; switching overvoltage: Short line or kilometric fault, energizing transients - closing and re-closing of lines, methods of control; temporary overvoltages: line dropping, load rejection; voltage induced by fault; very fast transient overvoltage (VFTO).

**UNIT III - PARAMETERS AND MODELLING OF OVERHEAD LINES**
(9 hours)
Review of line parameters for simple configurations: series resistance, inductance and shunt capacitance; bundle conductors : equivalent GMR and equivalent radius; modal propagation in transmission lines: modes on multi-phase transposed transmission lines, α-β-0 transformation and symmetrical components transformation, modal impedances; analysis of modes on untransposed lines; effect of ground return and skin effect; transposition schemes.
UNIT IV - PARAMETERS OF UNDERGROUND CABLES

Distinguishing features of underground cables: technical features, electrical parameters, overhead lines versus underground cables; cable types; series impedance and shunt admittance of single-core self-contained cables, impedance and admittance matrices for three phase system formed by three single-core self-contained cables; approximate formulas for cable parameters.

UNIT V - COMPUTATION OF POWER SYSTEM TRANSIENTS - EMTP

Digital computation of line parameters: why line parameter evaluation programs? salient features of mtline; constructional features of that affect transmission line parameters; elimination of ground wires bundling of conductors; principle of digital computation of transients: features and capabilities of EMTP; steady state and time step solution modules: basic solution methods.

REFERENCES

PS2104  SMART GRID DESIGN AND ANALYSIS  L  T  P  C

| Total Contact Hours - 45 | 3 0 0 3 |

PURPOSE
To enable the students acquire knowledge on smart grid, different options of architectural design and communication technology for various aspects of smart grid, System analysis and stability analysis in smart grid, renewable energy sources and storage integration with smart grid.

INSTRUCTIONAL OBJECTIVES
1. To understand the concepts and design of Smart grid
2. To understand the various communication and measurement technologies in smart grid
3. To understand the analysis and stability of smart grid.
4. To learn the renewable energy resources and storages integrated with smart grid

UNIT I - SMART GRID ARCHITECTURAL DESIGNS  (9 hours)

UNIT II - SMART GRID COMMUNICATIONS AND MEASUREMENT TECHNOLOGY  (8 hours)

UNIT III - PERFORMANCE ANALYSIS TOOLS FOR SMART GRID DESIGN  (9 hours)

UNIT IV - STABILITY ANALYSIS TOOLS FOR SMART GRID  (10 hours)
UNIT V - RENEWABLE ENERGY AND STORAGE    (9 hours)
Renewable Energy Resources-Sustainable Energy Options for the Smart Grid-Penetration and Variability Issues Associated with Sustainable Energy Technology-Demand Response Issues-Electric Vehicles and Plug-in Hybrids-PHEV Technology-Environmental Implications-Storage Technologies-Grid integration issues of renewable energy sources.

REFERENCES


<table>
<thead>
<tr>
<th>PS2105</th>
<th>MODERN OPTIMIZATION TECHNIQUES IN POWER SYSTEMS</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Contact Hours - 45</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

PURPOSE
To learn the concepts and techniques of evolutionary and optimization techniques in power system applications.

INSTRUCTIONAL OBJECTIVES
1. To have knowledge on optimization techniques applied to power systems.
2. To understand the different evolutionary computation techniques and multi objective optimization and their applications in power systems.

UNIT I - FUNDAMENTALS OF OPTIMIZATION    (9 hours)
Definition-Classification of optimization problems-Unconstrained and Constrained optimization-Optimality conditions-Classical Optimization techniques (Linear and non linear programming, Quadratic programming, Mixed integer programming)-Intelligent Search methods (Optimization neural network, Evolutionary algorithms, Tabu search, Particle swarm optimization, Application of fuzzy set theory).
UNIT II - EVOLUTIONARY COMPUTATION TECHNIQUES  
(10 hours)

UNIT III - PARTICLE SWARM OPTIMIZATION  
(9 hours)
Fundamental principle-Velocity Updating-Advanced operators-Parameter selection- Hybrid approaches (Hybrid of GA and PSO, Hybrid of EP and PSO) -Binary, discrete and combinatorial PSO-Implementation issues- Convergence issues- PSO based OPF problem and unit commitment-PSO for reactive power and voltage control-PSO for power system reliability and security.

