# POWER SYSTEM OPERATION AND CONTROL

## General Course Information:

| | |
|---|---|
| Course Code: **PEC-EE417-T**<br>Course Credits: 4.0<br>Mode: Lecture (L)<br>Type: Program Elective<br>Teaching Schedule L T P: 3 1 0<br>Examination Duration: 3 hours | **Course Assessment Methods (Internal: 30; External: 70)** Two minor test each of 20 marks, class performance measured through percentage of lecture attended (4 marks), assignments, quiz etc. (6 marks) and end semester examination of 70 marks.<br><br>For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus; it will contain seven short answer type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the four units. All questions carry equal marks. |

## Course outcomes:

| **Sr. No.** | **Course outcomes**<br>At the end of the course students will be able to: | **RBT* Level** |
|---|---|---|
| CO1. | Explain the operation and control of all the major components of power systems | **L1(Remembering)** |
| CO2. | Understand the unit commitment problems and methods to solve the problems | **L2(Understanding)** |
| CO3. | Deploy frequency control, voltage control, active and reactive power control schemes on power system | **L3(Apply)** |
| CO4. | Compare various reactive power compensation schemes | **L4(Analysis)** |
| CO5. | Assess the best possible control for power system operation | **L5( Evaluating)** |
| CO6. | Develop generation dispatching, power system monitoring and control schemes for optimal operation and control | **L6(Creating)** |

***Revised Bloom's Taxonomy Action verbs/Levels**

## Course Content

### UNIT- I

**AUTOMATIC GENERATION CONTROL:** Introduction to AVR and ALFC loops, Modeling of turbine speed governing system, Generator Load model, load frequency control of an isolated area, its steady state performance and dynamic performance for first order approximate system, Load frequency Vs economic control, dead band, digital load flow control, decentralized control.

### UNIT-II

**EXCITATION & VOLTAGE CONTROL**: Role of Exciter and its control, Classification of Excitation System, Rotating self excited and pilot excited type Voltage regulators, static excitation system, brushless excitation system, boost buck excitation system and development of block diagram and transfer function for it, Role of PID Controller in Excitation system, Voltage control through shunt compensation; Series compensation; Tap changing transformer; Booster transformer; induction regulators,

## UNIT-III

**Power Systems Stability**: Definitions: angular stability- steady state stability, dynamic stability, transient stability, Dynamics of synchronous machine and swing equation, equal area criteria for various types of disturbances, critical clearing angle, solution of swing equation, technique of improving transient stability, Voltage stability, voltage stability concept for pure inductive load, Voltage collapse, voltage collapse proximate indicator.

## UNIT-IV

**ECONOMIC LOAD DISPATCH**: Generators operation cost, Economic dispatch problem, Economic Dispatch including transmission loss, derivation of transmission loss formula, Classification of hydro plants, Long range and short range problem, Short range fixed head hydrothermal scheduling.

## REFERENCES:


1. A. J. Wood, B. F. Wollenberg, "Power Generation Operation and Control", Wiley India, 2nd edition, 2009.
2. Nagrath Kothari, "Modern Power System", TMH Publication New Delhi.
3. S K Gupta, "Power Systems Operation Control and Restructuring", Ik International Publishing House.
4. Abhijit Chakrabarti & Sunita Halder, "Power System Analysis- Operation & Control", PHI NewDelhi, 3rd edition, 2010.
5. K Uma Rao, "Power System Operation & Control", Wiley India, 1st edition, 2013.
6. Robert H.Miller, James H.Malinowski, "Power System Operation", Tata McGraw-Hill, 2nd edition, 2009.
7. H. Saadat, "Power System Analysis", PSA Pub., 3rd edition, 2011.
8. A Chakrabarti, D. P. Kothari, A. K. Mukhopadhyay, Abhinandan De, "An introduction to Reactive Power Control and Voltage Stability in Power Transmission Systems", PHI, 2010

**Course Articulation Matrix:**

| Course/Course Code: Power System operation and Control (PEC-EE417-T), | | | | | | | | | | | | | | | Semester: VII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| CO1 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | - | 1 | - | 2 | 2 | 3 | 2 | 1 |
| CO2 | 3 | 3 | 1 | 1 | 2 | 1 | 1 | - | 1 | - | 2 | 2 | 3 | 2 | 1 |
| CO3 | 2 | 3 | 2 | 3 | 2 | 2 | 1 | - | 1 | - | 2 | 2 | 2 | 2 | 1 |
| CO4 | 2 | 3 | 2 | 2 | 2 | 1 | 1 | - | 1 | - | 2 | 2 | 2 | 2 | 1 |
| CO5 | 2 | 3 | 2 | 2 | 2 | 1 | 1 | - | 1 | - | 2 | 2 | 2 | 2 | 1 |
| CO6 | 3 | 3 | 3 | 2 | 3 | 1 | 1 | - | 1 | - | 2 | 2 | 2 | 2 | 2 |

**Correlation level:** **1**- slight /Low **2-** Moderate/ Medium **3**- Substantial/High

## MINOR PROJECT

| | |
|---|---|
| Course Code: **PROJ-EE419-P**<br>Course Credits : 4<br>Mode: Practical<br>Contact Hours: 8/week | **Course Assessment Method: (Internal: 30; External: 70)** |

**Course Outcomes:**

| **Sr. No.** | **Course Outcomes**<br>**At the end of the semester, students will be able:** | **RBT Level** |
|---|---|---|
| **CO 1** | Relate practical knowledge within the chosen area of technology for project development | L1 |
| **CO 2** | Understand methodologies and professional way of documentation and communication. | L2 |
| **CO 3** | Illustrate the key stages in development of the project. | L3 |
| **CO 4** | Identify, analyze, formulate and handle projects with a comprehensive and systematic approach | L4 |
| **CO 5** | Contribute as an individual or in a team in development of technical projects | L5 |
| **CO6** | Develop effective communication skills for presentation of project related activities | L6 |

**NOTE:** The minor project will be completed and evaluated at the end of the 7$^{th}$ semester on the basis of its implementation, presentation, viva-voce and report.

**Course Articulation Matrix:**

| Course/Course Code: Minor Project (PROJ-EE419-P), | | | | | | | | | | | | | Semester: VII | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** | **PO12** | **PSO1** | **PSO2** | **PSO3** |
| **CO1** | 3 | 3 | 2 | 2 | 2 | 3 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 2 | 2 |
| **CO2** | 3 | 3 | 2 | 2 | 2 | 3 | 2 | - | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 2 | 2 | 3 | 3 | 2 | - | 2 | 2 | 3 | 3 | 3 | 2 | 2 |
| **CO4** | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 2 | 3 |
| **CO6** | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 2 |

**Correlation level:** **1**- slight /Low **2-** Moderate/ Medium **3**- Substantial/High

# PRACTICAL TRAINING-II

| Course Code: **INT-EE421-P**<br>Course Credits : 1<br>Type: Program Core<br>Mode: Practical<br>Contact Hours: 2/week | **Course Assessment Method: (Internal:100)**<br>Assessment of Practical Training-II will be based on presentation/seminar, viva-voce, report and certificate for the practical training taken at the end of 6th semester. |
|---|---|

**Course Outcomes:**

| **Sr. No.** | **Course Outcomes**<br>**At the end of the semester, students will be able to:** | **RBT Level** |
|---|---|---|
| **CO 1** | Outline technical documents and give oral presentations related to the work completed. | L1 |
| **CO 2** | Prepared to engage in independent and lifelong learning in the industry. | L2 |
| **CO 3** | Acquire and apply fundamental principles of engineering for working in an actual working environment. | L3 |
| **CO 4** | Analyze practical application of the subjects taught during the program. | L4 |
| **CO 5** | Develop, social, cultural, global and environmental responsibilities as an engineer. | L5 |
| **CO6** | Design and implement solution methodologies with technical & managerial skills for solving engineering problems. | L6 |

**Course Articulation Matrix:**

| Course/Course Code: Practical Training-II (INT-EE421-P), | | | | | | | | | | | | | | Semester: VII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** | **PO12** | **PSO1** | **PSO2** | **PSO3** |
| **CO1** | 3 | 3 | 2 | 2 | 2 | 3 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 2 | 2 |
| **CO2** | 3 | 3 | 2 | 2 | 2 | 3 | 2 | - | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 2 | 2 | 3 | 3 | 2 | - | 2 | 2 | 3 | 3 | 3 | 2 | 2 |
| **CO4** | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 2 | 3 |
| **CO6** | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 2 |

**Correlation level:** **1**- slight /Low **2-** Moderate/ Medium **3**- Substantial/High

# COMPUTER METHODS IN POWER SYSTEMS

## General Course Information:

| | |
|---|---|
| Course Code: PCC-EE402-T<br>Course Credits: 4.0<br>Mode: Lecture (L) and Tutorial (T)<br>Type: Program Core<br>Teaching Schedule L T P: 3 1 0<br>Examination Duration: 3 hours | **Course Assessment Methods (Internal: 30; External: 70)** Two minor test each of 20 marks, class performance measured through percentage of lecture attended (4 marks), assignments, quiz etc. (6 marks) and end semester examination of 70 marks.<br><br>For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus; it will contain seven short answer type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the four units. All questions carry equal marks. |

## Course outcomes:

| Sr. No. | **Course outcomes**<br>At the end of the course students will be able to: | RBT* Level |
|---|---|---|
| CO1. | Memorize the formulation of various network matrices and model the power system components | **L1(Remembering)** |
| CO2. | Understand the importance of computer applications in electrical power system operation | **L2(Understanding)** |
| CO3. | Investigate the state of power system of any size by applying various computer methods under steady state and fault condition | **L3(Applying)** |
| CO4. | Perform load flow, short circuit and stability applicable in various power system problems | **L4(Analyzing)** |
| CO5. | Compare and identify the most appropriate algorithm for load flow, short circuit and stability studies | **L5(Evaluating)** |
| CO6. | Develop appropriate mathematical models of power systems for performance analysis, planning and control | **L6(Creating)** |

***Revised Bloom's Taxonomy Action verbs/Levels**

## Course Content

### UNIT- I

**Network Topology and Matrices:** Elementary Graph theory, Incidence matrices, Primitive network and primitive network matrices, Formation of various network matrices by singular transformations, Building algorithm for Bus Impedance matrix ($Z_{bus}$), Modification of bus impedance matrix for change of reference bus and network changes, formation of bus admittance matrix.

### UNIT- II

**Load-Flow Studies:** Introduction, Importance of load flow studies, Classification of buses, load-flow equations, Iterative methods, Computer algorithms and load flow solutions using Gauss-Seidel and Newton-Raphson methods, Decoupled and fast decoupled Load-flow solutions, Representation of regulating and off-nominal ratio transformers, Comparison of load-flow solution methods.

## UNIT- III

**Fault studies:** Symmetrical faults, Calculation of fault currents, Use of current limiting reactors, Unsymmetrical faults, Symmetrical components theory, Transformation matrix, Unsymmetrical short circuit analysis: LG, LL, LLG using matrix method,

## UNIT- IV

**Stability Studies:** Steady state and transient stability, swing equation, Steady state stability analysis, Transient stability analysis, Equal area criterion, Algorithms and flow charts for transient stability solution using Runge-Kutta and modified Euler methods, multi-machine stability analysis

**REFERENCES:**


1. G. W. Stagg and A. EI-Abiad, "Computer Methods in Power System Analysis", McGraw-Hill, 1986.
2. L.P Singh, "Advanced Power System Analysis and Dynamics", New Age International.
3. B. R. Gupta, "Power System Analysis and Design", S. Chand, 7th edition, 2014.
4. G. L. Kusic, "Computer-Aided Power Systems Analysis", PHI
5. J. J. Grainger and W. D. Stevenson, "Power System Analysis", McGraw-Hill, 2003.
6. D. P. Kothari, I. .J Nagrath, "Modern Power System Analysis", 3rd Edition, 2011.
7. H. Saadat, 'Power System Analysis ', Tata McGraw - Hill Education, 2nd Edition, 2002.
8. M.A. Pai, "Computer Techniques in Power System Analysis", Tata McGraw-Hill, Education2005.
9. K.U. Rao, "Computer Methods and Models in Power Systems", I.K. International, 2009.

**Course Articulation Matrix:**

| Course/Course Code: Computer Methods in Power Systems (PCC-EE402-T), | | | | | | | | | | | | | | Semester: VIII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| CO1 | 2 | 2 | 3 | 1 | 2 | 2 | - | - | 2 | - | 1 | 1 | 3 | 2 | 1 |
| CO2 | 3 | 2 | 2 | 1 | 2 | 2 | - | - | 1 | - | 1 | 1 | 3 | 3 | 1 |
| CO3 | 3 | 2 | 2 | 2 | 3 | 2 | - | - | 1 | - | 1 | 1 | 3 | 2 | 1 |
| CO4 | 3 | 3 | 2 | 2 | 3 | 2 | - | - | 1 | - | 1 | 1 | 3 | 3 | 1 |
| CO5 | 3 | 3 | 2 | 3 | 3 | 2 | - | - | 1 | - | 2 | 1 | 3 | 3 | 2 |
| CO6 | 3 | 3 | 3 | 2 | 3 | 3 | - | - | 1 | - | 2 | 1 | 3 | 3 | 2 |

**Correlation level:** **1**- slight /Low **2-** Moderate/ Medium **3**- Substantial/High

# COMPUTER METHODS IN POWER SYSTEMS LABORATORY

## General Course Information:

| | |
|---|---|
| Course Code: **PCC-EE402-P**<br>Course Credits: 1<br>Mode: Practical<br>Type: Program Core<br>Contact Hours: 2 hours per week.<br>Examination Duration: 03 hours. | **Course Assessment Methods (Internal: 30; External: 70)** Internal continuous assessment of 30 marks on the basis of class performance and attendance in practical classes.<br><br>For the end semester practical examination the assessment will be done out of 70 marks by the external and internal examiners. |

## Course Outcomes:

| **Sr. No** | **Course outcomes**<br>At the end of the course students will be able to: | **RBT* Level** |
|---|---|---|
| CO1. | Learn the applications and working of software tools for electrical power system analysis | **L2 (Understanding)** |
| CO2. | Calculate the state of power system of any size by applying various computer methods under steady state and fault condition | **L3 (Apply)** |
| CO3. | Analyze the impact of changes in power system parameters on the state and stability of the system | **L4 ( Analyzing)** |
| CO4. | Acquire the skill of implementing the various methods and create Software tools for analysis of real time power systems | **L6 (Creating)** |

## LIST OF EXPERIMENTS:

The following experiments may be performed with the help of MATLAB based power system analysis tools PSAT, PST, PSCAD, ETAP etc.

1. Formation of $Y_{bus}$ matrix by inspection / analytical method
2. Formation of $Z_{bus}$ using building algorithm
3. Load flow analysis using Gauss Seidal method
4. Load flow analysis using Newton Raphson method
5. Load flow analysis using Fast decoupled method
6. Simulation of single line to ground fault
7. Simulation of single line to Line fault
8. Simulation of double line to ground fault
9. Simulation of Three Phase Short Circuit fault
10. Transient stability simulation for single machine and multi-machine system.

**NOTE:** At least eight experiments are to be performed in the semester, out of which at-least six experiments should be performed from above list. Remaining experiments may either be performed from the above list or designed & set as per the scope of the syllabus.

## MAJOR PROJECT

| | |
|---|---|
| Course Code: **PROJ-EE420-P**<br>Course Credits : 6<br>Mode: Practical<br>Contact Hours: 12/week | **Course Assessment Method: (Internal: 30; External: 70)** |

**Course Outcomes:**

| **Sr. No.** | **Course Outcomes**<br>**At the end of the semester, students will be able:** | **RBT Level** |
|---|---|---|
| **CO 1** | Extend or use the idea in minor project for major project. | L1 |
| **CO 2** | Describe a through and systematic understanding of project contents | L2 |
| **CO 3** | Use effectively oral, written and visual communication | L3 |
| **CO 4** | Identify, analyze, and solve problems creatively through sustained critical investigation. | L4 |
| **CO 5** | Demonstrate an awareness and application of appropriate personal, societal, and professional ethical standards. | L5 |
| **CO6** | Know the key stages in development of the project. | L6 |

**NOTE:** The major project will be completed and evaluated at the end of the 8$^{th}$ semester on the basis of its implementation, presentation, viva-voce and report.

**Course Articulation Matrix:**

| Course/Course Code: Major Project (PROJ-EE420-P), | | | | | | | | | | | | Semester: VIII | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** | **PO12** | **PSO1** | **PSO2** | **PSO3** |
| **CO1** | 3 | 3 | 2 | 2 | 2 | 3 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 2 | 2 |
| **CO2** | 3 | 3 | 2 | 2 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 2 | 2 | 3 | 3 | 2 | - | 2 | 2 | 3 | 3 | 3 | 2 | 2 |
| **CO4** | 3 | 3 | 3 | 3 | 2 | 3 | 1 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 3 | 2 | 3 | 3 | 3 | 2 | 3 |
| **CO6** | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 |

**Correlation level:** **1**- slight /Low **2-** Moderate/ Medium **3**- Substantial/High

# RENEWABLE ENERGY RERSOURCES

## General Course Information:

| | |
|---|---|
| Course Code: PEC-EE308-T<br>Course Credits: 3<br>Mode: Lecture (L)<br>Type: Compulsory<br>Teaching Schedule L T P: 3 0 0<br>Examination Duration: 03 hours. | **Course Assessment Methods (Internal: 30; External: 70)** Two minor test each of 20 marks, class performance measured through percentage of lecture attended (4 marks), assignments and quiz etc. (6 marks) and end semester examination of 70 marks.<br><br>For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answer type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the four units. All questions carry equal marks. |

## Course outcomes:

| **Sr. No.** | **Course outcomes**<br>At the end of the course students will be able to: | **RBT* Level** |
|---|---|---|
| CO1. | List and describe the various conventional and renewable energy resources and technologies | **L1 (Remembering)** |
| CO2. | Recognize the impact of renewable energy utilization on society and environment | **L2 (Understanding)** |
| CO3. | Interpret and apply the concepts of renewable energy sources for electricity generation and grid integration | **L3 (Applying)** |
| CO4. | Make comparisons among renewable energy resources and technologies | **L4(Analyzing)** |
| CO5. | Assess and select the options among renewable energy resources and technologies | **L5 (Evaluating)** |
| CO6. | Do the basic design of various renewable energy systems for different requirements | **L6 (Creating)** |

***Revised Bloom's Taxonomy Action verbs/Levels**

## Course Content

## UNIT-I

**Introduction:** Over view of conventional & renewable energy sources, Limitations of conventional energy sources, need & development of alternate energy sources, basic schemes and applications of direct energy conversion types of renewable energy systems, Future of Energy Use, Global and Indian Energy scenario, Potential of renewable energy sources, renewable electricity and key elements, Global climate change, $CO_2$ reduction potential of renewable energy, concept of Hybrid systems. ENERGY STORAGE: Sizing and Necessity of Energy Storage.

## UNIT-II

**Solar and Wind Energy**:

Solar radiation spectra, solar geometry, Earth Sun angles, observer Sun angles, solar day length, Estimation of solar energy availability, Photovoltaic effect, characteristics of photovoltaic cells, conversion efficiency, solar batteries and applications, Design of standalone PV system, Solar energy in India, solar collectors, solar furnaces & applications, Design of solar water heater,

History of wind power, wind generators, theory of wind power, wind speed statistics-probability distributions, wind speed and power- cumulative distribution functions characteristics of suitable wind power sites, scope in India, advantages and limitations.

## UNIT-III

**Thermo-electric and MHD Generators:** Seeback effect, Peltier effect, Thomson effect, Thermo-electric convertors, Brief description of the construction of thermoelectric generators, Applications and economic aspects.

Hall Effect, Basic principles of MHD generator, Different types of MHD generators, Conversion effectiveness, Practical MHD generators, Applications and economic aspects.

## UNIT-IV

**Fuel Cells and Miscellaneous Sources**: Principle of action, Gibbs free energy, general description of fuel cells, types, construction, operational characteristics and applications, Geo-thermal system, characteristics of geothermal resources, Low head hydro-plants, Network Integration Issues: Overview of grid code technical requirements, Power system interconnection experiences in the world

**REFERENCES:**


1. G.D. Rai, Non-Conventional sources of Energy, Khanna Publishers, 2009
2. R.A. Coobe, An Introduction to Direct Energy Conservation, Pitman, 1968
3. M. A. Kettani, Direct Energy Conversion, Addison-Wesley Educational Publishers Inc, 1970
4. Robert L. Loftness, Energy Hand book, Van Nostrand Reinhold, 1984
5. D. M. Considine, Energy Technology Hand Book, McGraw-Hill; 1977
6. S. S. Rao, B. B. Parulekar, Energy Technology, Khanna Publishers, 1994
7. A. Ter-Gazarian, Energy storage for Power system, Peter Peregrinus Ltd, 1994
8. G. N. Tiwari and M. K. Ghosal, “Renewable Energy Applications”, Narosa Publications, 2004
9. S. A. Abbasi. and N. Abbasi, Renewable Energy Sources and Their Environmental Impact, Prentice Hall of India, 2001
10. G. S. Sawhney, Non-Conventional Energy Resources, PHI Learning, 2012
11. B. H Khan., Non-Conventional Energy Resources, Tata McGraw Hill, 2009

| Course/Course Code: Renewable energy Resources (PEC-EE308-T), | | | | | | | | | | | | | | Semester: VI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| CO1 | 2 | - | 2 | - | - | 2 | 3 | - | - | - | -[ | 2 | 1 | 2 | 1 |
| CO2 | - | - | 2 | - | | 3 | 3 | - | - | - | - | 2 | 1 | 1 | 1 |
| CO3 | 2 | - | 2 | - | 1 | 2 | 3 | - | - | - | 1 | 1 | 2 | 2 | 1 |
| CO4 | 2 | - | 2 | 1 | 1 | 2 | 3 | - | - | - | 2 | 1 | 2 | 2 | 2 |
| CO5 | 1 | - | 2 | 1 | 2 | 3 | 3 | - | - | - | 2 | 1 | 1 | 3 | 2 |
| CO6 | 1 | - | 3 | 1 | 2 | 2 | 3 | - | - | - | 1 | 1 | 1 | 2 | 3 |

**Course Articulation Matrix:**

**Correlation level:** **1**- slight /Low **2-** Moderate/ Medium **3**- Substantial/High

# NETWORK SYNTHESIS AND FILTER

## General Course Information:

| | |
|---|---|
| Course Code: PEC-EE310-T<br>Course Credits: 3.0<br>Mode: Lecture (L)<br>Type: Program Elective<br>Teaching Schedule L T P: 3 0 0<br>Examination Duration: 3 hours | **Course Assessment Methods (Internal: 30; External: 70)** Two minor test each of 20 marks, class performance measured through percentage of lecture attended (4 marks), assignments, quiz etc. (6 marks) and end semester examination of 70 marks.<br><br>For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus; it will contain seven short answer type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the four units. All questions carry equal marks. |

## Course outcomes:

| Sr. No. | **Course outcomes**<br>At the end of the course students will be able to: | RBT* Level |
|---|---|---|
| CO1. | Recall the knowledge about the reliability of network functions | **L1(Remembering)** |
| CO2. | Convert the mathematical driving point or transfer relations into realizable electrical circuits | **L2(Understanding)** |
| CO3. | Solve the numerical problem for system stability checking stability of the network function. | **L3(Apply)** |
| CO4. | Compare the different type of electrical components and materials. | **L4(Analysis)** |
| CO5. | To select the electrical circuit and filters in the field of engineering application. | **L5( Evaluating)** |
| CO6. | Convert the mathematical expression in the design form. | **L6(Creating)** |

***Revised Bloom's Taxonomy Action verbs/Levels**

## Course Content

### UNIT- I

Fundamental Concepts: Energy considerations, positive real condition, Hurwitz polynomials, Bounded realness, scattering description of networks.

### UNIT-II

Lossless one port network functions, Foster reactance functions and theorem, canonical forms: Cauer's and Foster's, Synthesis of lossless LC Immitance functions, Synthesis of lossy RL and RC functions, Certain RLC function realizations. Fundamentals of two port network synthesis.

### UNIT-III

Passive Filter Design: Analysis and Design of Constant K and m-derived filters, Active Filter Design: Amplitude and phase functions, amplitude approximations, phase approximations, simultaneous amplitude and phase approximations, Group delay response and equidistant linear phase approximations.

**UNIT-IV**

Maximally flat and Equi-ripple filters, Magnitude and frequency normalizations, frequency transformations; high Pass, Band-Pass, Band-stop filters, Impedance matching networks, Phase shift networks.

**REFERENCES:**


1. M.E. Vanvalkenburg, "Network Analysis", PHI, 3rd Edition, 2014.
2. H. Baher, "Synthesis of Electrical Networks", John Wiley & Sons, 1984.
3. S. P. Ghosh, A.K. Chakraborthy, "Network Analysis and Synthesis" McGraw Hill, 2010
4. Franklin Kuo, "Network Analysis and Synthesis", Second Edition, Wiley, 2009.
5. D. Roy Choudhury, "Networks and Systems", New Age International Publications, 1988.
6. W. H. Hayt and J. E. Kemmerly, "Engineering Circuit Analysis", 9th Edition, McGraw Hill Education, 2018.