UNIT IV - ADVANCED OPTIMIZATION METHODS  
(8 hours)
Simulated annealing algorithm-Tabu search algorithm-SA and TS for unit commitment-Ant colony optimization- Bacteria Foraging optimization.

UNIT V - MULTI OBJECTIVE OPTIMIZATION  
(9 hours)
Concept of pareto optimality-Conventional approaches for MOOP-Multi objective GA-Fitness assignment-Sharing function-Economic Emission dispatch using MOGA-Multiobjective PSO (Dynamic neighbourhood PSO, Vector evaluated PSO) –Multiobjective OPF problem.

REFERENCES


<table>
<thead>
<tr>
<th>PS2106</th>
<th>POWER SYSTEM STATE ESTIMATION</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Contact Hours - 45</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

**PURPOSE**
To enable the students to impart knowledge on power system state estimation

**INSTRUCTIONAL OBJECTIVES**
1. To introduce the state estimation on DC network.
2. To impart in-depth knowledge on power system state estimation.
3. To study alternative formulations of WLS state estimation.
4. To get insight of network observability.
5. To gain knowledge on bad data deduction and identification.

**UNIT I - INTRODUCTION TO STATE ESTIMATION (9 hours)**

**UNIT II - WEIGHTED LEAST SQUARE ESTIMATION (9 hours)**

**UNIT III - ALTERNATIVE FORMULATION OF WLS STATE ESTIMATION (9 hours)**
Weakness of normal equation formulation, Orthogonal factorization, Hybrid method, Method of Peters and Wilkinsons, Equality constraints WLS State estimation, Augmented matrix approach, Blocked formulation and comparison of techniques.
UNIT IV - NETWORK OBSERVABILITY ANALYSIS  (9 hours)

UNIT V - BAD DATA DETECTION AND IDENTIFICATION  
(9 hours)
Properties of measurement residuals - Classification of measurements - Bad data detection and identification using Chi-squares distribution and normalized residuals - Bad data identification - Largest normalized residual test and Hypothesis testing identification. Role of PMU in bad data detection.

REFERENCES


<table>
<thead>
<tr>
<th>PS2107</th>
<th>ADVANCED POWER SYSTEM DYNAMICS</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>Total Contact Hours - 45</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PURPOSE
To enable the students to develop understand transient and voltage stability analysis of power system.

INSTRUCTIONAL OBJECTIVES
1. To perform transient stability analysis using unified algorithm.
2. To impart knowledge on sub-synchronous resonance and oscillations.
3. To analyze voltage stability problem in power system.
4. To familiarize the methods of transient stability enhancement.
UNIT I - TRANSIENT STABILITY ANALYSIS (9 hours)

UNIT II - SUBSYNCHRONOUS OSCILLATIONS (9 hours)

UNIT III - SUBSYNCHRONOUS RESONANCE (SSR) (9 hours)

UNIT IV - TRANSMISSION, GENERATION AND LOAD ASPECTS OF VOLTAGE STABILITY ANALYSIS (9 hours)

UNIT V - ENHANCEMENT OF TRANSIENT STABILITY AND COUNTER MEASURES FOR SUBSYNCHRONOUS RESONANCE (9 hours)
Principle behind transient stability enhancement methods: high-speed fault clearing, reduction of transmission system reactance, regulated shunt compensation, dynamic braking, reactor switching, independent pole-operation of circuit-breakers, single-pole switching, fast-valving, high-speed excitation systems; NGH damper scheme.

REFERENCES


<table>
<thead>
<tr>
<th>PS2108</th>
<th>WIND AND SOLAR ENERGY SYSTEMS</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Contact Hours - 45</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

PURPOSE
To impart knowledge on wind and solar energy in power systems

INSTRUCTIONAL OBJECTIVES
1. To educate the students scientifically the new developments in wind and solar energy systems.
2. To emphasize the significant influence of wind and solar energy in power system.