**Course Articulation Matrix:**

| Course/Course Code: Network Synthesis And Filter(PEC-EE310-T), | | | | | | | | | | | | | | Semester: VI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | - | - | - | 1 | 2 | 3 | 3 | 1 |
| CO2 | 3 | 2 | 3 | 2 | 2 | 3 | 1 | - | - | - | 1 | 1 | 2 | 3 | 1 |
| CO3 | 3 | 3 | 3 | 2 | 1 | 1 | 1 | - | - | - | 1 | 2 | 2 | 2 | 1 |
| CO4 | 3 | 2 | 3 | 1 | 3 | 2 | 2 | - | - | - | 2 | 1 | 3 | 2 | 1 |
| CO5 | 2 | 3 | 2 | 2 | 1 | 2 | 2 | - | - | - | 2 | 1 | 2 | 3 | - |
| CO6 | 1 | 2 | 3 | 2 | 2 | 1 | 2 | - | - | - | 2 | 1 | 2 | 3 | 1 |

**Correlation level:** **1-** slight /Low **2-** Moderate/ Medium **3-** Substantial/High

# DIGITAL SIGNAL PROCESSING

## General Course Information:

| | |
|---|---|
| Course Code: PEC-EE312-T<br>Course Credits: 3<br>Mode: Lecture (L)<br>Type: Compulsory<br>Teaching Schedule L T P: 3 0 0<br>Examination Duration: 03 hours. | **Course Assessment Methods (Internal: 30; External: 70)** Two minor test each of 20 marks, class performance measured through percentage of lecture attended (4 marks), assignments and quiz etc. (6 marks) and end semester examination of 70 marks.<br><br>For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answer type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the four units. All questions carry equal marks. |

## Course outcomes:

| **Sr. No.** | **Course outcomes**<br>At the end of the course students will be able to: | **RBT* Level** |
|---|---|---|
| CO1. | Understand the concept and advantages of digital signal processing. | **L1 (Remembering)** |
| CO2. | Summarize differences between time domain and frequency domain analysis tools. | **L2 (Understanding)** |
| CO3. | Apply DFT and FFT tools to determine the spectral components of a discrete time signal. | **L3 (Applying)** |
| CO4. | Examine the realization of digital filters using different realization structures. | **L4(Analyzing)** |
| CO5. | Design and implement Finite Impulse Response (FIR) and Infinite Impulse Response (IIR) digital filters for processing of discrete time signals. | **L6 (Creating)** |

***Revised Bloom's Taxonomy Action verbs/Levels**

## Course Content

## UNIT-I

**Discrete Fourier Transform (DFT):** Frequency Domain Sampling and Reconstruction of Discrete-Time signals, Discrete Fourier Transform, DFT as a Linear Transformation, Properties of DFT, Linear filtering methods based on DFT: use of DFT in linear filtering, Filtering of long data Sequences.

**Fast Fourier Transform (FFT):** Fast Fourier Transform Algorithms, Radix-2 and Radix-4 FFT Algorithms, Applications of FFT Algorithms: Efficient Computation of the DFT of Two Real Sequences, Efficient Computation of the DFT of a 2N-Point Real Sequence, use of FFT in Linear filtering and correlation.

## UNIT-II

**Structures for FIR Systems:** Direct Form Structures, Cascade Form Structures, Frequency Sampling Structures, Lattice Structure.

**Structures for IIR Systems:** Direct Form Structures, Signal Flow graphs & Transposed Structures, Cascade Form Structures, Parallel Form Structures; Lattice & Lattice-Ladder Structures for IIR Systems.

## UNIT-III

**FIR & IIR Filter Design:** FIR and IIR filters properties, Design of FIR filters: importance of Linear Phase response, Design of linear phase FIR filters using Windows, Desirable Window function properties for FIR filter design, Frequency Sampling method for Linear Phase FIR Filter Design. Design steps for IIR Filter design, Design of IIR low pass analog filters: Butterworth, Chebyshew, Elliptic; Conversion of analog system to digital system by: Approximation of Derivatives, Impulse Invariance, Bilinear Transformation, Frequency Transformations.

## UNIT-IV

**Multirate Digital Signal Processing:** Introduction to Multirate digital signal processing, interpolation and decimation, sampling rate conversion by rational factor, filter design and implementation for sampling rate conversion, multistage decimator and interpolators, Applications of Multirate Signal Processing.

**REFERENCES:**


1. J. G. Proakis, D. G. Manolakis, "Digital Signal Processing, Principles, Algorithms, & Applications", Prentice –Hall India.
2. T.K. Rawat, "Digital Signal Processing" Oxford University Press.
3. S. Mitra, "Digital Signal Processing- A computer based approach" TMH.
4. L. R. Rabiner & B. Gold, "Theory and Application of Digital Signal Processing", Prentice Hall India.
5. A. V. Oppenheim, R. W. Schafer, J. R. Buck, "Discrete-Time Signal Processing", Prentice Hall India.
6. A. V. Oppenheim, R. W. Schafer, "Digital Signal Processing", Prentice Hall India.
7. Salivahanan, Vallavaraj and Gnanapriya, "Digital Signal Processing", TMH.

**Course Articulation Matrix:**

| Course/Course Code: Digital Signal Processing(PEC-EE312-T), | | | | | | | | | | | | | Semester: VI | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| CO1 | 2 | 2 | 1 | 1 | 1 | 1 | - | - | 1 | 2 | 1 | 1 | 3 | 2 | 1 |
| CO2 | 2 | 2 | 2 | 1 | 1 | - | - | - | 1 | 2 | 1 | 1 | 3 | 2 | 1 |
| CO3 | 3 | 3 | 2 | 1 | 3 | - | - | - | 1 | - | 1 | 1 | 3 | 3 | 2 |
| CO4 | 3 | 3 | 2 | 1 | 3 | - | - | - | 1 | - | 1 | 1 | 3 | 3 | 2 |
| CO5 | 3 | 3 | 3 | 2 | 3 | 1 | 1 | 1 | 1 | 3 | 3 | 2 | 2 | 3 | 3 |

**Correlation level:** **1-** slight /Low **2-** Moderate/ Medium **3-** Substantial/High

# MODELLING AND SIMULATION

## General Course Information:

| | |
|---|---|
| Course Code: PEC-EE314-T<br>Course Credits: 3.0<br>Mode: Lecture (L) and Tutorial (T)<br>Type: Program Core<br>Teaching Schedule L T P: 3 0 0<br>Examination Duration: 3 hours | **Course Assessment Methods (Internal: 30; External: 70)** Two minor test each of 20 marks, class performance measured through percentage of lecture attended (4 marks), assignments, quiz etc. (6 marks) and end semester examination of 70 marks.<br><br>For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus; it will contain seven short answer type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the four units. All questions carry equal marks. |

## Course Outcomes

| Sr. No. | **Course outcomes**<br>At the end of the course students will be able to: | RBT* Level |
|---|---|---|
| CO1. | Recall the mathematical formulation. | **L1(Remembering)** |
| CO2. | Illustrate the complexity of real life problems with stochastic modeling | **L2(Understanding)** |
| CO3. | Solve the real life problems with comprehensive solution. | **L3(Apply)** |
| CO4. | Compare the performance of different frameworks. | **H1(Analysis)** |
| CO5. | Judge and utilize the simulation model on the basis of their performance. | **H2 (Evaluating)** |
| CO6. | Formulate the solution of different problems in the field of research and development. | **H3 (Creating)** |

***Revised Bloom's Taxonomy Action verbs/Level**

## Course Content

### UNIT-I

Review of Probability and Random Number generation, Generating continuous and discrete time random variables, Discussions on deterministic and stochastic modeling of engineering systems, Need for stochastic models, Ideas of model validation.

### UNIT-II

Modeling of systems as discrete event systems (DES), Continuous time and discrete time Markov chains, Properties of DES (observability and controllability), Supervisory control of DES, Queuing models.

### UNIT-III

Heuristic modeling, Neural, Fuzzy and Neuro-Fuzzy modeling and simulation of dynamical systems, Modeling of time delays and introduction to networked dynamical systems.

### UNIT-IV

Dynamical system simulation, Monte Carlo simulations, generation of simulation data and its statistical analysis, Statistical validation techniques, Goodness of fit test $\chi 2$, and others, Agent based simulation, Numerical issues in simulation of dynamical systems.

**REFERENCES:**

1. Sheldom Ross, “Simulation”, Academic Press, Elsevier Imprint, 2006.
2. Sankar Sen Gupta. “System Simulation and Modeling”, Pearson Education, 2013.
3. J. Banks, J. S. Carson, B. Nelson and D. M. Nicol, “Discrete Event system simulation”, Pearson Education, 5th Edition, 2014.
4. J. R. Jang and C. Sun, “Neuro-Fuzzy Modeling and Control”, Proceedings of IEEE, Vol. 83, No. 3, March 1995.


**Course Articulation Matrix:**

| Course/Course Code: Modeling and Simulation (PEC-EE314-T) | | | | | | | | | | | | | | | Semester: VI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| CO1 | 3 | 2 | 2 | 2 | 2 | - | - | - | 1 | - | 1 | 1 | 3 | 2 | 1 |
| CO2 | 2 | 2 | 2 | 2 | 2 | 2 | - | - | - | 1 | 1 | 1 | 3 | 2 | - |
| CO3 | 2 | 2 | 2 | 2 | 2 | 2 | - | - | - | 1 | 2 | 2 | 3 | 1 | - |
| CO4 | 2 | 3 | 3 | 3 | 2 | 1 | - | - | - | 1 | 2 | 2 | 3 | 2 | - |
| CO5 | 2 | 2 | 2 | 2 | 2 | 1 | - | - | - | 1 | 2 | 2 | 3 | 2 | - |
| CO6 | 2 | 2 | 3 | 2 | 3 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 2 | 1 |

**Correlation level:** **1-** slight /Low **2-** Moderate/ Medium **3-** Substantial/High

# Electrical Machine Design

**General Course Information:**

| | |
|---|---|
| Course Code: PEC-EE403-T<br>Course Credits: 3.0<br>Mode: Lecture (L) and Tutorial (T)<br>Type: Program Core<br>Teaching Schedule L T P: 3 0 0<br>Examination Duration: 3 hours | **Course Assessment Methods (Internal: 30; External: 70)** Two minor test each of 20 marks, class performance measured through percentage of lecture attended (4 marks), assignments, quiz etc. (6 marks) and end semester examination of 70 marks.<br>For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus; it will contain seven short answer type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the four units. All questions carry equal marks. |

**Course Outcomes**

| Sr. No. | **Course outcomes**<br>At the end of the course students will be able to: | **RBT* Level** |
|---|---|---|
| CO1. | Recall the basics of electric machines | **L1(Remembering)** |
| CO2. | Understand the performance of different types of electric machines. | **L2(Understanding)** |
| CO3. | Solve the problems related with electric machines. | **L3(Apply)** |
| CO4. | Compare the performance characteristics of electric machines. | **H1(Analysis)** |
| CO5. | Judge and use the machines on the basis of their utilization and performance. | **H2 (Evaluating)** |

***Revised Bloom's Taxonomy Action verbs/Level**

## Course Content

### UNIT-I

**INTRODUCTION TO DC MACHINES:** Major considerations in Electrical Machine Design, Electrical Engineering Materials, Space factor, Choice of Specific Electrical and Magnetic loading, Thermal considerations, Heat flow, Temperature rise, Rating of machines, Standard specifications.
DC machines, Output Equations, Design of main dimensions, Magnetic circuit calculations, Carter's Coefficient, Net length of Iron, Real and Apparent flux densities, Selection of number of poles, Design of Armature, Design of commutator and brushes.

### UNIT-II

**TRANSFORMERS:** Output Equations, Main Dimensions, kVA output for single and three-phase transformers, Window space factor, Overall dimensions, Operating characteristics, Regulation, No load current, Temperature rise in Transformers, Design of Tank, Methods of cooling of Transformers

### UNIT-III

**INDUCTION MOTOR:** Output equation of Induction motor, Design of main dimensions, Length of air gap, Rules for selecting rotor slots of squirrel-cage machines, Design of rotor bars and slots, Design of end rings.
**SYNCHRONOUS MACHINES:** Pole construction, run away speed, output equation, choice of specific loading, Short circuit ratio, shape of pole face, Armature design, Armature parameters, Estimation of air gap length, Design of field system.

## UNIT-IV

**COMPUTER AIDED DESIGN:** Introduction, manual versus Computer aided design, Approach to Computer aided design, Design synthesis, Special Requirements, Program for Different machines, Computer aided design in industry, Illustrative design, limitations in Computer aided designs.

**REFERENCES:**


1. A. K. Sawhney, "A Course in Electrical Machine Design", Dhanpat Rai & Sons, New Delhi, 2013
2. M.V. Deshpande, "Design and Testing of Electrical Machines", PHI learning Pvt Ltd, 2015.
3. G. Veinot Cyril, "Computer Aided Design of Electrical Machinery", MIT press London, UK.
4. H.M. Rai, "Electrical Machine Design", Sathiya Prakashan Publications, Third edition, 2004.
5. A.Shanmugasundaram, G.Gangadharan, R.Palani, "Electrical Machine Design Data Book", New Age Intenational Pvt. Ltd., Reprint 2007.