UNIT I - INTRODUCTION (9 hours)
Recent trends in energy consumption - World energy scenario - Energy sources and their availability - Qualitative study of different renewable energy resources: Solar, wind, ocean, Biomass, Fuel cell, Hydrogen energy systems and hybrid renewable energy systems - need to develop new energy technologies.

UNIT II - WIND ENERGY CONVERSION SYSTEMS (9 hours)
Basic principle of wind energy conversion - nature of wind - Wind survey in India - Power in the wind - components of a wind energy - conversion system - Performance of induction generators for WECS - classification of WECS - Analysis of different wind power generators - IG - PMSG - DFIG – SEIG.
UNIT III - GRID CONNECTED WIND ENERGY SYSTEMS  
(9 hours)  

UNIT IV - SOLAR ENERGY CONVERSION SYSTEMS  (9 hours)  
PV Applications: Stand alone inverters - Charge controllers - Water pumping, audio visual equipments, street lighting - analysis of PV systems.  

UNIT V - OPERATION OF POWER SYSTEM WITH WIND AND SOLAR ENERGY SYSTEMS  (9 hours)  

REFERENCES  
PS2109

<table>
<thead>
<tr>
<th>POWER QUALITY</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
<th>Total Contact Hours - 45</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

PURPOSE
To enable the students acquire knowledge on various power quality issues.

INSTRUCTIONAL OBJECTIVES
1. To understand the various power quality characterizations, sources of issues, their mitigation and monitoring.
2. To understand the effects of various power quality phenomena in various equipments.

UNIT I - POWER QUALITY - AN OVERVIEW (9 hours)

UNIT II - VOLTAGE VARIATIONS (9 hours)

UNIT III - POWER QUALITY ANALYSIS (9 hours)
UNIT IV - POWER QUALITY MONITORING (9 hours)
Monitoring considerations: Power line disturbance analyser, power quality measurement equipment, harmonic / spectrum analyser, flicker meters, disturbance analyser. Analysis of power outages, Analysis of unbalance: Symmetrical components of phasor quantities, Instantaneous symmetrical components, Instantaneous real and reactive powers, Analysis of distortion: On–line extraction of fundamental sequence components from measured samples.

UNIT V - POWER QUALITY ENHANCEMENT (9 hours)

REFERENCES

<table>
<thead>
<tr>
<th>PS2110</th>
<th>INDUSTRIAL POWER SYSTEM ANALYSIS AND DESIGN</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Contact Hours – 45</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

PURPOSE
To gain knowledge on various aspects of power system analysis and design in industries.

INSTRUCTIONAL OBJECTIVES
1. To impart knowledge on Motor Starting Studies.
2. To study about Power Factor Correction.
3. To analyze Harmonic, Flicker, Ground Grid Analysis problem in power system.
UNIT I - MOTOR STARTING STUDIES (9 hours)

UNIT II - POWER FACTOR CORRECTION STUDIES (9 hours)

UNIT III - HARMONIC ANALYSIS (9 hours)

UNIT IV - FLICKER ANALYSIS (9 hours)
Sources of Flicker-Flicker Analysis-Flicker Criteria-Data for Flicker analysis- Case Study-Arc Furnace Load-Minimizing the Flicker Effects-Summary.

UNIT V - GROUND GRID ANALYSIS (9 hours)

REFERENCES

PURPOSE
To enable the students to acquire a comprehensive idea on the various aspects of planning and reliability on power system.

INSTRUCTIONAL OBJECTIVES
1. To introduce the objectives of Load forecasting.
2. To study the fundamentals of Generation system, transmission system and Distribution system reliability analysis
3. To illustrate the basic concepts of Expansion planning

UNIT I - LOAD FORECASTING (9 hours)
Objectives of forecasting - Load growth patterns and their importance in planning - Load forecasting Based on discounted multiple regression technique-Weather sensitive load forecasting-Determination of annual forecasting-Use of AI in load forecasting.

UNIT II - GENERATION SYSTEM RELIABILITY ANALYSIS (9 hours)
Probabilistic generation and load models- Determination of LOLP and expected value of demand not served –Determination of reliability of ISO and interconnected generation systems.

UNIT III - TRANSMISSION SYSTEM RELIABILITY ANALYSIS (9 hours)
Deterministic contingency analysis-probabilistic load flow-Fuzzy load flow probabilistic transmission system reliability analysis-Determination of reliability indices like LOLP and expected value of demand not served.

UNIT IV - EXPANSION PLANNING (9 hours)
Basic concepts on expansion planning-procedure followed for integrate transmission system planning, current practice in India-Capacitor placer problem in transmission system and radial distributions system.

UNIT V - DISTRIBUTION SYSTEM PLANNING OVERVIEW (9 hours)
Introduction, sub transmission lines and distribution substations-Design primary and secondary systems-distribution system protection and coordination of protective devices.

REFERENCES


<table>
<thead>
<tr>
<th>PS2112</th>
<th>ENERGY MANAGEMENT AND AUDITING</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Contact Hours - 45</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

PURPOSE
To acquire an in depth knowledge about the energy management and auditing

INSTRUCTIONAL OBJECTIVES
1. To study the concepts behind economic analysis and load management.
2. To emphasize the energy management on various electrical equipments and metering.
3. To illustrate the concept of lighting systems and cogeneration.

UNIT I – INTRODUCTION (9 hours)
Need for energy management – energy basics – designing and starting an energy management program – energy accounting – energy monitoring, targeting and reporting- energy audit process.

UNIT II – ENERGY COST AND LOAD MANAGEMENT (9 hours)
Load management: demand control techniques – utility monitoring and control system-HVAC and energy management – economic justification.

UNIT III – ENERGY MANAGEMENT FOR MOTORS, SYSTEMS, AND ELECTRICAL EQUIPMENTS (9 hours)
Systems and equipment – electric motors – transformers and reactors – capacitors and synchronous machines.
UNIT IV – METERING FOR ENERGY MANAGEMENT  (9 hours)

UNIT V – LIGHTING SYSTEMS AND COGENERATION  (9 hours)

REFERENCES

<table>
<thead>
<tr>
<th>PS2113</th>
<th>DISTRIBUTED GENERATION AND MICROGRID</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Contact Hours – 45</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

PURPOSE
To provide knowledge on the various aspects of distributed generations and micro grids.

INSTRUCTIONAL OBJECTIVES
1. To illustrate the concept of distributed generation
2. To analyze the impact of grid integration.
3. To study concept of Microgrid and its configuration.
UNIT I – INTRODUCTION (9 hours)

UNIT II – DISTRIBUTED GENERATIONS (DG) (9 hours)

UNIT III – IMPACT OF GRID INTEGRATION (9 hours)
Requirements for grid interconnection, limits on operational parameters,: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.

UNIT IV- MICROGRIDS (10 hours)
Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids, communication infrastructure, modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques.

UNIT V- POWER QUALITY ISSUES IN MICROGRIDS (8 hours)

REFERENCES


<table>
<thead>
<tr>
<th>PS2114</th>
<th>DESIGN OF CONTROLLERS IN POWER APPLICATIONS</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Contact Hours – 45</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

**PURPOSE**
To provide knowledge on the various types of controllers in power applications.

**INSTRUCTIONAL OBJECTIVES**
1. To introduce the mathematical representation of controller components and solution techniques.
2. To impart in-depth knowledge on different methods of modern controllers.
3. To get insight of contingency analysis problem and the solution methods.
4. To gain knowledge on transient stability analysis and the associated solution techniques.

**UNIT I – CLASSICAL CONTROLLER DESIGN** (9 hours)

**UNIT II – SLIDING MODE CONTROL & VARIABLE STRUCTURE CONTROLLER** (9 hours)

**UNIT III – CURRENT CONTROLLER DESIGN** (9 hours)
Hysteresis current control (HCC) – Design of HCC with PWM schemes-Case Studies
Predictive current controller (PCC) –Model predictive control (MPC)-PWM predictive control (PPC).