**Course Articulation Matrix:**

| Course/Course Code: Electrical Machine Design (PEC-EE403-T) | | | | | | | | | | | | Semester: VII | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| CO1 | 3 | 2 | 1 | 2 | - | - | - | - | - | - | - | 2 | 1 | 1 | 1 |
| CO2 | 3 | 2 | 1 | 2 | 2 | 1 | - | - | - | - | - | 1 | 2 | 2 | 1 |
| CO3 | 3 | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | 1 | 3 | 3 | 1 |
| CO4 | 3 | 2 | 2 | 2 | 1 | - | - | - | 1 | - | 1 | 2 | 2 | 3 | 1 |
| CO5 | 3 | 2 | 2 | 1 | - | 1 | - | 2 | - | 2 | 3 | 2 | 2 | 2 | 2 |

**Correlation level:** **1-** slight /Low **2-** Moderate/ Medium **3-** Substantial/High

# ADVANCE POWER ELECTRONICS

## General Course Information:

| | |
|---|---|
| Course Code: PEC-EE405-T<br>Course Credits: 3.0<br>Mode: Lecture (L)<br>Type: Program Elective<br>Teaching Schedule L T P: 3 0 0<br>Examination Duration: 3 hours | **Course Assessment Methods (Internal: 30; External: 70)** Two minor test each of 20 marks, class performance measured through percentage of lecture attended (4 marks), assignments, quiz etc. (6 marks) and end semester examination of 70 marks.<br><br>For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus; it will contain seven short answer type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the four units. All questions carry equal marks. |

## Course outcomes:

| Sr. No. | **Course outcomes**<br>At the end of the course students will be able to: | RBT* Level |
|---|---|---|
| CO1. | Reproduce technical and intellectual capability in Power Electronics & Power System and to develop interest for life-long learning. | **L1(Remembering)** |
| CO2. | Identify the drawbacks of speed control of motor by conventional methods. | **L2(Understanding)** |
| CO3. | Solve problems satisfactorily in the field of Power Electronics and Power System and arrive at appropriate solution. | **L3(Apply)** |
| CO4. | Compare, formulate and analyze a power electronic software based circuit design and its control drive performance. | **L4(Analysis)** |
| CO5. | Select the simulation software based on alternative solutions in an industries. | **L5( Evaluating)** |
| CO6. | Formulate and design mathematical modeling for various engineering problems | **L6(Creating)** |

***Revised Bloom's Taxonomy Action verbs/Levels**

## Course Content

### UNIT- I

Introduction to ordinary differential equation solvers, steps of using ODE solvers, Types of mathematical models, developing a model, Mathematical modeling of simple electrical, Mechanical and electro mechanical systems.

### UNIT-II

Simulation of power electronic converters: State-space representation, Trapezoidal integration, M and N method.

## UNIT-III

**Modeling:** Steady state analysis of converters, dynamic analysis of converters, state space average modeling, PWM modeling, modeling of converters operating in continuous and discontinuous conduction mode, converter transfer functions.

**Simulation of electric drives:** Modeling of different PWM Techniques, Modeling and simulation of Induction motor, Vector controlled 3-Ph Induction motor.

## UNIT-IV

**Control Techniques in Power Electronics:** State space modelling and simulation of linear systems, conventional controllers using small signal models, Fuzzy control, Hysteresis controllers, Output and state feedback switching controllers. Modeling, simulation of switching converters with state space averaging, State Space Averaging Technique and its application in simulation and design of power converters.

## REFERENCES:


1. M. B. Patil, V. Ramnarayanan and V. T. Ranganathan, “Simulation of Power Electronic Converters”1st Edition, Narosa Publishers, 2010.
2. Ned Mohan, T.M. Undeland and William P.Robbins, “Power Electronics-Converters, Applications”, 3rd Edition, John Wiley & Sons, 2009.
3. Chee-Mun Ong, “Dynamic Simulation of Electric Machinery”, Using Matlab/Simulink.

**Course Articulation Matrix:**

| Course/Course Code: Advance Power Electronics (PEC-EE405-T), | | | | | | | | | | | | Semester: VII | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| CO1 | 3 | 3 | 2 | 1 | 1 | 2 | 1 | - | - | - | 2 | 3 | 2 | 3 | 1 |
| CO2 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | - | - | - | 3 | 3 | 2 | 2 | 1 |
| CO3 | 3 | 3 | 3 | 2 | 3 | 1 | 1 | - | - | - | 1 | 2 | 2 | 2 | - |
| CO4 | 2 | 3 | 2 | 1 | 2 | 2 | - | - | - | - | 2 | 2 | 2 | 3 | 1 |
| CO5 | 3 | 1 | 2 | 2 | 1 | 2 | 1 | - | - | - | 1 | 2 | 3 | 2 | - |
| CO6 | 3 | 3 | 1 | 2 | 2 | 2 | 1 | - | - | - | 3 | 2 | 2 | 3 | 1 |

**Correlation level:** **1**- slight /Low **2-** Moderate/ Medium **3**- Substantial/High

# RELIABILITY ENGINEERING

## General Course Information:

| | |
|---|---|
| Course Code: PEC-EE407-T<br>Course Credits: 3.0<br>Mode: Lecture (L)<br>Type: Program Elective<br>Teaching Schedule L T P: 3 0 0<br>Examination Duration: 3 hours | **Course Assessment Methods (Internal: 30; External: 70)** Two minor test each of 20 marks, class performance measured through percentage of lecture attended (4 marks), assignments, quiz etc. (6 marks) and end semester examination of 70 marks.<br><br>For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus; it will contain seven short answer type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the four units. All questions carry equal marks. |

## Course outcomes:

| Sr. No. | **Course outcomes**<br>At the end of the course students will be able to: | RBT* Level |
|---|---|---|
| CO1. | Recall the concepts of probability and relate it with the reliability | **L1(Remembering)** |
| CO2. | Equip with fundamentals of reliability concepts and applications in the various fields of engineering with the focus on power systems | **L2(Understanding)** |
| CO3. | Apply various methods for reliability evaluation, prediction, allocation and optimization. | **L3(Apply)** |
| CO4. | Examine the failure modes & effects of different models of networks, generatio system and distribution systems. | **L4(Analysis)** |
| CO5. | Draw reliability logic diagrams, fault trees, market graphs and find reliability functions | **L5( Evaluating)** |
| CO6. | Apply reliability theory to assessment of reliability in engineering design and power system planning | **L6(Creating)** |

***Revised Bloom's Taxonomy Action verbs/Levels**

## Course Content

### UNIT- I

**Basic Reliability Concepts:** Reliability and its importance, mortality curve, hazard rate, causes of failures, modes of failure, general reliability function and other reliability functions, Mean time to failure (MTTF), repair rate, mean-time-between failures (MTBF), availability, uptime, downtime, Failure frequency and failure distributions.

### UNIT- II

**Reliability models:** Reliability models – statistical, structural, Markov and fault tree, Reliability evaluation using various models, Network modeling and reliability analysis of Series, Parallel, Series-Parallel networks and complex networks, Decomposition method.

## UNIT- III

**Redundancy techniques and Reliability Testing:** Redundancy techniques, Reliability allocation and Redundancy optimization, Reliability Testing, Basic principles of maintainability, availability and security, Availability evaluation using Markov technique, Basic concepts of fuzzy reliability, failure frequency and loss of load probability

## UNIT- IV

**Generation and Distribution system reliability:** Reliability model of a generation system, recursive relation for unit addition and removal, Load modeling, Merging of generation load mode, Evaluation of transition rates for merged state model, Cumulative probability, Cumulative frequency of failure evaluation – LOLP, LOLE.

Distribution system reliability analysis – radial networks, Weather effects on transmission lines, Evaluation of load and energy indices

**REFERENCES:**


1. E. Balaguruswamy, "Reliability Engineering", Tata McGraw-Hill Education, 1984
2. K. K. Aggarwal, "Reliability Engineering", Springer, 2012
3. M. L. Shooman, "Probabilistic Reliability-An Engineering approach", Krieger Pub Co.,1990
4. R. Ramkumar, "Reliability Engineering", Prentice Hall, 1st edition, 1996
5. A. K. Govil, "Reliability Engineering", McGraw-Hill Inc., 1983
6. R. Billinton, R. N. Allan, "Reliability Evaluation of Egg. System", Plenum Press, 1992
7. R. Billinton, R. N. Allan, "Reliability Evaluation of Power System", Plenum Press, 2008
8. S. E. Ebeling, "An Introduction to Reliability and Maintainability Engineering" Tata McGraw Hill,

**Course Articulation Matrix:**

| Course/Course Code: Reliability Engineering (PEC-EE407-T), | | | | | | | | | | | | | Semester: VII | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| CO1 | 3 | 2 | 2 | 1 | 1 | 2 | 1 | - | 1 | - | 2 | 2 | 1 | 2 | 1 |
| CO2 | 3 | 3 | 2 | 1 | 1 | 2 | 1 | - | 1 | - | 2 | 2 | 2 | 2 | 1 |
| CO3 | 2 | 3 | 2 | 2 | 2 | 1 | 1 | - | 1 | - | 3 | 2 | 2 | 3 | 1 |
| CO4 | 2 | 3 | 2 | 2 | 2 | 3 | 1 | - | 1 | - | 3 | 2 | 2 | 3 | 1 |
| CO5 | 2 | 3 | 2 | 3 | 2 | 1 | 1 | - | 1 | - | 2 | 2 | 2 | 3 | 1 |
| CO6 | 3 | 3 | 2 | 2 | 2 | 2 | 1 | - | 1 | - | 3 | 2 | 2 | 3 | 1 |

**Correlation level:** **1**- slight /Low **2-** Moderate/ Medium **3-** Substantial/High

# UTILIZATION OF ELECTRICAL ENERGY

## General Course Information:

| | |
|---|---|
| Course Code: PEC-EE409-T<br>Course Credits: 3.0<br>Mode: Lecture (L)<br>Type: Program Elective<br>Teaching Schedule L T P: 3 0 0<br>Examination Duration: 3 hours | **Course Assessment Methods (Internal: 30; External: 70)** Two minor test each of 20 marks, class performance measured through percentage of lecture attended (4 marks), assignments, quiz etc. (6 marks) and end semester examination of 70 marks.<br><br>For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus; it will contain seven short answer type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the four units. All questions carry equal marks. |

## Course outcomes:

| Sr. No. | **Course outcomes**<br>At the end of the course students will be able to: | RBT* Level |
|---|---|---|
| CO1. | State the working principle of electric power utilization and their application in real life | **L1(Remembering)** |
| CO2. | Select proper traction systems depending upon application considering economic and technology up-gradation. | **L2(Understanding)** |
| CO3. | Employ mathematical and graphical analysis considering different practical issues to design of traction system; analyze the performance parameter of the traction system. | **L3(Apply)** |
| CO4. | Examine various applications in indoor and outdoor application areas where use of light sources are essential. | **L4(Analysis)** |
| CO5. | Develop a clear idea on various illumination techniques and hence design lighting scheme for specific applications. | **L5( Evaluating)** |
| CO6. | State the working principle of electric power utilization and their application in real life | **L6(Creating)** |

***Revised Bloom's Taxonomy Action verbs/Levels**

## Course Content

### UNIT- I

**Illumination:** Terminology, Laws of illumination, Photometry, lighting calculations. Electric lamps – Different types of lamps, LED lighting and Energy efficient lamps. Design of lighting schemes – factory lighting - flood lighting – street lighting.

### UNIT-II

**Electric Heating:** Types of heating and applications, Electric furnaces - Resistance, inductance and Arc Furnaces, Electric welding and sources of welding, Electrolytic processes – electro-metallurgy and electro-plating. Refrigeration-Domestic refrigerator and water coolers – Air -Conditioning- Various types of air conditioning system and their applications, smart air conditioning units - Energy Efficient motors

## UNIT-III

**Electrolytic Processes:** Introduction, Electrolyte, Ionization, Definition of various terms used in Electrolysis, Faradays' laws of Electrolysis, Extraction of Metals, Refining of metals, Electro-Deposition, Power Supply for Electrolytic Processes.

## UNIT-IV

**Traction System:** Requirement of an ideal traction system, power supply, traction drives, electric braking, Train movement (speed time curve, simplified speed time curve, average speed and schedule speed).Use of AC series motor and Induction motor for traction.

**Traction motor control:** DC series motor control, multiple unit control, braking of electric motors.

### REFERENCES:


1. Dr. Uppal S.L. and Prof. S. Rao, "Electrical Power Systems", Khanna Publishers, New Delhi, 15th Edition, 2014.
2. Gupta, J.B., "Utilization of Electrical Energy and Electric Traction", S. K. Kataria and Sons, 10th Edition, 2012.
3. Rajput R.K., "Utilization of Electrical Power", Laxmi Publications, 1st Edition, 2006.
4. N. V. Suryanarayana, "Utilization of Electrical Power", New Age International Publishers, Reprinted 2005.
5. C. L. Wadhwa, "Generation Distribution and Utilization of Electrical Energy", New Age International Publishers, 4th Edition, 2011.
6. H. Partab, "Modern Electric Traction", Dhanpat Rai & Co., 3rd Edition, 2012.

**Course Articulation Matrix:**

| Course/Course Code: Utilization Of Electrical Energy(PEC-EE409-T), | | | | | | | | | | | | | | Semester: VII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| CO1 | 3 | 3 | 2 | 1 | 2 | 2 | 1 | - | - | - | 1 | 3 | 3 | 3 | 1 |
| CO2 | 3 | 2 | 2 | 1 | 2 | 2 | 1 | - | - | - | 3 | 3 | 2 | 2 | 1 |
| CO3 | 2 | 3 | 1 | 2 | 3 | 2 | 2 | - | - | - | 2 | 2 | 3 | 2 | - |
| CO4 | 3 | 3 | 2 | 1 | 2 | 2 | - | - | - | - | 2 | 2 | 2 | 3 | 1 |
| CO5 | 3 | 2 | 2 | 2 | 1 | 2 | 1 | - | - | - | 1 | 2 | 2 | 2 | - |
| CO6 | 3 | 3 | 1 | 2 | 2 | 2 | 2 | - | - | - | 2 | 2 | 2 | 3 | 1 |

**Correlation level:** **1**- slight /Low **2-** Moderate/ Medium **3**- Substantial/High

# ENERGY MANAGEMENT AND AUDITING

## General Course Information:

| | |
|---|---|
| Course Code: PEC-EE411-T<br>Course Credits: 3.0<br>Mode: Lecture (L) and Tutorial (T)<br>Type: Program Core<br>Teaching Schedule L T P: 3 0 0<br>Examination Duration: 3 hours | **Course Assessment Methods (Internal: 30; External: 70)** Two minor test each of 20 marks, class performance measured through percentage of lecture attended (4 marks), assignments, quiz etc. (6 marks) and end semester examination of 70 marks.<br><br>For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus; it will contain seven short answer type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the four units. All questions carry equal marks. |

**Course Outcomes**

| Sr. No. | **Course outcomes**<br>At the end of the course students will be able to: | RBT* Level |
|---|---|---|
| CO1. | Describe the basics of energy scenario | **L1(Remembering)** |
| CO2. | Describe the energy management and savings through the different levels during utilization | **L2(Understanding)** |
| CO3. | Solve the problems related with energy management and audit. | **L3(Apply)** |
| CO4. | Perform economic and energy efficiency analysis of various electrical devices on the behalf of their energy audit repot. | **H1(Analysis)** |
| CO5. | Create energy audit report for industrial, residential and commercial consumers | **H3 (Creating)** |

***Revised Bloom's Taxonomy Action verbs/Level**

## Course Content

### UNIT-I

**Energy Scenario:** Commercial and Non-Commercial Energy, Primary and Secondary Energy Resources, Conventional and non-conventional energy, Commercial Energy Production, Final Energy Consumption, Energy Needs of Growing Economy, Long Term Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy and Environment: Air Pollution, Climate Change, Energy Security, Energy Conservation and its Importance, Energy Strategy for the Future

### UNIT-II

**Energy Management Functions:** Need for energy management, Energy management program, Organizational Structure, Energy Policy, Planning, Audit Planning, Educational Planning, Strategic Planning, Reporting

### UNIT-III

**Electrical Energy Management:** Electricity tariff, Electrical Load Management and Maximum Demand Control, Maximum demand controllers, Power Factor & Its importance, Automatic power factor controllers, Energy efficient motors, Soft starters with energy saver, Energy efficient transformers, Electronic ballast, Energy efficient lighting controls

### UNIT-IV

**Energy Audit:** Definition, Energy audit- need, Types of energy audit, Energy Auditing Services, Basic Components of an Energy Audit, Specialized Audit Tools, Industrial Audits, Commercial Audits, Residential Audits, Indoor Air Quality and basics of economic analysis.

**REFERENCES**:


1. Wayne C. Turner, Steve Doty, "Energy Management Hand book", The Fairmont Press, 6th Edition, 2007
2. Amit K. Tyagi, "Handbook on Energy Audits and Management", Tata Energy Research Institute, 2nd reprint, 2003.
3. Barney L. Capehart, Wayne C. Turner, William J. Kennedy, "Guide to Energy Management", CRC Press.
4. www.bee-india.nic.in, BEE Reference book: no.1/2/3/4.

**Course Articulation Matrix:**

| Course/Course Code: Energy Management and Auditing (PEC-EE411-T) | | | | | | | | | | | | | | Semester: VII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| CO1 | 2 | 2 | 2 | - | - | 3 | 3 | - | - | - | - | 3 | 2 | 2 | 2 |
| CO2 | 3 | 2 | 1 | - | 2 | - | - | - | 2 | - | - | - | 2 | 2 | 1 |
| CO3 | 2 | 3 | 2 | 2 | - | - | - | - | - | - | 2 | - | 3 | 3 | 2 |
| CO4 | 2 | 2 | 2 | - | 2 | - | - | 2 | - | 2 | 3 | 3 | 2 | 3 | 2 |
| CO5 | 2 | 2 | 2 | 2 | 2 | - | - | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |

**Correlation level:** **1-** slight /Low **2-** Moderate/ Medium **3-** Substantial/High

# SOFT COMPUTING

## General Course Information:

| Course Code: PEC-EE413-T<br>Course Credits: 3.0<br>Mode: Lecture (L) and Tutorial (T)<br>Type: Program Core<br>Teaching Schedule L T P: 3 0 0<br>Examination Duration: 3 hours | **Course Assessment Methods (Internal: 30; External: 70)** Two minor test each of 20 marks, class performance measured through percentage of lecture attended (4 marks), assignments, quiz etc. (6 marks) and end semester examination of 70 marks.<br><br>For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus; it will contain seven short answer type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the four units. All questions carry equal marks. |
|---|---|

**Prerequisites:**

**Course Outcomes**

| Sr. No. | **Course outcomes**<br>At the end of the course students will be able to: | **RBT* Level** |
|---|---|---|
| CO1. | Recall the basics of power system. | **L1(Remembering)** |
| CO2. | Describe the performance of different soft computing techniques in the context of power system. | **L2(Understanding)** |
| CO3. | Solve the problems related with soft computing techniques in the context of power system. | **L3(Apply)** |
| CO4. | Compare the performance soft computing techniques for optimization of system. | **H1(Analysis)** |
| CO5. | Judge and analyze the performance of system with the implementation of soft computing techniques. | **H2 (Evaluating)** |
| CO6. | Create new algorithm (model) for the betterment of power system operation with economics parameters. | **H3 (Creating)** |

***Revised Bloom's Taxonomy Action verbs/Level**

## Course Content

### UNIT-I

**Soft Computing:** Introduction, requirement, different soft computing techniques and their characteristics, comparison with hard computing, applications.

### UNIT II

**Fuzzy sets and Fuzzy logic:** Introduction, Fuzzy sets versus crisp sets, properties of fuzzy sets, operations on fuzzy sets, Extension principle, Fuzzy relations, Linguistic variables, linguistic terms, Linguistic hedges, Fuzzy reasoning, Mamdani and TSK fuzzy inference systems, Applications.

### UNIT III

**Artificial Neural Network:** Introduction, comparison with biological neural network, basic models of artificial neuron, different architectures of ANN, Learning techniques, Applications.

### UNIT IV

**Evolutionary algorithms:** Genetic Algorithm (GA), different operators of GA, convergence of Genetic Algorithm, Particle swarm optimization algorithm, other Applications of GA.

**REFERENCES:**

1. J.S.R.Jang, C.T.Sun, E.mizutani, "Neuro Fuzzy & Soft Computing", Pearson Education.
2. S. Rajasekaran, GA Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic & Genetic Algorithms -Synthesis & Applications", PHI Publication.
3. D.E.Goldberg, "Genetic Algorithms in Search optimization & Machine Learning", Addison - Wesley Pub. Co.
4. J.M. Zurada, "Artificial Neural Systems", West Publishing Co., New York.
5. Simon Haykin, "Neural Networks - A Comprehensive Foundation", Prentice Hall.
6. Bart Kosko, "Neural Networks & Fuzzy Systems", PHI Publication.

**Course Articulation Matrix:**

| Course/Course Code: Soft Computing (PEC-EE413-T) Semester: VII | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| CO1 | 2 | 1 | 1 | 1 | 1 | - | - | - | - | - | - | 1 | 2 | 1 | 1 |
| CO2 | 2 | 2 | 2 | 2 | 3 | - | - | - | - | - | - | 1 | 2 | 2 | 1 |
| CO3 | 3 | 2 | 2 | 2 | 2 | - | - | - | - | - | - | 1 | 3 | 3 | 1 |
| CO4 | 3 | 2 | 2 | 2 | 2 | - | 1 | - | - | - | - | 1 | 2 | 3 | 1 |
| CO5 | 3 | 2 | 2 | 2 | 2 | - | 1 | - | - | - | - | 1 | 2 | 2 | 1 |
| CO6 | 3 | 2 | 2 | 2 | 3 | 1 | 1 | 1 | 2 | 1 | 3 | 2 | 2 | 2 | 1 |

**Correlation level:** **1-** slight /Low **2-** Moderate/ Medium **3-** Substantial/High

# SCADA SYSTEM AND APPLICATIONS

## General Course Information:

| | |
|---|---|
| Course Code: PEC-EE415-T<br>Course Credits: 3.0<br>Mode: Lecture (L)<br>Type: Program Elective<br>Teaching Schedule L T P: 3 0 0<br>Examination Duration: 3 hours | **Course Assessment Methods (Internal: 30; External: 70)** Two minor test each of 20 marks, class performance measured through percentage of lecture attended (4 marks), assignments, quiz etc. (6 marks) and end semester examination of 70 marks.<br><br>For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus; it will contain seven short answer type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the four units. All questions carry equal marks. |

## Course outcomes:

| Sr. No. | **Course outcomes**<br>At the end of the course students will be able to: | RBT* Level |
|---|---|---|
| CO1. | Describe the basic tasks of Supervisory Control Systems (SCADA) as well as their typical applications | **L1(Remembering)** |
| CO2. | Identify different elements of SCADA. | **L2(Understanding)** |
| CO3. | Solve the problems related to I/O module, Data Acquisition System and Communication Networks using Standard Devices. | **L3(Apply)** |
| CO4. | Examine the problem associated with the industrial application. | **L4(Analysis)** |
| CO5. | Evaluate the SCADA performance on the basis of application and behaviour. | **L5( Evaluating)** |
| CO6. | Design and analysis of general structure of an automated process for real time applications using SCADA | **L6(Creating)** |

***Revised Bloom's Taxonomy Action verbs/Levels**

## Course Content

### UNIT- I

**Introduction:** Introduction to SCADA systems, Fundamental Principle of Modern SCADA Systems, Monitoring and supervisory functions, Application area of SCADA system.

### UNIT- II

SCADA System Components, Remote Terminal Unit-(RTU), Intelligent Electronic Devices (IED), Programmable Logic Controller (PLC), Communication Network, SCADA Server, SCADA/HMI Systems.

### UNIT- III

**SCADA Architecture:** Various SCADA architectures, advantages and disadvantages of each system - single unified standard architecture -IEC 61850 SCADA Communication: various industrial communication technologies -wired and wireless methods and fiber optics. Open standard communication protocols.

## UNIT- IV

**SCADA Applications:** Utility applications- Transmission and Distribution sector -operations, monitoring, analysis and improvement. Industries - oil, gas and water. Case studies, Implementation, Simulation Exercises.

**REFERENCES:**


1. Stuart A. Boyer, "SCADA-Supervisory Control and Data Acquisition", Instrument Society of America Publications,USA,2004
2. William T. Shaw, "Cybersecurity for SCADA systems", Penn Well Books, 2006
3. David Bailey, Edwin Wright, "Practical SCADA for industry", Newnes Publication, 2003
4. KLS Sharma, "Overview of Industrial Process Automation", Elsevier Publication

**Course Articulation Matrix:**

| Course/Course Code: SCADA System and Applications(PEC-EE415-T), | | | | | | | | | | | | | | | Semester: VII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| CO1 | 3 | 3 | 3 | 2 | 2 | 1 | - | - | - | - | 2 | 3 | 2 | 3 | 2 |
| CO2 | 3 | 2 | 3 | 2 | 3 | 2 | - | - | - | - | 2 | 3 | 2 | 3 | 1 |
| CO3 | 2 | 3 | 3 | 2 | 2 | 3 | - | - | - | - | 3 | 2 | 3 | 3 | 1 |
| CO4 | 3 | 2 | 2 | 2 | 3 | 1 | - | - | - | - | 3 | 1 | 2 | 2 | 1 |
| CO5 | 2 | 3 | 3 | 2 | 2 | 1 | - | - | - | - | 2 | 1 | 2 | 2 | 2 |
| CO6 | 2 | 3 | 2 | 2 | 2 | 2 | - | - | - | - | 2 | 2 | 2 | 1 | 1 |

**Correlation level:** **1**- slight /Low **2-** Moderate/ Medium **3**- Substantial/High

# INTERNET OF THINGS (IOT)

## General Course Information:

| | |
|---|---|
| Course Code: PEC-EE417-T<br>Course Credits: 3.0<br>Mode: Lecture (L) and Tutorial (T)<br>Type: Program Core<br>Teaching Schedule L T P: 3 0 0<br>Examination Duration: 3 hours | **Course Assessment Methods (Internal: 30; External: 70)** Two minor test each of 20 marks, class performance measured through percentage of lecture attended (4 marks), assignments, quiz etc. (6 marks) and end semester examination of 70 marks.<br><br>For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus; it will contain seven short answer type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the four units. All questions carry equal marks. |

## Course Outcomes

| Sr. No. | **Course outcomes**<br>At the end of the course students will be able to: | RBT* Level |
|---|---|---|
| CO1. | Memorize the basic concepts of Internet, embedded system and wireless network. | **L1(Remembering)** |
| CO2. | Understand the concepts of Internet of Things | **L2(Understanding)** |
| CO3. | Choose the specific application to apply the concept of IOT. | **L3(Apply)** |
| CO4. | Analyze basic protocols in wireless sensor network. | **H1(Analysis)** |
| CO5. | Design IOT applications in different domain and be able to analyze their performance | **H3 (Creating)** |

***Revised Bloom's Taxonomy Action verbs/Level**

## Course Content

### UNIT-I

**Introduction and Concepts of IOT:** Introduction to IOT, definition and characteristics of IOT, Architecture of Internet of Things, Physical and logical design of IOT, IOT enabling technologies, IOT levels and deployment templates, Domain specific IOTs, home automation, cities, environment, Domain specific IOTs, Energy, retail, agriculture, industry, health and lifestyle.