UNIT IV – H-INFINITY CONTROL & ROBUST CONTROL THEORY (9 hours)
Robust Control Theory- Robust Controller Design- Robust decision methods- Analytic tools for robust decision making-Case Studies.

UNIT V – CONTROLLER DESIGN (9 hours)
Controller synthesis and tuning, Linear Matrix Inequalities, LMI solvers, control system analysis and design with LMIs using MATLAB/Simulink
Uncertain System Analysis -Statistical and worst-case analysis of stability and performance Analysis.
Survey and Review of different controller’s used in power system and power electronics practices.

REFERENCES

ANALYSIS OF ELECTRICAL MACHINES

<table>
<thead>
<tr>
<th>Purpose</th>
<th>To have a fair knowledge on various aspects of Electrical Machines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructional Objectives</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>To learn about the basic principles of Electromechanical energy conversion</td>
</tr>
<tr>
<td>2.</td>
<td>To impart in-depth knowledge on modelling of DC and AC machines</td>
</tr>
<tr>
<td>3.</td>
<td>To get insight of steady state and dynamic analysis of Electrical machines</td>
</tr>
</tbody>
</table>

**UNIT I - PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION**

9 hours

General expression of stored magnetic energy, co-energy and force/ torque – example using single and doubly excited system – Calculation of air gap mmf and per phase machine inductance using physical machine data.

**UNIT II - REFERENCE FRAME THEORY**

9 hours


**UNIT III - DC MACHINES**

9 hours

Voltage and torque equations – dynamic characteristics of permanent magnet and shunt DC motors – state equations - solution of dynamic characteristic by Laplace transformation.

**UNIT IV - INDUCTION MACHINES**

9 hours


**UNIT V - SYNCHRONOUS MACHINES**

9 hours

REFERENCES


<table>
<thead>
<tr>
<th>PS2116</th>
<th>SPECIAL MACHINES AND THEIR CONTROLLERS</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Contact Hours - 45</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

PURPOSE
To have a fair knowledge on various aspects of special machines and their controllers.

INSTRUCTIONAL OBJECTIVES

1. To know about the constructional features, principle of operation and mode of excitation of various special machines.

2. To acquire the knowledge of both open loop and closed loop control Torque- Speed Characteristics and Dynamic Characteristics of different Special Machines.

UNITI - SYNCHRONOUS RELUCTANCE MOTORS (9 hours)

UNITII - STEPPING MOTORS (9 hours)
Drive systems and circuit for open loop control & Closed loop control of stepping motor.

UNIT III - SWITCHED RELUCTANCE MOTORS (9 hours)

UNIT IV - PERMANENT MAGNET BRUSHLESS D.C. MOTOR (9 hours)
Difference between mechanical and electronic Commutators, Hall sensors, Optical sensors, Square - Wave permanent magnet brushless motor drives, torque and EMF equation, torque - speed characteristics of Permanent Magnet Brush less DC Motors - controllers PM DC Motor, applications.

UNIT V - PERMANENT MAGNET SYNCHRONOUS MOTOR (9 hours)

REFERENCES

PS2117
SYSTEM THEORY

Total Contact Hours - 45

PURPOSE
To impart students to have a fair knowledge about the use of advanced mathematical techniques in Control Engineering problems.

INSTRUCTIONAL OBJECTIVES
1. To gain knowledge about state variable representation models.
2. To understand reduction techniques and realization of transfer functions.
3. To get exposed to state space design and analysis of non-linear systems.

UNIT I - STATE SPACE ANALYSIS & CONTROLLABILITY, OBSERVABILITY (10 hours)
Introduction to state variable representation models of linear continuous time system solution of state equation by various methods. Diagonalization of matrices. Calculation of generalized eigen vectors. Reduction to canonical and Jordan’s canonical form. Gilberts and Kalman’s test for controllability and observability

UNIT II - TRANSFER FUNCTION AND STATE SPACE DESIGN (8 hours)
Impulse response and transfer function matrices. Properties of transfer functions, reducibility, Realization of transfer functions. State space design. Design by state feedback and pole placements.