### UNIT-II

**IOT Challenges & IOT-M2M Communication:** Design challenges, Development challenges, Security challenges, Other challenges, Machine to Machine, Difference between IoT and M2M, Software define Network, Wireless medium access issues, MAC protocol survey, Survey routing protocols, Sensor deployment & Node discovery, Data aggregation & dissemination,

### UNIT-III

**Introduction to Hardware used for IoT:** Microcontrollers, Microprocessors, Sensors, Introduction to Arduino, RF Protocols: RFID, NFC, Bluetooth Low Energy (BLE), IPv6 for Low Power and Lossy Networks (6LoWPAN) and Routing, Protocol for Low power and lossy networks (RPL).

### UNIT-IV

**Developing IOTs:** Introduction to Python, Introduction to different IOT tools, Developing applications through IOT tools, Developing sensor based application through embedded system platform, Implementing IOT concepts with python.

**REFERENCES:**


1. Arshdeep Bahga, Vijay Madisetti, “Internet of Things, A Hands -on Approach”, 1st Edition University Press, 2015.
2. Oliver Hersent, David Boswarthick, Omar Elloumy, “The Internet of Things”,1st Edition , 2015.
3. Michael Miller, “The Internet of Things, How Smart TVs, Smart Cars, Smart Homes, and Smart Cities are changing the World”, 1st edition, Pearson 2015.

**Course Articulation Matrix:**

| Course/Course Code: Internet of Things (PEC-EE417-T) | | | | | | | | | | | | | Semester: VII | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| CO1 | 3 | 2 | 2 | 2 | 2 | 1 | 2 | - | - | 2 | 2 | 2 | 3 | 2 | 1 |
| CO2 | 3 | 2 | 2 | 2 | 3 | 2 | 1 | - | 1 | 2 | 2 | 1 | 3 | 2 | - |
| CO3 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | - | 1 | 1 | 2 | 2 | 3 | 2 | - |
| CO4 | 2 | 3 | 3 | 2 | 3 | 1 | 2 | - | 2 | 1 | 2 | 2 | 3 | 2 | 1 |
| CO5 | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 1 | 2 | 2 | 3 | 3 | 3 | 2 | 1 |

**Correlation level:** **1-** slight /Low **2-** Moderate/ Medium **3-** Substantial/High

# FLEXIBLE AC TRANSMISSION SYSTEMS

## General Course Information:

| | |
|---|---|
| Course Code: PEC-EE404-T<br>Course Credits: 3.0<br>Mode: Lecture (L)<br>Type: Program Elective<br>Teaching Schedule L T P: 3 0 0<br>Examination Duration: 03 hours | **Course Assessment Methods (Internal: 30; External: 70)** Two minor test each of 20marks, class performance measured through percentage of lecture attended (4 marks), assignments, quiz etc. (6 marks) and end semester examination of 70 marks.<br><br>For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus; it will contain seven short answer type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the four units. All questions carry equal marks. |

## Course outcomes:

| **Sr. No.** | **Course outcomes**<br>At the end of the course students will be able to: | **RBT* Level** |
|---|---|---|
| CO1. | Revise the basics of power transmission networks and need for FACTS controllers | **L1(Remembering)** |
| CO2. | Understand and classify different power system FACTS Controllers | **L2(Understanding)** |
| CO3. | Demonstrate the scope of the specific FACTS controllers for power flow control issues in transmission lines. | **L3(Apply)** |
| CO4. | Analyze the operation of various FACTS controllers and solve simple powe systems with FACTS controllers | **L4(Analysis)** |
| CO5. | Select the specific FACTS controllers for power system compensation | **L5( Evaluating)** |
| CO6. | Design simple FACTS controllers | **L6(Creating)** |

***Revised Bloom's Taxonomy Action verbs/Levels**

## Course Content

### UNIT- I

**Introduction:** 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):** Configuration of SVC, Voltage regulation by SVC, Modeling of SVC for load flow and stability analysis, Modeling of SVC for 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):** Concepts of Controlled Series Compensation – Operation of TCSC and GCSC- Analysis of TCSC-GCSC – Modeling of TCSC and GCSC for load flow and stabilityanalysis, Applications of TCSC and GCSC

## UNIT- IV

**Voltage source converter based facts controllers:** Static synchronous compensator (STATCOM), Static synchronous series compensator(SSSC), Operation of STATCOM and SSSC, Power flow control with STATCOM and SSSC, Modeling of STATCOM and SSSC for power flow and transient stability studies, Operation of Unified and Interline power flow controllers(UPFC and IPFC), Modeling of UPFC and IPFC for load flow studies, Applications.

**REFERENCES:**


1. R. M. Mathur, , R. K. Varma, "Thyristor – Based Facts Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, Inc.
2. K.R. Padiyar, "FACTS Controllers in Power Transmission and Distribution", New Age International (P) Ltd., Publishers, New Delhi, Reprint 2008,
3. A.T. John, "Flexible AC Transmission System", Institution of Electrical and Electronic Engineers (IEEE), 1999.
4. N. G. Hingorani, L. Gyugyi, "Understanding FACTS Concepts and Technology of Flexible AC Transmission System", Standard Publishers, Delhi 2001.
5. V. K. Sood, "HVDC and FACTS controllers- Applications of Static Converters in Power System", 2004, Kluwer Academic Publishers.
6. T. J. E. Miller, "Reactive Power Control In Electric Systems", Wiley Publications, 1982.

**Course Articulation Matrix:**

| Course/Course Code: Flexible Ac Transmission System(PEC-EE404-T), | | | | | | | | | | | | | | Semester: VIII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| CO1 | 3 | - | 1 | - | 2 | 2 | 2 | - | - | - | 1 | 2 | 1 | 1 | 1 |
| CO2 | 2 | - | 1 | 1 | 1 | - | 1 | - | - | - | - | 2 | 2 | 1 | 1 |
| CO3 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | - | 1 | - | 1 | 2 | 2 | 1 | 1 |
| CO4 | 2 | 3 | 2 | 2 | 2 | 3 | 1 | - | 1 | - | 1 | 2 | 2 | 1 | 1 |
| CO5 | 2 | 2 | 2 | 3 | 2 | 1 | 1 | - | 1 | - | 1 | 2 | 2 | 3 | 1 |
| CO6 | 2 | 2 | 3 | 2 | 2 | 2 | 1 | - | 1 | - | 1 | 2 | 2 | 3 | 1 |

**Correlation level:** **1-** slight /Low **2-** Moderate/ Medium **3-** Substantial/High

# DISTRIBUTED GENERATION

**General Course Information:**

| | |
|---|---|
| Course Code: PEC-EE406-T<br>Course Credits: 3.0<br>Mode: Lecture (L)<br>Type: Program Elective<br>Teaching Schedule L T P: 3 0 0<br>Examination Duration: 3 hours | **Course Assessment Methods (Internal: 30; External: 70)** Two minor test each of 20 marks, class performance measured through percentage of lecture attended (4 marks), assignments, quiz etc. (6 marks) and end semester examination of 70 marks.<br><br>For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus; it will contain seven short answer type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the four units. All questions carry equal marks. |

**Course outcomes:**

| **Sr. No.** | **Course outcomes**<br>At the end of the course students will be able to: | **RBT* Level** |
|---|---|---|
| CO1. | Describe the various technical and economic benefits of Distributed Generations. | **L1(Remembering)** |
| CO2. | Recognize the need of siting and sizing of distributed generation along with their effect on distribution system. | **L2(Understanding)** |
| CO3. | Apply economic feasibility analysis | **L3(Apply)** |
| CO4. | Examine the technical issue in Distributed Generations system | **L4(Analysis)** |
| CO5. | Evaluate the appropriate optimization technique suitable for Distributed Generations. | **L5( Evaluating)** |
| CO6. | Develop a Model a micro grid taking into consideration the planning and operational issues of the Distributed Generations to be connected in the system | **L6(Creating)** |

***Revised Bloom's Taxonomy Action verbs/Levels**

## Course Content

### UNIT- I

**Introduction:** Conventional power generation: advantages and disadvantages, Energy crises, Nonconventional energy (NCE) resources: basics of Solar PV, Wind Energy systems, Fuel Cells, micro-turbines, biomass, and tidal sources.

### UNIT-II

**Distributed Generations:** Concept of distributed generations, Topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547, Energy storage elements: Batteries, ultra-capacitors, flywheels, Superconducting magnetic energy storage.

## UNIT-III

**Micro grids:** Concept and definition of micro grid, micro grid drivers and benefits, review of sources of Micro grids, typical structure and configuration of a Micro grid, AC and DC Micro grids, Power Electronic interfaces in DC and AC Micro grids.

## UNIT-IV

**Impact of Grid Integration:** Requirements for grid interconnection, limits on operational parameters: voltage, frequency, THD Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.

## REFERENCES:


1. D. N. Gaonkar, "Distributed Generation", In-Tech publications.
2. Magdi S. Mahmoud, Fouad M. AL-Sunni, "Control and Optimization of Distributed Generation Systems", Springer International Publishing.
3. Loi Lei Lai, Tze Fun Chan, "Distributed Generation: Induction and Permanent Magnet Generators", October 2007, Wiley-IEEE Press.
4. M.Godoy Simoes, Felix A.Farret, 'Renewable Energy Systems – Design and Analysis with Induction Generators', CRC press.
5. F. Katiraei, M.R. Iravani, "Transients of a Micro-Grid System with Multiple Distributed Energy Resources", International Conference on Power Systems Transients (IPST'05) in Montreal, Canada on June 19-23, 2005.

**Course Articulation Matrix:**

| Course/Course Code: Distributed Generation(PEC-EE406-T), | | | | | | | | | | | | | | | Semester: VIII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| CO1 | 2 | 1 | 2 | - | - | 2 | 3 | - | - | - | 1 | 2 | 1 | 2 | 1 |
| CO2 | - | 1 | 2 | - | | 3 | 3 | - | - | - | - | 2 | 1 | 1 | 1 |
| CO3 | 2 | 2 | 2 | - | 1 | 2 | 3 | - | - | - | 1 | 1 | 2 | 2 | 1 |
| CO4 | 2 | 2 | 2 | 1 | 1 | 2 | 3 | - | - | - | 2 | 1 | 2 | 2 | 2 |
| CO5 | 2 | 2 | 2 | 1 | 2 | 3 | 3 | - | - | - | 2 | 1 | 1 | 3 | 2 |
| CO6 | 2 | 3 | 3 | 1 | 2 | 2 | 3 | - | - | - | 1 | 1 | 1 | 2 | 3 |

**Correlation level:** **1-** slight /Low **2-** Moderate/ Medium **3-** Substantial/High

# POWER QUALITY

## General Course Information:

| | |
|---|---|
| Course Code: PEC-EE408-T<br>Course Credits: 3.0<br>Mode: Lecture (L) and Tutorial (T)<br>Type: Program Core<br>Teaching Schedule L T P: 3 0 0<br>Examination Duration: 3 hours | **Course Assessment Methods (Internal: 30; External: 70)** Two minor test each of 20 marks, class performance measured through percentage of lecture attended (4 marks), assignments, quiz etc. (6 marks) and end semester examination of 70 marks.<br><br>For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus; it will contain seven short answer type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the four units. All questions carry equal marks. |

## Course Outcomes

| **Sr. No.** | **Course outcomes**<br>At the end of the course students will be able to: | **RBT* Level** |
|---|---|---|
| CO1. | Describe the basics of power electronic devices and quality of power supply. | **L1(Remembering)** |
| CO2. | Illustrate the issues related with power quality. | **L2(Understanding)** |
| CO3. | Solve the problems related with power quality. | **L3(Apply)** |
| CO4. | Compare the power quality problems. | **H1(Analysis)** |
| CO5. | Evaluate and judge the solutions related with power quality. | **H2 (Evaluating)** |
| CO6. | Design can be formulated as per required specification and issue. | **H3 (Creating)** |

***Revised Bloom's Taxonomy Action verbs/Level**

## Course Content

### UNIT-I

**Introduction to Power Quality:** Introduction to power distribution system- deregulated environment, Power Quality (PQ): definitions, concerns, and evaluations, Terminology: under-voltage, over voltage, transients, harmonics, voltage unbalance, voltage sags, voltage swells, flicker, interruptions, and power frequency variations, Concepts of transients - short duration variations such as interruption - long duration variation such as sustained interruption, International standards of power quality, Computer Business Equipment Manufacturers Associations (CBEMA) curve.

### UNIT-II

**Voltage Sags, Interruptions and Over voltages:** Sources of sags and interruptions - estimating voltage sag performance, Voltage sag due to induction motor starting, Estimation of the sag severity, Active Series Compensator, Static transfer switches and fast transfer switches, Sources of over voltages - Capacitor switching - lightning, Mitigation of voltage swells - surge arresters - power conditioners, Lightning protection - shielding - line arresters.

### UNIT-III

**Power System Harmonics:** Harmonic sources from commercial and industrial loads, locating harmonic sources, Power system response characteristics - Harmonics Vs transients, Effect of harmonics - harmonic distortion - voltage and current distortion - harmonic indices, Devices for controlling harmonic distortion - passive and active filters, IEEE and IEC standards.

## UNIT-IV

**Power Quality Monitoring and Distributed Generation:** Power Quality Monitoring - Industry requirements - standards, Power Quality Measurement Equipment: Power line disturbance analyser, Harmonic analyser-Spectrum analyser, Flicker meters and Disturbance analyser.

**Introduction to DG Technologies**: Interface to the Utility System-Power Quality issues, Site study for Distributed Generation-Interconnection standards, Issue on Power Quality in Smart Grids and Micro Grids

**REFERENCES:**


1. Roger C. Dugan, Mark McGranaghan, Surya Santoso, H.Wayne, H. Wayne Beaty, “Electrical Power Systems Quality”, Tata McGraw Hill, Third edition, 2012.
2. J. Arrillaga, N.R. Watson, S. Chen, “Power System Quality Assessment”, Wiley, 2011.
3. Dash.S.S, Rayaguru.N.K, “Power Quality Management”, 2nd Edition, Vijay Nicole Publishers, 2016.
4. Jos Arrillaga, Neville R. Watson, “Power System Harmonics”, 2nd Edition, Wiley Publishers, 2015.
5. ArindamGhosh ,“Power Quality Enhancement Using Custom Power Devices”, Kluwer Academic Publishers, 2002.
6. G.T. Heydt, “Electric Power Quality”, 2nd edition, Stars in a Circle Publications, 1994.

**Course Articulation Matrix:**

| Course/Course Code: Power Quality (PEC-EE408-T) | | | | | | | | | | | Semester: VIII | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| CO1 | 3 | 1 | 2 | 1 | 1 | 1 | 1 | - | - | - | 1 | 1 | 3 | 1 | 1 |
| CO2 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 |
| CO3 | 3 | 2 | 2 | 1 | 1 | - | - | - | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| CO4 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 |
| CO5 | 3 | 1 | 2 | 3 | 2 | 1 | 1 | - | 1 | 1 | 2 | 2 | 2 | 2 | 2 |
| CO6 | 3 | 2 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 1 | 3 | 3 | 2 | 2 | 2 |

**Correlation level:** **1-** slight /Low **2-** Moderate/ Medium **3-** Substantial/High

# SMART GRID TECHNOLOGIES

## General Course Information:

| | |
|---|---|
| Course Code: PEC-EE410-T<br>Course Credits: 3.0<br>Mode: Lecture (L) and Tutorial (T)<br>Type: Program Core<br>Teaching Schedule L T P: 3 0 0<br>Examination Duration: 3 hours | **Course Assessment Methods (Internal: 30; External: 70)** Two minor test each of 20 marks, class performance measured through percentage of lecture attended (4 marks), assignments, quiz etc. (6 marks) and end semester examination of 70 marks.<br><br>For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus; it will contain seven short answer type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the four units. All questions carry equal marks. |

**Prerequisites: PCC-EE206-T, PCC-EE302-T**

**Course Outcomes**

| Sr. No. | **Course outcomes**<br>At the end of the course students will be able to: | RBT* Level |
|---|---|---|
| CO1. | Recall the basics of Power system and its design aspects. | **L1(Remembering)** |
| CO2. | Describe the structure of smart grid on the basis of traditional grid with the role of automation in transmission and distribution. | **L2(Understanding)** |
| CO3. | Demonstrate the operation, scheduling and economics using evolutionary algorithms for smart grid and maximum utilization of renewable energy resources. | **L3(Apply)** |
| CO4. | Compare its performance with conventional grid and analyze the role of frequency for the control of grid. | **H1(Analysis)** |
| CO5. | Judge and evaluate the efficiency of system on the basis of supply of electricity with its economic indices. | **H2 (Evaluating)** |
| CO6. | Formulate algorithm or automation so that maximum consumer can be benefitted and losses of the system can be minimized. | **H3 (Creating)** |

***Revised Bloom's Taxonomy Action verbs/Level**

## Course Content

### UNIT-I

**Introduction to Smart Grid:** Smart Grid, Need of Smart Grid, Working definitions of Smart Grid and associated concepts, Smart Grid Functions, Traditional Power Grid and Smart Grid, New Technologies for Smart Grid, Advantages, Whole sale energy market in smart grid, Indian Smart Grid, Key Challenges for Smart Grid.

### UNIT-II

**Smart Grid Architecture:** Components and Architecture of Smart Grid Design, Review of the proposed architectures for Smart Grid, Fundamental components of Smart Grid designs, Transmission Automation, Distribution Automation, Renewable Integration, Energy Management in smart grid.

### UNIT-III

**Tools and Distribution Generation Technologies:** Introduction to Renewable Energy Technologies, Micro grids, Storage Technologies, Electric Vehicles and plug-in hybrids, Environmental impact and Climate Change, Economic Issues, Advanced metering infrastructure.

### UNIT-IV

**Communication Technologies and Smart Grid:** Introduction to Communication Technology, Synchro Phasor Measurement Units (PMUs), Wide Area Measurement Systems (WAMS).

**Control of Smart Power Grid System:** Load Frequency Control (LFC) in Micro Grid System – Voltage Control in Micro Grid System, Reactive Power Control in Smart Grid, Case Studies for the Smart Grids.

## REFERENCES:


1. James Momoh, "Smart Grid - fundamentals of design and analysis", John Wiley and Sons, 2012.
2. Janaka Ekanayake, "Smart Grid -Technology and Applications", John Wiley and Sons, 2012.
3. Stuart Borlase, "Smart Grids, Infrastructure, Technology and Solutions", CRC Press, 2013.
4. Gil Masters, "Renewable and Efficient Electric Power System", Wiley-IEEE Press, 2004.
5. A.G. Phadke and J.S. Thorp, "Synchronized Phasor Measurements and their Applications", Springer Edition, 2010.
6. T. Ackermann, "Wind Power in Power Systems", Hoboken, NJ, USA, John Wiley, 2005.

**Course Articulation Matrix:**

| Course/Course Code: Smart Grid Technologies (PEC-EE410-T) | | | | | | | | | | | | | | Semester: VIII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| CO1 | 3 | 2 | 2 | 1 | 1 | - | - | - | - | 1 | 1 | 1 | 3 | 2 | 1 |
| CO2 | 3 | 2 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| CO3 | 3 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 3 | 2 | 1 |
| CO4 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| CO5 | 3 | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 3 | 2 | 2 |
| CO6 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 1 | 3 | 3 | 3 | 3 | 3 |

**Correlation level:** **1-** slight /Low **2-** Moderate/ Medium **3-** Substantial/High

# EHV AC and DC TRANSMISSION

## General Course Information:

| | |
|---|---|
| Course Code: PEC-EE412-T<br>Course Credits: 3.0<br>Mode: Lecture (L)<br>Type: Program Elective<br>Teaching Schedule L T P: 3 0 0<br>Examination Duration: 3 hours | **Course Assessment Methods (Internal: 30; External: 70)** Two minor test each of 20 marks, class performance measured through percentage of lecture attended (4 marks), assignments, quiz etc. (6 marks) and end semester examination of 70 marks.<br><br>For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus; it will contain seven short answer type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the four units. All questions carry equal marks. |

## Course outcomes:

| **Sr. No.** | **Course outcomes**<br>At the end of the course students will be able to: | **RBT* Level** |
|---|---|---|
| CO1. | Elicit the major components, advantages, limitations and applications of EHV AC and DC transmission Systems | **L1(Remembering)** |
| CO2. | Recapitulate the fundamental aspects of Extra High Voltage A.C and DC transmission design and analysis | **L2(Understanding)** |
| CO3. | Apply the remedial measures against the problems associated with EHVAC and DC transmission such as Corona, AN, RI, Over-voltages, Ferro-resonance, Harmonics in converters | **L3(Apply)** |
| CO4. | Perform in-depth analysis of various control techniques for controlling the power flow through a dc link and multi-terminal operation of HVDC | **L4(Analysis)** |
| CO5. | Critically evaluate AC and DC transmission system with respect to all aspects | **L5( Evaluating)** |

***Revised Bloom's Taxonomy Action verbs/Levels**

## Course Content

### UNIT- I

**Introduction**: Need of EHV transmission, standard transmission voltage, Power handling capacity, Comparison of EHV AC & DC transmission systems and their applications & limitations, Bundled conductors, Surface voltage gradients in conductor, Distribution of voltage gradients on sub-conductors, mechanical considerations of transmission lines, modern trends in EHV AC & DC transmission.

### UNIT- II

**EHV AC Transmission**: Corona, Corona loss formulae, corona current, Audible noise-generation and characteristics corona pulses their generation and properties, Radio interference

(RI) effects, Over voltage due to switching, Ferro-resonance, reduction of switching surges on EHV system, principle of half wave transmission**.**

## UNIT- III

**Components of EHV D.C.:** Converter circuits, Rectifier and inverter valves, Reactive power requirements, Harmonics generation, Adverse effects, Classification, Remedial measures to suppress, Filters, Ground return, Converter faults & protection harmonics misoperation, Commutation failure, Multi-terminal D.C. lines.

## UNIT- IV

**Control of EHV D.C.:** Desired features of control, control characteristics, Constant current control, Constant extinction angle control. Ignition Angle control, Parallel operation of HVAC & DC system, Problems & advantages.

**REFERENCES:**


**1.** R.D. Begamudre, "EHV AC Transmission Engineering", Wiley Eastern Press, 2011
**2.** S. S. Rao, "EHV AC & DC Transmission", Khanna publishers, 2008
**3.** E. Kimbark, "HVDC Transmission", John Wiley and Sons, 1971
**4.** J. Arrillaga, "HVDC Transmission", 2nd Edition, IEEE Press, 1998
**5.** K. R. Padiyar, "HVDC Transmission, New Age International", 2nd edition, 2012
**6.** P. Kundur, "Power System Stability and Control", Tata McGraw Hill, 1994

**Course Articulation Matrix:**

| Course/Course Code: EHVAC and DC Transmission (PEC-EE412-T), | | | | | | | | | | | | | | Semester: VIII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| CO1 | 3 | 1 | 2 | 1 | 1 | 1 | - | 1 | 1 | - | 2 | 2 | 3 | 2 | 1 |
| CO2 | 3 | 1 | 2 | 1 | 1 | 1 | - | 1 | 1 | - | 2 | 2 | 3 | 2 | 1 |
| CO3 | 3 | 2 | 2 | 2 | 1 | 1 | - | 1 | 1 | - | 2 | 1 | 2 | 2 | 1 |
| CO4 | 2 | 3 | 2 | 2 | 1 | 1 | - | 1 | 1 | - | 2 | 1 | 2 | 2 | 1 |
| CO5 | 2 | 3 | 2 | 2 | 1 | 1 | - | 1 | 1 | - | 2 | 1 | 2 | 2 | 1 |

**Correlation level:** **1-** slight /Low **2-** Moderate/ Medium **3-** Substantial/High

# RESTRUCTURED POWER SYSTEM

## General Course Information:

| | |
|---|---|
| Course Code: PEC-EE414-T<br>Course Credits: 3.0<br>Mode: Lecture (L) and Tutorial (T)<br>Type: Program Core<br>Teaching Schedule L T P: 3 0 0<br>Examination Duration: 3 hours | **Course Assessment Methods (Internal: 30; External: 70)** Two minor test each of 20 marks, class performance measured through percentage of lecture attended (4 marks), assignments, quiz etc. (6 marks) and end semester examination of 70 marks.<br><br>For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus; it will contain seven short answer type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the four units. All questions carry equal marks. |

**Prerequisites: PCC-EE206-T, PCC-EE302-T**

**Course Outcomes**

| Sr. No. | **Course outcomes**<br>At the end of the course students will be able to: | RBT* Level |
|---|---|---|
| CO1. | Recall the basics of Power system and its design aspects. | **L1(Remembering)** |
| CO2. | Describe the structure of restructured power system on the basis of conventional power system design. | **L2(Understanding)** |
| CO3. | Demonstrate the operation, scheduling and economics of with an emphasis on recent research in this area. | **L3(Apply)** |
| CO4. | Compare its performance with conventional (bundled) power system. | **H1(Analysis)** |
| CO5. | Judge and evaluate the efficiency of system on the basis of supply of electricity with its economic indices. | **H2 (Evaluating)** |
| CO6. | Design can be formulated so that maximum consumer can be benefitted. | **H3 (Creating)** |

***Revised Bloom's Taxonomy Action verbs/Level**

## Course Content

### UNIT-I

**Introduction:** Measures for Energy Conservation, History of Electrical Power Generation, Laws, Efficient Transmission Arrangements, Measures for Energy Conservation, History of Electrical Power Generation, The Laws, Challenges and Issues in Competition Market, Competition in Generation, Efficient Transmission Arrangements. Role of different Authorities in Power Sectors.