UNIT III - NONLINEAR SYSTEMS (9 hours)

UNIT IV - STABILITY CONCEPTS (9 hours)
UNIT V - OPTIMAL CONTROL & ADAPTIVE CONTROL (9 hours)

REFERENCES

<table>
<thead>
<tr>
<th>PS2118</th>
<th>ARTIFICIAL NEURAL NETWORKS APPLIED TO POWER SYSTEMS</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Contact Hours - 45</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

PURPOSE
To enable the students to understand the concepts of artificial neural networks and its applications in power engineering.

INSTRUCTIONAL OBJECTIVES
1. To understand the fundamental concepts of ANN and different architectures and its learning methodologies.
2. To gain knowledge about different network architectures and its
applications in power systems and power electronics.

3. To learn the concepts of the various training/learning algorithms and its use.

UNIT I - INTRODUCTION (9 hours)

UNIT II - FEED FORWARD NEURAL NETS (9 hours)

UNIT III - STATISTICAL METHODS BASED NEURAL NETS (9 hours)

UNIT IV - COMPETITIVE NETWORKS (9 hours)
Kohonen’s self organizing maps[SOM]-learning vector quantization[LVQ] and its types- Adaptive resonance theory – ART 1, ART2- architecture, algorithms.

UNIT V - APPLICATIONS OF ANN (9 hours)

REFERENCES


<table>
<thead>
<tr>
<th>PS2119</th>
<th>DIGITAL SIGNAL PROCESSING</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total contact hours - 45</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

**PURPOSE**
To familiarize the students with the most important application oriented concepts of digital signal processing.

**INSTRUCTIONAL OBJECTIVES**
1. To understand basic concepts in signals and systems.
2. To gain knowledge on the related mathematical tools in signal processing.
3. To design and analyze digital filters for power applications.

**UNIT I - DISCRETE TIME SYSTEMS** (9 hours)

**UNIT II - FOURIER TRANSFORMS** (9 hours)

**UNIT III - SAMPLING** (9 hours)
Sampling of continuous signals – analog filter design – anti aliasing filters – Sample and hold circuits – Reconstructing fillers – Digital to analog and analog to digital converters.

**UNIT IV - FIR & IIR FILTER DESIGN** (9 hours)
Realization of FIR and IIR Filters – Impulse invariance and Bilinear transform methods of IIR filter design – Design of FIR filter using windows – Comparison of IIR and FIR Digital filters.

UNIT V - FINITE LENGTH WORD EFFECTS AND QUANITSATION
(9 hours)

REFERENCES


PS2120 INTELLIGENT CONTROLLERS

<table>
<thead>
<tr>
<th></th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

Total contact hours – 45

PURPOSE
To enable the students to apply the neural networks, Genetic algorithms & fuzzy logic concepts in power Systems and electronics systems.

INSTRUCTIONAL OBJECTIVES
1. To learn the basic knowledge regarding activation function, learning rules and various neural networks.
2. To understand the knowledge of crisp set, fuzzy set and Fuzzy logic controllers
3. To apply the Genetic algorithms in the tuning of controllers
4. To design controllers using Simulation Software fuzzy logic toolbox & NN tool box.

UNIT I - NEURAL NETWORKS
(9 hours)
Neural Networks – biological neurons – Artificial neurons – activation function – learning rules – feed forward networks – supervised &

UNIT II - ASSOCIATIVE MODELS AND CONTROL SCHEMES IN NN (9 hours)

UNIT III - FUZZY LOGIC AND ITS CONTROLLERS (9 hours)

UNIT IV - GENETIC ALGORITHMS (9 hours)

UNIT V - APPLICATIONS (9 hours)
Applications of Neural network, Fuzzy system & Genetic algorithms for power systems and power electronics systems-Designing of controllers using Simulation Software, NN tool box & Fuzzy Logic Toolbox.

REFERENCES

PROGRAM SUPPORTIVE COURSES

MA2008

APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS

<table>
<thead>
<tr>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

Total Contact Hours - 45

PURPOSE
To develop analytical capability and to impart knowledge in Advanced Matrix theory, Linear and Non linear programming, Calculus of variations and Random Processes and their applications in Engineering and Technology and to apply these concepts in Engineering problems they would come across.

INSTRUCTIONAL OBJECTIVES
1. To understand mathematical and statistical techniques.
2. To explain logically the concepts.
3. To apply the concepts in solving the engineering problems.

UNIT I - MATRICES (9 hours)

UNIT II - LINEAR PROGRAMMING (9 hours)
Linear programming - Graphical Method - Simplex method - Duality Theorems - Dual Simplex method - Integer programming.

UNIT III - BOUNDARY VALUE PROBLEMS (9 hours)
Solution of Initial and boundary value problems - Characteristics - D'Alembert's Solution - Significance of Characteristic curves - Laplace transform solutions for displacement in a long string - a long string under its weight - a bar with prescribed force on one end - free vibration of a string.

UNIT IV - CALCULUS OF VARIATIONS (9 hours)
Calculus of variations - Concepts of functionals - Euler's equation - Brachistochrone problem - Variational problems involving several unknown functions - Functionals involving two or more independent variables - Variational problems with moving boundaries - Isoperimetric problems.

UNIT V - PROBABILITY AND RANDOM PROCESSOR (9 hours)
Probability - Baye's Theorem for conditional probability - Random variables - Distribution function - Density function - Variance and covariance -
Stochastic process - Auto correlation - Auto covariance - Cross correlation and cross covariance - Stationary process - Auto correlation and cross correlation functions - Power spectrum.

REFERENCES


<table>
<thead>
<tr>
<th>PS2201</th>
<th>OBJECT ORIENTED PROGRAMMING</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Total Contact Hours - 45</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PURPOSE

This course gives a fundamental understanding of the Object Oriented concepts with the help of the programming language C ++.

INSTRUCTIONAL OBJECTIVES

1. To understand the basic concepts of Object Oriented programming.
2. To learn the C and C ++ language concepts and programming.
3. To study the detailed understanding of OOPS concepts like Inheritance and Polymorphism.
4. To learn advanced concepts like Templates and file I/O

UNIT I - OBJECT ORIENTED CONCEPTS (9 hours)


UNIT II - C++ CLASSES AND METHODS (9 hours)

UNIT III - INHERITANCE (9 hours)

UNIT IV - POLYMORPHISM (9 hours)

UNIT V - TEMPLATES AND STREAMS (9 hours)

REFERENCES

<table>
<thead>
<tr>
<th>PS2202</th>
<th>COMPUTER NETWORKS</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

Total Contact Hours - 45

PURPOSE
The purpose of this course is to make the students acquire fairly good knowledge on networking computers for reliable and secured operation and also to provide a wide-ranging introduction to modern computer networks and their applications.

INSTRUCTIONAL OBJECTIVES
1. To learn the functions of different layers.
2. To appreciate and understand state-of-the-art in network protocols, topologies and applications
3. To learn the principles of routing and the semantics and syntax of IP
4. To study about internetworking, transport and application layer
To learn network security aspects

UNIT I - INTRODUCTION AND PHYSICAL LAYER  (8 hours)
Evolution of data networks, Network architecture, ISO Reference model examples of networks, Application of networks, Physical layer, and communication medium characteristics.

UNIT II - DATA LINK LAYERS  (10 hours)
Local area networks, conventional channel allocation methods, pure-ALOHA, S-ALOHA, Collision free protocols, Limited contention protocols – IEEE 802 for LAN’s - Data link layer design issues – Service primitives – Stop and wait Sliding window protocols – Comparison of stop and wait and sliding window protocols.

UNIT III - NETWORK LAYERS  (9 hours)
Network layer design issues -Routing– Types of Routing algorithm- Congestion control algorithms –internetworking- IP protocol.

UNIT IV - TRANSPORT LAYER  (8 hours)

UNIT V - APPLICATION LAYER  (10 hours)

REFERENCES


**AMENDMENTS**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Details of Amendment</th>
<th>Effective from</th>
<th>Approval with date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>