### UNIT-II

**Power Trading**: Term-Ahead Market (TAM), Short-Term Open Access in Inter-state Transmission, (Collective Transaction/Pool Transaction), Present Practice, Market Clearing Process (MCP), Linear Bid Market, Determination of MCP for Single Sided Linear Bid Market

### UNIT-III

**Load Frequency control**: Power Industry Scenario, Introduction to AVR and ALFC Loops, review of modeling of an Isolated Generating System, Model for a Vessel, Reheat Type Steam Turbine Model, Complete Block Diagram Representation of LFC of an Isolated Area , Indian Power Industry Restructuring, Challenges in Load Frequency Control, Disco Participation Matrix (DPM), ACE Participation Factors, Transaction During Contract Violation/Pool Based Transaction, Mathematical Modeling of AGC with Restructuring

## UNIT-IV

**Available Power Transfer Capability**: Fundamentals and Importance of ATC, Algorithm for ATC Determination, Methods of ATC Determination, Power Transfer Distribution Factors Based on D.C. Load Flow Approach, Static ATC Determination Using A.C. Power Transfer Distribution Factor.

## REFERENCES:


1. L. L. Lai, "Power System Restructuring and Deregulation", John Wiley& Sons Inc., New York, HRD Edition, 2001.
2. S. K. Gupta, "Restructuring Electric Power Systems", I K International Publishing House.
3. Kankar Bhattacharya, Math H.J.Bollen and Jaap E. Daalder, "Operation of Restructured Power Systems", USA: Kluwer Academic Publishers, 2001.
4. Mohammad Shahidehpour, Hatim Yamin, "Market Operations in Electric Power Systems", John Wiley & Sons Inc., 2002.
5. Lorrin Philipson, H. Lee Willis, "Understanding Electric Utilities and Deregulation", Taylor & Francis, New York, 2nd Edition, 2006.
6. Mohammad Shahidehpour, Muwaffaq Alomoush, "Restructured Electrical Power Systems", Marcel Dekker, INC., New York, 1st Edition, 2001.
7. Overview of Power Sector in India 2005: Indian Core Publishing.

**Course Articulation Matrix:**

| Course/Course Code: Restructured Power System (PEC-EE414-T) | | | | | | | | | | | | | | | Semester: VIII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| CO1 | 3 | 1 | 2 | 1 | 1 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 3 | 3 | 1 |
| CO2 | 3 | 2 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| CO3 | 3 | 1 | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 3 | 2 | 1 |
| CO4 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| CO5 | 3 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 3 | 2 | 2 |
| CO6 | 3 | 2 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 1 | 3 | 3 | 3 | 2 | 3 |

**Correlation level:** **1-** slight /Low **2-** Moderate/ Medium **3-** Substantial/High

# HIGH VOLTAGE ENGINEERING

## General Course Information:

| | |
|---|---|
| Course Code: PEC-EE416-T<br>Course Credits: 3.0<br>Mode: Lecture (L)<br>Type: Program Elective<br>Teaching Schedule L T P: 3 0 0<br>Examination Duration: 3 hours | **Course Assessment Methods (Internal: 30; External: 70)** Two minor test each of 20 marks, class performance measured through percentage of lecture attended (4 marks), assignments, quiz etc. (6 marks) and end semester examination of 70 marks.<br><br>For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus; it will contain seven short answer type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the four units. All questions carry equal marks. |

## Course outcomes:

| **Sr. No.** | **Course outcomes**<br>At the end of the course students will be able to: | **RBT* Level** |
|---|---|---|
| CO1. | Describe the Knowledge about high voltage generation | **L1(Remembering)** |
| CO2. | Discuss the testing methods of High Voltage Equipment | **L2(Understanding)** |
| CO3. | Find the problem occur in high voltage generation | **L3(Apply)** |
| CO4. | Test various apparatus and their measurement method for generating high voltages. | **L4(Analysis)** |
| CO5. | Select the reasons of overvoltage in power system and protection methods against them. | **L5( Evaluating)** |
| CO6. | Formulate the incidence, network matrices and model of the power system components. | **L6(Creating)** |

***Revised Bloom's Taxonomy Action verbs/Levels**

## Course Content

### UNIT- I

**Break Down Mechanism of Gaseous Materials:** Mechanism of Breakdown of gases, Townsend's first Ionization Co-efficient, Townsend's second Ionization Co-efficient, Townsend's Breakdown Mechanism, and Streamer Theory of Breakdown in gases, Paschen's law.

### UNIT-II

**Breakdown in Liquid and Solid Dielectrics:** Suspended Particle Theory, Cavity Breakdown, Electro- convection Breakdown, Breakdown in solid Dielectrics, Intrinsic Breakdown, Electromechanical Breakdown, Breakdown due to Treeing and Tracking, Thermal Breakdown, Electrochemical Breakdown

## UNIT-III

**Generation of High Dc and Ac Voltages:** Introduction, Rectifier circuits, Cockcroft- Walton voltage multiplier circuit, electrostatic generator, generation of high ac voltages by cascaded transformers, series resonant circuit.

## UNIT-IV

**High Voltage Testing & Measurement:** Sphere-Gap, Uniform field Spark gap, Rod Gap, Electrostatic Voltmeter, Generating Voltmeter, Impulse Voltage Measurement using Voltage divider, Measurement of high DC, AC and Impulse Current., Testing of line Insulator, Testing of Cable, Testing of Bushings, Testing of Power Capacitor, Testing of Power Transformers, Testing of Circuit Breaker.

### REFERENCES:


1. M.S. Naidu & V. Kamaraju, "High Voltage Engineering", Publication TMH
2. S Kamakshaiah/V Kamaraju, "HVDC Transmission," McGraw Hill
3. Rakos Das Begamudre, "Extra EHV A.C Transmission" PHI Publication.
4. C.L Wadhwa, "High Voltage Engineering", New Age International Ltd.
5. Ravindra Arora & Wolfgang Mosch, "High voltage Insulation Engineering", New Age International Publishers, 2011.
6. E. Kuffel, W.S. Zaengl, J. Kuffel,"High voltage Engineering Fundamentals", Newnes Publishers, 2011.
7. M.S. Naidu & Kamaraju, "High voltage Engineering Fundamentals", TMH, 2008.

**Course Articulation Matrix:**

| Course/Course Code: High Voltage Engineering(PEC-EE416-T), | | | | | | | | | | | | | | Semester: VIII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| CO1 | 2 | 3 | 2 | 1 | 2 | 1 | 1 | - | - | - | 1 | 1 | 3 | 2 | 1 |
| CO2 | 3 | 2 | 2 | 2 | 1 | 2 | 1 | - | - | - | 2 | 1 | 2 | 1 | 1 |
| CO3 | 2 | 2 | 2 | 3 | 2 | 1 | - | - | - | - | 1 | 1 | 3 | 3 | 1 |
| CO4 | 2 | 2 | 1 | 2 | 3 | 2 | 1 | - | - | - | - | - | 2 | 2 | 1 |
| CO5 | 3 | 3 | 2 | 1 | 1 | 3 | 1 | - | - | - | 2 | 1 | 2 | 1 | 1 |
| CO6 | 2 | 2 | 3 | 2 | 1 | 3 | 1 | - | - | - | 1 | 2 | 2 | 2 | 1 |

**Correlation level:** **1**- slight /Low **2-** Moderate/ Medium **3**- Substantial/High

# OPTIMIZATION THEORY

## General Course Information:

| | |
|---|---|
| Course Code: PEC-EE418-T<br>Course Credits: 3.0<br>Mode: Lecture (L)<br>Type: Program Elective<br>Teaching Schedule L T P: 3 0 0<br>Examination Duration: 3 hours | **Course Assessment Methods (Internal: 30; External: 70)** Two minor test each of 20 marks, class performance measured through percentage of lecture attended (4 marks), assignments, quiz etc. (6 marks) and end semester examination of 70 marks.<br><br>For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus; it will contain seven short answer type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the four units. All questions carry equal marks. |

## Course outcomes:

| **Sr. No.** | **Course outcomes**<br>At the end of the course students will be able to: | **RBT* Level** |
|---|---|---|
| CO1. | Describe the different optimization algorithms and formulate optimization problems | **L1(Remembering)** |
| CO2. | Understand the need of optimization theory and how it may be applied to different applications and areas of engineering | **L2(Understanding)** |
| CO3. | Apply classical and modern optimization techniques to solve engineering problems | **L3(Apply)** |
| CO4. | Differentiate between various optimization techniques | **L4(Analysis)** |
| CO5. | Select the appropriate optimization technique suitable for a given system and its model | **L5( Evaluating)** |
| CO6. | Formulate optimization problems and obtain an optimal solutions | **L6(Creating)** |

***Revised Bloom's Taxonomy Action verbs/Levels**

## Course Content

## UNIT- I

**Introduction and Classical Optimization Techniques:** Statement of an Optimization problem, Design vector, Design constraints, Constraint surface, Objective function, Objective function surfaces, Classification of Optimization problems, Classical Optimization Techniques: Single variable Optimization and multi variable Optimization without constraints, Necessary and sufficient conditions for minimum/maximum, Multivariable Optimization with equality constraints, Solution by method of Lagrange multipliers, Multivariable Optimization with inequality constraints, Kuhn – Tucker conditions.

## UNIT- II

**Linear programming:** Linear programming problem formulation, Simplex method, Two phase simplex method, Dual simplex method, Duality in linear programming, Sensitivity analysis and its applications, Integer linear programming, Cutting plane method, Linear programming approach to game theory, Dynamic programming problems.

## UNIT- III

**Nonlinear programming:** Introduction to nonlinear programming, Unconstrained optimization: formulation of quadratic optimization problem, Newton Raphson method, Gradient method, Constrained optimization: Quadratic programming, Separable programming.

## UNIT- IV

**Dynamic programming and Evolutionary algorithms:** Dynamic programming multistage decision processes, Types, Concept of sub-optimization and the principle of optimality, Computational procedure in dynamic programming, Examples illustrating the calculus method of solution, Examples illustrating the tabular method of solution, Evolutionary Algorithms: Genetic algorithms, simulated annealing, fuzzy optimization.

**REFERENCES:**


1. S. S. Rao, "Engineering Optimization: Theory and Practice", Wiley, 6th edition, 2019.
2. H. A. Taha, "Operations Research: An Introduction", 10th Edition, Pearson, 2017.
3. H. S. Kasana & K. D. Kumar, "Introductory Operations Research", Springer (India), Pvt. Ltd., 2004
4. V. Chvatal, W. H. Freeman, "Linear programming", New York, 1985
5. G. B. Dantzig, M. N. Thapa, "Linear programming", Springer, 3rd edition, 2003
6. D. P. Bertsekas, "Nonlinear Programming" Athena Scientific, 2nd edition, 2016,
7. P.K. Gupta and D.S. Hira, "Operations Research", S. Chand, Revised edition, 2014
8. K. Deb, "Multi-objective optimization using evolutionary algorithms", Wiley, 2001

**Course Articulation Matrix:**

| Course/Course Code: Optimization Theory (PEC-EE418-T), | | | | | | | | | | | | Semester: VIII | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| CO1 | 3 | 1 | 2 | 1 | 1 | 2 | 1 | - | - | - | 3 | 3 | 1 | 2 | 1 |
| CO2 | 3 | 2 | 2 | 1 | 2 | 2 | 1 | - | - | - | 3 | 3 | 1 | 2 | 1 |
| CO3 | 2 | 2 | 2 | 2 | 3 | 2 | 1 | - | - | - | 3 | 2 | 2 | 2 | 1 |
| CO4 | 2 | 3 | 2 | 2 | 2 | 2 | 1 | - | - | - | 3 | 2 | 2 | 3 | 1 |
| CO5 | 3 | 3 | 2 | 2 | 2 | 2 | 1 | - | - | - | 3 | 2 | 2 | 3 | 1 |
| CO6 | 3 | 3 | 2 | 2 | 2 | 2 | 1 | - | - | - | 3 | 2 | 3 | 3 | 1 |

**Correlation level:** **1**- slight /Low **2-** Moderate/ Medium **3**- Substantial/High